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Identifying Prehistoric Interaction on Rapa Nui (Easter Island): Modelling the Development of Social Complexity in Extreme Isolation

Dale F. Simpson Jr.

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Abstract

Anthropological archaeologists have been investigating ancient human interaction for decades as interaction studies highlight how humans have communicated for 200,000 years at a variety of spatial and temporal scales. With the development of provenance studies and improved geochemical sourcing techniques, researchers can better document the movement of raw materials and formed artefacts from sources to habitation and ceremonial sites to understand economic, ideological, and sociopolitical interaction. In the Pacific, numerous researchers have documented how Oceanic people were highly mobile and adept at intra– and inter–island interaction across the great 'sea of islands' (Hau'ofa 1993). Within Polynesia, tracing interaction has mostly been accomplished through geochemical analyses of stone materials, especially basalt adzes. These findings uncovered regional voyaging and interaction spheres between numerous islands and archipelagos.

Rapa Nui (Easter Island) has been the subject of various scientific investigations. Much of this work has been dedicated to *moai* (statues) and *ahu* (platforms) and how these megalithic features venerated the island's chiefly ancestors and supported sociopolitical organisation, ideological communication, economic (re)distribution, and elite management over the island's ancient political economy. Although *moai* and *ahu* have been studied for centuries, archaeological investigation of the island's many basalt sources and artefacts, including their geological provenance and geochemistry, has been minimal. Consequently, this lack of comprehensive geochemistry for basalt sources and artefacts has restricted the potential of ancient interaction studies on Rapa Nui.

To fill this gap in the archaeological literature, the "Rapa Nui Geochemical Project (RNGP)" was established in 2013. The main goals of the RNGP include: 1) to identify, geologically, the various types of basalt used archaeologically and document the stages of production for artefacts and construction stones; 2) to elucidate spatial and temporal patterns of basalt acquisition, transfer, and use; 3) to delineate economic, ideological, and sociopolitical interaction, including pathways that accompanied and facilitated stone exchange between members of the ancient Rapanui culture; 4) to highlight the attributes of Rapa Nui's chiefly controlled ancient political economy through documenting the spatial and temporal distributions of archaeological basalt industries; 5) to evaluate economic and sociopolitical interpretations put forward by the 'ecocide' or 'collapse' narrative (Bahn and Flenley 1992;

Diamond 1995, 2005); and 6) to create public archaeology and educational opportunities for the local Rapa Nui community.

Over six years, the RNGP collaborated with more than 30 individuals from 20 institutions from around the globe to conduct field archaeology (four campaigns from 2014–2018), geoarchaeological and material culture documentation (SLR camera and drone photos/videos and artefactual 3D scanning), geochemical analyses (inductively coupled plasma–mass spectrometry and portable x–ray fluorescence), radiometric dating (^{14}C), artistic site reconstructions, and educational outreach.

RNGP results from six study areas reveal a diversity of operational sequences for basalt tool making which parallels the numerous economic, ideological and sociopolitical pathways used by the ancient Rapanui to acquire basalt for artefact and construction stone creation. The RNGP geochemically identified eight unique basalts during analysis and highlighted how quarries and sources at Ava o‘Kiri and Pu Tokitoki provided most of the material used to manufacture the sample of basalt artefacts (adzes, picks, knives, and axes) analysed in this study.

Four pathways for the transfer of basalt were uncovered in this investigation, they included, opportunistic, communal, and confederation and elite (re)distribution. Thus, the complexity of interaction outlined in this Ph.D. thesis refutes economic and sociopolitical propositions put forward by the ‘collapse narrative’ for Rapa Nui’s pre–contact period. Instead, it establishes the common interaction and collaboration within and between *mata* (clans) and the two island confederations that existed during the island’s past, especially regarding the access to and use of culturally valuable stone such as basalt.

Declaration by author

This thesis is composed of my original work, and contains no material previously published or written by another person except where due reference has been made in the text. I have clearly stated the contribution by others to jointly-authored works that I have included in my thesis.

I have clearly stated the contribution of others to my thesis as a whole, including statistical assistance, survey design, data analysis, significant technical procedures, professional editorial advice, financial support and any other original research work used or reported in my thesis. The content of my thesis is the result of work I have carried out since the commencement of my higher degree by research candidature and does not include a substantial part of work that has been submitted to qualify for the award of any other degree or diploma in any university or other tertiary institution. I have clearly stated which parts of my thesis, if any, have been submitted to qualify for another award.

I acknowledge that an electronic copy of my thesis must be lodged with the University Library and, subject to the policy and procedures of The University of Queensland, the thesis be made available for research and study in accordance with the Copyright Act 1968 unless a period of embargo has been approved by the Dean of the Graduate School.

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Publications during candidature

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Publications included in this thesis

Chapters 3–6 of this thesis are manuscripts accepted for publication in peer–reviewed journals. I am the lead author of all of these publications. I was responsible for conception and design of the research, analysis and interpretation of data, and the writing, submission, and revision of all manuscripts. I was the second author on a fifth manuscript. I worked closely with the lead author on conception and design of the research, analysis and interpretation of data, and writing of the manuscript.

Chapter 3: "Reviews of Rapa Nui's geodynamic, volanic, and geologic evolution and archaeological sourcing studies" has been peer–reviewed and accepted for publication in *Apuntes de la Biblioteca William Mulloy.*

Contributor	Statement of contribution
Dale F. Simpson Jr. (Candidate)	Collation and review of literature (100%) Wrote and edited the paper (100%)

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No animal or human subjects were involved in this research.

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basalt adze quarries, collapse, geoarchaeology, geochemistry, inductively coupled plasma–mass spectrometry (ICP–MS), East Polynesia, elite political economy, prehistoric interaction, Rapa Nui (Easter Island)

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CHAPTER 1: Introduction

Introduction

One of the defining characteristics of our species is how we have economically, ideologically, and sociopolitically interacted across time and space. From the first human interactions some 200,000 years ago (McDougall et al. 2005; López et al. 2015; Stringer 2015) until today, *Homo sapiens* have networked in multiple 'modes' (Finnegan 2002), including within local, regional, intercontinental, and global 'interaction spheres' (Caldwell 1964). Interested in documenting and investigating the various spatial and temporal scales of human interaction, anthropological archaeologists use a diversity of paradigms, methodologies, and practices to examine ancient and historic contexts found throughout the world (Bauer and Agbe–Davies 2011; Dillian and While [eds] 2011; Knappet 2011, 2013; Schortman and Urban 1987, 1992; Stein 2002).

Archaeological theories such as diffusionism, culture–history, processualism, post–processualism, and network analysis have been used to frame human interaction studies across North, Central, and South America, Europe, Africa, Asia, and the Pacific, often focusing on archaeological materials including ceramics, obsidian, cherts, basalts, metals, glass, semiprecious materials such as jade, amber, and turquoise, and building materials including marble, basalt, and sandstone (Ammerman [ed.] 1985; Baugh and Ericson [eds] 1994; Evett 1973; Hallam et al. 1976; Harbottle 1982; Kristiansen and Larsson 2005; Lightfoot and Martinez 1995; Renfew 1975, 1977; Schortman and Urban [eds] 1992; Torrence 1996a, 1996b; Weisler [ed.] 1997). Results from these efforts provide case studies and assist to define concepts such as reciprocity, redistribution, exchange, connectivity, and trade that help to frame, support, and inform investigations into ancient and historic human interaction (Chapter Two).

For much of this research, providing the hard evidence for the intercommunication and interconnections between human groups has come in the form of material fingerprinting studies (Dussubieux et al. [eds] 2016; Glascock [ed.] 2002; Glascock et al. 2007; Shackley 1998; Weisler 1998). These studies have allowed for the identification of an artefact's geological source (using archaeometry), and the recognition of the various economic, ideological, and sociopolitical mechanisms responsible for the acquisition, transfer, use, and discard of an artefact (using anthropological archaeology theory).

Characterisation or sourcing studies are normally focused on non–perishable raw materials and finished hard goods that are foreign to the place of deposition (Cochrane and Hunt 2017; Kirch 1997; Rolett 2002; Weisler 1997a). They range in sophistication from macroscopic observation of gross physical properties (colour, size, texture), to microscopic viewing (inclusions, streaking), and analyses of chemical and elemental composition using, for example, inductively coupled plasma–mass spectrometry (ICP–MS), instrumental neutron activation analysis (INAA), proton–induced X–ray emission/proton–induced gamma ray emission (PIXE–PIGME), and X–ray fluorescence (XRF) (Deutchman 1980; Dillian and White 2010; Ericson 1981; Glascock [ed.] 2002; Glascock et al. 2007; Lattanzi 2007; Shackley 1998; Summerhayes et al. 1998; Weisler [ed.] 1997). A benefit of using the latter set of fingerprinting techniques is that technical precision and accuracy in elemental characterisation and sourcing have greatly improved over the years (Earle 2010). This includes resolving difficulties in discriminating source and artefact chemistry, the recognition of proper sampling sizes for geological settings as well as for artefacts, the use of precise and accurate analytical technologies and statistical programs for parts per million (ppm) and weight percentage (wt%) elemental calculations, and the development of universal geological blanks and controls (for example, Standard Reference Samples [SRSs] of the United States Geological Survey) for statistical calculations and comparative analyses within and between research laboratories (Dussubieux et al. [eds] 2016; Ma et al. 2011; Weisler et al. 2016a).

While much work still needs to be done to identify and geochemically analyse additional sources and artefacts, altogether, sourcing techniques, when aligned with anthropological archaeology theory, help researchers to document and explain 200,000 years of human interaction in local, regional, intercontinental, and global nodes and networks.

Archaeological interaction studies within the Pacific 'sea of islands'

Oceanic people were highly mobile and adept at intra– and inter–island contact and interaction in the great 'sea of islands' (Hau'ofa 1993). As Pacific islands were colonised from west to east, the introduction of imported artefacts and raw materials into new geological and environmental contexts are often readily apparent in Oceanic archaeological assemblages (Rolett 2002; Weisler 1997a). Therefore, the movement of Pacific people, and the translocation of materials from Near Oceania into Remote Oceania (Green 1991) and from West Polynesia into East Polynesia (Green 1968; Kirch 1990; Marack 1996; Weisler and Walter 2017), have been of particular interest for archaeological interaction studies (Cochrane and Hunt 2018;

Erlandson 2008; Kirch and Weisler 1994; Kirch 2017; Kirch and Kahn 2007; Weisler 1997a; Weisler [ed.] 1997). In turn, tracing the movement of people and materials throughout Oceania has informed on the timing, the geographic scale, the duration, and the complexity of ancient human interactions in the Pacific.

Due to more than 30,000 years of human occupation in the Pacific, archaeologists have studied human interaction through three main periods: from the Pleistocene to the early Holocene; during the period of the Lapita Cultural Complex of the mid–Holocene; and during Polynesian exploration, expansion, and development in the late Holocene (Kirch 2017; Simpson 2015a; Chapter Two). Results from interaction studies concerning these periods have resulted in particular models – 'diffusionist', 'debt', 'isolationist', and 'interactionist' – to explain the pattering and the divergence of material in the archaeological record within and between Pacific islands (see, for example, Emory 1968; Erlandson 2008; Hunt and Graves 1991; Irwin 1992; Kirch and Green 1987; Rolett 1993; Sinoto 1996; Terrell 1986; Weisler 1997a).

More specific outcomes of this work have uncovered Pleistocene interactions, including the first inter–island networks in Near Oceania from 24,000 to 8000 years ago (Flannery and White 1991; Fredericksen 1997; Summerhayes 2009; Summerhayes et al. 1998; Torrence 1996b; Torrence et al. 2013), spatially large and complex interaction spheres in the Papuan Highlands (Hughes 1977) and around the Bismarck Archipelago (Pengilley et al. 2019), and 'central manufacturing places' that developed into specialised pottery production and distribution centres that continued for many generations (Irwin 1974, 1978a 1979b, 1985).

Lapita interaction studies have used mostly obsidian and pottery to highlight the navigational efficacy of Austronesian speaking seafarers in the mid–Holocene, and the extent of exchange of material throughout Near and Remote Oceania at this time (Ambrose and Green 1972; Best 1984; Frederickson 1997; Green and Kirch 1997; Hunt 1989; Kirch 1991, 1997, 2017; Spriggs 1997). Interaction studies focused on West and East Polynesia are divided between investigating the interconnections between Lapita's most far–flung sites in Fiji, Samoa, and Tonga, and investigating the interaction of the ancient *Ma'ohi* (Polynesian) culture.

Archaeological sourcing work in Polynesia, particularly of basalt adzes, has been responsible for reconstructing a complex regional interaction sphere that once existed from 900–1500 AD, linking the Societies, Tuamotus, and Marquesas, along with the southern Cooks, Australs, and Mangareva, Henderson, and Pitcairn Islands (Collerson and Weisler 2007; Weisler 1998; Weisler and Walter 2017). Regarding the Mangareva, Henderson, and Pitcairn (MHP) interaction sphere, Weisler (1994, 1995, 1996, 1997b, 2002; Weisler et al. 2004) reconstructed 400–500 years of ancient interaction, demonstrating how inter–island voyaging within the MHP interaction sphere, and the inter–island transfer of raw materials and artefacts, sustained small, marginal human populations on ecologically impoverished islands in the far eastern Pacific. As Rapa Nui (Easter Island) may have been colonised from this region, understanding patterns of interaction within the MHP prehistoric network, along with careful review of archaeological interaction studies within the 'sea of islands' (Chapter Two), informs Rapa Nui interaction studies and interpretations that are the focus of this thesis.

Rationale

Rapa Nui has been the focus of numerous scientific studies, reports, articles, books, presentations, museum exhibitions, conferences, movies, and TV shows (for example, see www.moaiculture.com). An overwhelming majority of these are archaeological in nature, with many aiming to explain the so–called 'mysteries' or 'enigmas' of Rapa Nui (Chapman and Santa–Coloma 2010; Edwards and Edwards 2013; Flenley and Bahn 2003; Hunt and Lipo 2017). These include, for example, the geographic origins of the Rapanui, *moai* statue carving and transport, *ahu* platform construction, and the various meanings of the *kohau rongorongo* proto–language script.

While early anthropological and archaeological surveys were conducted by Routledge (1919), Knoche (1925), Lavachery (1939), Métraux (1940, 1957), and Englert (1948), scientific archaeology was first conducted on the island in 1955 with the Norwegian Archaeological Expedition (NAE). Led by Thor Heyerdahl, the NAE obtained the first radiometric dates from archaeological contexts and presented the first three–phase culture history for Rapa Nui (Heyerdahl and Ferdon et al. 1961, 1965). From this first scientific investigation until 2019, Rapa Nui has provided ample opportunity to analyse a multiplicity of palaeoecological and archaeological materials, for instance: stone, coral, bone, wood, shell, pollen, microfossils, construction stone, statuary, and monumental architecture. Rapa Nui's archaeological record also includes a variety of sites and features, including: megalithic platforms, roads, boat ramps and slips, habitation sites for both elite and non–elite Rapanui, horticultural features and plantations, ovens and oven houses, petroglyphs and petroglyph panels, chicken husbandry sites, water collection features, and stone quarrying sites. As such, the island's archaeological record has been interpreted by researchers using a diversity of theories, including: diffusionism, culture history, cultural ecology, settlement pattern studies, evolutionary, interpretive, and political economy (Chapter Two).

In a recent review of Rapa Nui archaeology, Hunt and Lipo (2017) noted that, especially in the last 20 years, an understanding of Rapa Nui's pre–contact past has been fostered through systematic re–evaluations of previous archaeological assumptions using detailed scientific data. Such re–assessments have included determining when the island was colonised, how *moai* were manufactured and transported, and where and why *ahu* were constructed throughout the island (Hunt and Lipo 2011, 2017).

One archaeological topic that has been comprehensively re–evaluated is the notion of Rapa Nui's alleged pre–contact socio–ecological collapse (Bahn and Flenley 1992; Diamond 2005). The collapse narrative postulates that before contact with the outside world in 1772, Rapanui caused "deforestation [to fell trees to transport *moai*] of Easter Island which allowed wind to blow off the island's thin topsoil: starvation, a population crash and a descent into cannibalism followed, leaving those haunting statues for the Europeans to find" (Easterbrook 2005:1). While this quote succinctly sums up the Rapa Nui collapse narrative, more recent multi–disciplinary scientific investigations (including this thesis) have focused efforts on empirically testing suppositions put forth by the collapse narrative, to ultimately demonstrate that its conclusions are unsound (Hunt 2007, Hunt and Lipo 2006, 2007, 2010, 2011; Jarman et al. 2017; Lipo et al. 2013, 2016; Larsen and Simpson 2014; Mulrooney 2012, 2013; Mulrooney et al. 2009; Rull et al. 2013, 2016; Simpson and Dussubieux 2018; Simpson et al. 2018; Stevenson et al. 2015; Thromp and Dudgeon 2015; Chapters Six and Seven).

Concurrently, in the last 20 years improved geodynamic, volcanological, and geological knowledge about Rapa Nui (see Simpson 2014), and more geochemical analyses of lithic quarries/sources[1] and artefacts, have elaborated on previous studies to illuminate ancient interactions based on material culture use (Chapter Three). A benefit of studying quarries and sources is that they are often distributed unevenly, allowing archaeologists to use geochemical analyses to document patterns of access, control, distribution, and use. This information, in turn, can inform economic, ideological, and sociopolitical interaction and organisation for Rapa Nui, as it has been employed elsewhere in Polynesia (Clark et al. 2014; McAlister and Allen 2017; Rolett et al. 2015; Weisler and Walter 2017; Weisler et al. 2014, 2016b).

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[1] The term 'source/quarry' is used as only a few stone locales on Rapa Nui are actual 'quarries' defined by the presence of extraction pits, while other locales are more properly called 'sources' as tool–quality stone or construction materials were merely collected from the surface (after Weisler and Sinton 1997:180).

One important methodological issue in quarry studies is how to document reduction and transfer processes used to make and exchange lithic materials. While Shott (1996, 2003) judged the staged manufacture concept for stone artefacts as highly problematic and of limited utility, McCoy (2014) notes that all reduction technologies are a 'continuum', and because of this, parent material is reduced in size as the process unfolds, allowing the identification of operational sequences or stages. This information, then, adds detail to artefact life–histories, commodity chains, and human–material entanglements (Blair 2009; Earle 2011; Hodder 2015; Simpson 2015c). Five general stages can be identified regarding the use of archaeological quarries, sources, mines, and workshops to produce, transfer, and use stone tools: 1) *procurement*, often involving mining and quarrying; 2) *reduction*, frequently involving more than one step, often with specialists, to manufacture lithics; 3) *exchange* of objects through varying economic, ideological, and sociopolitical contexts; 4) the *multiple uses* of lithics in both mundane and sacred contexts; and 5) the *discard* of stone tools.

To describe these stages of lithic manufacture and use to inform interaction studies, Rapa Nui archaeologists have predominantly focused on the island's four obsidian sources: Maunga Orito; Te Manavai; Rano Kau; and Motu Iti (Chapter Three, Figure 24) and the artefacts produced from these sources (Bollt et al. 2006; Mulrooney et al. 2014, 2015; Stevenson and Williams 2018; Thomas 2009). This is because obsidian is found at most Rapa Nui archaeological sites (McCoy 1976; Vargas et al. 2006), it can be dated by obsidian hydration (Stevenson 1984, 1986, 1997, 2000; Stevenson et al. 2015), and has diagnostic geochemical signatures that are useful for assigning artefacts to sources (Beardsley and Goles 1998, 2001; Beardsley et al. 1996; Cristino et al. 1999; Morrison and Dudgeon 2012; Mulrooney et al. 2014, 2015; Stevenson et al. 2013; Thomas 2009).

Distribution studies based on characterisation data propose that obsidian from the four quarries was differentially utilised based on glass quality, geological location, and the different needs for obsidian between elite and non–elite Rapanui (Beardsley et al. 1996; Martinsson–Wallin 1994; Mulrooney et al. 2014; Stevenson et al. 2013). While results from obsidian provenance investigation prompted Thomas (2009:49) to conclude that "analysis appear[s] to demonstrate a lack of competition and instead promote[s] the idea of communal resource access and/or implications of a trade network on [Rapa Nui]", Stevenson et al. (2013:119) questioned how archaeological obsidian could have been used "in formalized trading partnerships between those lineages with obsidian deposits and those without". McCoy (2014:16, 18) predicted that some archaeological stone was sourced from 'common' areas and "was obtained through exchange with *mata* (clans) or lineages from other parts of the island". However, none of these researchers could demonstrate why, how, or when obsidian material was acquired and/or exchanged within and between the ancient *mata*. Therefore, this is a major gap in the archaeological literature regarding how the pre–contact island culture transferred and exchanged archaeological stone, including obsidian.

While nine different geochemical studies have been conducted on Rapa Nui's archaeological obsidian (Chapter Three, Table Two), only four publications (none of which used the same analytical technology, which limits comparison of elemental data and interpretations between studies) have been dedicated to fine–grain archaeological basalt (Chapter Three). Of these, one used macroscopic and microscopic analyses of only archaeological samples (Ayres et al. 1998), one used INAA analysis of only geoarchaeological samples (Stevenson et al. 2000), one used ICP–MS of both geological and archaeological samples (Harper 2008), and one used pXRF of only archaeological samples (Fischer and Bahamondez 2011). Whereas results from the first of these studies led Ayres et al. (1998) to propose that patterns of ancient basalt adze exchange best fit into opportunistic and kin–based geographic exchange patterns (see Peterson et al. 1997), Stevenson et al. (2000) argued that the lack of ceremonial and domestic features associated with basalt quarries and sources suggest that 'task groups', organised by 'corporate strategies' (see Blanton et al. 1996; Simpson 2008; Stevenson 1997), visited communal areas to extract basalt on a routine basis. Harper's (2008) work showed how selected adzes (*toki*) were provenanced from inside the Rano Kau area, while *ahu* platform blocks (*paenga*) were quarried from somewhere in the Terevaka volcanic complex, and then moved to *ahu* sites later. Results of geochemical analyses of *toki* (adze and pick) by the Easter Island Statue Project hinted at possible centralised distribution of adzes and picks from one or two main quarries outward to Rano Raraku, the *moai* quarry (Fischer and Bahamondez 2011). Still, similar to the investigation of archaeological obsidian, none of these aforementioned researchers could demonstrate why, how, or when fine–grain basalt material was acquired and/or exchanged within and between the ancient *mata* and the two island confederations (Hotus et al. 1988; Routledge 1919; Vargas et al. 2006). Therefore, this is a major gap in the archaeological literature regarding how the pre–contact island culture transferred and exchanged archaeological stone, including basalt.

Consequently, this lack of comparable and comprehensive geochemistry for basalt sources and artefacts has restricted the potential of Rapa Nui interaction studies, as investigators have reported multiple basalt sources, quarries, and workshops throughout the island (Chapter 3,

Figure 24; Chapter 4, Table 1) and have archaeologically recovered abundant basalt artefacts and construction stone including adzes, chisels, knives, axes, fishhooks, *keho* (flat basaltic laminates), *pae* (non–dressed basaltic blocks), and *paenga* (dressed stone). Hence, as basalt tools were necessary for woodworking, canoe building, *moai* and *ahu* stone sculpting (Simpson et al. 2017, 2018; Van Tilburg 1994), understanding their sources, manufacture, distribution, and timings of use can inform interpretations of ancient island economy, ideology, and sociopolitical interaction and organisation through time (Best et al. 1992; Duff 1959; Emory 1968; Weisler 1997b, 1998; Weisler 1997 [ed.]). Such analysis is the subject of this thesis.

Thesis Research Aims

The main goal of this thesis is to use a political economy (PE) theoretical lens (Earle 1997, 2002; Earle and Spriggs 2015; Simpson 2008, 2009; Stevenson 1997) to interpret the archaeological evidence for acquisition, transfer, and use of fine–grain basalt during Rapa Nui's past (Simpson and Dussubieux 2018; Simpson et al. 2017, 2018). To address the transfer of basalt artefacts – from geological sources to archaeological sites – and to understand economic, ideological, and sociopolitical interactions, there is a need to develop an approach that utilises high quality geoarchaeological and geochemical methods that are accurate, precise, and replicable. This approach provides archaeological site and archaeometric data that, when joined with anthropological archaeology theory (i.e. PE), helps to uncover and describe patterns of access to, and control of quarries/sources, along with patterns of exchange, use, and discard of stone materials and artefacts. This information will assist in filling gaps that exist in Rapa Nui's archaeological literature regarding access to basalt from quarries and sources, the manufacturing process of basalt artefacts, and the exchange of basalt between and amongst the Rapanui in pre–contact times.

Supplementary goals of this thesis include: 1) to identify, geologically, the various types of basalt and document the reduction stages used to produce artefacts and construction stones; 2) to use a variety of approaches and methods (literature review, field archaeology, drone and SLR photography and videography, 3D scanning, ^{14}C dating, an online datashare [www.terevaka.com/toki], and artist's reconstructions [Appendix H]) and state–of–the–art geochemical technologies (pXRF and ICP–MS) to reveal temporal and spatial patterns of basalt acquisition, reduction, transfer, and use; 3) to highlight attributes of Rapa Nui's elite–controlled ancient political economy; 4) to determine economic, ideological, and sociopolitical contexts that accompanied and facilitated basalt exchange between members of the ancient Rapanui culture; 5) to revisit the 'ecocide' or 'collapse' narrative (Bahn and Flenley 1992; Diamond 2005) and argue that it is an inadequate framework to understand Rapa Nui history (see also Larsen and Simpson 2014); and 6) to create public archaeology and educational opportunities for the island community (see Shepardson et al. 2014; Simpson 2015b, 2016b, 2019; Torres and Hereveri 2015; Torres et al. 2015; Appendix G). Therefore, to attain my main and supplementary goals, the following individual research questions (RQ) were posited:

RQ1: What types of economic, ideological, and sociopolitical interactions were evident during Rapa Nui's pre–contact and historic/contact periods?

RQ2: What are the characteristics of Rapa Nui's chiefly and elite–controlled ancient political economy?

RQ3: What fine–grain basalts are found in the Rapa Nui Geochemical Project study areas and what types of basalts were used to manufacture portable artefacts according to total alkali versus silica (TAS) analysis? What were the geological formation processes that created tool–grade basalt? What elements should geochemists use to discriminate between Rapa Nui's basalt sources in the future?

RQ4: What are the spatial distributions, physical characteristics, and timing of use for Rapa Nui's fine–grain basalt mines, sources, quarries, and workshops?

RQ5: What were the economic, ideological, and sociopolitical mechanisms that facilitated the access to and use of archaeological stone, including fine–grain basalt, during Rapa Nui's past?

RQ6: What do the overall results from this thesis suggest about economic and sociopolitical interpretations put forward by proponents of the 'ecocide' or 'collapse' narrative?

To help answer these six research questions and to formalise a research approach, I established the Rapa Nui Geochemical Project (RNGP) in 2013 (Simpson 2019; Simpson and Dussubieux 2018; Simpson et al. 2018). Since then, the project has used four campaigns (2014–2018) of field archaeology (Simpson 2015a,b, 2016a,b), archaeological site and material culture documentation (Simpson 2015c,d, 2016c, 2017b), geochemical analyses (Simpson 2017a, 2018a,b; Simpson and Dussubuiex 2018; Simpson et al. 2017, 2018), radiometric dating (Simpson et al. 2018), and quarry site interpretations by Rapanui artist Veri Lobos Haoa (Appendix H) to reconstruct patterns of past interaction and archaeological basalt use on Rapa Nui (Simpson 2013, 2016d; Simpson and Dussibiuex 2018; Chapter Seven).

Theoretical Orientation

The conceptual framework for this thesis is PE theory, as this approach can "identify alternative patterns of [cultural] development that archaeologists are now recording" (Earle and Spriggs

2015:517). PE is an important framework for explaining the mobilisation and control of surpluses in subsistence goods (staple resources) and the administered exchange of wealth objects (luxury resources). As a consequence, PE, as an explanatory trope, has gained considerable interest in Pacific archaeology, as the importance of chiefs and elites in overseeing and manipulating ancient political economies to serve their individual agency is well documented (Dow and Reed 2013; Earle 1997, 2002; Earle and Spriggs 2015; Firth 1967; Goldman 1970; Graves and Sweeny 1993; Hommon 2013; Kirch 1984, 1990, 2010; Kirch et al. 2011; Kolb 1991, 1992, 1994; Lass 1998; Sahlins 1958; Younger 2012).

Encouraging the use of a PE approach for past Pacific sequences, Earle and Spriggs (2015:515) argue that PE theory, supported by traditional Marxist principles and scientific data, "provides the means to look at how specific [and interrelated] archaeological histories have resulted in striking parallels, conjunctures, and divergences". Drawing upon case studies from the Lapita Cultural Complex, post–Lapita Vanuatu, and the Hawaiian Islands, Earle and Spriggs (2015) focus on how power – acquired by certain individuals and derived from their influence over the economy, land ownership and labour control, warrior might, and religious ideology (Earle 1997, 2002; Mann 1986) – was asserted via control over various 'bottlenecks' or constriction points in staple and luxury resource commodity chains. So–called bottlenecks offered chiefs and aspiring leaders the opportunity to limit access to specific segments of resource production and/or to limit access to whole artefacts, thus creating ownership over staple and luxury resources, technologies, and/or knowledge. In turn, ownership and intemperate access gave chiefs and elites the ability to finance, direct, and legitimise economic, ideological, and sociopolitical development and influence cultural evolution through time.

An important goal for archaeologists interested in reconstructing ancient political economies and the agency played by chiefs and elites to foster cultural developmental, is to reveal 'bottlenecking dynamics' found in the archaeological record across time and space (Earle and Spriggs 2015). This is done by identifying the concrete elements of the general economy (Sayer 1987) and then examining its staple and luxury resource commodity chains for potential bottlenecks that would allow for surplus extraction and manipulation by chiefly and elite members.

On Rapa Nui, the use of PE theory to interpret archaeological data has led to a nuanced appreciation of the various economic, ideological, and sociopolitical structures present in ancient Rapa Nui culture (Howard, 2007; Simpson 2008, 2009; Simpson et al. 2017; Stevenson 1997, 2002; Stevenson and Haoa 1998; Stevenson et al. 2005, 2013). It highlights how chiefly

Rapanui used ceremonial and domestic architecture to construct elite–controlled landscapes (which promoted hegemony and enforced particular ancestor worship systems), employed corporate work strategies for staple resource production and monumental architecture construction, and engaged in bottlenecking efforts such as first–fruits ceremonies, which were all legitimised by elite *mana* and protected by chiefly *tapu* and *rahui* (Chapters Two and Seven). Together, these sources of power allowed Rapanui chiefs and elites to maintain control over territories and landscapes, the labour force, and the most significant stages of staple resource commodity chains. Ultimately, economic, ideological, and sociopolitical hegemony created by control over the PE helped to legitimise Miru (the highest ranked island clan) and *tangata honui* (clan leaders) management of *mata kainga* (clan land), *mata* (clan) inhabitants living inland (commoners), and the island's productive resources over time (Simpson 2008, 2009).

By controlling (and redistributing) staple food resources (e.g. sweet potato, taro, sugarcane, chicken) and their production sectors (e.g. gardens, chicken houses), each Rapanui chief and his retainers facilitated individual *mata* to be more–or–less self–sufficient with regards to food production and consumption during pre–contact times (Hunt and Lipo 2011, 2017). As such, each district's *moai–ahu* complex (Stevenson 2002) and the development of its accompanying *mata kainga*, can be conceptualised as being the unique product of the individual agency (both successes and failures) of multiple chiefs and elites over numerous generations. Arguably, intergenerational success was measured by each generation's ability to: 1) maintain connections to the Miru and the *ariki mau* (paramount chief) for spiritual and ideological support, as well as with other clans for non–localised material and marriage partner exchange; 2) organise corporate labour works within *mata kainga* including the construction, maintenance, and expansion of *moai–ahu* complexes and horticultural and chicken husbandry productive features; and 3) properly invest, divert, and (re)distribute both staple and luxury resources to maintain the economic, ideological, and sociopolitical sustainability of their *mata*.

Yet, a constraint for chiefs and elites lay in the fact that deposits of culturally valuable stone used by the ancient Rapanui (e.g. tuff, scoria, obsidian, basalt) were not evenly distributed across the island's distinctive volcanic landscapes (Chapter Three). For example, while some clan lands were rich in obsidian sources, their *mata kainga* was completely devoid of tuff stone to manufacture *moai*. Similarly, red scoria, used to carve topknots or *pukao*, is concentrated around Puna Pau, but this area lacked the fine–grain basalt to make *toki* (adzes) and picks, needed to carve *pukao*.

These limiting geological factors resulted in an island–wide stone–use pattern where multiple clans accessed identical stone material from a minimum number of localised quarries and sources. This communal pattern of stone use is exemplified by the fact that 96% of all *moai* come from one source, Rano Raraku, but statues are distributed throughout the island in each *mata kainga*. This is the same for the ~100 *pukao* found at almost all district centres, but which were all sourced from a single quarry at Puna Pau (Van Tilburg 1994; Vargas et al. 2006; Thomas 2014).

It would seem, then, that there existed at least three general forms of economic, ideological, and sociopolitical interaction during pre–contact times: 1) within the *mata* – which was managed and directed by the individual agency of each *tangata honui* and his retainers; 2) between *mata* – which helped to negotiate and exchange for valuable stone resources (amongst other staple and luxury resources and marriage partners) used in ceremonial and domestic constructions and activities; and 3) within and between the island's two confederations. What is still unknown, however, is if this communal pattern for access to and use of valuable stone is also the same regarding the island's fine–grain basalt resources. Did chiefs and elite retainers have access to, and could they bottleneck superior basalt deposits for their own ambition and use, including to manufacture adzes and picks that were utilised for prestigious *moai* carving and canoe building? These questions are explored and answered in this thesis.

I argue that by using results gained by precise and accurate sourcing analyses (archaeometry) to understand prehistoric basalt acquisition, control, exchange, and use, along with frameworks and interpretations provided by Pacific and Rapa Nui PE investigations (anthropological archaeology theory), this thesis provides the basis for understanding economic, ideological, and sociopolitical interaction of the ancient Rapa Nui island culture.

Ph.D. Thesis Structure

This Ph.D. thesis comprises seven chapters: an introduction (Chapter One); a methodological and theoretical review of interaction studies in the Pacific and on Rapa Nui (Chapter Two); four chapters based on papers published in peer–reviewed journals (Chapters Three through Six); and a conclusion (Chapter Seven). Nine appendices (A – I) are also included to support the aims and goals of this doctoral thesis.

Chapter Two reviews major archaeological theories, methodologies, and key terms (reciprocity, redistribution, exchange, trade, connectivity, and interaction) used to frame human interaction studies. This chapter then examines archaeological interaction studies in the ‘sea of islands’, including Near and Remote Oceania, Polynesia, and Rapa Nui. By connecting historic, ethnohistoric, and ethnographic records with results and interpretations from archaeology, an evaluation of ancient and historic Rapa Nui economic, ideological, and sociopolitical interaction is presented, along with a recreation of the island’s ancient political economy. Research questions addressed: RQ1, RQ2, RQ5, RQ6.

Chapter Three synthesises the robust records that describe the geodynamic, volcanic, and geologic evolution of Rapa Nui. This chapter also focuses on: Rapa Nui’s geomorphological formation and dating; the island’s main volcanoes and their associated geological material; and Rapa Nui rock types, their locations in the landscape, and their pre–contact use to fabricate archaeological structures and artefacts. Previous Rapa Nui geological and geoarchaeological research that has produced geochemical data and/or interpretations about archaeological stone use are also presented and complied. Research questions addressed: RQ3, RQ4, and RQ5.

Chapter Four details a geochemical pilot study conducted at The University of Queensland’s Earth Science Laboratories, which utilised 10 samples from the adze quarry at Rua Tokitoki and a fine–grain basalt source found on Poike. This chapter also provides site descriptions, describes two unique basalt stone quarrying processes, and reports on quarry and source geochemistry. This information contributes to an understanding of ancient mining, economic, ideological, and sociopolitical interaction, and elite oversight over valuable stone resources on Rapa Nui. Research questions addressed: RQ1, RQ2, RQ3, RQ4, and RQ5.

Chapter Five draws on the research collaboration between two active archaeological projects on Rapa Nui – the Easter Island Statue Project and the RNGP. Working collaboratively, our work traces the archaeological transfer of basalt resources from the Ava o‘Kiri and Pu Tokitoki quarry complexes to the *moai* (statue) quarry at Rano Raraku between 1455–1645 AD. This chapter highlights how pre–contact Rapanui were sophisticated Polynesian stone workers who developed multiple tool reduction sequences for several types of basalt, creating unique anthropogenic landscapes in the process. Conclusions made in this chapter highlight interactions during Rapa Nui’s past, while delineating the relationship between adze and pick production and *moai* manufacture. Research questions addressed: RQ1, RQ4, RQ5, and RQ6.

Chapter Six reports RNGP results from fieldwork and material culture and archaeometric analyses focused on Rapa Nui’s archaeological basalt industries. Using results obtained from ICP–MS geochemistry from 209 geoarchaeological samples, it is argued that, similar to other culturally valuable stone (e.g. obsidian, scoria, and tuff), there was opportunistic and communal access to and use of certain basalt resources throughout the past. Concurrently, evidence is documented that suggests that elite Rapanui (and their confederations) maintained control over a patchy, but valuable fine–grain basalt deposit, highlighting chiefly and elite bottlenecking over certain stone resources used within the island's ancient political economy. Together, opportunistic and communal access to, and confederation and elite control over culturally valuable, but spatially limited stone, hint at patterns of economic, ideological, and sociopolitical interaction on this eastern Polynesian outpost. Lastly, the empirically derived conclusions from this study cast doubt on cultural interpretations proposed by Easter Island's collapse narrative (Bahn and Flenley 1992; Diamond 2005) and instead allows this thesis to propose another way to interpret Rapa Nui's past. Research questions addressed: RQ1, RQ2, RQ3, RQ4, RQ5, and RQ6.

Chapter Seven is a summary of the main research findings, future research objectives, and final remarks. A description of the RNGP is also provided.

The nine appendices are titled: Appendix A – Previous geochemical data for Rapa Nui including stone types, major and minor elements (in both WT% and ppm), and scientific source; Appendix B – Database of all RNGP archaeological sites under study (n=84); Appendix C – EISP and RNGP archaeological artefacts under study (n=78); Appendix D – Photographs of selected RNGP archaeological sites under geochemical study (n=31); Appendix E – EISP & RNGP LA–ICP–MS elemental data; Appendix F – Letters of support, letters of permission, and authorisation permits; Appendix G – RNGP educational outreach efforts; Appendix H – Artistic site reconstructions; Appendix I – Total doctoral thesis and RNGP academic production.

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CHAPTER 2: Interacting sea of islands – A review of interaction studies in Near and Remote Oceania, with particular reference to West and East Polynesia, and Rapa Nui (Easter Island)

Abstract: Interaction studies are important topics for archaeology. These investigations help reconstruct patterns of human communication across time and space. Interested in human communication, I review major archaeological theories used to frame cultural interaction studies and synthesise case studies that use archaeological evidence to identify human interaction. This review defines key terms used throughout this chapter and thesis – reciprocity, redistribution, exchange, connectivity, trade, and interaction. Using these terms, I examine archaeological interaction studies in the Pacific, including Near and Remote Oceania and Polynesia. This includes providing detailed evidence for human interaction during the Pleistocene into the Holocene, during the Lapita Cultural Complex, and throughout Polynesia. However, the majority of this chapter is dedicated to expounding economic, ideological, and sociopolitical interaction on Rapa Nui. By connecting historic, ethnohistoric, and ethnographic records, along with interpretations from archaeological theory, a comprehensive evaluation of human interaction, and a detailed portrayal of the island's ancient political economy, are presented.

Keywords: archaeological theory, interaction studies, Oceania, Pacific archaeology, political economy theory, Polynesia, Rapa Nui (Easter Island)

Introduction

In 1994, Kirch and Weisler appraised the current state of Pacific archaeology research (see earlier reviews by Clark and Terrell 1978; Green 1993; Kirch 1989). Discussing trends in the discipline at the time, Kirch and Weisler considered social interaction between cultures within the world's largest ocean. While they highlight theories, methods, and results of interaction studies conducted in the Pacific, they also lay out future directions and avenues of inquiry for archaeologists in Oceania. Some 13 years later, Kirch and Kahn (2007) synthesised archaeological studies conducted in Polynesia from 1993–2004. This work outlined common themes in Polynesian archaeology including human impacts of colonisation and island settlement and the variation in Polynesian economic systems and their transformations over time. Importantly, Kirch and Kahn provide a base upon which to understand Polynesian interaction studies, and how archaeologists have used method, theory, and practice to uncover human interaction, exchange, and connectivity in both Western and Eastern Polynesia.

Cochrane and Hunt's (2018) recently edited volume presents an introductory chapter which elucidates the most current research trends in Pacific archaeology. They explore the history of archaeological research in the Pacific by focusing on such topics as Oceanic colonisation and population origins, changes in political complexity, and connections between groups. They demonstrate that in the years since the reviews by Kirch and Weisler (1994), and Kirch and Kahn (2007), inter– and intra–island interaction studies still remain a recurrent and important focus for Pacific archaeological research. Thus, in an attempt to continue the discussion started by these previous investigators, this chapter presents a detailed literature review of the archaeological investigation of human interaction, including relevant theory, methods, and results from Near and Remote Oceania and Polynesia. This review ends with an examination of how archaeological theory and practice have been used on Rapa Nui (Easter Island) to describe and document interaction and exchange. This includes a detailed reconstruction of Rapa Nui's ancient political economy based on historic, ethnohistoric, ethnographic, and archaeological records.

Archaeology and human interaction

While many animal species interact socially, *Homo sapiens* have uniquely interacted in micro, local, regional, and global networks for thousands of years. Documenting this interaction – both spatially and temporally – has long interested anthropologists and archaeologists (Bauer and Agbe–Davies 2011; Baugh and Ericson [eds] 1994; Caldwell 1964; Cochrane and Hunt 2018; Dillian and While [eds] 2011; Erlandson 2008; Finnegan 2002; Gamble 1998, 2007; Knappet 2011, 2013 [ed.]; Kristiansen and Larsson 2005; Mignon 1993; Schortman and Urban 1987, 1992; Stein 2002; Weisler 1997a).

Some human attributes that influenced and facilitated the growth of this complexity and variability include: interaction enabled through food sharing; interaction created by relationships between humans and their environment (both mental and physical); interaction fostered through the capacity of language; interaction abetted through the social use of space; and interaction fashioned through the sourcing, manufacture, exchange, use, and discard of material culture (Bird–David 1990; Hodder 1985; Isaac 1978; Knappet 2011; Mithen 1996; Schiffer and Miller 1999; Soffer 1994). For archaeologists, the latter two attributes are of great interest and have attracted much attention and investigation to better understand how the use of space and material culture influences human social interaction (Boivin 2008; Knappet 2005; Miller 2005 [ed.]). This is because the study of spatial organisation and artefact life–histories (Appadurai [ed.] 1986; Godsen and Marshall 1999; Hoskins 1998; Skeates 2002) provides inferences as to how space and material culture are used by different individuals, and in different cultures, to generate, facilitate, and control cultural interaction and organisation (Whitelaw 1991).

In reviewing archaeological theories and methods that have approached and interpreted cultural interaction, a few schools of thought can be identified. These include early culture–history studies, the New Archaeology of the 1960s and 1970s, the postprocessual and later interpretative schools of the 1980s and 1990s, and more recent investigations that use network analysis (Actor–Network Theory and Social Network Analysis) and geographic information systems (GIS) to document and explain the interconnections between human cultures and their physical materials and environments.

Commonly associated with V. Gordon Chile (1925, 1928), the culture–history school attempted to recognise, plot, and compare, over time and space, the distribution and styles of distinctive assemblages of archaeological material including artefacts and sites (Johnson 2010; Trigger 1989). These distributions were interpreted in terms of the origins and development of ethnic groups and their related lifeways. This approach focused on the material evidence of imports, exports, and stylistic influences, trade and interaction, as well as cultural change, described with reference to the phenomenon of diffusion and the migration of dominant and progressive ideas and peoples, within and between archaeological cultures (Belgiorno 1995; Knappett 2013; Skeates 2009).

In response to critiques of the culture–history school, the New Archaeology (often also called processualism), led by Binford in the U.S. and Clarke and Renfrew in Britain, called for greater scientific rigour based on explicit theory using increasingly accurate technical analysis for archaeological data, method, and explanations concerning human adaptation, behaviour, and long–term cultural evolution (Johnson 2010; O'Brien et al. 2005; Trigger 1989). Viewing archaeological cultures as systems, investigation and analyses in this approach to archaeology focused on uncovering the processes and linkages between subsystem variables (e.g. environment, material culture, subsistence, economy, social relations, trade, and interaction), to create models that aimed to describe prestige goods exchange, peer–polity interaction, centre–periphery relations, and world systems – all of which were considered to be integral to the evolution of complex societies (Frankenstein and Rowlands 1978; Renfrew and Cherry [eds] 1986; Rowlands et al. [eds] 1987; Sherratt 1993; Wallerstein 1974).

Influenced by the New Geography (see Chorley and Haggett 1967), processualists often utilised locational analysis, Thiessen polygons, point pattern analysis, central place theory, distribution maps with fall–off curves, and mathematical models to identify signatures of interaction, including different economic, ideological, and sociopolitical exchange processes (Baugh and Ericson [eds] 1994; Brumfiel and Earle [eds] 1987; Earle and Ericson [eds] 1977; Ericson and Baugh [eds] 1993; Ericson and Earle [eds] 1982; Hodder 1974; Johnson 1977; Plog 1977; Renfrew and Shennan [eds] 1982; Sabloff and Lamberg–Karlovsky [eds] 1975; Sidrys 1977; Wilmsen, [ed.] 1972). A seminal publication by Renfrew (1975) diagrammed ten modes of procurement and exchange transaction that could be identified and analysed archaeologically (Table 1), while Plog (1977; see also Weisler 1997b for an application of Plog's method) provided specific parameters to improve definitions and documentation of exchange networks. These include: 1) the *content* (kinds and range of materials) of the network; 2) the *magnitude* of the network; 3) the *diversity* of materials (richness and evenness) in the network; 4) the geographic *size* of the network; 5) the *time span* of the network; 6) the *directionality* (network flow) of exchange; 7) the *symmetry* or asymmetry of exchange between locations; 8) *centralisation* or decentralisation of the network; and 9) the overall *complexity* of the network (see Chaper Six for further discussion).

The investigation of these dynamic processes of interaction and exchange conducted under the auspices of New Archaeology was directly due to a shift from a description of artefacts and sites (i.e. culture–history), to attempts to explain these remains as the material consequences of dynamic human interaction (Caldwell 1966; see also Mignon 1993, Weisler 1997a). To document and describe this interaction, Earle (1982) suggested that researchers have three tasks: 1) to source the commodities of exchange; 2) to describe the spatial patterning of the commodities; and 3) to reconstruct the organisation of exchange. To provide hard evidence for interaction and exchange, processual inquiry often applied fingerprinting studies including macroscopic, petrological, and chemical techniques for the identification and analysis of archaeological ceramics, obsidian, cherts, basalts, metals, glass, semiprecious materials such as jade, amber, and turquoise, and building material including marble, basalt, and sandstone (Ammerman [ed.] 1985; Evett 1973; Hallam et al. 1976; Harbottle 1982; Renfew 1975; Torrence 1996b). In turn, provenance analysis added reliable detail to a generalised picture of the circulation of goods in past societies. Thus, hoping to add reliable detail to a generalised picture of the circulation of archaeological stone industries during Rapa Nui's pre–contact period, this thesis uses fingerprinting studies to trace fine–grain basalt artefacts to their geological sources. This will help to describe spatial patterns of basalt exchange and to reconstruct the organisation of exchange.

Nevertheless, questions of equifinality have been raised by Renfrew (1977) regarding such studies. He argued that alternative mechanisms of exchange could produce seemingly similar spatial patterns in traded objects (see also Earle 2010). Other critiques of New Archaeology approaches include how its overall focus underestimated the key role played by the very people who consciously, actively, and socially conceived and utilised resources throughout the course of their lives (e.g. agency). In addition, processualists were considered to undervalue the significance of past people's beliefs, values, experiences, and relations, including the dynamic social process within which trade, interaction, and material culture are embedded (Hodder 1992; Johnson 2010; Shanks and Hodder 1982a; Shanks and Tilly 1987; Skeates 2009; Trigger 1989; Wylie 1993).

With the wane of the New Archaeology, the postprocessual view, followed by an interpretative school in the U.K., established a new kind of social archaeology (Johnson 2010; Trigger 1989). These perspectives placed a greater focus on individuals in the past and their constructions of social relations and identities, through their complex material world. In turn, this led to a more sophisticated theorisation of material culture, which impacted directly upon the interpretation of ancient objects and the active role they took on during use, exchange, trade, and interaction (Fowler 2004; Hodder 1982b; Kirch and Kahn 2007; Miller 1994; Thomas 1991; Tilley 1998). Methodologically, postprocessual archaeologists have used a contextual approach which attempts to discern the interweaving and associations of material culture, in particular its historical and spatial situations, as well as the perspective of the contemporary archaeological analyst. In practice, this approach involves identifying the networks of patterned similarities and differences surrounding the object being examined, with reference to its temporal, spatial, depositional, and typological dimensions (Skeates 2009). This includes the exploration of the visual, tactile, and other sensory aspects of artefacts, along with people's multi–sensory phenomenological experience and embodiment of place, in and around past settlements, monuments, and landscapes (Hamilton 2007; Skeates 2005; Thomas 1993; Tilly 1994, 2004).

Influenced by the social, physical, biological, and information sciences, a more recent development in archaeology is network analysis (Brughmans 2013; Mitchell 2006). This paradigm often utilises Actor–Network Theory (ANT), Social Network Analysis (SNA), and GIS modelling to better document and interpret human interaction (Collar et al. 2015; Connolly and Lake 2006; Hodder and Mol 2016; Knappet 2011, 2013; Knappet [ed.] 2013; Orengo and Livarda 2016). ANT maintains that by noting symmetrical interaction in both cultural and physical space, both people and things can be identified as actors in social relations. On the other hand, SNA focuses on the multi–scalar connections or ties that join entities (e.g. nodes, vertices, or actors) rather than the entities themselves. The distance between entities, measured through viewsheds, geodesics, least–cost paths, and/or friction surfaces, is argued to represent different kinds of interaction, ranging from 'capital transactions' (Bourdieu 1986), to the sharing of ideas, identities, associations, and materials. A strength of using ANT, SNA, and GIS together is that they can be incorporated into research using different theoretical standpoints to look at how actors structure networks and networks structure interactions among actors (Knappet 2011; Mills 2017; Östborn and Gerding 2014). This would include archaeological theory such as 'practice' (Blair 2016, Knappett 2011, Mills 2016), ‘Marxist archaeology’ (Iacono 2016), ‘human behavioural ecology’ (Gjesfjeld 2015), and ‘complexity’ and ‘entanglement’ theories (Crabtree 2015; Hodder and Mol 2016).

Methodologically, network analysis has the capability to handle large data sets, is compatible with GIS and agent–based modelling, and has the ability to be digitally visualised for better analysis, experimentation, and interpretation (Isaksen 2013; Terrell 2013). Thus, Knappett (2011; see also Bernard 2005) argues that network analysis affords certain advantages including: 1) consideration of relations between entities; 2) being inherently spatial, with the flexibility to be both social and physical; 3) encompassing strong methods for articulation of scales; 4) the ability to incorporate both people and objects; and 5) the potential to incorporate temporal dimensions for the identification of network changes over time. Drawing upon these advantages, archaeological topics that have been investigated using network analysis include: diffusion of innovations (Östborn and Gerding 2016); religious and other social movements (Borck and Mills 2017; Collar 2007, 2013); identity (Blake 2013, 2014; Hart and Eenglebrecht 2012; Terrell 2013); migration (Mills et al. 2013a,b, 2016); social inequality (Pailes 2014; Wernke 2012); and political centralisation and the development of hierarchies (Fulminante 2012, Hart et al. 2017; Mizoguchi 2009).

Reviewing the history of archaeological theories and practices that have been used to document and interpret human interaction provides background and frameworks for this thesis. Yet, while human interaction has been a popular research topic for archaeologists throughout the history of the discipline, there is still much debate regarding: 1) how archaeologists can be certain that interaction (e.g. trade and exchange) existed in the past (Hodder 1984); 2) the differences in theoretical orientation between formalist (which employs mathematical modelling to predict and document how exchange is based on rational, efficient, and cost–conscious decision making) and substantivist approaches (which focuses on the ideological and sociopolitical context of economic behaviour – functioning to provide essential resources to maintain alliances and/or to establish prestige and status) (Earle 1982, 2010; Hodder 1982a; Polanyi, Arensber, and Pearson [eds] 1957; Sahlins 1972); and 3) the nomenclature used to discuss the interrelationships and the movement of people, ideas, and material culture between individuals and groups within geographic and cultural space. Despite these debates, some definitions that are pertinent to discussion and elucidation of human interaction include: reciprocity, exchange, redistribution, connectivity, and trade. Each of these concepts underpins the analysis presented in this thesis.

Reciprocity is the exchange between two nodes (usually individuals). When looking at reciprocity, archaeologists make a distinction between the exchange of utilitarian commodities (staple goods) and valuable luxury gifts (Brumfiel and Earle [eds] 1987; D'Altroy and Earle 1985; Dillian and While 2010; Earle 1997a, 2010; Renfrew 1975; Skeates 2009; Torrence 1996a). Using inference, and artefact life–histories (Appadurai [ed.] 1986; Godsen and Marshall 1999; Hoskins 1998; Skeates 2002), archaeologists attempt to reconstruct value and document reciprocal interchange by analysing the spatial distribution of artefacts (the distance material travels is often used as a measure of value), their production (assuming differing amounts of time, energy, and raw materials invested in acquiring material and manufacturing items reflect their value), and consumption (where the frequency of occurrence is used to measure value) (Arnold 1992; Bennyhoff and Hughes 1987; Hirth 1998; Hughes 1978; Marx 1867[1977]; Renfrew 1984). While staple commodities are formed, exchanged, and consumed in all kinds of societies, archaeologists commonly locate them in rubbish dumps, middens, and hearths (Torrence 1996b). On the other hand, valuable luxury gifts such as heirlooms and grave goods are most commonly found where there is competition for status (Malinowski 1922; Skeates 2009; Torrence 1996a). Throughout the world, amber, polished stone adzes and axes, artefacts of copper, obsidian, and gold, and ornaments of jade, shells, feathers, and teeth have been seen as valuable and have been used to infer social stratification between social groups and polities. These items usually have specific meaning within a social group, circulate in very specific ceremonial contexts, and may also be symbols of social status (Bradley and Edmonds 1993; Earle 1997b; Edmonds 1996; Sheratt 1976, 1996; Skeates 1995; Torrence 1996b).

Exchange is a term adopted by archaeologists to discuss the transfer and/or distribution of a range of goods, made from local and exotic resources, and wealth, usually in non–industrial societies (Davis 1992; Dillian and While [eds] 2010; Earle 1994, 1999, 2010; Earle and Ericson [eds] 1977; Ericson and Earle [eds] 1982; Webb 1974). In general, exchange refers to formal and informal reciprocal processes in which people give and receive something in place for another. Items may include a myriad of materials, commodities, and prestige goods. Through a formalist lens, people attempt to maximise their exchange by bidding to receive as much as possible for their offerings under exchange. Through a substantivist lens, exchange is characteristically regarded as more than an economic transaction, because it highlights cultural interconnections between individuals and groups, with particular reference to the principles of reciprocity and indebtedness, often seen in non–monetary societies (Dillian and While 2010; Edmonds 1996; Torrence 1996a). As such, the nature of exchange relationships between those involved can restrict the transfer of material and offerings (to avoid becoming manipulated or maximised), while the exchange of gifts can reflect, maintain, and transform the degree of personal/group relations wished for by participants.

Thus, exchange is often related to status, prestige, power, diplomacy, etiquette, and morality (Malinowski 1922; Mauss 1950[1990]; Skeates 2009). Exchange serves economic, ideological, and sociopolitical roles within and between societies as it provides items to buffer against risk and resource fluctuations (Arnold 1992; Cashdan 1985; Cohen 1981), distributes food, raw materials, and finished products (Torrence 1986), provides access to prestige goods (Appadurai 1986; Bennyhoff and Hughes 1987; Munn 1986), and creates pathways for material and information sharing, serving as a connecting force between disparate groups (Sahlins 1972; Hamilton et al. 2011).

In the Pacific, a useful distinction has been made between internal exchange (transactions of goods taking place within a social unit or community) and external exchange (inter–community transfers of materials) (see Green and Kirch 1997; Oliver 1989). To better understand Oceanic exchange, Hunt and Graves (1990:111) advocate using evolutionary (selectionist) theory because:

"1) exchange may play a crucial role with direct selective advantages in the colonisation of new environments, in terms of both the distribution of critical economic resources and the procurement of mates; 2) exchange is a mechanism that maintains contact among geographically isolated communities; and 3) exchange may play an integral part in the differential access of some individuals to critical resources, thus promoting hierarchical sociopolitical relations."

Redistribution is where goods derived from many nodes flow into a central point and are passed back to different persons or places by some form of central authority, like a headman or chief (Ames 1995; Polanyi, Arensber, and Pearson [eds] 1957; Torrence 1996b). In this manner, as redistribution moves goods throughout a region, local variation in resource availability creates a desire to obtain materials from neighbouring areas, ultimately resulting in exchange. This behaviour may eventually lead to the creation of central places such as markets or trade fairs for the purpose of exchange (Renfrew 1984; Irwin 1978a). Sahlins (1972) referred to redistribution as a type of economic exchange that 'pools' resources in an effort to organise systems of reciprocities. Redistribution can also mitigate resource fluctuations over time and space (Dillian and While 2010) and can provide access to valuable exotic goods (Dillian and While [ed.] 2010).

Archaeological evidence for elite–controlled redistribution includes the use and non–use of prestige goods, communal/elite storage, large holding vessels, and stone basins (D'Altroy and Earle 1985; Skeates 2009).

Trade is commonly defined as a commercial type of transaction between people and places, involving an exchange of commodities for money or other commodities and/or valuables. Most common in capitalistic economies, driven by supply and demand, trade is where entrepreneurs and purchasers freely participate in markets to sell privately controlled goods for maximum profit (Skeates 2009; Torrence 1996a). Childe (1925, 1928) emphasised the importance of trade in the social and economic development of early societies. This included how the trading of surplus food and manufactured goods played a key role in the diffusion of technological knowledge between ancient people found in both core and periphery locations. Torrence (1996a) also underlined the importance of trade and its role in causing cultural change, especially for early Mayan states.

Connectivity is a term used by archaeologists interested in Mediterranean maritime mobility and economic history to identify the social and geographical interdependence of small–scale, locally specific phenomenon within a dynamic network of relations found networked inside the wider world (Horden and Purcell 2000; Skeates 2009). In Polynesia, Weisler and Walter (2017:369) provide discussion which leads to a broader understanding of connectivity. They argue that "[c]onnectedness is about the establishment and maintenance of social and economic ties between communities and, in most parts of the world, it is described as *emerging* out of social, demographic, and technological processes". By highlighting case studies from the Cook Islands, the Tuamotu Archipelago, the Mangareva–Pitcarin group, and New Zealand, Weisler and Walter (2017) contend that each East Polynesian 'interaction network' has significant variation in form, function, and underlying drivers of interaction. However, in common, are patterns of early widespread communication and interconnectedness, followed by a contraction of interaction spheres, and changes in basic modes and materials of exchange.

Interaction is a broader term than connectivity, which refers to the action or influence of things and people on each other. In the social sciences, interaction often refers to a mutual human action – described as a connection, communication, and/or collaboration whereby two or more people act reciprocally on and between each other (Sherratt 1995; Skeates 2009). Although interaction may include a multitude of social scales (e.g. individual, unity, polity) through time and space, archaeologists recognise that interaction can include a variety of social processes including the transfer of information or knowledge, the exchange and trade of raw materials and material culture, warfare and military conquests, and the movement of people (Clarke 1968; Hegmon and Plog 1996; Skeates 2009).

Another term that has been adopted by archaeologists is the idea of interaction spheres, first developed by Cadwell (1964) in his research about Hopewell burial mounds in Ohio and Illinois. He noted that interaction spheres tend to develop around some central organising principle, such as shared religious beliefs and mortuary practices, including the persistence of distinctive artefacts found in graves over a wide geographic area. The interaction sphere concept was extended by American and British archaeologists (Binford 1965; Freidel 1979; Mignon 1993). For example, Renfrew (1986) envisaged how the competitive interaction of peer–polities played out through the symbolism of public monuments, burial customs, prestige goods, and writing. While Sherratt (1995) has favoured the term ‘interactionism’, which refers to the ever–widening series of cultural encounters and an ever–expanding universe of communication lying at the heart of long–term social evolution, Torrence (1996b), Smith (2005), and Jennings (2006) prefer the use of ‘interaction zones’.

The above review of human interactions witnessed in the archaeological record is relevant to the recognition of the place of Rapa Nui in the Pacfic and the wider world. Before turning to ancient interaction studies of Near and Remote Oceania, Polynesia, and Rapa Nui, it is first important to review the anthropological archaeology record of Oceania and Polynesia, to provide a contextual setting that elaborates on previous research into pre–contact economic, ideological, and sociopolitical interactions.

Oceania and Polynesia

Hau‘ofa’s pivotal publication (1993) challenged the notion that Oceanic people live in ‘smallness’ and argued for a recognition of the interconnectedness of Oceanic cultures (see also Terrell et al. 1997). He preferred to define the many atolls, high islands, and makatea islands of the Pacific, and the cultures that inhabit them, as a ‘sea of islands’ rather than as ‘islands in a far sea’. Notably, Hau‘ofa bemoans continental people, Europeans and Americans, who draw imaginary lines across the Pacific, making colonial boundaries that have confined ocean people to tiny spaces. Hau‘ofa, instead, argues that inhabitants of Oceania:

“moved and mingled unhindered by boundaries of the kind erected much later by imperial powers. From one island to another they sailed to trade and to marry, thereby expanding social networks for the greater flow of wealth. They travelled to visit relatives in a wide variety of natural and cultural surroundings, to quench their thirst for adventure, and even to fight and dominate (Hau‘ofa 1993:33)”.

In other words, Oceanic people were (and still are today) highly mobile and adept at intra– and inter–island contact and interaction within the great ‘sea of islands’. However, although Hau‘ofa critiques the use of geographic terms and boundaries that would dissect the Pacific, negating the timeless connections found within Oceania, in archaeology, these geo–cultural divisions have helped in understanding the region, establishing frameworks for research, analysis, and discussion. For example, Green’s (1991a) definitions of Near and Remote Oceania, based on anthropological, linguistic, and biological evidence, and the later definition of the Polynesian phylogenetic unit (Green 1995; Kirch 2000; Kirch and Green 1987, 2001), provide significant regional boundaries for interaction studies in Pacific archaeology (Cochrane and Hunt 2018; Kirch 2000; Kirch and Weisler 1994; Kirch and Kahn 2007; although see Clark 2003; Terrell 2012; and Thomas 1989 who question the usefulness of certain classifications). Additionally, Weisler (1997a) notes the importance of the Andesite Line, a geological–geographic border between Pacific continental islands (e.g. Australia, New Caledonia, New Zealand) and the Oceanic basalt islands of Polynesia (from Samoa to the east), for discussions about Pacific archaeology.

The story of Oceania has its roots in global geomorphic changes. As global temperatures fluctuated during the Ice Ages of the Pleistocene, ocean water was trapped in polar ice caps lowering sea levels around Wallacea (Chappell 1993), exposing coastal areas of the palaeo–landmasses of Sunda and Sahul (Ballard 1993; Bellwood 1985; Spriggs 1997; Figure 1). Wallacea effectively halted the progression of animals and plants (Wallace 1895) and early humans (Kirch 2000) into Sahul. Modern humans eventually crossed Wallacea onto the landmass of Australia by 65,000 B.P. (Clarkson et al. 2017; Irwin 1991; Roberts and Jones 1994). From there, humans passed into the Bismarck Archipelago by 35,000 B.P. to arrive to the Solomon Islands (Buka) by 29,000 B.P. (Allen et al. 1988, 1989; Leavesley and Allen 1998; Palvides and Gosden 1994; Spriggs 1997; Wickler and Spriggs 1988). This limit of the Solomon Islands in Near Oceania would be the farthest that Pleistocene people travelled into the Pacific (Kirch and Wiesler 1994; Kirch 2000).

Near Oceania was favourable for the development of navigational abilities and technologies due to the inter–visibility of islands. Irwin (1992) referred to this area as a ‘voyaging nursery’ where early Pacific seafarers could take advantage of seasonal and predictable environmental changes to exercise their navigational abilities for perhaps tens of thousands of years, creating even more opportunities for Oceanic people to interact, exchange, explore, and procure food and resources (Hunt and Lipo 2017b; Irwin 1993; Terrell 2004).

The biogeographic barrier that separates Near and Remote Oceania is a ~350km stretch of water that runs north–south between San Cristobal (Makira – Solomon Islands) to the west, and Nendö (Santa Cruz Islands – Solomon Islands) to the east (Green 1991a; Figure 1). Like Wallacea, this open water division impeded the movement and colonisation of plants, animals, and humans in the Pleistocene (Cochrane and Hunt 2018). However, originating around Taiwan ~3500 years ago (Friedlaender et al. 2008), the ancestors of the Polynesians appeared in the Austronesian–speaking Lapita Cultural Complex of Near Oceania during the mid–Holocene (Allen and Gosden [eds] 1991; Bellwood et al. 1995; Best 2002; Blust 1995; Clark et al. [eds] 2001; Fischer 2005; Kirch 1991, 1997, 2000; Kirch and Hunt [eds] 1988; Matisoo–Smith 2015; Specht et al. 2014; Spriggs 1984; Torrence and Swadling 2008).

Interpreting evidence for the interaction between immigrant Austronesian speakers and the Indigenous inhabitants who had occupied the area since the Pleistocene, Green (1991b) proposed the 'Triple–I Model' (intrusion, innovation, and integration) to describe Lapita origins in Near Oceania and the movement of Lapita's practitioners into Remote Oceania; although other models have also been proposed (see Allen 1984; Diamond 1988; Friedlaender et al. 2008; Hurles et al. 2003; Matisoo–Smith and Robins 2004; Oppenheimer 2004; Redd et al. 1995; Terrell 2000).

Referred to as a 'community of culture' (Golson 1961), a 'cultural complex' (Green 1982; Kirch 1997, 2000; Kirch and Kahn 2007; Spriggs 1984), and a 'community of practice' (Terrell 2014), Lapita is known for its dentate stamped ceramics (Lapita Ceramic Series), tattoo needles, pearl shell ornaments, shell and stone adzes, obsidian and chert lithics, shell scrapers, peeling knives, anvil stones, polishers, slingstones, arm–rings, bracelets, beads, discs, fishhooks, net sinkers, coastal stilt–houses, and elaborate burials (Kirch 1997, 2000; Petchey 2014; Spriggs 1997).

The distribution of Lapita (named after the Foué Peninsula site in New Caledonia; Gifford and Shutler 1956) is found throughout Near Oceania (Gosden et al. 1989; Kirch et al. 1991) and also east of the Solomon Islands into Remote Oceania (Figure 2). Specific islands that have Lapita archaeology include Reef and Santa Cruz Islands (Green 1976, 1991c), New Caledonia (Chiu

2003; Gifford and Shutler 1956; Sand 1998a), Vanuatu (Bedford et al. 2015; Spriggs 1990), Fiji (Anderson and Clark 1999; Best 1984; Clark and Anderson 2001; Davidson and Leach 1993; Nunn et al. 2004), Samoa (Hunt and Kirch 1988; Kirch and Hunt [eds] 1993) Tonga (Burley et al. 1995, 1999, 2001, 2002; Shutler et al. 1994), and ‘Uvea and Futuna (Sand 1996, 1998b).

Perhaps due to the wide–spread distribution of Lapita communities, there was never a single Lapita exchange network that spanned the entire geographic range over which Lapita sites are found (Green 1996; Green and Kirch 1997; Kirch 1997). Instead, distinct regional provinces existed including within Near and Remote Oceania as well as the Lapita Homeland centred on the Bismark Archipelago. Within these provinces there were differences in Lapita regionalisation, localisation, and specialisation between sites found in the older exchange networks and those found beyond the limits of Near Oceania. While the former tapped into 20,000–year–old networks (Gosden 1993; Green and Kirch 1997; Summerhayes and Allen 1993), the latter typically constituted foundation populations on uninhabited islands that formed a homogeneous and related set of societies throughout Remote Oceania (Green and Kirch 1997). Together, this evidence led Green (1996: 126) to suggest that “exchange systems [within Lapita provinces] …were complex, multi–modal, and involved a common range of materials” … “among a related group of peoples who possessed a sense of ethnicity derived from their common origin” (Green 2003: 113).

Purposely sailing into areas where earlier Pleistocene people could not was possible for Lapita voyagers due to their need to flee global/local natural risks and disasters, to relieve population pressures, and/or to settle new lands by junior siblings, assuring their own offspring access to new resources (Bellwood 1996; Kirch 1997, 2000; Sahlins 1981). Arguably, both eastward and return navigation was possible due to increased sailing technology and environmental knowledge (Earle 1997a; Irwin 1990, 1992; Pawley and Pawley 1994, 1998) and, perhaps, changing natural phenomena that aided ocean navigation, such as the Little Ice Age and *El Niño and La Niña* events (Anderson et al. 2006; McCall 1981; Montenegro et al. 2016). Other motivations for Lapita navigation and expansion may have been to find new economic resources that included pursuing migrating animal and fish species (sea turtles, birds, and tuna), visiting rich littoral and reef environments which included beds of oysters, cones, and spider conches, and exploiting diverse flora such as rattan, resins, and woods (Green and Kirch 1997; Kirch 1997, 2000).

While there exists ample evidence that Lapita were accomplished fisherfolk, hunters, and gatherers (Balouet and Olson 1989; Butler 1988; Edwards and Edwards 2013; Green 1986; Nagaoka 1988; Pregill and Dye 1989; Steadman 1993; Walter 1989), they also had a comprehensive understanding of intensive gardening (Burley et al. 2018; Godsen 1992; Kirch and Weisler 1994; Yen 1993), with at least 16 linguistically reconstructed words that apply to horticulture (Osmond 1998). Kirch (2000) reports more than 28 plant and tree species used by Lapita, species that would be later used by Polynesian descendants. Lapita also excelled at animal husbandry practices that involved pigs, dogs, and chickens (Anderson 2009; Kirch 1997, 2000; Oliver 1989).

A vital reason for Lapita's navigation around Remote Oceania was the necessity to maintain economic, ideological, and sociopolitical relationships between island communities (Green and Kirch 1997; Kirch 1988a; Sheppard 1993; Weisler 1997). By maintaining inter–island interaction, Lapita societies were able to facilitate resource, artefact, and marriage partner exchange, buffer against environmental risks and natural disasters, bring specialist skills into newly explored areas, and create interaction spheres that helped them to island–hop further eastward into the Pacific and, importantly, to return back to ancestral islands (Cochrane 2017; Earle 1997a; Friedman 1981; Hunt 1989; Hunt and Graves 1990; Kirch 1988a, 1991, 1997, 2000; Mead 1930; Sheppard 1993; Weisler 1997). Later in the Lapita Cultural Complex there was a simplification in interaction patterns that included a cessation in long–distance navigation and exchange, and a separation of the Lapita homeland from its far–flung communities (Green and Kirch 1997; Kirch et al. 1991; Kirch 2000).

Nevertheless, despite all this long–distance travel, just as the early Pleistocene peoples of Oceania did not navigate past the Solomon Islands, there is no evidence for Lapita east of Samoa and Tonga. This suggests that Samoa and Tonga provided the limits of Lapita people's knowledge of the eastern Pacific world. However, with evidence of Lapita found as far west as mainland Papua New Guinea (David et al. 2011), the spatial distribution of Lapita makes it one of the most geographically dispersed cultures in all of human history. Although Lapita cultures existed for only ~600 years, their most important legacy was as the parent culture for the Ancestral Polynesian Culture, the *Ma'ohi*, which eventually formed the founding group that settled Rapa Nui.

Polynesia (Figure 3), which is further divided between Western Polynesia (Tonga, Samoa, Futuna, and 'Uvea) and Eastern Polynesia (all islands and archipelagos to the east, north, and south of the Western Polynesian homeland core) (Burrows 1937; Cochrane and Hunt 2018; Green 1968; Kirch

1990; Kirch and Kahn 2007; Marack 1996; Weisler 1997; Weisler and Walter 2017), is the geo–cultural area between the Hawaii, New Zealand, Rapa Nui triangle. Within this triangle there are many bio–cultural similarities shared by the *Ma'ohi*. These include: biology and D.N.A.; navigational knowledge and ability; linguistics; sociopolitical, economic, and ideological organisation (including the importance of *mana* and *tapu*); material culture; tattoo, song, dance, and line–boards; subsistence and animal husbandry strategies; monumental architecture; and statuary (Allen and Kahn 2010; Beaglehole [ed.] 1967; Bellwood 1987; Biggs 1971; Clark 1991; Cochrane 2015; DiNapoli et al. 2017; Emory 1968; Fischer 2005; Finney 1977, 1994; Green 1966; Highland et al. [eds] 1967; Hill and Serjeanston [eds] 1989; Hiroa 1938, 1945; Houghton 1996; Howard 1967; Hunt and Lipo 2017; Jennings [ed.] 1979; Kayser 2010; Kirch 1984, 1994, 2000; Kirch and Green 1987, 2001; Love 1993; Martinsson–Wallin et al. 2013; O'Connor et al. 2016; Pawley 1966; Pietrusewsky 1996; Sahlins 1958; Shore 1989; Sinoto 1968, 1996a; Van Tilburg 1994; Walworth 2014; Weisler [ed.] 1997).

While these bio–cultural similarities are well documented, and are visible while travelling throughout Polynesia today, one existing inquiry relates to the timing of original *Ma'ohi* formation, colonisation, and island settlement (Anderson 2001; Anderson and Sinoto 2002; Kirch 1986, 2000; Kirch and Weisler 1994; Kirch and Kahn 2007). With the transformation of Lapita ~2500 years ago, evidence suggests that there was a 1000–year pause between the waning of Lapita and the appearance of the Polynesians. This pause may be artificial, with some attributing it to the inability of archaeologists to find the earliest *Ma'ohi* sites. Another reason may be the archaeological method and theory applied in Polynesia, including the arguments between Polynesian short and long chronologists (Hunt and Lipo 2017b). While the former chronologists insist that only direct artifactual and biological evidence from sealed archaeological deposits that have passed through 'radiometric hygiene' can identify human colonisation of an island (Anderson 1994, 1995, 1996a; 2000, 2002; Hunt and Lipo 2006; Mulrooney et al. 2011; Spriggs and Anderson 1993; Wilmshurst et al. 2008, 2011), the latter chronologists argue that a range of environmental evidence for human disturbance on fragile island ecosystems can provide acceptable proxy indicators of human arrival (Allen and Huebert 2013; Athens 1997; Kirch 2000; Kirch and Ellison 1994; Kirch and Kahn 2007).

Regardless of this debate, it seems plausible that it took some years for post–Lapita explorers to innovate navigation technologies, to study and learn more about new ocean ecosystems, and to build–up the resources and human personnel needed to push further east into the Pacific to island targets that were farther away (Irwin 1992, 1993, 1998; Kirch 2000; Pawley 1996; Spriggs and Anderson 1993). Some have even suggested that the environment also played a role in allowing periods of favourable seas, winds, and weather during climatic events that aided Polynesian exploration of the Pacific (Finney 1985, 1988, 1997; Finney et al. 1989; Goodwin et al. 2014). Motivations for long–distance navigation and the *Ma'ohi* colonisation of new islands almost certainly include the expulsion of groups defeated by wars, the resettlement of populations from densely inhabited regions, and/or the desire to explore for new lands to reach anticipated reserves of unowned and prestigious commodities (Anderson 1996b; Fischer 2005; Groube 1971; Métraux 1957; Weisler 1997a; Weisler and Walter 2017).

Within the Ancestral Polynesian Homeland between Fiji, Samoa, and Tonga (Davidson 1977, 1978, 1979; Green 1993, 1995; Kirch and Green 1987, 2001; Kirch et al. 1990; Kirch and Hunt [eds] 1993), the *Ma'ohi* purposely and repeatedly developed more sophisticated canoes and practised 'survival sailing strategies' (Finney 1977, 1994a, 1994b, 1996a, 1996b; Finney 1997; Fischer 2005; Irwin 1992, 1993; Kirch 2000; Levison et al. 1973) to navigate to and establish settlements beyond the limits of West Polynesia into the Cook Islands (Allen and Steadman 1990; Kirch et al. 1995; Walter 1998). From the Cooks, it was an open–water voyage to the Society Islands and the Tuamotus (Anderson 2001b; Anderson et al. 1999; Emory and Sinoto 1964; Kahn 2003; Lepofsky et al. 1992, 1996; Orliac 1997; Wallin 1993). Then, navigation continued to the Marquesas (Allen 2004; Anderson et al. 1994; Conte 2002; Conte and Anderson 2003; Rolett 1992, 1996, 1998; Rolett and Conte 1995; Sinoto 1996b), Hawaii (Emory et al. 1969; Graves et al. 2002; Kirch 1985, 2004; Ladefoged et al. 1996, 2003; Tuggle and Spriggs 2000), New Zealand (Anderson and Smith 1992; Anderson and Wallace 1993; Anderson et al. [eds] 1996; Campbell [ed.] 2004; Furey and Holdaway [eds] 2004; Irwin [ed.] 2004; Sutton [ed.] 1993; Sutton et al. 2003), the Austral Archipelago (Bollt 2005; Edwards 2003; Kennett et al. 2006; Hermann et al. 2015), Mangareva and the Pitcairn group (Anderson et al. 2003; Conte and Kirch [eds] 2004; Green and Weisler 2000, 2002; Weisler 1994, 1995, 1996, 2002), and eventually Rapa Nui (Heyerdahl and Ferdon [eds] 1961; Mulrooney 2013; Steadman et al. 1994; Vargas et al. 2006).

Interaction studies in Near and Remote Oceania

Malinowski's (1920, 1921, 1922) pioneering anthropological methods and later ethnographic accounts documented the Kula Ring in the Milne Bay Province, Papua New Guinea. This work highlighted the extensive interaction between 18 communities in the Massim archipelago including the Trobriand Islands. Malinowski's *Argonauts of the Western Pacific* (1922) became a benchmark for anthropology, highlighting Pacific islander trade, gift–giving, commodity exchange, and the development of social prestige and status (see also Damon 1980; Mauss 1950[1990]; Uberoi 1962; Weiner 1976, 1992). Other ethnographic examples from Oceania – the Papuan *hiri*, the *tee* and *moka* of the New Guinea Highlands, the activity of the Siassi middlemen in the Vitiaz Strait, and the red–feather 'money' trade of Santa Cruz – further demonstrate the diversity and complexity of the many interaction networks found in the Western Pacific (see Brookfield and Hart 1971; Davenport 1962, 1964; Dutton [ed.] 1982; Feil 1987; Hage 1977; Hage and Harary 1991, 1996; Harding 1967, 1970, 1994; Leach and Leach [eds] 1983; Miller 1978; Oliver 1989; Strathern 1971; Tueting 1935; Weiner 1976). But as Kirch (1991:158) rightly points out, "ethnographically documented patterns [in the Pacific] are but the latest episodes in continually changing configurations. Thus, the previous history of any particular ethnographic network is also vital to understanding and explaining its origins". As such, Weisler (1997a:9) proposed that ethnographic exchange networks in the Pacific:

> "can be described and better understood by exploring three key variables: *scale,* external or internal scale to a political or geographic unit; *commodities*, which are either material (e.g. raw materials, tools and food), or intangible goods such as songs, labour, or services of women (Oliver 1989:201); and *context*, i.e., commercial or ceremonial exchange".

Regarding archaeological interaction studies that focus on Near and Remote Oceania, Kirch (1991), Hunt and Graves (1991), Kirch and Weisler (1994), Weisler [ed.] (1997, 1998), Terrell (2013) and Cochrane and Hunt (2018) summarise the substantive methodological, technological, and theoretical reviews that have been undertaken. These reviews demonstrate how archaeological research in the Pacific provides details for the development and specialisation of exchange networks by delimiting the spatial and temporal dimensions of exotic imports. This includes stylistic, archaeometric, and network analyses of archaeological materials and museum material culture collections that: 1) document and characterise sources; 2) trace the movement between raw material origins, manufacturers, distributers, and the location of artefacts found in the archaeological record; and 3) outline interaction, communication, trade, and exchange (Allen 1977, 1985; Allen and Duerden 1982; Allen and Rye 1982; Allen et al. 1989; Ambrose 1976, 1993; Ambrose et al. 1981; Bird et al. 1981; Burton 1987; Dickinson and Shutler Jr. 1979; Egloff 1978, 1979; Fullagar et al. 1991; Gosden 1993; Golson and Gardner 1990; Lilley 1988; Rye and Duerden 1982; Specht et al. 1988; Summerhayes and Allen 1993; Terrell 1974, 1976, 1977, 1986, 2010a, 2010b; Torrence and Summerhayes 1997; White and Modjeska 1978; Wickler 1990).

Some of the earliest evidence suggesting human interaction between Near Oceanic islands includes the movement of obsidian from New Britain to New Ireland ~24,000 years ago (Fredericksen 1997; Summerhayes 2009; Summerhayes and Allen 1993). The open sea (implying watercraft technology) translocation of obsidian was paired with the later movement of mortars, pestles, and terrestrial mammals from mainland New Guinea into the Bismarck Archipelago around 8000 B.P. (Cochrane and Hunt 2018; Flannery and White 1991; Torrence 1996b; Torrence et al. 2013). Gosden (1993:133) posited that these developments in Near Oceania are indicators of new adaptation strategies: "instead of moving people to resources, resources were [now] moved to people". In the highlands of New Guinea, the long–distance appearance of exotic goods into the area dates to at least 9000 B.P., based on the marine cowrie shells found at the Kafiavana rockshelter (White 1972). While the distances of these transfers were quite considerable, Kirch (1991) claims that the amounts of material moved appear to have been small, and hence the frequency of exchanges were presumably low and non–intensive.

To better understand later highlands exchange, Hughes (1977) used ethnoarchaeological evidence to uncover exchange patterns of salt, stone axes, pottery, shells, and pigments over 7000km^2. Allen (1982:195–196; see also Earle 1997a; Kirch 1991; Green and Kirch 1997) describes this trading activity as "complex webs of exchange, but these webs themselves comprised fairly simple linked chains; while there is a general flow of goods away from a source, at any point the direction of the next transfer is not predictable. In this sense, and unlike coastal Papua New Guinea, we cannot speak of trading". On the Papuan coast, Vanderwal (1978:426) concluded that "exchange, and its corollary, communication, were very much part of the Papuan scene since at least the appearance of pottery". Allen (1982:202) echoed Vanderwal (1978) by suggesting that Papuan exchange included "a pattern of increasingly formal exchange throughout the first millennium AD which peaked and disintegrated about 800 AD".

Irwin's (1974, 1978a 1978b, 1985) work in Mailu used archaeometric and stylistic analyses, ethnoarchaeology, and graph–theory to demonstrate how over time, the island developed into a 'central manufacturing place' for highly specialised pottery production. This allowed Mailu to become a central place for interaction, control, and exchange even until historic times. Moving his gaze to Massim, Irwin (1983) continued to use graph–theory and archaeological evidence to locate the centrality of the Kula ring. Here, Irwin argues that the initial settlement for Massim was related to the appearance of pottery–producing locations along coastal Papua about 2000 B.P. This assertion was based on ceramic similarity and the presence of imported obsidian. However, while interaction and exchange between Massim and Papua may have been common during this period, there is no evidence like at Mailu for specialist manufacture or traders (Irwin 1983).

Using ethnographic collections from the Field Museum of Natural History (Chicago), ethnolinguistics, SNA, and human genetic data from the Sepik coast of Papua New Guinea, Terrell, Welsch, and colleagues (2010a, 2010b, 2013; Terrell and Welsch 1991; Welsch and Terrell 1998) have examined the correlations of material culture and language, often a defining characteristic of a so–called population (Terrell 2013). Welsch et al. (1992: 592) note that "the similarities and differences among these village [material culture] assemblages are most strongly associated with geographic propinquity, irrespective of linguistic affinities". This suggests that language–defined populations do not have distinct material culture repertoires as has been argued elsewhere for the area (Roberts et al. 1995). This observation may come as a cautionary tale for archaeologists, as using material culture may not truly document the interaction of distinct populations, such as those defined by language (Cochrane and Hunt 2018).

Synthesising previous archaeological investigations conducted in the Western Pacific helps to highlight the diversity in the development and manifestations of exchange networks. These networks were created and influenced by environmental factors, demographic growth, continued/failed communication, inter–generational relationships, creations and relations of debt, simple down–the–line exchange chains, central islands/places, and specialised artefact manufacture centres (Earle 1997a; Gosden 1989; Terrell 2013; Welsch and Terrell 1998). Although intra– and inter– island interaction and exchange networks in Near Oceania can be traced back for more than 23,000 years, Allen and White (1989:139) have noted that "travel and transport of this kind [by early Pacific peoples] foreshadow…similar but longer–distance exploits by the makers of Lapita pottery”.

Whereas Ambrose and Green (1972) first documented the long–distance Lapita transport of Talasea obsidian from New Britain to the Reef Islands, Best (1984) found the same material in Fiji, and Bellwood and Koon (1989; see also Fredericksen 1997) reported Talasea obsidian flakes found in Sabah, Borneo. This wide spatial distribution of Talasea obsidian highlights the navigational efficacy of Austronesian speaking seafarers and the extent of their exchange of material. Further work by Green (1974, 1976, 1979, 1982, 1987) demonstrated a complex pattern of human interaction which included the importation of Western Pacific obsidian, ceramics with motif similarities, adzes, oven stones, and chert, over a period of 700 years.

Using this evidence, Green (1979) has argued that a ‘trader model’ best fits the evidence for Lapita interaction, and proposed three models based on Renfrew’s (1975) definitions and geographic distances for Lapita exchange: 1) direct access and local reciprocity at distances up to 100km; 2) one–stop reciprocity with communities about 250–400km away; and 3) down–the–line exchange over distances up to 1500–2000km (Green 1987; Green and Kirch 1997). As a consequence of the increased movement of objects across the seascape, the importance of material sourcing, stylistic studies, and graph–theory to understand Lapita and other interactions, including raw material and artefact exchange, has expanded (Allen and Bell 1988; Anson 1989; Best 1987; Clark and Wright 1995; Dickinson et al. 1996; Galipaud 1990; Green 1991b, 1996; Green and Bird 1989; Green and Anson 1991; Green and Kirch 1997; Hunt 1988, 1989; Kirch 1976, 1987, 1988a, 1988b, 1990b, 1991, 1997, Kirch et al. 1991; Sheppard 1993, 1996).

In summary, interaction and exchange was essential for social aspects of Lapita’s colonisation and settlement strategies. Early on, maintaining linkages between homeland and outpost communities was of utmost importance (Kirch 1988a; 1997, 2000). Yet, as new settlements grew, they became more regionalised, independent, and less reliant on parent villages. As they started to employ more local materials from closer intra–island interaction networks, these later Lapita descendants, separated from their ancestral homeland, were in effect (re)creating their social worlds, and were only intermittently in contact with other down–the–line descendants (Green and Kirch 1997; Kirch 1997). This has important implications for expansion into Polynesia.

Interaction studies in West and East Polynesia

Prior reviews regarding archaeological interaction studies in Polynesia provide substantive methodological, technological, and theoretical discussion (see Cochrane and Hunt 2018; Earle 1997a; Hunt and Graves 1991; Kirch and Kahn 2007; Kirch and Weisler 1994; Weisler [ed.] 1997). While the documentation of exchange in Polynesia has not paralleled the ethnographic and archaeological examples from Near and Remote Oceania (Kirch 1991; Kirch and Weisler 1994; Weisler 1997a), Green and Kirch (1997) argue that archaeologists studying Polynesia have an advantage by analysing the accumulated residues from long successions of repeated transactions, allowing for an evaluation of long–term interaction and exchange not readily accessible to ethnographers. But linking ethnographic records with ethnohistoric interpretations can certainly help archaeologists by providing examples of long–distance communication and interaction between and within Polynesian islands (e.g. Best et al. 1992; Cachola–Abad 2000; Kirch 1986; Kirch and Green 2001; Sand 1999; Weisler 1997a). The archaeological evidence for interaction in Polynesia is mostly based on the identification of non–perishable raw materials and finished artefacts foreign to the place of deposition (Cochrane and Hunt 2018; Rolett 2002; Weisler 1993a, 1993b, 1997a). This is important to note, as much of the evidence used to elucidate Polynesian island interaction is not archaeologically visible, but is strongly represented by the transfer of obsidian and basalt stone and tools, pottery, and pearl shell artefacts (Allen and Steadman 1990; Burley and Clark 2003; Clark et al. 1997; Dickinson 2003; Dye 1987; Hunt and Erkelens 1993; Kirch 1988c; Kirch and Weisler 1994; Rolett 1996; Walter 1998; Weisler 1993b, 1997a, 1998; Weisler [ed.] 1997; Weisler and Walter 2017).

The oldest and most extensive long–distance networks in Western Polynesia include those found in the eastern region of a Lapita Cultural Complex delimited by the archipelagos of Fiji, Tonga, and Samoa (Best et al. 1992; Cochrane and Rieth 2016; Davidson 1977, 1978, 1979; Kaeppler 1978; Kirch and Green 1987; Figure 4). Colonised by Lapita some 2800 years ago (Burley et al. 2012), the heterogeneous geological and ecological complexity of this region, along with the need to bring new marriage partners, cultigens, and specialist skills not present in founder groups, may have contributed to continuing Lapita contact and interaction after initial colonisation (Weisler 1997a). Later, with the economic, ideological, and sociopolitical divergence of each island group, and the parallel cultural emergence of Tonga (Goldman 1970; Sahlins 1958), the transfer of marriage partners between Fiji, Samoa, and Tonga provided a context to exchange staple and luxury resources such as pots, canoes, sails, red feathers, decorated barkcloth, mats, and stone adzes (Bentley 2000; Dickinson and Shutler 2000; Dickinson et al. 1996; Dye and Dickinson 1996; Kaeppler 1978; Kirch 1984; Weisler 1997a). Eastward from Tonga, archaeological evidence illustrates contact and interaction with the Cook Islands (Allen and Johnson 1997; Walter 1998; Walter and Dickinson 1989; Walter and Sheppard 1996), showing the important role Tonga assumed in crossing the waters between Remote Oceania and Western Polynesia. In turn, inhabitants of the Cook Islands not only had external connections to places such as Tonga, Taumako, Tokelau, the Marquesas, Samoa and the Austral and Society Islands (Weisler et al. 2016a), but also intra–archipelago exchange between the northern and southern islands (Sheppard et al. 1997; Weisler and Kirch 1996).

In East Polynesia a well–known interaction network, identified by oral traditions and material culture and resource transfer, was between the low coral Tuamotu atolls (Figure 5) and the high volcanic Society and Hawaiian Islands (Weisler 1997a). For example, Collerson and Weisler (2007) identified one Tuamotuan adze as originating from the Hawaiian Islands, a distance of ~4000km – making it the longest known, continuous martitime trip in the pre–colonal period (Weisler and Walter 2017).

Providing the 'hard evidence' (Weisler 1998) for Polyneisan interaction has mostly been the result of identifying the geographic locations of stone sources and their use in different lithic reduction strategies and the elemental sourcing of basalt adzes and tools (Bayman and Nakamura 2001; Clarkson et al. 2014; Hermann 2017; Jennings et al. 2018; Kirch 2000; Leach 1993; Leach and Leach 1980; McCoy 1990, 1999; McCoy et al. 2012; Turner 1992; Simpson and Dussubieux 2018; Simpson et al. 2017, 2018; Weisler 1997a; Weisler [ed.] 1997; Weisler 2011; Winterhoff 2007). This work has included petrological analyses, chemical and elemental analyses, and the creation of regional geochemical databases of both basalt geological sources and archaeological quarries and artefacts (Sinton and Sinoto 1997; Weisler and Woodhead 1995; Weisler and Sinton 1997; Weisler [ed.] 1997).

Using these analyses and databases, archaeologists have traced regional voyaging and interaction spheres between numerous islands and island archipelagos. This includes a complex regional interaction sphere in central Eastern Polynesia that linked the Societies, Tuamotus, and Marquesas, along with the southern Cooks, Australs, and Mangareva, Pitcairn and Henderson Islands, from perhaps as early as 900 AD until ~1500 AD (Cochrane and Hunt 2018; Collerson and Weisler 2007; Hermann *et al.* 2017; Kirch and Kahn 2007; Rolett et al. 1997; Weisler 1998; Weisler and Woodhead 1995; Weisler and Kirch 1996; Weisler and Sinton 1997; Weisler and Walter 2017; Woodhead and Weisler 1997). After this time, a decrease in the frequency and in the volume of imported exotic material suggests that this larger exchange network collapsed, or retracted into smaller spheres (Diamond 2005; Irwin 1992; Rolett 1996, 2002; Weisler 2002; Weisler and Walter 2017). Other geoarchaeological and geochemical research in Polynesia has identified elite control over highly valued stone resources (Cleghorn 1986; Hamilton et al. 2011; Hermann et al. 2019; Kirch et al. 2011; Lass 1998; McAlister and Allen 2017; Rieth et al. 2013; Simpson et al. 2017; Stevenson et al. 2013). Table 2 compiles archaeological and geochemical analyses that note different spatial and temporal manifestations of stone acquisition, control, exchange, and use in Polynesia. The relatively large number of studies show the great interest and valuable contribution that geological, archaeological, and geochemical studies have made with regards to identifying and defining ancient interaction.

One East Polynesian interaction sphere that is of importance for Rapa Nui is the network between Mangareva, Henderson, and Pitcairn (MHP). Considering that it was perhaps this network that was responsible for the colonisation of Rapa Nui, understanding patterns of interaction within the MHP informs Rapa Nui archaeological studies (Figure 6). For example, through archaeological investigation and sourcing work, Weisler and colleagues (1994, 1995, 1996, 1997b, 2002; Weisler and Woodhead 1995, Weisler et al. 2004) reconstructed patterns of spatial and temporal exchange in this 'provenance environment'. This includes 400–500 years of interaction where inter–island voyaging between MHP was necessary to sustain small, marginal human populations on ecologically impoverished islands. However, it seems that the more marginal Henderson and Pitcairn Islands were not only on the receiving end of material exchanges from Mangareva, but played an important reciprocal role with regards to the transfer of staple resources and luxury materials and artefacts. While fine–grain basalt from Tautama quarry on Pitcairn was transported as a raw material and arguably as finished artefacts to Henderson and Mangareva, large quantities of pearl shell from lagoon locations around Mangareva were sent to Pitcairn and Henderson to manufacture fishhooks. This two–way movement of exotic commodities, along with the transfer of oven stones, horticultural plants, marriage partners, and possibly turtles and red feathers, allowed for almost 500 years of communication between islands in one of the most isolated interaction spheres in the world. This is quite remarkable when one considers the 100km of distance between Henderson and Pitcairn and the 400km distance between Mangareva and Henderson and Pitcairn. Yet, over time, periods of drought and low food productivity, along with diminishing staple resource (i.e. bird colonies) supply, put the existence of the MHP interaction sphere in jeopardy. These risks, along with landscape degradation, the effects of population increase, evolving social conditions, and climate change not only limited the connections within the MHP, but also played a role in the cessation of inter–archipelago voyaging in East Polynesia (see also Irwin 1992; Rolett 2002).

In summary, the MHP interaction sphere highlights the high degree of communication that existed in ancient Polynesia. The ability to communicate and segment resources amongst MHP populations is concrete evidence for how East Polynesian populations found ways to survive and thrive on geographically isolated and depauperate islands. It also demonstrates how interaction and the exchange of staple and luxury resources and artefacts were important driving forces for further exploration of the Pacific (including Rapa Nui), the development of elite political economies, and the materialisation of Polynesian economy, ideology, and sociopolitics. Therefore, drawing upon the Polynesian phylogenetic unit (Kirch and Green 1987) and the homologues that existed between Polynesian cultures, an argument is made here that the communal interaction between MHP, and the mechanisms that facilitated this interaction, should have been inherited by the settlers of Rapa Nui. This would include protocols that allowed access to important, but patchy resources. Thus, a review of interaction studies on Rapa Nui should bring to light and provide evidence for interaction on the most isolated, inhabited island in the world.

Interaction studies on Rapa Nui

This last section reviews the observations, theories, and methodologies used to describe and interpret interaction on Rapa Nui. It begins by tracing and examining how early explorers, missionaries, colonisers, and ethnographers described and provided insight into Rapa Nui cultural interaction. This is followed by an assessment of how archaeologists have used theoretical and explanatory frameworks – diffusionism, culture–history and culture–ecology, settlement pattern studies, and evolutionary, interpretive, and political economy theory – to understand ancient interaction and exchange. Figure 7 notes places mentioned in the text.

Early explorers, missionaries, colonisers, and ethnographers

After hundreds of years of Polynesian habitation, Rapa Nui was located by the Dutch Admiral Jacob Roggeveen on Easter Sunday, 5 April 1722; hence the name Easter Island. Combined with this first encounter, later interactions with Europeans, missionaries, North and South Americans, and ethnographers provide details about social interaction on Rapa Nui (see McCall 1990 for a complete ship list from 1722 until 1900; see also Altman [ed.] 2004; Foerster 2012; Foerster and Lorenzo 2016; Richards 2008). This early work is also notable as it collectively forms the first records of Rapanui place names, original locations and descriptions of landscape features, and qualitative and quantitative information about the island's archaeological sites and artefacts. However, as many of the early visitors to Rapa Nui stayed on the island for such short periods, the motivations and the validity of their observations must be considered in context (see Fischer 2005; Flenley and Bahn 2003; Hunt and Lipo 2011; Martinsson–Wallin 1994; Mulloy 1979; Simpson 2008; Stevenson 2002 for a similar critique).

Roggeveen's visit on Rapa Nui only lasted one day, hardly enough time to provide substantive details about ancient island life. Yet, amongst other observations, Roggeveen (1722) describes a ceremony of interaction between the living members of the Rapanui culture and their deceased ancestors, represented by the *moai–ahu* (statue–platform) complex. Other forms of interaction, including the presenting of items for gift–giving and/or exchange, were observed by Behren (1722:133), the first European to set foot on Rapa Nui. He stated that the islanders approached the three Dutch ships in small skiffs (*vaka ama*) filled with "uncooked and baked hens, together with many roots" that were most likely destined to become welcoming presents and/or items used for prestige building and bartering (Fischer 2005). Tragically, during the interaction between the Dutch and the Rapanui, a miscommunication between the groups resulted in stones being picked up by the islanders and shots being fired by the visitors; the result was the murder of a dozen islanders, including the first islander who visited the Dutch *Thienhoven* ship. But, after this moment, both crowds returned with friendly gestures and with no apparent resentment; a chief ordered the locals to offer fowls, sugar cane, bananas, sweet potatoes, and yams to the visitors. The Rapanui were rewarded with Haarlem cloth, which they accepted with apparent gratitude.

Another interesting observation from both Roggeveen and Behrens, is their identification of what they believed to be more elite individuals amongst the Rapa Nui community. These individuals wore white feathers on their heads, were tattooed (*tatau*) and painted (*takona*), and carried wooden staffs (*ua*). Roggeveen (1722:13) speaks of a certain native "who seemed to be in authority [perhaps an *ariki paka* – secondary chief] over the other headmen [perhaps the *tangata honui* – elite retainers]", and whose "order was promptly obeyed with reverence and bowing by those round about". In another place, the Dutch captain speaks of "the king or head chief" [perhaps the *ariki mau* – paramount chief] who lived on the other side of the island, most likely in Hanga Rau, 'Anakena district (Roggeveen 1722:19). Lastly, Roggeveen (1722:21) found Rapa Nui's soil to be perfect for cultivation as it was "exceedingly fruitful, producing bananas, potatoes, sugarcane of remarkable thickness, and many other kinds of the fruits of the earth".

Arriving 48 years after the Dutch, the Spaniard Don Felipe González de Haedo and crew sailed to Rapa Nui from Peru in two ships, the *San Lorenzo* and *Santa Rosalia*. These vessels anchored around Rapa Nui for six days, giving more time to frame observations about ethnohistoric interaction. Remarks from crew members also highlight how the island was still seen as fertile, with 'greenery' found throughout the island (Métraux 1940). Agüera (1770:98–99), one of Gonzalez's companions, noted how the islanders were "fond of taking other people's property that what one man obtains another will take from him, and he yields it without feeling aggrieved: the most he will do is to resist a little, then he loosens his hold of it and they remain friends". Heyerdahl (1961, 1975) held that the Spanish were puzzled by the lack of personal property among the Rapanui, only noting a few utilitarian artefacts such as fishing lines (*hau hī*), fish nets (*kupega*), and bone needles (*tia ivi*). Other material culture, including men's feather crowns (*hei huru huru*) and coloured poncho–like capes (*kahu*), were also observed.

To exchange with the Rapanui, the Spanish offered trousers, shirts, ribbons, seaman's jumpers, and tiny metal crosses; items that would be seen in use by the Rapanui by the later English expedition in 1774 (Fischer 2005). The remarks by Agüera (1770), and later interpretations by Heyerdahl (1961, 1975), highlight possible patterns of interaction between different members of the Rapa Nui culture. This includes the impression that Rapanui interaction and exchange were based on patterns of reciprocity and/or rank, as certain members: 1) received and retained particular materials from the interaction with Europeans; and 2) used specific artefacts (clubs, crowns, and cloaks) and body decoration (*tatau* and *takona*) during interactions, likely due to their higher status. Agüera (1770:98) also observed that higher ranked "principle men, or those in authority" were also painted differently from others, with the whole of the body decorated with *kie'a* (mineral pigment paint). Some of these men and their 'ministers' resided near the *moai–ahu* complex, in elite homes called *hare paenga* (Lee 1992; Martinsson–Wallin 1994; McCoy 1979; Van Tilburg 2003; Vargas et al. 2006).

A last observation about the interaction between Rapanui and the Spanish is found during the annexation ceremony at Poike. While the Spanish conducted a solemn ritual complete with a treaty signing and a demonstration of holy images marching towards Poike, the Rapanui crowd cried *Makemake* (creator god), offered cloaks and chickens to the procession, and signed the annex treaty using symbols possibly from the famous *kohau rongorongo* script (Englert 1970; Fischer 1997, 2005; Heyerdahl 1961, 1970; Métraux 1957; Routledge 1919). It would seem, then, that the visit of the Spanish not only highlights different forms of interaction on Rapa Nui, but also provides evidence for a ranked society that included an elite class, at least during the island's ethnohistoric period.

English Captain James Cook reached Rapa Nui four years after the Spanish (1774) on his second of three trips around the Pacific looking for large quantities of provisions for his weary and sick crew. Interestingly, observations from the *Resolution* about the island were radically different from the earlier accounts by Roggeveen, González, and their crews. For example, Cook (1777:285, 288) was dismayed about the island's living conditions and lack of supplies, stating: "[n]o nation need contend for the honour of the discovery of this island" and that ships only under "the utmost distress, touch at this island". Cook's companion, Forster (1777:597–598), also portrayed the 'wretched' living conditions for the Rapanui during the English expedition's five–day call to the island, two of which involved visits ashore. Regardless of these interpretations, both Cook and Forester provide important insights into islander interactions at this time. One interesting detail is as follows: whereas the Spaniards did not notice any foreign materials (of Dutch provenance) in use by the Rapanui, the English noticed several Spanish artefacts being worn, including a hat, a jacket, and several handkerchiefs. Perhaps it was the desire to acquire and use European goods, along with Tahitian *tapa* (barkcloth) and coconut shells, that motivated the Rapanui to exchange luxury artefacts including *moai miro* (wood figure) carvings (Cook 1777; Forster 1777). Also on the *Resolution* was the Tahitian wayfinder Mahine, who acted as a translator. As the quality of the *moai miro* was so fine, Mahine exchanged ship's goods for multiple figures as he believed that they would be greatly valued in Tahiti, like the Tahitian *ti'i* carvings (Fischer 2005). Richards (2008) posited that during the British visit, exchange was conducted by both fair traders (balanced and generalised reciprocity) and those who were dishonest by hiding stones in the bags of sweet potatoes used for barter (negative reciprocity).

Regarding *moai* statues, Forster (1777:57) concluded that the "monuments [were] erected to the memory of some of their areekee [sic; *ariki*], or kings. This led us to believe that the pedestal was perhaps to be considered as a burying–place, and on looking carefully round it, we found a number of human bones, which confirmed our conjecture". Moreover, Cook (1777) noticed that many *moai* had personal names that would be joined with the word *ariki*, highlighting the prominence of the individual represented in stone. Métraux (1957:210–211) would later point out that, similar to Rapa Nui's statuary, Marquesan statues that dominated "the terraces of the sanctuaries [also] represented famous chiefs or priests whose spirits had entered the ranks of the tribe's tutelary deities … These stones were eventually looked upon as vessels into which the spirits entered when they were invoked".

Together, comments made by Cook and Forster demonstrate that the Rapanui had found new materials to interact and exchange with Europeans, including their wooden *moai miro* carvings. Observations from the English expedition also highlight how the *moai* mostly represented chiefly and elite members of the ancient Rapanui society.

The last 18th Century expedition to the island was led by J.F.G de La Pérouse, a French sea captain. He and his two ships (*Astrolabe* and *Boussole*) visited Rapa Nui in 1786, twelve years after Captain Cook. Observations during the ten–hour interaction between the French and Rapanui revealed "a gay and happy [island] population with a seemingly sound economy, who received the visitors with every sign of joy" (Heyerdahl 1961:56). This population included some 2000 individuals with a balance in numbers between men and women. The French also noted that several new houses were being built, indicating to them that the population was certainly not decreasing (La Pérouse 1797). In regard to horticultural production, La Pérouse (1797:238) comments on the island's productive soils: "[t]he size and goodness of their potatoes, yams, sugar canes, etc. are proofs of great fertility and strong vegetation". On another occasion, La Pérouse and his crew noted that some one tenth of the island was cultivated, and that about three days of labour per each native would be sufficient to procure subsistence for a year. Noteworthy, the French believed that while harvest was common to the people of the district, “there [was] probably a chief in each district, who looks more particularly after the plantations” (La Pérouse 1797:12).

The period after the ‘pioneer visitors’ (Richards 2008) turned out to be a very dark period for Rapa Nui history (Englert 1970; Fischer 2005; Métraux 1957; Peiser 2005). It would see the arrival of aggressive colonisers, whalers, and blackbirders (e.g. the *Nancy* in 1805; Peruvian slave raids in the 1860s) and the appearance of diseases (e.g. smallpox and tuberculosis) that decimated the Rapanui population to just 110 by 1877. Métraux (1957:38) recognised the abuse, slavery, and near–extermination of the Rapanui during this period as “the most hideous [of] atrocities committed by white men in the South Seas”. Eleven years later (1888), Chile would annex Rapa Nui, becoming the first and only South American country to claim and control a Polynesian island.

The 1800s also included visits by Russian vessels and their captains (Lisjanskij, Kotzebue, and Miklukho–Maklaj) who desired to come ashore and exchange materials with the islanders. In 1804, Lisjanskij (1812), the captain of the *Neva*, observed some 30 standing *moai* throughout the island, located 23 adjacent houses near the southern coast, and estimated the population at less than 2000. Lisjanskij sent Lieutenant Povalishin ashore in a yawl with five armed men and trade goods. He returned with sweet potatoes, yams, bananas, and sugar cane, along with a collection of woven bags and *moai miro* which are now housed in the Ethnographical Institute in Leningrad (Heyerdahl 1975; Richards 2008).

Five years after the enslaving and murdering activities of the crew of the *U.S.S. Nancy*, the *Albatross* called to Rapa Nui, bringing Captain Nathan Winship and William Alden Gale (1810). Gale would later write about the interaction he witnessed between members of the *Albatross* and the Rapanui.

“While we were trading with the natives at a short distance from the shore in the boat, they swam off to us with potatoes, sugar cane, bananas, etc. for which we exchanged small bits of old iron hoops, fishhooks, and nails, the last of which they seemed to set great story by … Amongst other things that they brought off to see, were some small figures rudely carved in wood, and three large pieces of fish netting” (Gale 1810 as cited by Richard 2008:29–30).

Gale (1810 as cited by Richard 2008) also identified individual Rapanui chiefs from their prominent tattoos.

On 28 March 1816 the second Russian expedition called to Rapa Nui in the exploring ship *Rurik*. Upon first contact, trading was allowed in the water, but as time passed, the captain, O.E. Kotzebue, and crew were met by greater hostility and bombardments of stones from the islanders deterring their landing (Kotzebue 1821). Forcing their way ashore with gunfire, and amidst stone throwing and the roaring of the two meeting crowds, the Russians and Rapanui carried out a brief exchange with scraps of iron and knives in exchange for nets, sweet potatoes, yams, and fruits (Heyerdahl 1961, 1975; Métraux 1940; Richards 2008). Unlike Lisjanskij, Kotzebue and crew only observed two *moai* statues standing, but they did not circumnavigate the island.

The British whaleship *Spring Grove* interacted with Rapa Nui in mid–1823. A young seaman named T.W. Smith (1844:168) wrote about the exchange between the islanders and the crew. "Two boats were sent in to trade with the natives while the ship lay off and on. The bartering articles consisted of bent needles and pins, buttons, beads and other trinkets, for which we received in return potatoes and sugarcane. The pins and needles were used by them to catch fish". Like the previous observations about the use of tattoo, Smith proclaimed that Rapanui chiefs were handsomely tattooed on their faces, necks, lips, tongues, and arms (Richard 2008).

In 1825, Captain F.W. Beechey landed at Cook's Bay (Hanga Roa) in the *H.M.S. Blossom* (Gough 1973). While Heyerdahl (1961, 1975) proposed that the Rapanui were trying to lure the English ship into a trap, Englishmen who first arrived ashore in small skiffs where met by islanders who, without any bargaining, simply threw items into rowboats (Métraux 1940). Peard (as cited by Gough 1973:70) stated: "[t]hey came fearlessly alongside and held up bananas, yams, sugar cane, celery [sic] and small baskets of potatoes, but were not disposed to barter them for nails or arrow heads … wanting fishhooks. Our clothes seemed to be more valued by them more than anything else". Two small *moai miro* were also collected by the *H.M.S. Blossom* (Heyerdahl 1961, 1975). Wolf (as cited by Richard 2008) believed that products brought to the English vessel were intended to be presents. Once closer ashore, however, the English were exposed to a short interaction of exchange, until one of the *ariki* or *tangata honui*, dressed with a *hei huru huru* (crown of feathers) and *kahu* (cloak) and men (*matatoa* – warriors) with short clubs (*paoa*), appeared suddenly. After the blowing of a conch–shell, the English were attacked and pillaged by Rapanui men with clubs, sticks, and stones. A Rapanui chief and possibly another native were shot during this skirmish (Peard as cited by Gough 1973; Wolf as cited by Richards 2008).

Observations from the 1830s highlight the friendliness and eagerness of the Rapanui to exchange with foreign visitors. For example, a manuscript letter from H. Cuming reveals that the schooner *Discoverer* had briefly called to the island in 1831 (Heyerdahl 1961; Métraux 1940; Richards 2008). During this period, the natives were found to be lively and good–natured, providing the crew with bananas, yams, and sweet potatoes. Seven years later (1838), representing an attempt to promote French commerce and whaling in the Pacific, the Admiral DuPetit–Thouars reached Rapa Nui from Mexico in the *Venus*. Once stopped, two Rapanui men climbed aboard and:

"asked in sign language to be shaved, which was done for them. One of them, having received the gift of a cap and collar, put them on immediately and proudly walked on the bridge, admiring himself as if he was richly dressed. All the natives repeated frequently and vigorously the word miro, and became impatient when it was not understood. This word is the name of the wood the Polynesian used to build their canoes. This was what they desired above all and they used several methods to make themselves understood. They did not want to eat or drink; they seemed to attach little importance to the knives and scissors; the hammocks pleased them greatly as did the mirrors and coloured handkerchiefs" (DuPetit–Thouars 1841 as cited by Richard 2008:71–72).

During other calls to shore, DuPetit–Thouars (1841) believed that in order to have a favourable reception and interaction with the French, the Rapanui brought bananas, sweet potatoes, and yams enveloped in their reeds. One double–headed *moai miro* was also acquired by Dupetit–Thouars' crew (Dupetit–Thouars 1841; Heyerdahl 1961, 1975). In return, the islanders once more requested wood, most likely to be used to patch canoes and/or to carve *moai miro* figures (Métraux 1940, 1957). Fischer (2005) noted that Dupetit–Thouars and his crew would be the last outsiders to see standing *moai*. These three contacts in the 1830s shed light on how the Rapanui still used forms of gift–giving and exchange to interact with visitors to the island. This included the transfer of staple crops and luxury goods to acquire social prestige and valuable wood raw material.

Richards (2008) meticulously marshalled through 33 known whaling visits to Easter Island between 1841 and 1862 highlighting the sheer volume of horticultural produce and materials that were exchanged by the Rapanui with visitors to the island. For example, besides acquiring multiple chickens and boatloads of yams and sweet potatoes where specific measurements were not noted, hundreds of barrels of sweet potatoes, yams, bananas, and sugar cane were obtained by the visiting whalers. This led Richard (2008:93) to conclude that:

"local people ashore were not so impoverished, nor so hungry, that they would not barter valuable food, often playfully and in quite large quantities, for the curiosities offered by the visiting foreigners. Also the Islanders' willingness to trade their own curiosities, such as *moai kavakava* [*moai miro*] and *moai moko* [or lizard figures] began vigorously from a very early date".

In turn, the Rapanui received scraps from the whaling process including blubber, skin, and bone. The islanders also requested wood, metal fishhooks, and clothing. Unfortunately, however, the very desire by the Rapanui to acquire foreign materials was ultimately used against them by the Peruvian slave raiders of the 1860s:

> "… about five hundred of the Easter Islanders were gathered, mostly on their knees examining the trade goods, the slave raider fell upon them and captured two hundred, while nearly a dozen were shot dead. The rest escaped by climbing up the rock or diving into the sea. The captives were tied and carried onboard the various ships, where they met with a great many more of their countrymen who had been captured while coming out to the foreign guests for the purpose of trade. Among those kidnapped were the island king, Kaimakoi, and his son Maurata, as well as nearly all the maori, or learned men, all of whom died" (Heyerdahl 1961:671).

In response to the blackbirding on Rapa Nui, and the removal of almost 1500 natives, Bishop Jaussen of Tahiti pleaded with the French Minster in Lima and the Peruvian government to return the enslaved Rapanui. However, disease and wicked working conditions killed most of the enslaved natives, leaving only a few islanders who attempted the trip back home from South America. Of these, only fifteen survived the journey. Worse still is that these fifteen individuals carried smallpox with them, and when joined with the tuberculosis already on the island, had devastating consequences for the island, changing the Rapanui community forever (Altman [ed.] 2004; Hunt and Lipo 2011; Heyerdahl 1961, 1975; Métraux 1940; Peiser 2005).

Arguably, the atrocities committed by enslavers also motivated religious entities to send missionaries to monitor the island. These included members of the Congrégation des Sacrés Coeurs of Picpus including Eugène Eyraud, Hippolyte Roussel, Père Gaspard Zumbohm, Albert Montiton, and Frère Théodule Escolan (Altman [ed.] 2004; Fischer 2005; Heyerdahl 1961). But the island that these missionaries visited was radically different from the island that was described at the beginning of European contact during the 1700s and early 1800s. Olivier (1866: 254), reporting from Valparaíso, Chile, comments on this situation:

"The mission is being established at the time when the destructive work has reached its extreme limits; destruction of both material and moral kind … The instinct of destruction seems, together with theft, to be the dominant characters of the people of Rapa [Nui]. If they conserve any religious conceptions among these ruins, they have at least forgotten any practice of its cult, and they barely recall Makemake, the god worshipped by their ancestors. No more authority, no more subordination: Easter Island presents a kind of anarchy to the normal state. During the nine months of his first sojourn, Fr. Eugène could not discover any truly recognised chiefs; some groups, headed by the hardiest individuals [most likely *tangata manu* – birdman and/or *matato'a* – warriors], decided over the peace of the island".

Although Eyraud (1864) became the first foreigner to live on Rapa Nui for a total of nine months, he constantly highlighted the grave living conditions on the island and repeatedly reported that he, along with his self–appointed bodyguard (and tormentor) Torometi, were constantly struggling to guard against violence and theft. This was because when Eyraud arrived, he came at a time of great upheavals, as attempts were being made to readjust after the murder and loss of the chiefs, priests, parents, and children. There was also the problem of the re–assignment of lands, some of which were left ownerless as a result of blackbirding (Altman [ed.] 2004). But Eyraud would make important observations, including being the first to report *kohau rongorongo* (tablets that contain proto–writing symbols), the use of *moai miro* figures by the Rapanui in their homes, and the importance of Mataveri for ceremonial proceedings (Eyraud 1864).

After escaping the island for Chile, Eyraud came back to Rapa Nui with Roussel and seven Mangarevans. Together, they were charged to run the new mission and convert the natives to Christianity. In fact, Eyraud's dying wish was to make sure that the island had been completely converted; Roussel would confirm to Eyraud that this was so before the Feast of Assumption in 1868. Eyraud died of tuberculosis and was buried on Rapa Nui (his grave is next to the island's Catholic church). While trying to save Rapanui souls, he also infected many of the islanders with the disease, helping it spread throughout the already decimated community (Altman [ed.] 2004). Roussel would stay on Rapanui until 1871 when he returned to Mangareva, where he had originally been posted with the formidable Father Honoré Laval. Roussel would be followed by numerous Rapanui who paid their passage by selling their own land. This exodus of Rapanui people eastwards toward Mangareva would represent a re–interaction between the two East Polynesian islands. During his time on the island, Roussel (1869, 1908) wrote about Rapanui war, marriage, customs, religion, and status, among other topics. He also created a Rapanui lexicon and the first 'kings–list', noting the various *ariki mau* (paramount chief) through time. The missionary also wrote about Rapa Nui's social structure, including the authority and power of *ariki* before the slave raiders.

"From Hotu [Matu'a] to the last king, who had been taken away with two of his sons and his two daughters on Peruvian ships, there had been an uninterrupted succession of great chiefs or kings. These kings, who were regarded as gods, exercised absolute power over the island and used their authority to retain the prestige associated with the gift of apparently superhuman powers, as well as certain personal privileges. To the kings alone belonged all the first–fruits of the land. These offerings were brought to them with great ceremony … The kings head was taboo. The king had to let his hair grow, without ever touching it with a stone blade … The kings' hands were also taboo – they were allowed only to make fishing lines and nets. They were allowed to fish from a canoe but their homes, their lands, their food and their entire persons and everything that they used were taboo for people of both sexes" (Roussel 1869 as cited in Altman [ed.] 2004:40–41).

Subsequently, Métraux (1957:114) would record that:

"[a]fter the harvest the natives still came in procession to pay tribute of the first–fruits to the heir of Hotu Matu'a. The bearers of the yams headed the procession, followed by two files of young men carrying standards made of *hau* [stick with feathers] branches, peeled and stained black. They advanced to the sound of hymns mingled with exclamations of respect".

Roussel (1869; as cited in Altman [ed.] 2004:41) also observed the implementation and severity of chiefly *tapu* over the harvesting and allocation of horticultural and maritime resources: "[w]oe unto anyone who dared to violate the taboo. Often, such an act would cost him the destruction of his property and sometimes, even, the loss of life".

Roussel (1869) witnessed how Rapa Nui's plantations, held in common by members of a single or extended family (*paenga* and *ivi*), were defined by a few stones placed at regular intervals. Fields were cultivated synchronously and when the first–fruits were ready they were taken to the *tangata honui*. After the crop was perfectly ripe, the plantation became the focus of feasting and exchange festivities for the village (*hatu*) and sometimes, for several villages (*koro*), depending on the size of the plantation(s) and the importance of the person who was considered the owner. For these festivals, the Rapanui gathered as much food as they could, with chickens making the greatest contribution (see also Métraux 1940). Importantly, Roussel (1869:360) recorded members of the Rapanui society including 'chiefs' (*ariki*), 'priests' (*ivi atua*), 'warriors' (*matato'a*), and 'commoners' (*kio*). Regarding the *ariki*, Roussel (1869) noted that chiefs would abdicate their position when their first son got married; but this would be held off for some time, so the current *ariki* could hold onto his position and further his reign as the island's *ariki mau*.

As such, revelations by Roussel highlight: 1) a once sociopolitically, ideologically, and economically complex society that included elite control and manipulation over the island's staple resources and political economy; and 2) an island society that was directed by *mana* and *tapu*, ascribed genealogical positioning, and rank.

During the missionary period, two notable ships called to Rapa Nui. They were the English *H.M.S. Topaze* in 1868 and the Chilean corvette *O'Higgins* in 1870. While the former ship would bring the surgeon J.L. Palmer to the island, the latter vessel would be under Commander I.L. Gana, representing the second interaction between Chile and Easter Island (Gana 1870). The *O'Higgins* returned to Rapa Nui in 1875, under Commander Lopez's mandate. While listed as a cadet on the *O'Higgins*' 1870 Easter Island visit, Policarpo Toro, who returned in 1875 as an officer on board, later visited the island in 1887 to help annex Rapa Nui on behalf of Chile (Fischer 2005; Heyerdahl 1975).

One of the most significant results of the *Topaze* visit was its acquisition of two basalt *moai* named Hoahakananai'a and Hava respectively (Van Tilburg 2004). Both of these *moai* are now found in England. Significant observations by Palmer include how he saw no *moai* standing on *ahu*, but he did comment about *moai* found upright in the central statue quarry of Rano Raraku. The English surgeon also speaks of the red scoria cremation stone or pillar found at Vinapu (see also Mulloy 1961), notes the presence of the *hare moa* (chicken house) in the landscape, and describes multiple types of Rapa Nui material culture including *moai miro*, *mata'a* (obsidian biface tool), stone fishhooks (*mangai ma'ea*), and swimming rafts called *pora* (Palmer 1875).

The missionaries would stay on Rapa Nui until their retreat to Mangareva in 1871 with ~275 natives, leaving ~230 Rapanui on the island. The departure by the Congrégation des Sacrés Coeurs of Picpus missionaries was due to the horrid relationship between them and the French captain Jean–Baptiste Onéxime Dutroux–Bornier ("Pito Pito"), who arrived on the island in 1870 as a commercial sheep rancher. His arrival, along with his partnership with his associate J. Brander in Tahiti, would signal the first attempt to commercially and physically exploit Rapa Nui, its land, and its people (Fischer 2005; Métraux 1940). For example, not only did Dutroux–Bornier (with the assistance of Torometi) play the remaining Rapanui against each other (e.g. advocating for raids, setting fire to villages, and shelling Hanga Roa with cannon and gunfire), but he also attempted to remove many Rapanui to Tahiti to work Brander's plantations so he could have "Easter Island for himself and his sheep ranching" (Heyerdahl 1961:75).

Although Dutroux–Bornier would meet his demise by being killed by the remaining Rapanui in 1877, he would see the arrival of the French ship *La Flore* in 1872. Aboard this vessel was Admiral de Lapelin and a midshipman named Julien Viaud, later famous as a poet under the pseudonym Pierre Loti. Like Cook, Loti believed 'indisputably' the islanders were of Polynesian origin. This orientation helped him during the expedition, along with his communication to his five Rapanui 'friends' (Atamou, Petero, Houga, Marie, Iouaritaï), as he was able to visit Rano Raraku, various *moai–ahu* complexes, multiple *hare paenga*, and even inland sites to produce many important observations and drawings about Rapanui culture. Heyerdahl (1975:54–55) argues that drawings "made on the spot were remarkably accurate", providing Loti's personal interpretation of Rapa Nui and its landscapes. One particular drawing is Loti's "Idol Festival on Easter Island" that was printed in *Harper's Weekly* in 1873. This drawing recalls observations by the Dutch in 1722, displaying many Rapanui at a fire offering in front of a remaining *moai–ahu* complex that had standing *moai* (although no *moai* were standing in 1872). Loti's drawing also noted chiefs and elites using traditional paraphernalia like *ao* (large double–sided paddle with a face), *ua*, and *hei huru huru* at the ceremony. The painting by Loti may also represent other types ceremonies that were carried out in front of and around the *moai–ahu* complex, including the *paina*, *koro*, *ko peka*, *areauti*, *puke*, *kaunga*, and *'ei* (Englert 1970; Métraux 1940, 1957; Routledge 1919).

A second drawing by Loti presents a scene of a Rapanui chief, dressed with a *kahu*, a *hei huru huru*, and holding a *ua* next to a *hare paenga*. This painting provides support for Agüera's earlier observation (1770) that noted elite men and retainers living in *hare paenga* near *moai–ahu* complexes. Inside the elite home, Loti (1872 as cited by Altman [ed.] 2004:74) found:

"a thousand items … careful[ly] attached to the walls: little idols made of black wood [*moai miro*], which are wrapped in crude macramé [knotted cords]; spears with flake flint [sic] tips [*mata'a*]; paddles with human faces [*ao*]; feather headdresses [*hei huru huru*]; decorations for dance or battle; and many rather perturbing tools or weapons, whose use I cannot fathom and which all seem to be extremely old".

On one landfall excursion, Loti (1872) claims to have met a chief who received him in a cave adjacent to his hut where he spent his life knelling, with his hands clasped on his blue–tattooed knees. Loti noted how the chief had tattoos on his face and throughout his body, and he wore his hair very long. Another chief offered to tattoo Loti, but instead, gave him a pouch of *ti* (*Cordyline fruticose*) leaves which were used to make the black dye often used in the tattooing process (Simpson 2010).

When discussing the *moai–ahu* complex, Atamou told Loti that they were for the great chiefs who fell in battle as they are buried under rocks that have been piled together to form tumuli (Loti 1872 as cited by Altman [ed.] 2004). The 1872 expedition by the French acquired a *moai* from Ahu O'Orongo in Hanga Roa by separating it into two pieces at the neck. Including the *kohau rongorongo*, *moai miro*, *hei huru huru*, and shark vertebra earrings collected by Loti, the French crew also acquired other small stone statuary and pieces of wooden material culture. While some artefacts collected from the *La Flore* would become holdings of the Musee de l'Homme, other pieces became parts of private collections (Heyerdahl 1975; Pinart 1877). Together, these pieces would be used by Stéphen Chauvet (1934) to create his significant publication about Rapa Nui material culture, which included artefact photos, descriptions, and interpretations.

After the death of Dutroux–Bornier in 1877, Alexander P. Salmon, left Tahiti and came to settle on Rapa Nui in Dutroux–Bornier's stead. 'Ariki Paea Salmon' would be later joined and assisted by J. Brander (Fischer 2005; Métraux 1940). Heyerdahl (1961:78) accredited Salmon for his humanitarian efforts on Rapa Nui as "he took great personal interest in the remaining population and did much to improve their miserable living condition". This would include salvaging and recording Rapa Nui language, beliefs, and traditions. Salmon is also noted for his work to transform Rapanui material culture into 'commercial art' for trade with foreigners (Fischer 2005; Heyerdahl 1975; Métraux 1940; Routledge 1919). For example, after visits by Geiseler in 1882 and Thomson in 1886 (see below) in which Salmon acted as a guide, he also witnessed the great interest by visitors to acquire material culture such as *kohau rongorongo*, *moai miro*, *mangai ma'ea*, featherwork, and other objects. As such, Salmon encouraged a renewal in carving and in the traditional arts to replenish the number of existing artefacts and to recreate the kind of objects that had been in the greatest demand by collectors.

Days after the death of Dutroux–Bornier, the French warship, the *Seignelay*, called to La Pérouse Bay on Easter Day 1877. Aboard this vessel was the 25 year–old French trained anthropologist Alphonse Pinart (1877). He is perhaps best known for his famous count of 110 natives still living on the island at the time, and his visit and dinner with the then widowed Koreto, the wife (and 'queen' of Rapa Nui) of Dutroux–Bornier. Over six days, Pinart would also make valuable sketches and observations about the ceremonial village of 'Orongo, various *moai–ahu* complexes, the *moai* quarry, gardens including *manavai*, and the contemporary living conditions at Vaihu (old missionary church) and Mataveri (the old home and headquarters of Dutroux–Bornier). Dr. Thoulon, the doctor for the *Seignelay*, looted multiple *moai–ahu* complexes, removing more than twenty skulls and two complete skeletons. Other bones, skulls, and remains were offered to the expedition in exchange for leaves of tobacco (Pinart 1877).

The 1880s would see the arrival of two important vessels that provide interesting details about late Rapanui ethnohistoric interaction. These include the 1882 visit by the German *Hyäne* and the 1886 visit by the American *U.S.S. Mohican*. While both expeditions were assisted by Salmon, the former excursion lasted four days and was carried out under the direction of Paymaster Weisser and Commander Geiseler. While much of the German investigation was based on the ethnographic collection of artefacts and material culture (Métraux 1940), considerable effort focused on the documentation of the ceremonial village of ʻOrongo and the description of the *tangata manu* (birdman) ceremony.

Members of the *Hyäne* also recorded interviews with elders who revealed pertinent information about *moai,* including their names, their measurements, how they were carved, and how the statues were still considered to be equipped with great power (*mana*) and therefore considered *tapu* by islanders (Geiseler 1882). With Salmon as his interpreter, Geiseler was told that specialist (*māori*) *moai* carvers (*tangata māori anga moai*) were a noted class of professionals who were engaged in no other work. Métraux (1940, 1957) and Fischer (2005) refer to *māori* as *tufunga*, as Fischer (2005) argues that the word *māori* was introduced through later contact with the Tahitian language. Other craft specialists have also been noted during Rapa Nui's past including *tangata māori anga paenga* (a specialist who made *paenga* [dressed stone blocks] for *hare paenga* and *ahu*) and *tangata māori anga maʻea* (a specialist who made stone tools) (Englert 1970; McCoy 2014; Métraux 1940; Simpson and Dussubieux 2018; Simpson et al. 2017, 2018). When joined with other observations, this identification helps us to recognise seven classes of Rapa Nui sociopolitical units: *ariki* (*mau* and *paka*), *tangata honui*, *ivi atua*, *māori*, *matatoa* and *paoa*, and *kio*.

Regarding *ariki*, Geiseler (1882) was shown certain burials and large cloaks (which only chiefs could adorn) that were made for them, leading him to suggest that "[i]n early days when the kings enjoyed important power and respect, they functioned as priests and they started and they led the religious festivities" (Geiseler 1882:33). Although Geiseler did not obtain *kohau rongorongo* (but later acquired three through purchase), an elder man told Salmon that Rapanui's proto–writing system was used to deliver important messages to chiefs in other districts without the runner knowing the text and to preserve important genealogies (*haka'ara*).

Six years after Geiseler and the *Hyäne*, the *U.S.S. Mohican* arrived to Easter Island (1886). Led by Paymaster W.J. Thomson (1891; see also Cooke 1899), this American expedition would stay on Rapa Nui for eleven days, conducting wide–ranging survey and very rudimentary and non–scientific excavation. Fischer (2005) comments on how even dynamite was used at Ahu Vinapu. Nonetheless, during this time the crew impressively documented 'Orongo and registered some 113 *ahu* complexes and 555 *moai*. Of the latter, Thomson provides evidence for the existence of both male and female types. When asked about their function, the islanders responded that they were "effigies of distinguished persons and intended as monuments to perpetuate their memory" (Thomson 1891:498). These distinguished persons were ultimately kindred to the island's first chief Hotu Matu'a and his six sons.

"After the lapse of a number of unrecorded years, during which the island had been made to produce an abundance of food, and the people had increased and multiplied in numbers, Hotu Matu'a at an advanced age was stricken with a mortal illness. Before his end drew near, the chief men were summoned to meet in council. The king nominated his eldest son and his successor (Tuumae–Heke), and it was ordained that the descent of the kings should always be through the eldest son. This important matter having been settled, the island was divided up into districts and portioned out to the children of the king" (Thomson 1891:572).

Commenting on the administration of Rapa Nui after the original division by Hotu Matu'a and his sons, Thomson (1891:472) states:

"[t]he supreme authority was vested in a king [*ariki mau*] and was hereditary in his family [Miru]. The person of the king was held sacred … The king reigned over the entire island and was not disturbed by the defeat or the victory of any of the clans [*mata*]. The island was divided into districts [*mata kainga*] having distinct names governed by chiefs [*tangata honui*] all whom acknowledged the supremacy of the king. The title of chief was also hereditary and descended from father to son … The chiefs wore peculiar feather hats to denote their rank, and they presided at feasts".

Besides the collection of two *moai* (one complete statue and one head) and one *pukao* (topknot) from Ahu O'Pepe, the *U.S.S. Mohican* gathered a variety of material culture that is now housed at the Smithsonian Museum. Thomson (1891) noted how certain artefacts were used by elite Rapanui including wooden clubs and feathered hats. Regarding *kohau rongorongo*, Thomson (1891:514) writes:

> “Hotu Matu‘a, the first king, possessed the knowledge of this written language, and brought with him to the island 67 tablets containing allegories, traditions, genealogical tables, and proverbs relating to the land from which he had migrated. A knowledge of the written characters was confined to the royal family [Miru], the chiefs of the six districts into which the island was divided, sons of those chiefs, and certain priests or teachers, but the people were assembled at ‘Anakena Bay once each year to hear all of the tablets read. The feast of the tablets was regarded as their most important fête day, and not even war was allowed to interfere with it”.

As such, observations and information recovered by both Geiseler and Thomson and their crews highlight the following: 1) original Rapa Nui land divisions, call *mata kainga*, were created and legitimised through chiefly primogeniture birth – *atariki*; 2) the *ariki mau* was the absolute leader on the island. He was followed by lesser chiefs (*ariki paka*) and elite men (*tangata honui*) from the other clans throughout the island; and 3) chiefly and elite members used luxury material culture (capes, clubs, and crowns) and proto–writing to manifest their power and authority and to control sacred knowledge and genealogies.

After Policarpo Toro’s 1877 visit to Rapa Nui, Salmon sold the Brander Easter Island holding to the Chilean government on 2 January 1888. This would be followed by the official annexation of Easter Island on 9 September 1888, by means of the *Treaty of Annexation of the Island*. Toro represented the Chilean government and Atamu Tekena, designated *ariki* by the remaining Rapanui after the *ariki mau* and his heir had died, represented the island (Fischer 2005; Métraux 1940).

The financial interests in the former J. Brander Easter Island estate were for some time in the hands of businessman Henri Merlet, who later took control of island land by purchase, lease, and usurpation from both islanders and the Chilean government (Fischer 2005). To thwart the thieving of roaming sheep that now inhabited the island, a stone wall was constructed around Hanga Roa. This is why today there is only one main town on the island, and arguably a basis for why there is noted conflict regarding contemporary Rapa Nui land use and ownership (see Simpson 2015; Young 2012). To secure the wall, it was supplemented by guards, gates, fencing, and a pass system (Métraux 1957). If islanders protested against forced labour and containment, Merlet burned crops and treated the Rapanui poorly.

The Williamson–Balfour Company succeeded Merlet, providing employment, resources, and opportunity for the island community. Known as CEDIP (*Compania Explotadora de la Isla de Pascua*) or the Easter Island Exploitation Company, it became the effective sovereign of Easter

Island and was mainly run by the English–Scotsman Percy H. Edmunds from 1904 to 1929 (Cristino and Fuentes [eds] 2011; Simpson 2010). It would be during this time that the flow of the recently produced wood carvings, stimulated by Ariki Salmon, would now go back to Chile and throughout the world. For example, Fischer (2005) noted that it would be Edmunds who had Rapanui search caves for original artefacts, while others carved reproductions for later exchange and trade.

"Attempts were now also made to imitate the exquisitely carved and polished fishhooks, but the result was far short of the quality of the original specimens … It was different in the case of wood carving and featherwork … Their traditional manufacture simply continued and can therefore hardly can be considered imitation. In fact, the same individuals who had until now carved wooden images and paraphernalia for magical or ceremonial purposes carried on their work as before, but now for commercial purposes" (Heyerdahl 1975:65).

As such, Victorian collectors like Captain A.W.F. Fuller would negotiate with Edmunds, and Edmunds' family in England, to acquire Rapa Nui material culture (Fischer 2005; Simpson 2010). Some of the pieces acquired by Edmunds and later by Fuller included, for example, *moai miro*, lithics, *ua*, *rapa*, and turtle shell ornaments. In turn, Fuller sent many exchange items:

"I only got them [artefacts] by sending out enormous bales of trade goods … I used to send them old army blankets, they were not worn, but excess of stock – they were in red. They loved the red uniforms of soldiers. I sent them out old clerical suits of my father … Beads, I sent them out. Hundreds of yards of silk ribbon – different colors for the women you see. Gramophones, records, and all sorts of things. I kept Edmunds generally supplied with tobacco, which was in tins" (Fuller 1958 as cited by Simpson 2010:22).

During his time on the island, Edmunds produced valuable photos (see the University of Hawai'i Library's Pacific Collection) and was present for two important expeditions to Easter Island: the first by the Chilean government in 1911, and the second by the English *Mana* between 1914–1915.

The first trained scientist to investigate Rapa Nui, preforming systematic research, was the German Dr. Walter Knoche (Fischer 1997; Heyerdahl 1975; Métraux 1940; Mückler 2017a,b). After arriving and living in Chile, Knoche was included in a group of immigrants who established the dominance of German scientists in meteorology and geophysics in South America, especially in the south of Chile. After being invited by the Chilean government, then led by President Pedro Montt, Knoche travelled to Rapa Nui with the Chilean Navy training vessel *General Baquedano*. Knoche was accompanied by Francisco Fuentes (a botanist), Edgardo Martínez (an assistant), and Juan Calderón (a mechanic) who stayed on Rapa Nui from 13 April to 25 April 1911. The objectives of the expedition were to establish an observation station to carry out seismological and meteorological measurements during a one–year period and to improve the health and hygiene of the island population. Of interest for Rapa Nui scholars are Knoche's 38 scientific articles (mostly in German and Spanish; see Mückler 2017b) and one book (Knoche 1925), which provide ethnohistoric evidence of interaction and exchange on Rapa Nui in the early 1900s (Fischer 1997). For example, Knoche noted the horrible living conditions the Rapanui faced under the Williamson–Balfour Company and Chilean rule including blood feuds and the various stages of leprosy found amongst the islanders. Regardless of this, Knoche managed to collect 73 valuable artefacts that can today be found in various museums throughout the world, including the Fonck Museum in Viña de Mar, Chile (Heyerdahl 1975; Mückler 2017b). Photographs of many of these objects were used in Brown's 1924 publication, *The Riddle of the Pacific.*

Knoche also interviewed two men who were able to describe traditional myths, customs, feasts, songs and dances, ceremonies, and other cultural manifestations. This allowed Knoche to go into some detail about sociopolitical, economic, and ideological characteristics of the traditional Rapanui society. He paid special attention to the islanders' tattoos, documenting the last remaining Rapanui women with *tatu* (Knoche 1925).

Significantly, as this review section has highlighted in other cases of the eagerness by the Rapanui to interact and exchange with visitors to the island, Knoche (1921:20) confirms this eagerness, stating: "[t]he Easter Islanders happily brought their garden produce, fish, and manufactured things on board the visiting vessels and quite unabashedly grasped, as they were wont to do, whatever they fancied". This insight prompted Mückler (2017b) to argue that the behaviours interpreted by earlier visitors as thieving were possibly misinterpreted, as the traditional Rapanui exchange system was likely governed by reciprocity and 'communist principles'. Lastly, Knoche believed that the *moai–ahu* complex still received a certain degree of veneration, and he suggested that these remains represented a sort of ancestor cult (Heyerdahl 1975).

Three years after Knoche and the Chilean expedition, the Englishwoman Katherine Routledge and her husband William Scoresby Routledge, sailing in their state–of–the–art ship named *Mana*, called in to Rapa Nui on 29 March 1914. The *Mana* was especially made for the voyage and was skippered by Captain H.J. Gillam. Working in collaboration with the British Association for the Advancement of Science, the British Museum, and the Royal Geographical Society, the Mana

Expedition to Rapa Nui stayed on the island until August 1915, conducting valuable anthropological work that resulted in one of the most important sources about Rapa Nui, *The Mystery of Easter Island* (1919). Later publications have further highlighted the importance of Routledge's work for both Rapa Nui and Pacific scholars (e.g. Hunt and Lipo 2017; Van Tilburg 2002, 2003).

Van Tilburg (2002:67) synthesised the research questions of the *Mana* expedition: "Who were the people who had discovered and settled remote and nearly inaccessible Rapa Nui? Where did they come from? What exactly, was the significance of the statues? How are the statues linked to the present inhabitants of the island?" Guided by these questions, the *Mana* expedition examined nearly 1000 archaeological sites and conducted some 100 rude excavations which mainly included house sites at 'Orongo and *moai* at Rano Raraku (Simpson et al. 2018). Some 260 *ahu* were assigned to one of three major categories (image, semi–pyramidal, *poe poe*) on the basis of design, and valid prototypes were drafted (Routledge 1919:169, 173). Routledge considered image *ahu* as 'theatre stages' from which the ancient Rapa Nui society was displayed and where cultural acts (including exchange) were performed. Clan identities were attached to some *moai–ahu* complexes and 391 statues were inventoried. Multiple detailed maps, photos, and diagrams were also produced, providing valuable data for archaeologists and researchers today (Hamilton 2007).

While this research output was quite impressive for the time, Van Tilburg (2002) argued that K. Routledge's ethnographic methods were far superior to her archaeological procedures, as she used triangulation (plausibility, consistency, and comprehensiveness) to improve the validity of her data. This technique helped to avoid hearsay and to evaluate data using reasoned speculation and reasonable presumption. As such, her ethnographic work provides valuable clues to understand the 'pre–Christian culture'. For example, while Thomson (1891) noted six clans, Routledge (1919:221–222) mapped ten *mata* and associated them to different parts of the island, though she did believe that some "boundaries blend and overlap; [with] members of one division settled not infrequently among those of another". She also supposed that marriage between clans (except for the Miru) was likely a mechanism for interaction and emigration.

Regarding the Miru, K. Routledge's informants told her that "[m]embers of this group had … the supernatural and valuable gift of being able to increase all food supplies, especially that of chickens, and this power was particularly in evidence after death" (Routledge 1919:240). The Miru were also unique as they were the only *mata*:

"which had a headman or chief, who was known as the *ariki*, or sometimes as the *ariki mau*, the great chief, to distinguish him from the *ariki paka*, a term which seems to have been given to all other members of the clan. The office of the *ariki mau* was hereditary, and he was the only man who was obliged to marry into his own clan" (Routledge 1919:241).

This practice of royal endogamy made sure that only the most royal Honga *ure* (lineage) married women from certain *ure*, including the Te Kena or Kao (Fischer 2005). Osteological remains from archaeological sites on Miru land support this claim, as Gill (2000) found evidence for genetic isolation and inbreeding in the ancient Rapanui population. One of K. Routledge's informants, Te Haha, a Miru royal servant, described Nga'ara, the last known *ariki mau* who died shortly before the blackbirding raids (Fischer 2005; Métraux 1940). "He was short, and very stout, with white skin, as had all his family, but so heavily tattooed as to look black. He wore feather hats of various descriptions and was hung round both back and front with little wooden ornaments, which jingled as he walked" (Routledge 1919:241). Nga'ara, like other *ariki mau*, was not permitted to be seen eating and nobody beside servants were able to enter his home at Hanga Rau.

Functions of the *ariki mau* included the responsibility: to bless and honour newly constructed elite *hare paenga* by being the first to eat in them; to review and criticise *tatau*; and to oversee the manufacture, use, and instruction of *kohau rongorongo* (see also Englert 1970; Fischer 2005). Regarding the latter, specialists called *tangata māori anga kohau rongorongo*, who were normally the chief's sons, conducted schools where the proto–language was taught and duplicated (Routledge 1919). These schools were similar to the Māori learning huts called *whare wananga* where *whakapapa* (genealogies) were discussed and proclaimed (Métraux 1940). Every year, there was a great gathering to celebrate *kohau rongorongo* at 'Anakena. There, guests brought offerings to the *ariki mau* including food and feathered sticks, and watched as the Miru, led by the paramount chief, judged the accuracy and execution of the island's proto–language script (see also Fischer 1997, 2005).

Under the position of the *ariki mau*, the *ariki paka* were denoted by being painted (using *kie'a*), with red on one side, black on the other, and a stripe down the centre. These secondary chiefs were tasked with ceremonies and protocols that included praying for rain and placing *hau* (strings of white feathers tied on to sticks) among the yams to make them grow. Routledge (1919; see also

Métraux 1940, 1957) noticed the importance and desirability of large white cock feathers, which were carefully kept in gourd containers (*ipu kaha*). Similar feathers were also employed to make *hei huru huru*, which were used for special occasions and ceremonies. *Ariki paka* also buried fish amongst the sugarcane plantations to bring up the plants, and before a *koro* festival was held, their responsibility included increasing the fertility of chickens by painting red symbols called a *reimiro* (the symbol found on the contemporary Rapa Nui flag) on the bottom of chicken houses (Routledge 1919). Métraux (1940) would later discover that elite skulls were deemed to have the power (*mana*) to multiply chickens. Called *puoko moa*, these sacred skulls were highly valued, marked with incised lines, and kept as precious talismans in the *hare moa.* This belief in the reproductive powers of skulls is also found in other parts of Polynesia, including the Marquesas and New Zealand (Edwards and Edwards 2013; Métraux 1940; Englert 1970).

In the end, results from the *Mana* expedition prompted K. Routledge to argue that Rapa Nui and its material remains were the product of an integrated and long–lasting culture whose genesis was not from South America, but instead, from somewhere in the Pacific.

Arriving 19 years after the departure of the *Mana*, a French–Belgian expedition called to Rapa Nui in the French man–of–war *Rigault–de–Genouilly* on 27 July 1934. The expedition stayed there until 2 January 1935, when it returned to France after visiting other Polynesian islands in the Belgian training ship the *Mercator*. Although the French–Belgian expedition arrived some 212 years after the Dutch in 1722, it still noted the eagerness of the Rapanui to interact and exchange curios with visitors to the island.

"The most coveted foreign goods are clothes, soap, and perfume. The first things the natives ask for aboard a foreign ship are shirts and trousers. Money is accepted, but a shirt is preferred to a sum of money four or five times as great as the value of the article. In order to obtain clothes, they resort to the making of curios, the most flourishing industry of the island. The men carve wooden images, canes, and swords; and the women plait hats, crowns, or feather strings. Most individuals are able to produce these articles, but some are unusually gifted and have specialised in their crafts. Those who want a stock of curios to trade during the visit of a ship may acquire from the expert's articles to trade on their own account" (Métraux 1940:48).

The expedition was planned and organised by noted social scientists of the time including Marcel Mauss and Paul Rivet (Fischer 2005). Members of the expedition included the Swiss–Argentine anthropologist Alfred Métraux, the Belgian archaeologist Henry Lavachery, and the Chilean doctor Israel Drapkin, who was the first to study the island's leprosy outbreak. He also collected specimens for the Natural History Museum in Paris, studied the islander's demography (counting 456 islanders) and blood types, and generously gave medical assistance to the natives.

Some of the most important publications from the French–Belgian expedition include Métraux's 1940 *Ethnology of Easter Island* and his 1957 *Easter Island: a Stone Age Civilisation of the Pacific*. The former book, written in collaboration with and published under the Bishop Museum, was influenced and guided by early Oceanic experts such as Te Rangi Hiroa (Sir Peter Buck) and Kenneth Emory who helped to locate Rapa Nui within the Polynesian anthropological literature of the time. Lavachery published important works including his 1935 *Île de Pâques* article and 1939 *Les pétroglyphs de Île de Pâques* book. Together, these sources provide rich archaeological, ethnographic, ethnohistoric, and ethnological information about Rapanui and Polynesian culture. However, it is repeated throughout Métraux's (1940, 1957) publications that the Rapanui culture had greatly transitioned after the blackbirding and missionary periods, leaving only a few old women who were still alive that knew the old ways (e.g. Viriamo, the mother of Juan Tepano). However, fortunate for Métraux, was his access to the seasoned informant Juan Tepano, the Miru Victoria Rapahango, and the once Thomson informant, Ure vaeiko, who together, provided extensive interviews and discussion.

Using mostly an ethnographic methodology, Métraux describes the Rapanui culture, but throughout his interpretations, he relies on Pacific ethnology to present and elaborate upon multiple topics regarding the Rapanui culture and its connection to other Polynesian cultures. These included: oral traditions and genealogies, origin narratives, rituals, rites of passage, daily life, recreation, religion, material culture, tattoo, monumental architecture, *kohau rongorongo*, and social organisation and interaction. Like Routledge (1919), Métraux (1940:120) identified ten *mata* (which he called tribes) whose "old territorial divisions thus came to be mere districts [*mata kainga*] where the main part of the *mata*, perhaps the senior line [e.g. the Miru line, Honga], was settled". This original senior line included Hotu Matu'a and his six sons, for which Rapa Nui's land was first divided. Interpreting the kings list, Métraux (1957) dated Hotu Matu'a's arrival to the island in the 12th Century, which parallels current radiometric dates for the island's colonisation (Hunt and Lipo 2006; Mulrooney 2013; Stevenson *et al.* 2015; Weisler and Green 2011). Over time, as the numbers of *paenga* (family), *ivi* (extended family), and *ure* (lineage) grew, the number of *mata* (clan) increased from six into ten, and *moai–ahu* complexes were used to unite certain *paenga*, *ivi*, and *ure* to specific lands (Métraux 1957; Englert 1970; Fischer 2005; Roussel 1869).

Interestingly, later ethnolinguistic and genealogical research by the Rapanui Elder's Council identified 18 total clans and their corresponding lands (Hotus et al. 1988). Therefore, over time, more *mata* and *mata* sub–districts were created (Métraux 1957; Englert 1970; Mulloy 1995). Further separating and organising Rapanui's clans was the Ko Te Mata Pipi O Moro line, which divided two *hānau* (confederations); the high–status northern clans (Ko Tu'u Aro Ko Te Mati Nui) and the low–status southern clans (Ko Tu'u Hotu Iti Ko Te Mata Iti) (Hotus *et al.* 1988; Fischer 2005; Métraux 1957; Stevenson 2002; Vargas *et al.* 2006; Figure 7). Within these districts, Métraux (1940, 1957) believed that *moai* carving, reciprocity (especially the exchange of chickens), intermarriage through *tumu* (groups who could have marriage interrelationships), adoption, and warfare influenced, and were catalysts for, Rapanui social interaction. Other interaction included when chiefs from different *mata* visited each other.

"When a chief paid a visit to the chief of another tribe he was met along the road by groups of warriors, who formed an escort. On these occasions no doubt the chanters recited long genealogies, as is still done on the Tuamotus. The two chiefs advanced to meet and pressed the wings of their noses together, inhaling deeply, as though to absorb the breath of the guest or friend. This salutation is called hongi" (Métraux 1957:127).

Informing on the 'classes of society', Métraux (1940, 1957) provides details about the *ariki*, *ivi atua*, *māori*, *matato'a*, *kio*, and notes the existence of a commoner class – known as *hurumanu* – who were responsible for producing food, clothing, and general construction (see also Fischer 2005 for an *'urumanu* spelling).

Discussing the *ariki mau*, Métraux (1940, 1957) emphasises the importance of chiefly *mana* and recognises the extensive *tapu* that was associated with paramount chiefs in Polynesia and on Rapa Nui (Fischer 2005; Kirch 1984, 2000; Shore 1989). With so much sacredness imbued by the chief, he himself became *tapu,* and could not be touched by other persons of both genders. In turn, this sacredness permitted the *ariki mau* to have a strong bearing upon the 'magico–economic structure' of the island culture. The *ariki mau* had multiple classes of servants (e.g. *tu'ura* and *haka'apa'apa*) who provided food and who cooked for him. As his hands were *tapu*, the paramount chief could only make fishing tackle, lines, and nets, but he could go out boat fishing. The *ariki mau* was only allowed to eat certain fish, which included *kahi* (tuna). However, during the winter *tapu* period

(May through September), fishing experts named *tangata māori rava ika maa* were able to catch fish for the paramount chief in his boat called the *vaka vaero*, which was decorated with valuable *moa* (chicken) feathers. Catch from this royal vessel were presented to the *ariki mau* who kept it for his own use, or more often, distributed it among the important old men (*tangata honui*). The first *kahi* taken after the lifting of the *tapu* were also taken to the king, who tasted a bit and gave the rest to the *tangata honui* (Eyraud 1864; Roussel 1869). After this, the chief lifted the *tapu* on other fish, rendering them *noa* (not under *tapu*), but any non–royal caught eating fish before this period would meet with serve punishment, including death. Moreover, other boats had to be inspected by the *ariki mau* to perform propitiatory rites before being launched into the sea.

The *ariki mau* also used specific tattoos and chiefly regalia that included a body–length *tapa* (barkcloth) *kahu* (poncho) stained yellow with *pua* (turmeric) and multiple feathered hats of various descriptions. He also used shell and wooden material culture on his person including fertility balls named *tahonga* and small wooden *reimiro* crescents. In his hands, the *ariki mau* carried an *ua* or *ao*, which was his official *bâton* of office. Oral traditions recorded by Métraux (1957) describe how the paramount chief made tours around the island to inspect the school for priests and listen to recitations of the sacred changes associated with various economic and social activities. Summarising the character and role of the *ariki mau*, Métraux (1940:136) states:

"The king was the man with the most aristocratic pedigree and the most exalted social position on the island. His person was overflowing with mana and his sacredness caused him to be feared and respected. His function in society was to insure through his very being the abundance of crops and the fertility of the ground and to exercise his influence on animal life. Certain religious activities were derived from his sacredness and he held supervisory control over various practices connected with religion".

Concerning *ivi atua* (lineage of the spirits), Métraux (1940; Fischer 2005; Roussel 1869) notes how this social rank was next to that of *ariki paka* and argues that some of the highest priests belonged to the families of the *ariki*. The close association between nobility and priesthood is a common feature of Polynesian culture with many instances recorded on other islands (Kirch 1984, 2000; Métraux 1957). Métraux (1957) posits, therefore, that priestly function, both sacred and secular, must have been specialised (see also Fischer 2005). For example, a distinct class of priests called *timo ika* performed mortuary rituals including chanting, the expelling of *varua* and *akuaku* (spirits and ghosts), and the overseeing and handing of the dead (Routledge 1919; Simpson 2010). Priests also healed sick and possessed individuals, presided at the procedures and rejoicings when a child was born, and provided fishermen with stone amulets or charms that were kept in small baskets (*kete*) during fishing expeditions. Using ethnological comparisons from Mangareva and the rest of Polynesian, Métraux supposed that *ivi atua* had a great deal of influence and played an important part in the pre–contact period, especially as they "disposed of the offerings of fowls, fish, and tubers that were made to the [ancestors] and gods" (Métraux 1957:122, 1940; Roussel 1869).

Regarding *māori*, Métraux (1940:137, 1957) defines them as "a privileged class, highly esteemed, and their profession was transmitted from father to son". *Māori* included *moai* carvers and engineers, canoe builders, orators, tattoo artists, *paenga* and stone tool manufactures, deep–sea fishermen, and *kohau rongorongo* specialists who received orders and supervised their execution. In turn, *māori* experts were paid in fish, lobsters, and eels for their art and crafts. Fischer (2005) later argued that *māori* or *tufunga* should not to be considered as 'guilds', but instead, kinship–based groups of labourers working together for the benefit of their own *paenga, ivi*, *ure*, and *mata*. Using an ethnological comparison, Métraux (1940) argues that *tangata māori anga rongorongo* were like the Mangarevan *taura rongorongo*, who were a special class of intellectuals who were responsible for the sacred chants including genealogies and songs in praise of the nobility at important festivals.

Métraux (1940, 1957) also discussed the island's warrior classes. This included the *matato'a* who were professional warriors and *paoa* which were ordinary soldiers. On Rapa Nui, it seems that over time, *matato'a* became more powerful, exerting their influence over the island culture (Métraux 1957; see also Englert 1970; Fischer 2005; McCoy 1976; Roussel 1869). This is especially true with regards to their roles and activities during the later *tangata manu* (birdman) ceremony at 'Orongo (see Drake 1992; Mulloy 1979; Lee 1992).

The last social class reviewed by Métraux (1940) was *kio.* Individuals of this group are best defined as 'farmers or servants' or 'defeated people' who were obliged to serve their conquerors or to pay tribute to them with the produce of their lands. In addition, some crops attended by *kio* were under *rāhui* (temporal restriction) and *tapu* (ban) until the moment of harvesting was authorised by the stars and the chief. Once authorised, *tangata honui* initiated first–fruit, *hatu*, and *koro* ceremonies, which were also festive means for resource redistribution (Métraux 1957; Fischer 2005). Again, using ethnological comparison, Métraux notes how the Mangarevan *kio*, the lowest class of small farmers on Mangareva, would sometimes put themselves under the protection of a landowner, whereby they would till and cultivate their land. Fischer (2005) has argued that elite land right over *kio*, and the use of socially lesser ranked members for labour, helped to uphold 'traditional economic stratification'.

In the end, evidence from the French–Belgian expedition prompted Métraux (1940, 1957) to conclude that Rapa Nui was a Polynesian culture that shared traits with many other islands, especially Mangareva, the Marquesas, and New Zealand. He did not support the Melanesian connection to Rapa Nui that was held at the time. Simply, Métraux argued that, in isolation, Rapanui developed and stressed certain aspects of the common *Ma'ohi* heritage that allowed them to reach levels of cultural elaboration not seen in other parts of the Pacific. "On the most solitary inhabited island of the world, Easter Islanders were able to develop and perfect the culture which they received from the Polynesian ancestors to the west" (Métraux 1940:420).

A year after the French–Belgian expedition, Father Sebastian Englert came to Rapa Nui (1936) where he would stay for nearly 35 years, documenting a great deal about the island's archaeology, language, oral traditions, and culture. After learning the Rapanui language and interviewing many informants, Englert produced multiple publications about the island (1948, 1970, 1980). Englert was a gifted linguist and researcher, allowing him to penetrate local insights far beyond the capacity of other investigators (Fischer 2005; Mulloy 1970). This included his descriptions of chiefly *mana* and *tapu* and how *ariki* were "respected as people of superior rank and as repositories of mana that could be expected to provide important benefits for everyone" (Englert 1970:51). This is most evident in an oral tradition about the island's first chief recorded by Englert (1970:84):

> "After leaving Anakena, Hotu Matu'a led a solitary life and devoted himself to agricultural pursuits. As he was an ariki henua and a sacred person, he should have delegated such work to subordinates and offered only the stimulation of this good advice. He was apparently obsessed with the desire to provide a secure economic future for his people".

Under the *ariki*, Englert (1948, 1970) highlights the importance of *tangata honui* who were the persons of rank within each *mata.* In turn, *tangata honui* were followed by several social classes including "war leaders, priests, craftsmen, farmers, and fishermen" (Englert 1970:51). Englert also mentions the existence in the oral tradition of two other specialised classes: *tangata heuheu henua* (farmers) and *tangata tere vaka* (fisherman). Judging from this diversity of social roles and the differences in power and authority, Englert concluded that, as occurred in other islands of

Polynesia, the Rapanui social system was clearly that of a class–organised or stratified society. Regarding social interaction and the creation of the *moai–ahu* complex, Englert (1970) argued that these monuments were not the product of a 'public–works–minded island–wide authority' but built independently by 'local kin–groups' in the territories where they were located. Nevertheless, he does imply that there was co–operation among these groups to complete construction tasks (Englert 1970). Ultimately, these local kin groups, represented by the *mata*, *ivi*, *ure*, and *paenga*, were led by *tangata honui* who had the sufficient authority, legitimised by the Miru and *ariki*, to bring together economically, ideologically, and sociopolitically related work groups for multiple types of projects.

In summary, a sythnesis of the nearly 50 ethnohistoric and ethnographic records allows for the following conclusions to be drawn regarding Rapa Nui society at the time of first contact: 1) the Rapanui culture did not experience a pre–contact socio–ecological collapse (contra Bahn and Fleney 1992; Diamond 1995, 2005) but instead was an economically, ideologically, and sociopolitically complex culture; 2) the island's population was more than 3000 upon the first interaction with the outside world in 1722 and its population did not drop to the low of 110 until 1877 after the dramatic influences of disease and blackbirding; 3) multiple *moai–ahu* complexes were still in place, with standing statues with topknots on platforms that were in use for ceremonies; 4) new houses were being constructed throughout the island; 5) copious amounts of horticultural and fowl staple resources were still being produced and later transferred between the Rapanui and visitors, and 6) chiefs and elites were still present in the society, overseeing and directing exchange activities between visitors.

Diffusionism

The first archaeological theory used to frame discussions about the island's past was diffusionism. This theoretical approach to understanding Rapa Nui history was pioneered by the intrepid Norwegian explorer and scholar Thor Heyerdahl. After time spent in the Marquesas, Heyerdahl used his Kon–Tiki adventure (1950) and the Norwegian Archaeological Expedition (Heyerdahl and Ferdon et al. 1961, 1965) to endorse his assumption that Rapa Nui was colonised first by South American cultures (specifically from the Tiahuanaco region), then Polynesians (Heyerdahl 1952, 1958, 1961, 1975, 1989). It was Heyerdahl's outstanding organisational skills that were largely responsible for bringing the first scientific expedition, including the first trained archaeologists, to

Rapa Nui. Their work, over five months of fieldwork, included controlled stratigraphic excavations, material culture analysis, and the documentation, dating, and interpretation of the island's monumental architecture (Heyerdahl and Ferdon et al. 1961).

After synthesising the expedition's results, and comparing the findings to the island's first radiometric regime, Heyerdahl argued that societal similarities between the Rapanui and South American cultures represented direct contact, interaction, and fusion between members from these groups (Mulloy 1979). Some of Heyerdahl's anchoring arguments were based on the proposed similarity between remains from South American and Rapa Nui archaeological sites, including stone cutting and statuary. Narratives from the Rapanui oral tradition were also used, and at times were superimposed onto selected and specific findings from the Norwegian Archaeological Expedition – those that supported South American colonisation of Rapa Nui. One claim in particular was that the seawall construction from Ahu Tahira at Vinapu was diffused from stonework sites of the Inca culture, like those found at Sacsayhuamán in Cuzco, Peru. Today, it is recognised that these similarly looking, but technologically different cut stones, came from two distinct stone working traditions, from two distinct cultures (Hunt and Lipo 2011).

While Heyerdahl's hypothesis for South American origins for the settlement of Rapa Nui has ultimately been falsified through rigorous empirical evidence over the years (Bahn and Flenley 1992; Chapman and Gill 1997; Flenley and Bahn 2003; Golson 1965; Green 2000; Hagelberg 2016; Hagelberg et al. 1994; Sharp 1963), Heyerdahl's work established the first culture–history timeline, dividing the island's past into Early (400–1100 AD), Middle (1100–1680 AD), and Late (1680 AD–Present) Periods. During these periods, Heyerdahl proposed that there were interactions between the early arriving South American (pre–Incan) colonisers, who were considered the stone carving experts, and the later Polynesian Rapanui. Heyerdahl proposed that over time there was great conflict on the island between the early and late colonisers (also referred to as different social classes, the so–called 'Short' and 'Long' ears), ending in a period of 'destruction', where the *moai–ahu* complexes were destroyed and the culture was replaced by the activities of the *tangata manu* or birdman ceremony (Drake 1992; Métraux 1940; Mulloy 1979; Lee 1992; Routledge 1919). While Heyerdahl's culture–history timeline has been revised over the years, it still acts as a framework from which much archaeological interpretations were/are made about Rapa Nui.

It should be mentioned that Heyerdahl's work undoubtedly acted as a catalyst to encourage Pacific and Polynesian scholars to champion and demonstrate not South American, but *Ma'ohi* colonisation and development for Rapa Nui. Yet the most influential outcome from Heyerdahl's work was the global promotion of Rapa Nui culture and its intriguing past, the introduction of American archaeologist William Mulloy (along with others such as E. Ferdon, C. Smith, C. Skottsberg, A. Skjølsvold, and G. Figueroa) to the island, and the first radiometric dates for island sites. In turn, these influences, introductions, and dates would stimulate later theories used on Rapa Nui to discuss interaction, including culture–history and cultural–ecology.

Culture–history and cultural–ecology

Radiometic dating (^{14}C) from the Norwegian Archaeological Expedition helped to form and reinforce the three–period culture–history timeline for Rapa Nui (Ferdon 1961, Mulloy 1961; Skjølsvold 1961; Smith 1961), which was further expanded and refined (Ayres 1973; McCoy 1976; Mulloy 1979; Mulloy and Figueroa 1978). The development of *ahu* was seen as key to this model, as the modification of these platforms over time served as temporal indicators of social interactions and cultural change during one continuous Rapa Nui sequence. This included *ahu* changing from East Polynesian altars during the Early Period, into foundations to support *moai* and large feature stones during the Middle Period, into graves during the Late Period. To support these claims, *moai–ahu* complexes were often excavated, dated, conserved, and/or restored (e.g. Akivi, Vai Teka, Tahai, Hanga Kio'e, Huri a Urenga), thus leaving a lasting legacy of past archaeological remains for contemporary and future generations (Mulloy 1995). The ceremonial village of 'Orongo was also originally restored under Mulloy's direction (Mulloy 1975).

Still more significant was Mulloy's suggestion for an extended archaeological survey of the entire island (which would influence later settlement pattern studies), and his premise that the diachronic change witnessed in the archaeological record was not a product of diffusion, but was instead cultural–ecological in nature (Mulloy 1974). Because Mulloy believed that Rapa Nui's fragile environment was overexploited through the process of megalithic feature construction, this, in turn, created the narrative of ecological change as the motivation for violent actions against the social class (elite) who represented the *ahu* (Mulloy 1974; Mulloy and Figueroa 1978). The indication for resource depletion, warfare, cannibalism, and subsequent societal collapse in the 16th or 17th centuries, before the arrival of the Europeans, became the main explanation for interaction and cultural change on the island (Bahn and Flenley 1992; Diamond 2005; Flenley and Bahn 2003; Kirch 1984; McCoy 1976; Stevenson 1986). More recently however, the collapse narrative has been ardently challenged (Hunt 2006; Hunt and Lipo 2007, 2010, 2011, 2017; Larsen and Simpson 2014; Peiser 2005; Simpson and Dussubieux 2018), including by this doctoral thesis.

Although critiques and modifications of the culture–history model have been proposed (Golson 1965; Ayres 1973; Love 1993; McCoy 1979; Martinsson–Wallin 1994; Mulrooney et al. 2009; Shepardson 2006; Stevenson 1997; Vargas et al. 2006), including recalibrations based on Spriggs and Anderson's (1993) 'short chronology' premise (Hunt and Lipo 2006; Mulrooney et al. 2011; Wilmshurst et al. 2011), the three–phase culture–history baseline and narratives of cultural–ecological collapse are still used to frame archaeological interpretations made about the timing of ancient interaction on Rapa Nui (Kirch 1984, 2000; Lee 1992; Van Tilburg 1994; Van Tilburg and Lee 1987).

Settlement Pattern Studies

With a desire to add more spatial considerations to culture–history interpretations, settlement pattern studies gained prominence in Polynesian archaeology in the late 1960s (Green 1967), playing a notable role in understanding the interrelationships between habitation sites and monumental architecture centres on Rapa Nui. Most notable is the work by Patrick McCoy (1976, 1979), Claudio Cristino, Patricia Vargas, and colleagues (1981, 2006 and references therein), and Chris Stevenson and colleagues (1984, 1986, 2002) who have extensively surveyed and excavated throughout the island, providing invaluable information about a broad range of pre–contact activity including settlement patterns, food production, raw material extraction, burial patterns, and monumental architecture construction and use.

Although McCoy's (1976) research focused on documenting a large number of sites and features and placing those locations on topographic maps for the long–term recording and conservation of sites (he noted 1,738 sites in five island quadrangles), his work was temporally uninformed. Regardless, McCoy (1976:149) identified an elite settlement pattern around the *moai–ahu* complex stating: "there was a positive correlation between discreteness of social status and discreteness in residence" which included:

"… a community center consisting of usually one large feast house [*hare nui*] and surrounding dwellings of nobility [*hare paenga*] in a nucleated pattern which are well removed from the lineage *ahu*. In terms of function and complementarity in the settlement 'network' (Chang 1972:12), the components can be viewed as three discrete activity locales: (1) subsistence; (2) communal events, including social functions of dancing, chanting, feasting and also, redistribution of food; and (3) religion. The communal center can be viewed as the fundamental unit of economics, since it functioned as a base of supply and redistribution" (McCoy 1976:152).

This elite pattern was opposite to the one McCoy (1976:152) found inland, away from *ahu*, where "loosely clustered (2–3 households) and dispersed commoners' residences were within agricultural plantations". While highlighting that the household was the smallest unit of production, but in itself was not a self–sufficient economic unit, McCoy (1976, 1979) posits that its production was supervised by household heads (possibly *tangata honui*) rather than directly through island–wide chiefs such as the *ariki*. In addition, the general absence of gardens and *hare moa* in elite areas, including around *moai–ahu* complexes, promoted McCoy to believe that elite members of society were exempt from production, but were closely tied to the production cycle (see below).

For more than 40 years, Cristino, Vargas, and colleagues have conducted more island–wide archaeological surveys (and the restoration of Ahu Tongariki/'Orongo) than any other researchers (see Vargas et al. 2006 and reference within). Their seminal *Atlas Arqueológico de Isla de Pascua* (1981) has served the entire archaeological community, and has assisted in the island's archaeological conservation, the city planning of Hanga Roa, and site restoration generally. Their *1.000 años en Rapa Nui: Arqueología del asentamiento humano en la Isla de Pascua* (2006) publication is one of the most comprehensive works published to date regarding the palimpsest of ancient interactions and settlements on Rapa Nui, including nearly 20,000 archaeological features.

Although Vargas et al. (2006) pay tribute to McCoy's (1976) pioneering work, they highlight inaccuracies in his assumptions, and conclude: (1) multiple interior parts of the island were indeed intensively inhabited, exhibiting different archaeological structures from the coastal *ahu* network (see also Stevenson 1997; Mulrooney 2013); (2) structures in the interior were contemporaneous with the coastal *ahu* centres from AD 1100–1750; (3) multiple sources of water (gullies, catchments) certainly existed in central parts of the island (e.g. Ava Ranga Uka to Ahu Akahnaga; see Vogt and Moser 2010); and (4) there were a variety of complex use–zones throughout the island.

In the coastal areas of high–density monumental architecture, Vargas and colleagues (2006) define four *ahu* types: (1) *ahu–moai*; (2) rectangular *ahu*; (3) semipyramidal *ahu*; and (4) *ahu poe poe*.

While the *ahu–moai* complexes were the focal point for the majority of Rapa Nui's ancient period, the latter three platform types likely represent a later use pattern, where sacred *ahu–moai* centres were turned into mortuary features. Vargas et al. (2006 and references within) indicate that the largest *ahu–moai* (Figure 8) are megalithic constructions usually made from earlier *ahu* bases, which include a variety of stone material (see also Beardsely 1990; Hunt and Lipo 2011; Love 1993; Martinson–Wallin 1994; Simpson 2008).

As the *moai–ahu* complex evolved through time, central platforms were elongated and reinforced by adding fill and cut *paenga* to frame seawalls (Figure 8:A). This base would be the principal foundation for the later installation of *moai* (Figure 8:E) and *pukao* (Figure 8:F). Additional features added around the central platform included lateral wings (Figure 8:B), a *tohua* or ramp that was filled with large *poro* (beach) stones (Figure 8:C), and later funerary cists (Figure 8:H). Opposite of the *moai–ahu* complex would be a large plaza (Figure 8:D) that served as a stage for festivals (*hatu* and *koro*) and for ceremonies of the first–fruits, life, maturity, and death. In some *moai–ahu* complexes, it is not uncommon to find boat ramps to access the coast (Figure 8:I) and crematoria (*avanga*) behind the main platform (Figure 8:G). At the largest platforms, water retention features called *puna* were also constructed (DiNapoli et al. 2019). Found on the other side of the plaza is the elite settlement pattern (Figure 8:J) as described by McCoy (1976; see also Hamilton 2007). Vargas (1998:117–8) further defines this elite settlement pattern (Household Type I) as follows:

"These households are distributed in a wide semicircle inland from the ceremonial/religious structure (*ahu*), most frequently *ahu–moai*. As a general pattern, houses are situated in promontories or slopes, 5 to 25 meters above ground level of the artificially levelled plaza of the *ahu* … [Type I] houses correspond to the settlements of the tribe's elite families, composed by chiefs, priests, and probably some high status guild of 'experts' … Characteristic features of this household are a) house of elliptical plan (subtype 1) or boat shaped houses (*hare paenga*), b) stone lined earth ovens (*umu pae*) and cook houses or kitchens (*hare umu*)".

Vargas (1998:119; see also McCoy 1976) continues by describing the activities of elite Household Type I members:

"Major household activities are related with social organisation and the control of the territory, ancestor's [sic] worship, and religious practices and communal ceremonies. No evidence of productive activities such as fowl husbandry and agriculture related with *manavai* [gardens] or open plantations in stone fields [*pu'u*] and *hare moa* structures, were recorded in direct spatial and functional association with this household type".

Looking to add a temporal dimension often not included in settlement pattern studies, Stevenson (1984, 1986), who has comprehensively investigated Rapa Nui for more 35 years (Stevenson 1997, 2002; Stevenson and Haoa 1998, 2008; Steveson and Williams 2018; Stevenson et al. 1984, 1999, 2005, 2015), employed obsidian hydration to date *moai–ahu* complexes (n=57), crematoria (n=24), and their construction periods. With this chronological control, Stevenson generated 12 phases of development and established five *ahu* types based on multivariate cluster analysis of 13 architectural attributes. Interpreting these data, Stevenson (1984, 1986) was able to formulate a diachronic reconstruction of archaeological features that correlated to the interactions and transformations by 'corporate groups' (McCall 1979) on the island's southern coast from AD 1300–1864.

Of particular note, no *ahu* were identified as occurring on the southern coast before AD 1300, with early sites at Vaihu, Ura Uranga te Mahina, and Akahanga appearing by AD 1400 (Stevenson 1986). As these first platforms resembled the eastern Polynesian *marae*, their fabrication was likely influenced and organised by similar *Ma'ohi* economic, ideological and sociopolitical systems (Kirch 1984, 2000; Van Tilburg 1994). This included construction strategies directed by high ranking individuals with ascribed descent (Goldman 1970; Kirch 1984; Sahlins 1958), who had the ability to amass surplus goods and command labour (Van Tilburg 1994). Arguably, shortly after habitation of the southern coast, emerging *tangata honui* linked to the Miru began legitimising control over the domestic mode of production (Sahlins 1972), along with incipient monumental works (Stevenson 2002; Stevenson et al. 2013). Their early demarcation of significant and valuable coastal regions and resources would be essential (DiNapoli et al. 2019; Hamilton 2007; Simpson 2008), because unlike other Polynesian islands that have natural borders formed by the physical landscape, Rapa Nui's slow rising coastal plains prescribed a different system for visual display and control (Kirch 1990a; Martinsson–Wallin and Wallin 2000; Simpson 2009; Simpson and Dussubieux 2018). Evidently, this system facilitated the creation of multiple district centres to represent certain ancestors, to overtly denote territory and staple resource sectors, to advertise polity strength to other economic and sociopolitical units, and to remind local families of elite positioning within corporate groups (Simpson 2008, 2009; Stevenson 1997).

Notable developments for multiple *ahu* occurred between AD 1401 and AD 1500 including: (1) inchoate platforms at Hanga Hahave; (2) continued construction at Akahanga Bay (Love 1993);

and (3) the first district *moai–ahu* complex (Type I) appearing at Vaihu (Stevenson 1986; see also Martinsson–Wallin et al. 2013). By now, multiple *paenga*, *ivi*, and *ure* had developed around each southern district *ahu*, forming the basis of the *mata*. Over time, primary centres were linked to secondary *ahu* sites, and new *paenga*, *ivi*, and *ure* were connected to an expanding *mata* and *mata kainga.* Directing this expansion were *tangata honui* from the most elite *ure*, adjoined with a growing number of *ivi atua* and *māori* specialists (Métraux 1940; Simpson 2009; Vargas 1998; Van Tilburg 1994). Together, these groups represented the main catalysts and organisers for the propulsion of Rapa Nui's ancient economic, ideological, and sociopolitical systems.

Although there were not many new *ahu* sites from AD 1501 to AD 1600, there was further elaboration to Vaihu, while a number of new district centres appeared at Hanga Hahave and Hanga Poukura, along with one new centred at Akahanga and Ura Uranga te Mahina. Stevenson (1986) suggests this dual development at Akahanga and Ura Uranga te Mahina represents two larger elite *ure* groups merging together at the favourable bay location (similar to to Vinapu) that had access to the ocean and freshwater sources (see also DiNapoli et al. 2019).

Also dated to this phase was the large *hare paenga* village found to the north of Ahu Akahanga (Stevenson 1986; see also Love 1993; Vargas et al. 2006). Taken together, this increase in the number of *moai–ahu* district centres and large spatially–focused elite villages (including *hare nui* meeting houses), along with the inland expansion of horticultural features (McCoy 1976; Mulrooney 2012; Stevenson 1997; Stevenson and Haoa 1998, 2008; Stevenson et al. 1999; Vargas et al. 2006), support the idea that elite Rapanui, especially *tangata honui*, *ivi atua*, and *māori*, had paramount influence and control over the island's ancient political economy.

Interestingly, Stevenson (1986) found little evidence for new platform construction from AD 1601 to AD 1700. However, the adding to and rebuilding of district *ahu* was common, especially at Hanga Poukura and Ura Uranga te Mahina (see also Martinsson–Wallin and Wallin 2000 for a similar situation at Ahu Heki'i and Love 1993 for Ahu Akahanga). This notable decrease in new sites, but an internal focus on expanding existing district centres, corroborates Van Tilburg and colleagues' (2008:297) interpretation about the later "withdrawal from the larger procurement pattern" of Rano Raraku tuff for *moai*. With more difficult access to this material over time, *mata* conceivably turned their attention away from larger statue carving and transport (leaving multiple complete and near–complete *moai* in Rano Raraku and in transport), and instead focused on the refinement of design of the *moai–ahu* complex. The late introduction of red scoria *pukao* for topknots and some *ahu* façades (Hamilton et al. 2008; Thomas 2014; Van Tilburg 1994) may also support the idea that Rano Raraku became socially inaccessible in later periods, giving architects the opportunity to use new material and features on their existing district *ahu*. Notwithstanding, for a 300–year sequence on the island's southern coast, *ahu* were at the centre of corporate group interaction, identity, and elite economic, ideological, and sociopolitical control.

Evolutionary Theory

Since 2000, Terry Hunt and Carl Lipo, who were educated under the tutelage of evolutionary archaeologist R. Dunnel at the University of Washington, have extensively worked on Easter Island. Using exhaustive literature review, fieldwork, empirical data, mathematical modelling, and cutting edge archaeological methods and technologies framed in evolutionary theory, their publications focus on topics such as initial island colonisation, *moai* and *pukao* manufacture, transport, and installation, settlement patterns and community structure, water and horticultural management, and the island's proposed collapse (Bradford et al. 2005; Hixon et al. 2017, 2018, 2019; Hochstetter et al. 2011; Hunt 2006, Hunt and Lipo 2001, 2006, 2008, 2010, 2011, 2017; Lipo and Hunt 2005, 2016; Lipo et al. 2010, 2013, 2018; Wilmshurst et al. 2011). Guiding this research (and that of their protégés, e.g. Dudgeon 2008; Morrison 2012; DiNapoli and Morrison 2016; DiNapoli et al. 2017, 2019) has mostly been selectionist and human behavioural ecology theoretical frameworks (e.g. waste theory, bet–hedging, group selection, economic defendability, and costly signalling).

As Hunt, Lipo, and colleagues were unsatisfied with earlier models used to explain Rapa Nui's past, they at first employed a selectionist framework, namely 'waste theory', to explain Rapa Nui's cultural elaboration and effloresce and debate its proposed collapse. Originally developed by Dunnell (1989, 1999), the main argument of waste surrounds the notion that "[n]ot all of an organism's energy is devoted directly to reproduction or maintenance of [the] individual" (Dunnell 1989:47). Some of this extra energy is stored by means of fat that can be used in unforeseen environmental perturbations. "The behavioural component of the phenotype offers similar and additional potential when energy is expended in activities that do not enhance the rate of reproduction, activities that might be conceptualised as waste" (Dunnell 1989:47, 1999).

Wasteful behaviours that are practised to cope with environmental perturbation serve two purposes: 1) the use of energy itself necessarily lowers the birth rate; and 2) it provides, through its temporary abatement, a reservoir of time that an organism cannot devote to subsistence and/or reproduction in difficult (unpredictable) conditions. These underpinning theoretical tropes were first used in the Pacific by Graves and Ladefoged (1995) as an explanatory model to explain Polynesian 'superfluous' monumental works. But their work lacked an empirical criterion to test the archaeological record for wasteful behaviour.

Madsen et al. (1999) crossed this divide by creating the computational SWARM program, which developed and tested wasteful variables such as: 1) environmental effects; 2) mobility of agents; 3) age structure; and 4) the distribution of wasteful behaviour. Using results of analyses between Rapa Nui and Hawaii, Hunt and Lipo (2001) posit that Polynesian peoples, including the Rapanui, practised wasteful behaviour though monumental stone construction in unpredictable environments to increase their survivability by limiting human reproduction (this is why the authors have a strong argument for a maximum precontact Rapanui population, maybe 3000; see Lipo et al. 2018 versus Puleston et al. 2017). Interestingly, this conclusion is divergent from that normally put forward about Rapa Nui, in that it was the *over*production of *ahu* and *moai*, along with human *over*population, that caused the island's socio–ecological collapse. Instead, Hunt and Lipo (2001:1085) believe "the construction of stone monuments did not cause the destruction of the island's population and culture, but [through wasteful behaviour and the survival benefits gained] might have well fostered their persistence". Or, as they put it in their 2012 National Geographic Presentation – *The Statues that Walked:*

"Well a tradition of statue carving already existed in central Polynesia, where Rapa Nui people came from, and they did statue carving for religious reasons. It makes perfect sense, imagine their perspective on this. We build statues and monuments to our deified ancestors, because it is the right thing to do. Going back in time, they might ask you: don't you build statues to your ancestors? This cultural even religious rationale had the unintended consequences of diverting time and energy away from larger garden plots and therefore larger families, which the limited environment of the island could not possibly sustain. So, honouring your ancestors, appeasing the gods, was exactly the right thing to do and it yielded a sort of a big evolutionary payoff for people on the island. The basis of the argument is simple Darwinian evolution. Small isolated locations with unpredictable and limited resources, just like prehistoric Rapa Nui, are exactly the kind of places that one would except to see elaborate cultural investments appear in a population. Now this making statue may be amazing to us, but really, building statues was exactly the right thing to do in this type of environment…"

Hunt, Lipo, and colleagues also identified 'community structure' in the archaeological record through reconstructions of Rapanui interaction, as represented by settlement patterns (Hunt and Lipo 2011, 2017). For example, they argue that *moai–ahu* complexes were: 1) constructed near access to three key subsistence resources: agriculture, marine resources, and most important, freshwater (DiNapoli et al. 2019); and 2) used for group–level 'costly signalling' which marked groups who cooperated (e.g. for horticultural and monumental works production) from those who did not (DiNapoli and Morrison 2017; DiNapoli et al. 2017, 2018, 2019; Hunt and Lipo 2011, 2017). *Moai–ahu* complexes "served as central locations for episodic gathering that served to bind communities in activities and resource sharing" and building them "likely served multiple purposes related to decreasing the threat of conflict over unevenly distributed resources (a form of costly signalling) and enforcing information sharing through communal activities" (Hunt and Lipo 2017:20).

Beside participation in these communal activities, it would seem that Rapanui unities and polities (e.g. *paenga*, *ivi, ure*) lived in relative isolation and were not under a centralised ruling authority outside the *mata*. Both archaeological evidence and studies in physical anthropology note 'microgeographic'variations within samples (Hunt and Lipo 2011). For the former, this included redundant sets of functionally differentiated domestic activity zones, the formation of oven stones in *umu*, and stylistic and functional differences in material culture and monumental architecture (DiNapoli et al. 2017; Hunt and Lipo 2011, 2017; Lipo et al. 2010; Morrison 2012). For the latter, genetically similar patterns amongst the Rapanui indicated that interaction was highly localised, especially for males, although there was movement of females between areas along the coast (Dudgeon 2008; Gill 1988, 2000; Gill et al. 1983; Stefan 1999; Stefan and Gill [eds] 2016). This archaeological pattern is supported by ethnographic accounts where marriage between clans (except for the Miru) was noted as a likely a mechanism for interaction and emigration, with women being introduced into new *mata* (Routledge 1919).

Inland, on the island's northwest and southern coasts, away from the *moai–ahu* complexes, extensive fieldwork by Hunt, Lipo, and colleagues indicate that inhabitants lived in relative peace as 'Rapa Nui doves', within dispersed and denucleated settlements, that were low in population numbers (Hunt and Lipo 2011:104). In turn, this system:

"allowed for the potential to exploit a larger and more diverse resource area. In cases where productivity is unpredictable over a region given rainfall, local soil conditions, or limitations of plant growth, dispersed communities tend to be more stable since they can average sometimes uneven returns, across an entire community" (Hunt and Lipo 2011:123).

Also inland, the authors highlight a robust record of horticultural features including *manavai* (numbering more than 3000 throughout the island) and *pu'u* lithic mulching grounds (which occupied more than 10% of the island's total surface area) (Baer et al. 2008; Bork et al. 2004; Bradford et al. 2005; Flaws 2010; Ladefoged et al. 2013; Stevenson and Haoa 1998, 2008; Stevenson et al. 1999; Wozniak 1997, 1999). Together, these horticultural features helped to protect crops, while improving soil fertility in lands that were mostly low in nutrients before the *Ma'ohi* who colonised Rapa Nui even arrived (Ladefoged et al. 2005, 2010; Louwagie and Langohr 2003; Louwagie et al. 2006; Stevenson et al. 2015; Vitousek et al. 2014; Wofford 2006).

In short, a synthesis of nearly 20 years of archaeological research by Hunt, Lipo, and colleagues highlights the following: 1) Rapa Nui was colonised by an episode of rapid *Ma'ohi* expansion throughout the Pacific around AD 1200; 2) following colonisation, the population grew to an equilibrium around 3000 inhabitants, but this growth, along with the presence of the endocarp eating Polynesian rat (*kio'e*), changed Rapa Nui's palm forest landscape into an anthropogenic palimpsest composed of monumental architecture, domestic features, and horticultural structures; 3) populations resided in multiple, functionally redundant dispersed communities, but groups benefited from peaceful interaction through costly signalling activities at large ceremonial sites near freshwater and land and sea staple resources; 4) by using evolutionary frameworks, the benefits of *moai–ahu* complex construction allow for an explanation beyond the ceremonial and/or surplus; and 5) the Rapa Nui culture did not collapse before European arrival, but instead found a way to survive and thrive, in an unpredictable environment, on one of the most isolated inhabited islands in the world; the so–called, 'Rapa Nui Effect' (Hunt and Lipo 2011).

Interpretive Theory

Critiquing the processual orientation for Rapa Nui archaeological research, which has focused on functionalist pragmatics of environment and economy and on general models of chieftain social organisation, an interpretive approach was introduced to Rapa Nui archaeology through the Landscapes of Construction Project (LOC). This project involves UK researchers Sue Hamilton, Mike Seager Thomas, and Ruth Whitehouse (University College London), Colin Richards

(University of Manchester), Jane Downes (University of the Highlands and Islands), and Kate Welham (Bornemouth University). Together, they have explored the social, conceptual, and symbolic meanings of stone use in an interconnected Rapa Nui landscape at the scale of the individual (Hamilton 2007, 2010, 2013, 2016; Hamilton et al. 2008, 2011; Hamilton and Richards 2016; Richards 2010; Richards et al. 2011). While the theoretical underpinnings of the LOC follow that of British interpretivism and phenomenology (Tilly 1994, 2004), methodological analyses have included: remote sensing; GPS mapping of sites in larger landscape contexts; 3D photogrammetry and laser scanning of quarries to characterise working procedures within 'quarry bays' (Hamilton et al. 2008); geophysical prospecting to locate buried features (Saunders et al. 2009); excavation to gain dating evidence; and phenomenological survey to investigate the sensory characteristics of the places of construction, including what would be experienced in terms of visibility, inter–visibility, and sound between people, places, and monoliths (Hamilton 2007, 2010, Richards 2010; Richards et al. 2011). The LOC has also conducted public archaeology initiatives that have highlighted Rapa Nui's 'living archaeology' (Hamilton 2013). Through this, contemporary Rapanui have been provided an opportunity to participate in and learn about current archaeological efforts and interpretations.

In reviewing and interpreting Rapa Nui's 'taskscapes' (cf. Ingold 1993), the LOC attempts to understand how the ancient islanders expressed themselves by 'saying it with stone' in an ever changing and fluid monumental landscape (Hamilton et al. 2008, 2011). This includes how stone provenance (sea, crater, land, lava flow, and crag), colour, size, and shape played a role in the selection, manufacture, and utilisation of particular stone types for particular statuary and features (Hamilton et al. 2011; Hamilton 2013, 2016; see also Seelenfreund and Holdaway 2000). In addition, LOC research focuses on how experiential differences between *ao* (day) and *po* (night), light and dark, soft and hard, inside and outside, land and sea, and landward and seaward locations influenced the use and explain the placement of stone for sites and features (e.g. *ahu*, *pukao*, *hare paenga*, *poro* stones, *paenga* stone, *avanga*, *moai* and *pukao* roads, and canoe ramps and slips) found in the archaeological record (Hamilton 2007, 2010, 2013, 2016; Hamilton and Richards 2016; Hamilton et al. 2008, 2011; Richards et al. 2011).

Interpretations from these analyses have promoted a more 'body–centred understanding' of the ancient island, including how working in quarries, travelling on roads, constructing and adding onto *ahu*, entering *hare paenga*, and walking from coastal to inland areas and vice versa, sustained interactions between living people from different ancestors and sociopolitical ranks. Facilitated by the fact that quarrying, carving, material transport, and construction involved person–to–person and hand–to–hand interfaces from co–working labour groups, the LOC argues that a certain level of interaction was required to produce an island–wide pattern where similar stone types (e.g. toba, scoria, obsidian, and basalt), from limited sources, were used to fabricate the numerous monolithic features found at *moai–ahu* complexes. In other words, gathering maximum resources from minimum quarries indicates a shared island–wide understanding and use of resources for feature stones and material culture. Collectively, for the LOC, this is important for how members of Rapanui *mata* would have perceived, rationalised, and mythologised their island world.

Political Economy Theory

Political economy is a theoretical orientation that has a long history of development and application in the social and economic sciences (Earle and Spriggs 2015; Hirth 1996; Muller 1997; Roseberry 1988; Simpson 2008). It has been employed as a means to understand economic interactions and relationships (participation in and control of), labour, production, and exchange between populations in both developed and traditional societies. In anthropology, models of political economy have been implemented to understand both ethnographic and archaeological cases of state and non–state cultural entities (Earle 1997b, 2002; Nash 1979; Smith 2004; Wolf 1982). Many of these studies shed light on the processes by which an elite class economically, ideologically, sociopolitically, organises a culture to maintain control, solidarity, hierarchy, heterarchy, and hegemony. Notably, some archaeologists have approached political economy as if it were synonymous with an analysis of political development (Carneiro 1967). As a result, the most prominent studies of political economy in archaeology have become general theories for the development of complex societies, especially regarding the evolution of so–called states and chiefdoms (Kohl 1987; Earle 1978, 1987, 1991, Earle [ed.] 1991; Mann 1986; Sanders and Price 1968).

While other definitions exist (e.g. D'Altroy and Earle 1985; Cobb 1993; Hirth 1996; Muller 1997; Patterson 1999; Preucel and Hodder et al. 1996; Roseberry 1988; Scarborough et al. 2003), Earle (1997b:1) defines political economy as "[t]he material flow of goods and labour through which a society creates wealth and finances institutions of rule". Thus, for archaeologists to understand past cultures and their material remains, they must focus their investigations on the material flow(s) of goods and labour. This includes recovering evidence for the types (and uses) of economic resources found in ethnographic, ethnohistoric, historic and archaeological contexts, as they provided the means for an elite class to finance, enforce, legitimise, and materialise ideologies. This, in turn, helped to frame power relations, to finance small and largescale infrastructure, to influence social stratification, and to promote hierarchy, heterarchy, and hegemony (Simpson 2008).

Archaeologists interested in the development of ancient political economies have noted the relative importance of control over production (Earle 1997b, 2000, 2002; Earle and D'Altroy 1982; Kirch 1990a; Simpson 2008; Stevenson 1997) and exchange systems (Earle 1982, 1997b; Friedman and Rowlands 1978; Polanyi, Arensber, and Pearson [eds] 1957; Rowland 1979; Renfrew and Cherry [eds] 1986; Weisler 1997). However, concurrent influence over both production and exchange systems encouraged the development of ancient political economies and the emergence of potent chiefs and elites (Earle 1997b; Hirth 1996).

Other research in political economy has focused on the relative importance of having access to, and controlling different kinds of, resources such as food (staple resources) versus other non–perishable commodities (luxury goods) (D'Altroy and Earle 1985; Brumfiel and Earle 1987; Brumfiel and Earle [ed.] 1987; Earle 1987, 1997a, 1997b, 2002; Friedman 1981; Helms 1993; Muller 1997; Roscoe 1993; Testart 1982). Yet, Hirth (1996) pointed out that the dichotomisation between staple and luxury goods obscures the fact that both food and luxury items play complementary roles in the development of political economies.

A final concentration within the archaeological application of political economy theory is the extent to which sociopolitical organisation and development is a product of predominantly economic or ideological forces (D'Altroy and Earle 1985; Earle 1997a; Hirth 1996; Muller 1997) DeMarrais and colleagues (1996), however, argue that it is the materialisation of ideological constructs that truly give power to an elite class, not one factor over the other. Hirth (1996: 209) adds: "it is in the middle ground between materialist and ideational perspectives where the most complete explanations are found. While economic control provides the material means to support political bureaucracies, ideational systems provide the structure and justification that allow them to operate". Therefore, successful elite classes were those who could express and economically finance a specific ideology through, for example, ceremonies, landscapes and monuments, and the specific use of portable material culture (Simpson 2008, 2009).

In Polynesia, archaeologists interested in ancient political economies have highlighted the homologous relationship that existed with regards to how Polynesian chiefs and their elite retainers "managed and oversaw various aspects of the society, including food production, specialised craft production and prestige goods exchange, and the performance of ritual behaviour" (Graves and Sweeny 1993:113; Lass 1998) and used 'power strategies' to combine sources of power to pursue political goals (Earle 2002). Stevenson (1997:3) further outlines this chiefly and elite–controlled system:

"As documented elsewhere in the Pacific region, this type of social system was dominated by elite personnel who centralised management of the productive economy and legitimised this control through ideology, architecture, and ceremony (Kirch 1984). In addition, control was maintained through the ownership of land and by access restriction to key resources within its boundaries. The results of these management efforts were directed towards generating surplus production that could be funneled into the construction of monumental architecture. This, in itself, further substantiated claims to land and resources and legitimised the position of the elite".

Arguably, one of the most apparent *Ma'ohi* homologues is how elite classes manipulated aspects of the political economy to finance the construction and maintenance of monumental architecture. As a result, the prolific appearance of monumental works in, for example, Hawaii (Kirch 1984, 1990a, 1990b, 2000; Kolb 1991, 1992, 1994; Earle 1997b, 2002), Tonga (Kirch 1990b), and Rapa Nui (Mulloy and Figueroa 1978; Stevenson 1986, 2002; Simpson 2008; Stevenson and Haoa 1998), has been inferred to reflect the complex level of chiefly management, resource allocation and redistribution by elite groups, and the size of labour forces directed by corporate strategies; this is the explanation upheld in this thesis. The work of these authors, and in this thesis, has also shown that monumental architecture, in turn, helped bolster elite ideologies (Kirch 1990b; Earle 1987, 1997), helped demarcate elite built landscapes that reminded commoners of chiefly and elite hegemony (Hamilton 2013, 2016; Kirch 1990b; Martinson–Wallin 1994; Simpson 2009; Stevenson et al. 2005; Van Tilburg 1994), helped contribute to 'wasteful' cultural behaviours (Graves and Ladefoged 1995; Hunt and Lipo 2001, 2011), helped denote territoriality (Earle 1997b; Stevenson 2002), and, perhaps most importantly, helped (re)structure and (re)inforce the organisation of the political economy (Kolb 1992, Graves and Sweeny 1993; Earle 1997b; Stevenson 1997).

Earle's (1978, 1980, 1997b, 2002) work in Kaua'i (Hawaii) elucidates how chiefly control over commoners, corvée labour (with the assistance of lesser chiefs called *konokihi*), and wet taro farming plots (*ko'ele*) allowed access to labour and surplus staple resources. Yet, these surplus staple resources, created through 'social production' (Kirch 2000), were not used to feed more people, but instead were used by ancient Hawaiian chiefs to fulfil their individual agency. This included to acquire luxury goods like feathered cloaks and helmets (which were only used by chiefly and elite retainers [see also Linnekin 1988]), to finance warfare (which provided a way to capture land and increase *mana*), and to help fund the construction of elite built landscapes (land, natural features, and terrain that was demarcated, organised, and built–up through 'landesque capital intensification' to monitor land, people, and staple resource production [Blaikie and Brookfield 1987; Kirch 1994; Simpson 2008, 2009]).

To create this elite built environment, *ahupua'a* (clans) constructed trails, stone markers, walls, and *heiau* (monumental architecture) to designate community territory to both external (other *ahupua'a*) and internal social segments (elite versus non–elite). By constructing and manipulating the landscape of Kaua'i around highly visible monumental architecture, staple resource production centres, and those individuals whose labour was used, physical, social, and mental enclosures were effectually created for non–elite populations. These populations, then, would have been constantly reminded of their lower economic, ideological, and sociopolitical positions within their everyday lives and work, helping to promote elite hegemony and chiefly power consolidation. Therefore, the most successful chiefs and elites from Kaua'i were those who successfully managed and oversaw staple resource production and consumption, were successful on the battlefield, acquired politically charged luxury resources, and created elite–built landscapes. Joining these elements together, allowed chiefs to influence and direct the cultural development and evolution of ancient Kaua'i.

On Rapa Nui, historic, ethnohistoric, and ethnographic records, along with archaeological interpretations, can be used similarly to reconstruct the island's ancient political economy. For example, after reviewing accounts from early visitors to the island (e.g. Roggeveen, Behrens, Agüera, Cook, La Pérouse, Gale, Smith, Peard, Wolf, Loti, Thomson, Routledge and Métraux), it is clear that many observers identified an elite class of Rapanui. This elite class included: 1) deceased chiefs, who were materialised into *moai* and placed onto *ahu*; and 2) living chiefs and elites, who presided at early interactions with foreigners, often initiating or ending exchange activities. Whereas Forster (1777) noted that *moai* represented dead chiefs and that *ahu* were created to house elite burials, Cook (1777) claimed that *moai* had personal names that represented specific Rapanui chiefs (see also Geiseler 1882; Knoche 1925). Living Rapanui chiefs were identified as elder men who were heavily tattooed and/or painted. As human tattoos and painted bodies were inspirations for *moai* design, the tattoos of specific *ariki* would have been transferred, after death, to specific *moai*, making statues potent representations of divine ancestor chiefs (Van Tilburg 1994). For this reason, *moai* found at, for example, Rano Raraku and Ahu Nau Nau, still exhibit evidence for tattooing on their bodies, demonstrating how tattoos on both humans and *moai* promoted chiefly ideologies and the agency of distinct chiefs of the various *mata* (Fischer 2005; Van Tilburg 1994).

Other records certainly highlight how Rapanui chiefs were 'culture heroes' imbued with *mana*, that made them the originators of many institutions (Métraux 1940). This undoubtedly includes the island's first chief, Hotu Matu'a, and his offspring, who were responsible for forming the island's first *mata*, *mata kainga*, and *moai–ahu* complexes (Englert 1948; Routledge 1919; Sahlins 1958; Stevenson 2002). From these first *ariki* until Nga'ara and Kaimakoi (last known *ariki mau*), extensive 'kings–lists' have been made (Roussel 1869; Métraux 1940, 1957). These rosters of Rapanui chiefs easily note hundreds of years of ancestry and chiefly *haka'ara*, demonstrating how remembering and celebrating Hotu Matu'a's royal linage was of paramount importance for the ancient Rapanui culture. These sacred lineages were arguably listed on *kohau rongorongo* tablets, which were only understood and manipulated by the *ariki*, his sons, and experts (*tangata māori anga rongorongo*). By coding sacred information and consecrating Rapanui symbolism through *kohau rongorongo*, chiefs and elites retained control over ideological constructs such as founder genealogies, chants, and creation myths.

In addition to the use of *kohau rongorongo* tablets, many early visitors' observations highlight how chiefs and elite wore and utilised certain regalia – feathered hats, cloaks, paddles and bastons, and wooden carvings – to display their elevated status. While Agüera (1770) noted how chiefs and elites lived near the *moai–ahu* complex in *hare paenga*, Loti (1872 as cited by Altman [ed.] 2004) witnessed how several politically charged luxury artefacts were found carefully stored inside *hare* *paenga*. Not only were these artefacts used by chiefs and elites to display rank, they were also used during festivals and at rites of passage ceremonies that transpired at the *moai–ahu* complex.

Regarding staple resource production, allocation, distribution, and consumption, one of the most important food sources during both pre–colonial and historic times was the chicken (*moa*). This is due to the fact that unlike other Polynesian islands, the dog and pig were never introduced to Rapa Nui in the pre–contact period, making the chicken an extremely important staple resource. *Moa* was not only sought after for its eggs, meat, and bones, but also for its feathers (especially large white ones), as they were used to decorate hats, capes, artefacts, clothes, and the canoe of the *ariki mau*. As these items were frequently used by elite Rapanui, an argument is made here that there existed a strong economic, ideological, and sociopolitical relationship between *ariki* (*mau* and *paka*), *tangata honui*, and *moa* production. For example, *hare moa* (chicken house), which are found throughout Rapa Nui, were constructed to monitor and protect chickens (Palmer 1870; Geiseler 1882). To ensure fertile chicken production, especially before festivals such as *koro*, *ariki paka* were tasked to paint red *reimiro* symbols on the bottom of *hare moa* (Routledge 1919). In addition, incised skulls called *puoko moa* where regularly put inside *hare moa* to increase the fertility of chicken houses by linking specific elite ancestors to specific chicken houses (Métraux 1940). As such, chicken houses that were highly productive over years provided generations of *tangata honui* with a valuable staple resource base. However, chickens were also important for family and lineage distribution networks, as they were the most common staple resource offered up during exchange interactions and ceremonies, as reported by early island visitors (Behrens 1722; Roussel 1869; Routledge 1919).

Other early visitors (e.g. Behrens, La Pérouse, Roussel, Thomson, Englert) noticed how horticultural fields were supervised by chiefs and were organised into square plots which were divided by stones to possibly demarcate *tapu*, *rahui*, and *noa* boundaries. In turn, this demarcation of plantations allowed family groups (*paenga*, *ivi*, and *ure*) *hurumanu*, and *kio* to focus their labour on delineated plots. This also served *tangata honui* who could improve corporate labour efforts focusing on specific plots, monitor resource production, and later influence the allocation and redistribution of crops and surplus. For example, by using first–fruit ceremonies, which were held at *moai–ahu* complexes, *tangata honui* were able to appropriate the finest resources from each plantation. This is similar to Tikopia where Firth (1967) pointed out that the central role occupied by chiefs during its annual religious first–fruits cycle ultimately sanctioned and regulated production. This regulation, as Kirch (1984:38; see also Earle 1997b; Sahlins 1972) believes, "was intimately tied to ritual sanction and control" and "it is precisely at the level of ritually controlled production that the political economy held sway over the domestic mode of production" and provided a surplus for chiefly ambitions (see also Simpson 2008, 2009). Elite activities during first–fruit ceremonies were arguably similar to elite interactions during other ceremonies found in Polynesia, as in Tikopia (Firth 1967), and like the Tongan *'inasi* (Gifford 1929), the *matahiti* on the Society Islands (Oliver 1974), and the Hawaiian *makahiki* (Handy and Handy 1972).

Therefore, an argument is made here that elite Rapanui acted as the 'ritually sanctioned homeostat' for staple resource production and allocation systems (Peebles and Kus 1977). In turn, staple resources from first–fruit offerings funded: 1) *koro* and *hatu* ceremonies which redistributed horticultural resources to individual *paenga*, *ure*, *ivi*, and *mata*; 2) specialised craft and luxury resource production and acquistion; and 3) monumental construction and staple resource production projects. *Tangata honui* also counted on luxury resource redistribution efforts from the *ariki mau* which was used for later redistribution and/or consumption. This comprised fish from the paramount chief's royal vessel, the *vaka vaero*, along with the first *kahi* (tuna) after the winter *tapu* period (Métraux 1940).

As with their influence over chicken fertility, *ariki paka* were tasked with ceremonies and protocols to influence horticultural crop development, including ceremonies for praying for rain and placing *hau* and fish in plantations to stimulate harvest growth (Routledge 1919; Métraux 1940, 1957). In addition, *ivi atua* were responsible for spreading pieces of coral or seaweed on the plantations to promote crop fertility (Métraux 1940, 1957). Together, spatially divided and measured plantations, organised corporate labour, first–fruit ceremonies, ideological influence from *ariki paka* and *ivi atua*, and luxury resource redistribution efforts from the *ariki mau* helped the island's *tangata honui* to influence the economic, ideological, and sociopolitical development of Rapa Nui's ancient *mata* and their individual political economies.

Many archaeological studies on Rapa Nui have focused on reconstructing aspects of Rapa Nui's ancient political economy (Howard 2007; Simpson 2008, 2009; Stevenson 1997; Stevenson and Haoa 1998, 2008; Stevenson et al. 2005, 2013, 2018). These studies demonstrate how chiefly and elite resource control was "intimately and strongly linked to the typical Polynesian scheme of hereditary land use rights" (Van Tilburg 1994:94). This arrangement, in turn, was influenced and directed by the principles of *mana* and *tapu*, with control given to those men with the most senior and ranking genealogical position in relation to Hotu Matu'a and his sons. Initially, this hereditary, almost kinship–like control over resources supported the 'domestic mode of production' (Sahlins 1972), the 'production of use' (Brookfield 1972) and/or the 'subsistence economy' (Earle 2002; Johnson and Earle 2000) for *paenga*, *ure*, and *ivi* (Simpson 2008). However, with the increase in polity size (i.e. the formation of the *mata*) (Stevenson 1984, 1986) and the intensification of production over time (Kirch 1984, 2000; Stevenson and Haoa 1999), there was also a parallel increase in political complexity (Carneiro 1967) and the transformation of the subsistence economy into a political economy (Johnson and Earle 2000; Earle 2002). This latter transformation was ultimately due to the fact that kinship relations that once anchored the domestic mode of production were no longer sufficient to organise and/or control the 'social production' (Kirch 2000) of the *mata* and subsequently the use of surplus (Simpson 2008). Thus, the need for managerial organisation over economic production and redistribution, in addition to the oversight over ideological and sociopolitical sectors, fostered the appearance and development of ascribed chiefly and elite retainers (Earle 2002; Flannery 1972; Johnson 1978; Peebles and Kus 1977).

In addition, as Rapa Nui is generally seen as being ecologically depauperate (DiSalvo et al. 1988, 1993; Diamond 1995, 2005; Garcia 2000), with no endemic land mammals and a minimum marine biodiversity due to the island's subtropical location, proper management and redistribution of staple resources would have been of crucial importance for the success of particular *ariki* and *tangata honui*. Over time, Rapa Nui chiefs and elites who were successful in their managament, were able to further oversee, influence, and manipulate the political economy to not only produce and redistribute resources for *paenga*, *ure*, and *ivi* segments, but also to help finance their individual aspirations and agendas, including the construction and reconstruction of the *moai–ahu* complex, the funding of small and large festivals (e.g. *hatu* and *koro*), and the acquisition of luxury artefacts (e.g. hats, capes, wooden material culture) and *tatu* and *takona* (body decoration).

The most relevant archaeological work relating to how the elite Rapanui oversaw and monitored staple resource sectors has been undertaken by Howard (2007), Simpson (2008, 2009), Stevenson (1997), Stevenson and Haoa (1998), Stevenson et al. (1999, 2005, 2018), and Wallin et al. (2005). This related and accumulative research argues that the cultural elaboration (e.g. monumental architecture, extraction of material for exchange, and additional investments in food production) of each *mata* was supported by a 'staple financed economy' (D'Altroy and Earle 1985; Earle 1997b, 2002) "where foods from the agricultural, marine, and mammalian resource base were [monitored] and distributed by *tangata honui* to reimburse people for their time spent in corporate undertakings" (Stevenson and Haoa 1998:205).

Archaeological evidence for this system has been found in both coastal (Simpson 2008, 2009; Simpson et al. 2017) and inland regions of the island, with specific examples from Maunga Tari (Stevenson 1997), the Hanga Ho'onu area (Stevenson and Haoa 1998, 2008; Stevenson et al. 1999, 2002), and Vaitea (Stevenson et al. 2005; Wallin et al. 2005; Howard 2007). At coastal district *ahu*, Simpson (2008, 2009) used GIS viewshed analysis to demonstrate how the majority of staple resource sectors, such as *hare moa*, *umu pae*, and *manavai*, were installed to be intervisible between *moai–ahu* complexes (e.g. Vai Mata, Hanga Poukura, Vaihu, and Akahanga) and elite meeting and living houses found near district *moai–ahu* complex centres. Simpson (2008, 2009) argued that this pattern of intervisibility reflects a conscious attempt by Rapanui chiefs and elite to create panoptically controlled landscapes by directing the installation of staple resource sectors within the visualscape of coastal image *ahu* (Figure 9; see also Chapter 7). On one hand, this intervisibility between both deceased ancestors and living chiefs effectively helped elite agents to monitor staple resource production, allocation, and consumption. On the other hand, intervisibility effectually reminded *mata* inhabitants (from *paenga*, *ure*, and *ivi*) of corporate work responsibilities, chiefly hegemony, and elite control over the staple resource economy. In turn, *tapu* and *rahui*, as established by the Miru and the *ariki mau,* and enforced by the local *tangata honui*, abetted elites in acquiring and manipulating the use of staple resources produced in plantations and chicken houses.

Simpson's (2008, 2009) work also noted repeated intervisibility between *umu pae* and *hare umu* and *moai–ahu* complexes. He suggests that, in an attempt to build prestige among elite and to feed district inhabitants involved in corporate works, chiefly retainers installed ovens and oven houses to be intervisible between the living *tangata honui* and their *hare paenga*, and the deceased elite (*tupuna*) represented by the *moai–ahu* complex. This, in turn, helped to keep a particular eye over valuable cooked food resources that were used in redistribution efforts to feed members of each *mata*, and used to fund chiefly ambitions.

In inland regions, archaeological features such as small *ahu* (with and without *moai*), *hare paenga*, rectangular and *ao* (chiefly paddles) shaped homes, and petroglyphs have been interpreted as structures and ideological markers of an elite–built environment constructed to monitor horitcultural production and allocation. Considering that "generating a surplus production may not have come completely voluntarily and required some direct oversight" (Stevenson et al. 2005:135; see also Howard 2007), and that these inland areas were significantly removed from coastal ceremonial complexes, elite retainers used familiar features and symbols from chiefly ideologies and coastal settlement patterns to panoptically control: 1) staple resource production; 2) lower–ranked inland inhabitants; and 3) the labour of lower–ranked inland inhabitants. In short, by denoting an elite presence in the interior of the island, non–elite individuals working in plots, harvesting crops, and transporting produce to lowland *moai–ahu* complexes, would have been constantly reminded of who the correct owners were, and consumers of the staple resources would be (Simpson 2008).

Most recently, Stevenson and colleagues (2018) have argued that study areas inside the Hiva Hiva/Roiho region of Rapa Nui were developed around intensive gardening and the extraction and fabrication of *paenga* and *pae*. There are also multiple lava tubes, caves, and surface springs (e.g. Vai Teka and Vai Tapa Eru) in the Hiva Hiva/Roiho region which provided freshwater, space for gardening plots, protection from the elements, and stone raw materials for inhabitants (Simpson 2014). Importantly, located at the Hiva Hiva cinder cone there is a specialised quarry for the production of large stone slabs or *paenga* for use in *ahu* and elite homes. Concentrated feature complexes and several *hare paenga* in the area suggest that chiefly managers (*tangata honui*) had a role in the co–ordination of production and specialised task groups, led by master carvers (*tangata māori anga hare panega*). Surrounding Hiva Hiva were a number of large rock gardens within collapsed lava tubes and on the open terrain that provided food for redistributive efforts to task groups engaged in stone quarrying and dressing (Stevenson et al. 2018).

Cumulative archaeological research framed in political economy theory on Rapa Nui highlights two points. First, that there was a sustained elite presence in both coastal and inland regions of Rapa Nui until European contact with the island in 1722, showing no signs of a pre–contact collapse. Second, and perhaps most important, is that this presence translated into highly monitored and managed areas where surplus staple resources generated by horticultural production and chicken husbandry were used to finance the agenda of chiefly and elite retainers. Surplus staple resources from first–fruits ceremonies, when coupled with the spiritual, ideological and political power of district *ahu*, afforded *ariki* and *honui* the necessary resources and a permanent location from which they could sanction ancestral worship, enforce hereditary land use rights, command corporate work strategies, and allocate control of the political economy to the Rapanui elite.

Together, this hegemonic control over many ‘power strategies’ of the ancient society undoubtedly helped Rapanui chiefs and elite to influence the island’s cultural development (see Chapter Seven). However, drawing upon an interaction study from McCoy et al. (2011) on Hawai‘i Island where there was little chiefly involvement in the distribution of volcanic glass from the Pu‘u Wa‘awa‘a source – suggesting that alternative exchange systems based upon reciprocity between related individuals or more formalised exchange partnerships from different lineages existed – Stevenson et al. (2013:109) enquired: “are [Rapanui] elite members of society involved in the management of everyday exchange activities that involve basalt and obsidian cores, flakes, and finished tools? Is such micromanagement on an island–wide level feasible or even desirable to higher ranking individuals”? Could a similar system have existed during the Rapa Nui pre–contact period? One that might operate under the umbrella of a chiefly and elite–controlled political economy, but that would be independent of the redistributive system, especially between non–elite individuals? This thesis is very much interested in providing answers to these questions.

Conclusion

The overall goal of this review chapter was to survey and discuss interaction studies in archaeology, especially in Oceania, Polynesia, and on Rapa Nui. This chapter first demonstrated that through time, human interaction has been based on, enabled by, and developed through the sharing of food, the use of language, the creation of relationships between humans and their environment, the generation of socially constructed space, and the sourcing, manufacture, exchange, use, and discard of material culture.

Through time, many archaeological theories have investigated human interaction – by creating definitions and methodologies to identify interaction in the archaeological record – including practitioners of culture–history, processualism, postprocessualism, interpretivism, and those who now use network analysis to understand ancient human interaction. Together, this robust theoretical record, along with multiple archaeological case studies dedicated to human interaction, has assisted in the definition of important key terms used throughout this thesis such as reciprocity, redistribution, exchange, trade, connectivity, and interaction. Archaeological studies in Near and Remote Oceania and West and East Polynesia have provided a framework for delineating past human activity in the 'sea of islands' and situating the Pacific in anthropological and archaeological discourse. The chapter has demonstrated the diverse types and the extensive levels of interaction found between and amongst Pacific islands, during archaeological and ethnographic periods.

The last section of this chapter synthesised and interpreted how observations, theory, method, and practice have been used on Rapa Nui to describe and document intra–island prehistoric interaction and exchange. This included reviewing more than 50 historic, ethnohistoric, and ethnographic records, along with key theories (e.g. diffusionist, culture– history/culture–ecology, settlement pattern studies, evolutionary, and interpretive) and interpretations from Rapa Nui archaeological studies relating to pre–contact interactions. In summarising these records, Table 3A–C compile each Rapanui cultural postion and outline their various economic, ideological, and sociopolitical roles and responsibilities. Lastly, this review chapter provided a multiplicity of records to reconstruct Rapa Nui's ancient political economy, demonstrating how Rapanui chiefs and elites influenced many aspects of the ancient culture's economic, ideological, and sociopolitical organisation. As this thesis is based on the frameworks of the political economy theoretical orientation, this chapter serves as the basis for future discussion in this thesis.

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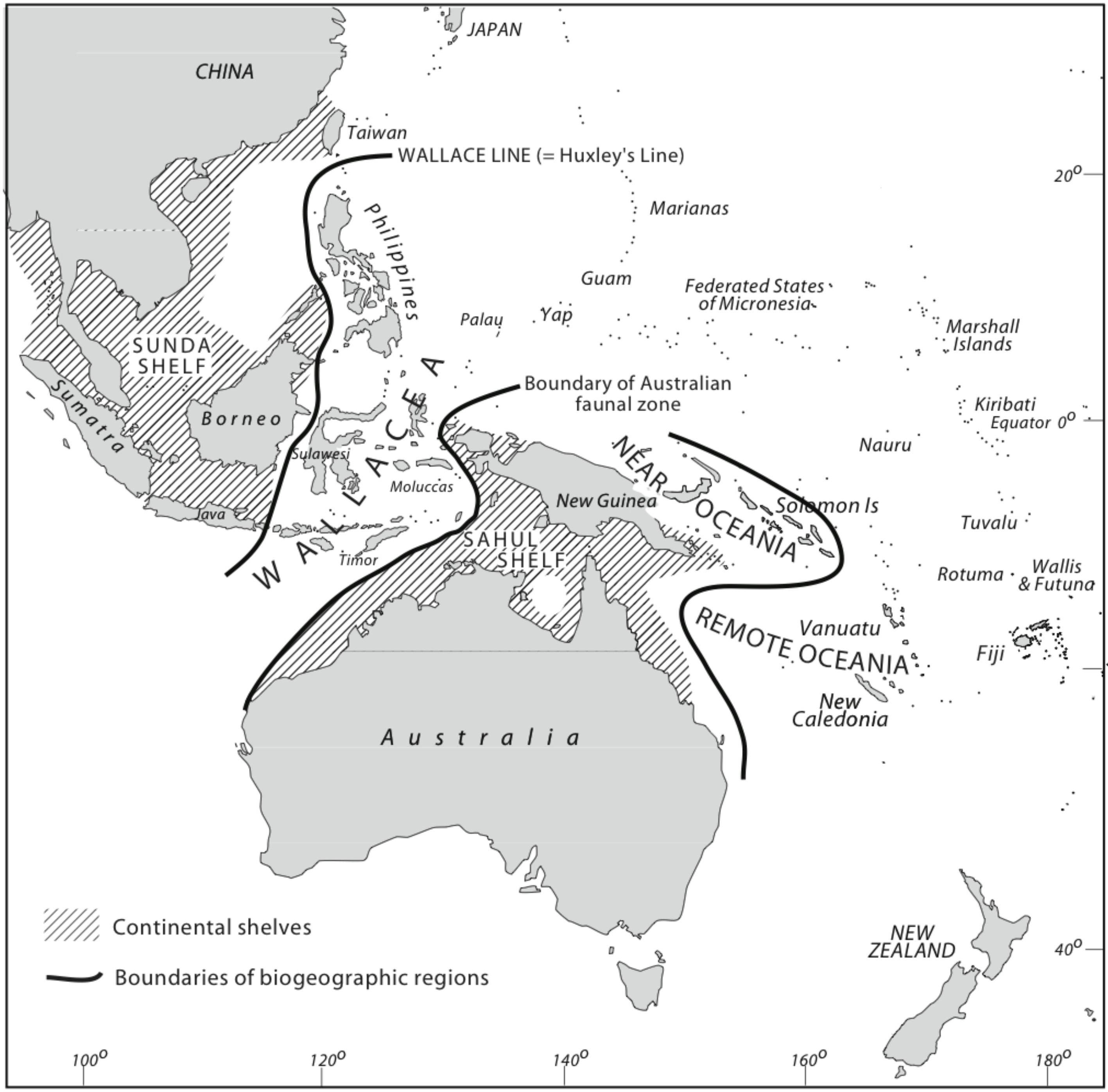

Figure 1. The palaeo–landmasses of Sunda and Sahul divided by Wallacea with the division between Near and Remote Oceania denoted (CartoGIS, College of Asia and the Pacific, The Australian National University 2017).

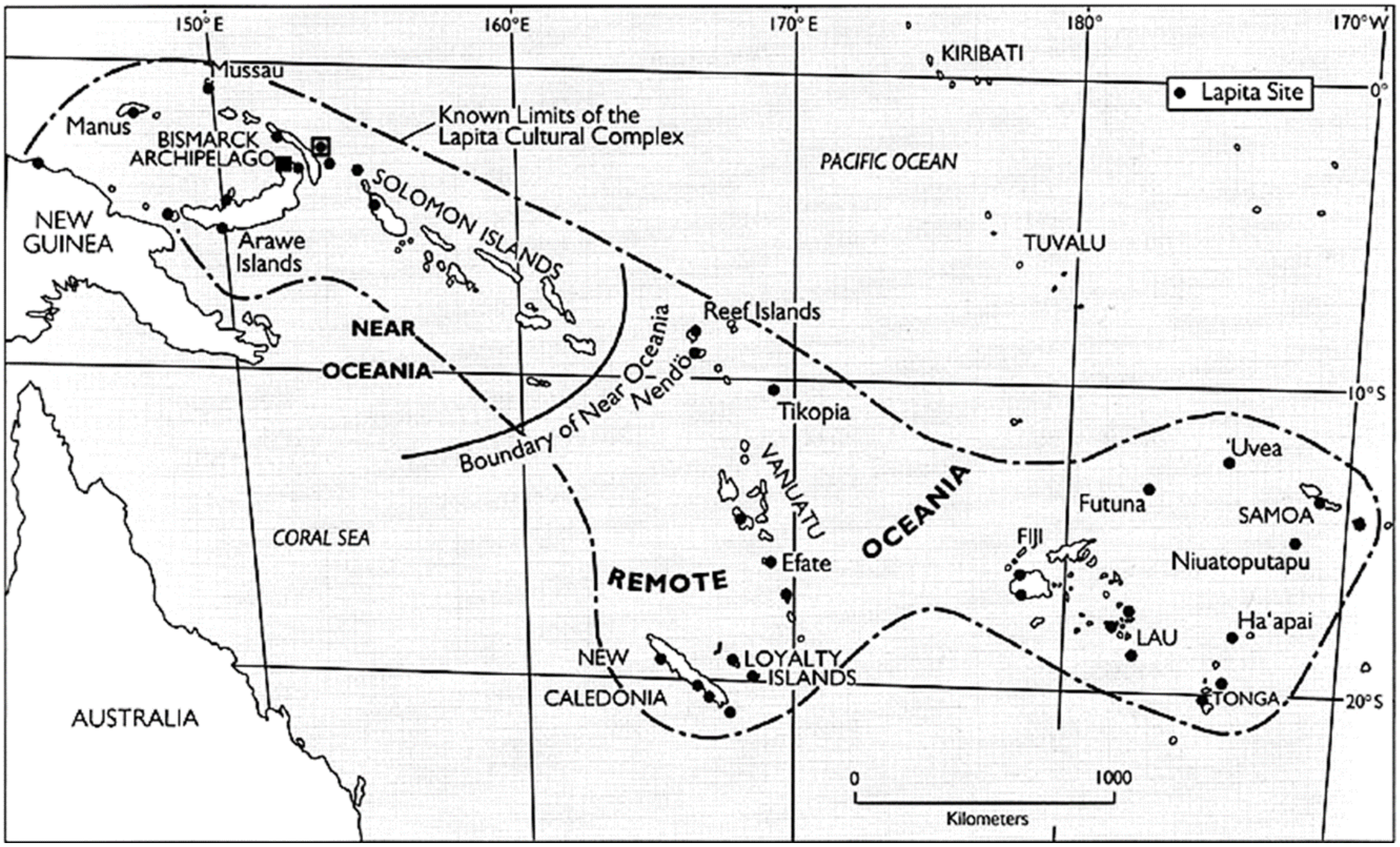

Figure 2. The distribution of Lapita sites within Near and Remote Oceania (Kirch 2000: 96).

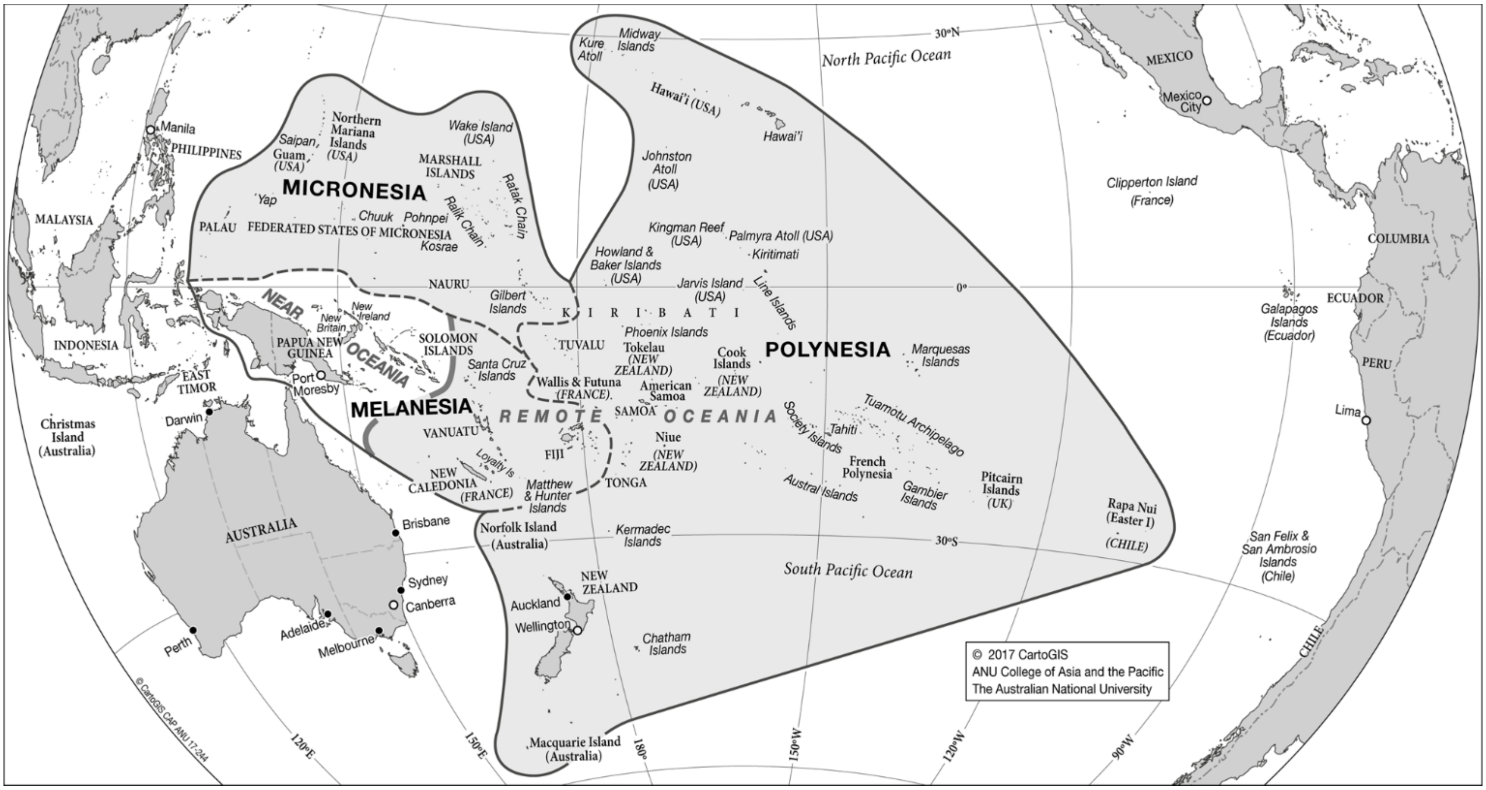

Figure 3. The main culture areas of the Pacific Islands: Melanesia, Micronesia and Polynesia (CartoGIS, College of Asia and the Pacific, The Australian National University 2017).

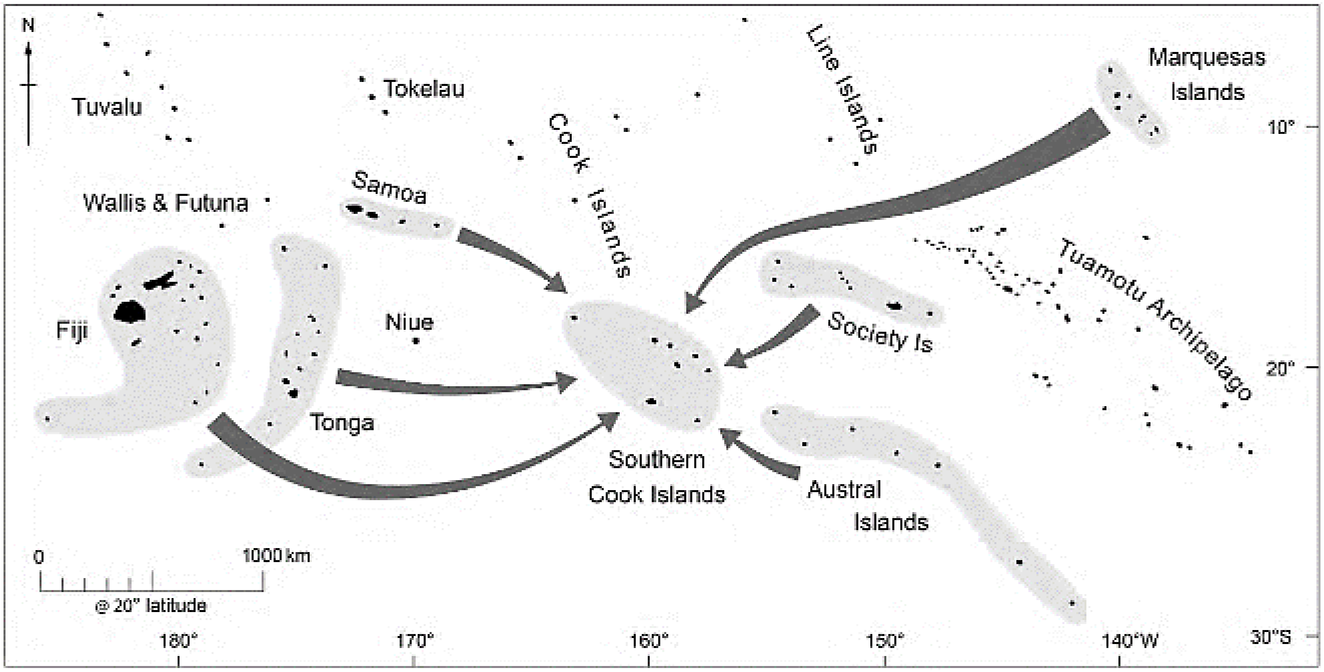

Figure 4. East Polynesia with archipelagos connected to the Cook Islands between 1100–1500 AD (Weisler and Walter 2017:374).

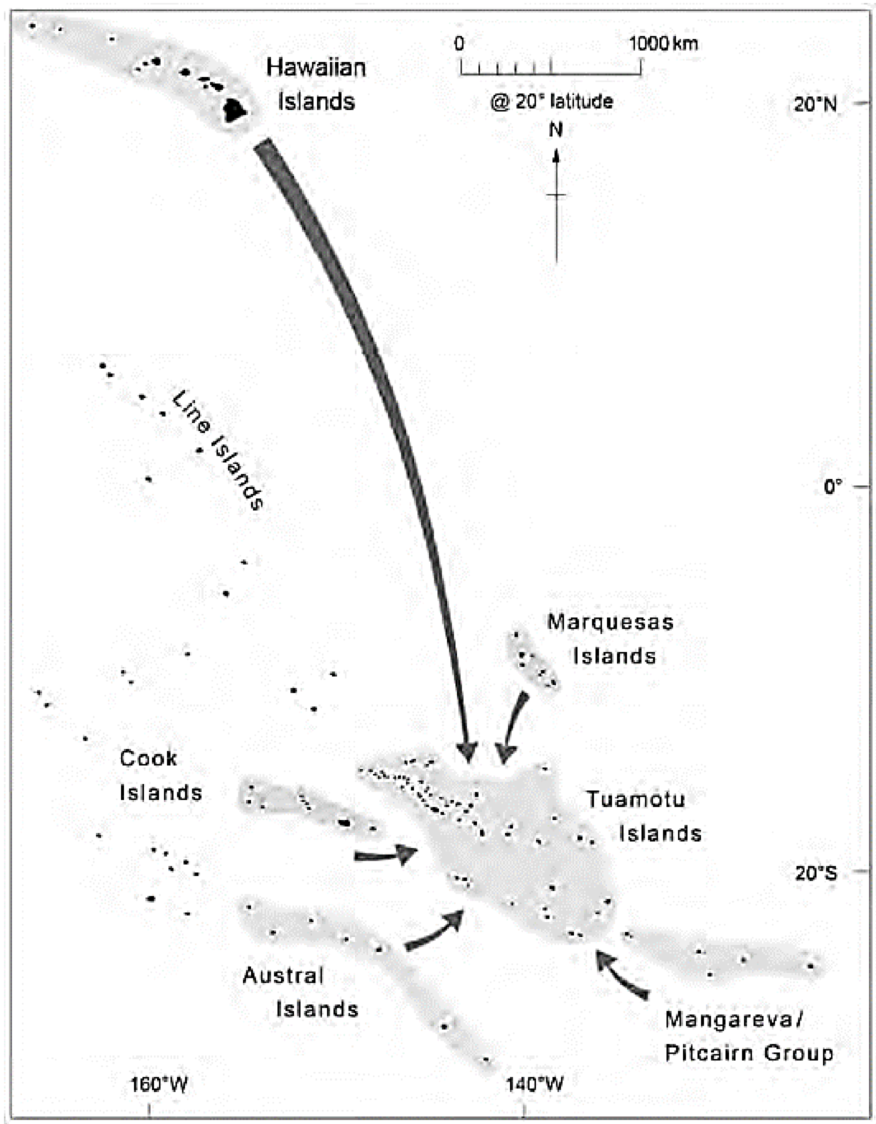

Figure 5. Tuamotus connectivity (Weisler and Walter 2017:375).

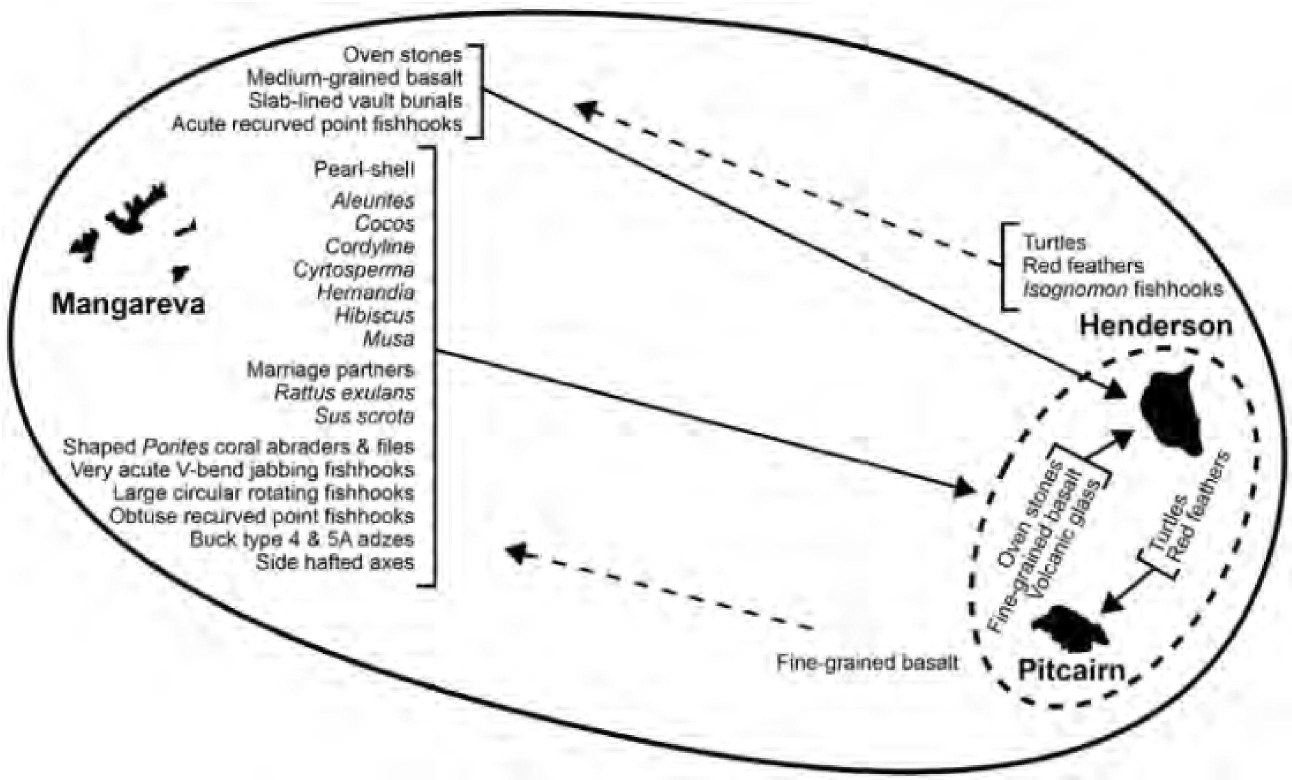

Figure 6. MHP interaction sphere (Weisler and Walter 2017:378).

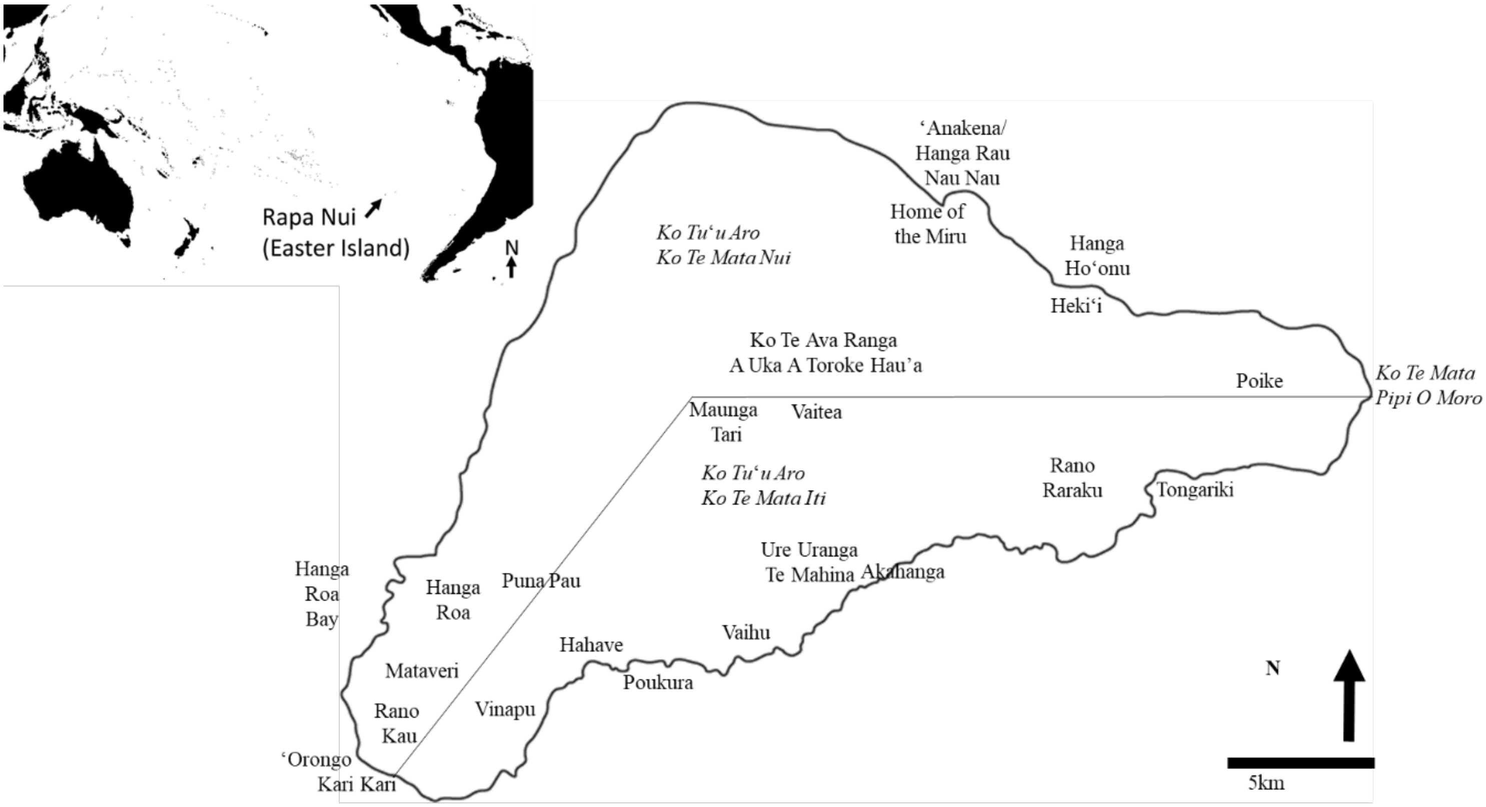

Figure 7. Location of Rapa Nui and places mention in text.

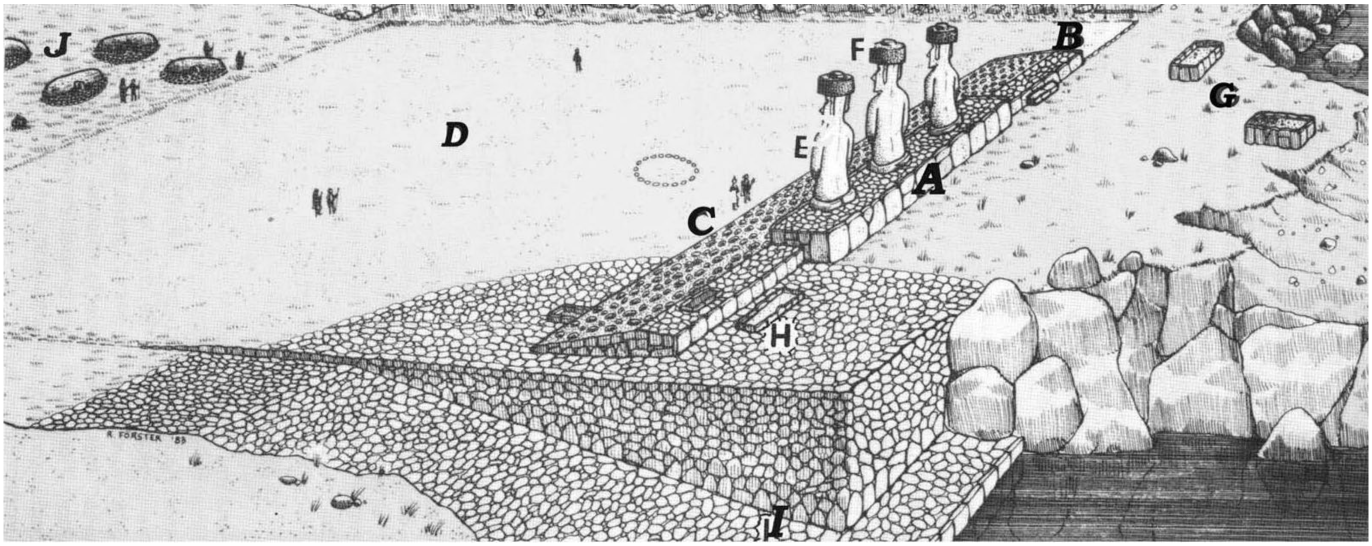

Figure 8. *Ahu–moai* complex (Cristino et al. 1986).

Figure 9. Elite Rapanui visualscape around Ahu Tongariki (Simpson 2008, 2009).

Procurement and exchange type	Procurement and exchange definition
Direct access	User travels directly to the source of the material.
Home–base redistribution	User travels to partner's home–base to exchange material
Boundary reciprocity	Users travel to common boundary area to exchange material
Down–the–line	Commodities flow across successive territories through repeated reciprocal exchanges.
Central place redistribution	Geographically diverse goods are appropriated from the members of a group by a central organisation or political leader then re–divided within the group.
Central place market exchange	Involves bargaining and price–fixing at a centralised location for commercial transactions.
Middleman trading	A freelance trader exchanges with various people but is not under their control.
Emissary trading	A leader or group sends a representative to exchange goods with another group on their behalf.
Colonial enclave	A leader or group sends emissaries to establish a base in or near the territory of a foreign group in order to engage in trade with them.
Port–of–trade	A place which specialises in trading activities, outside of the traders' jurisdiction, where traders from a wide variety of political units can freely meet.

Table 1. Procurement and exchange transactions according to Renfrew (1975).

Island or archipelago	**Source**
Austral Islands	Hermann 2013; Rolett et al. 2015
Cook Islands	Allen and Johnson 1997; Sheppard et al. 1997; Walter and Sheppard 1996, 2001; Walter 1996; Weisler et al.1994, 2016a
Hawaiian Islands	Kahn et al. 2008; Kirch et al. 2011; Mills et al. 2010, 2011; Mintmier et al. 2012 ; Weisler 1990; Weisler et al. 2013
Henderson, Mangareva, and Pitcairn Islands	Weisler 1994, 1995, 1996, 1997b, 2002; Weisler et al. 2004
Marquesan Islands	Allen 2014; Allen and McAlister 2013; McAlister, 2011; McAlister and Allen 2017; Rolett et al. 1997; Weisler 1998, Weisler et al. 2016b
New Zealand	Felgate et al. 2001; Lawrence et al. 2014; Phillips et al. 2016; Weisler and Walter 2017
Fiji, Samoa, Tonga	Best et al. 1992; Cochrane and Rieth 2016; Clark et al. 2014
Society Islands	Kahn et al. 2013; Hermann et al. 2019; Weisler 1998
Tuamotu Islands	Collerson and Weisler 2007

Table 2. Summary of geochemical analysis of archaeological remains from Polynesia.

Station	Economic roles and responsibilities
Ariki mau (AM)	Had strong bearing upon the island's prehistoric 'magico–economic structure'. Had chiefly fishing vessel – *vaka vevero* – used for deep sea fishing and the production of luxury resource. Redistributed *kahi* (tuna) and other fish to *tangata honui* during and after *tapu* periods. Manufactured fishing lines and nets, linking the AM to luxury ocean resources. Used first–fruit ceremonies to acquire the best resources from subsistence practices, especially yams.
Ariki paka	Supervisors of water production including evoking the rain god Hiro and managing water retention systems (e.g. Ava Ranga Uka).
Ivi atua	Were provided with offerings (chicken, fish, and tubers) which were given to the ancestors (at *ahu*?).
Tangata honui	Organised and monitored subsistence production using the demarcation of monumental architecture and elite rectangular homes, delineated horticultural plots, and corporate work strategies. Used first–fruit ceremonies to acquire the best resources from subsistence practices. Used *puoko moa* (chicken skulls) inside *hare moa* (chiken houses) to increase fertility and to claim specific chicken houses for the elite, especially before *koro* festivals. Provided *hatu* (family/local) and *koro* (clan/island–wide) ceremonies to (re)distribute valuable staple resources including horticultural crops and chickens and possible luxury resources.
Māori	Engaged in no other labour apart from specialised crafts including, for example: deep sea fishing, *moai, ahu,* and *paenga* manufacture, stone tool making, and *kohau rongorongo* carving. Paid in fish, lobsters, and eels for their knowledge, arts, and crafts.
Matatoa and *paoa*	???; After contact, are believed to have retained much economic power and authority (along with *ivi atua*) through the activity of the *tangata manu* competition.
Kio and hurumanu,	Lived under 'traditional economic stratification'. Lived inland and provided labour for corporate groups for horticultural and animal husbandry production Presented first–fruits of the harvest to *tangata honui.* Participated in *hatu* and *koro* celebrations which acted as (re)distribution events for staple resources.

Table 3A. Economic roles and responsibilities of the various Rapanui positions

Station	Ideological roles and responsibilities
Ariki mau (AM)	Source of *mana* for the island as direct ascribed descendant from Hotu Matu'a. As such, the AM was extremely sacred, especially his food, housing, head, hair, and hands. Lived in Hanga Rau, 'Anakena district to denote island–wide elite status. Directed original construction of *moai–ahu* complex to venerate the most elite ancestors. Used both *mana* and *tapu* to influence fertility and control the harvest and allocation of horticultural and maritime resources. Used tattoos (on face, necks, lips, and arms), body painting (*takona*), and specific artefacts (cloaks, chest plates, hats, clubs, paddles, and fertility symbols) to demonstrate rank and enforce social protocols including *tapu*. Blessed new boats which connected AM to luxury ocean resources such as tuna. Blessed *hare paenga* which connected AM to the unique *tangata honui* throughout the various *mata kainga*. Judged and critiqued tattoo designs. Judged and critiqued the manufacture of *kohau rongorongo* and used the proto–language script to conceal and protect sacred knowledge including *haka'ara*.
Ariki paka	Used *takona* to demonstrate rank and enforce social protocols including *tapu*. Tasked with praying to the deity "Hiro" for rain. Tasked with providing water fertility ceremonies, including those Ava Ranga Uka, using coral to promote water abundance. Buried fish amongst sugar cane plantations to increase fertility. Placed *huru* (feather sticks) amongst yam plantations to increase fertility. Before *koro* ceremonies, painted red *reimiro* symbols on the bottom of *hare moa* to increase fertility.
Ivi atua	Performed mortuary rituals. Oversaw the handling of the dead. Healed the sick and possessed. Provided fishermen with stone amulets or charms before expeditions. Presented offerings to the ancestors including chicken, fish, and tubers.
Tangata honui	Oversaw festivities. Used *tapu* to control the harvest and allocation of horticultural and maritime resources. Used tattoos, body painting, and specific artefacts to demonstrate rank and enforce social protocols. Lived in *hare paenga* near the *moai–ahu* complex to denote elite status within clans.
Māori	Produced sacred monumental architecture, statuary, artefacts, *kohau rongorongo*, and other luxury resources used by elite classes.
Matatoa and *paoa*	???; After contact, are believed to have retained much ideological power and authority (along with *ivi atua*) through the activity of the *tangata manu* competition.
Kio and *hurumanu*	Lived under *tapu*, *rahui*, and *noa* periods indicated by chiefly elites. Lived within elite–built landscapes which reminded lower class *kio* and *hurumanu* of rank, corporate work responsibilities, and chiefly hegemony.

Table 3B. Ideological roles and responsibilities of the various Rapanui positions

Station	Sociopolitical roles and responsibilities
Ariki mau (AM)	Ascribed ranking based on *mana* and AM's relationship to Hotu Matu'a and his own a*tariki* (first born). Used rank to enforce social protocols including *tapu*, *rahui*, and *noa.* Practiced polygamy and royal endogamy within their royal Honga *ure* with the Te Kena and/or Kao *ure* of the Miru *mata*. Delayed marriage of *atariki* to maintain power and authority for a longer time. Had servants (*tu'ura* and *haka'apa'apa*). Used *kohau rongorongo* script to conceal and protect sacred knowledge including *haka'ara*. The knowledge of *kohau rongorongo* was passed down to all of the chief's sons, maintaining royal lineages and promoting chiefly hegemony.
Ariki paka	Used rank based on *mana* to enforce social protocols. Practiced royal endogamy with in the Miru clan.
Ivi tupuna	Also belong to the Miru clan, highlighting the association between nobility and priesthood. Presided at the procedures and rejoicing when a child was born.
Tangata honui	Used rank based on *mana* to enforce social protocols. Used *hare nui* to unite entire *mata* under one roof. Visited other *mata* chiefs following specific protocol including the *hongi.* Directed the construction of *moai–ahu* complexes. Presided over community feasts such as *hatu* and *koro.* Directed exchange with early visitors to the island
Māori	Ascribed position where trade or craft knowledge was passed on from *māori* father to son. Maintained high levels of sociopolitical rank.
Matatoa and *paoa*	Protected chiefly elites; After contact, are believed to have retained much sociopolitical power and authority (along with *ivi atua*) through the activity of the *tangata manu* competition.
Kio and hurumanu,	Farmers, servants, and/or defeated people. Lived inland in loosely clustered households near staple resource production areas, including horticultural plots and chicken houses. Organised by *paenga* (family), *ivi* (extended family), and *ure* (lineage), and *mata* (clan). Provided labour for corporate groups for monumental architecture construction and resource acquisition.

Table 3C. Sociopolitical roles and responsibilities of the various Rapanui positions

CHAPTER 3: Reviews of Rapa Nui's geodynamic, volanic, and geologic evolution and archaeological sourcing studies

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Dale F. Simpson Jr.
School of Social Science, The University of Queensland, St Lucia, Qld 4072 Australia.
Department of Anthropology, College of DuPage, Glen Ellyn, IL. U.S.A.

dfsj381@gmail.com

Reviews of Rapa Nui's geodynamic, volanic, and geologic evolution and archaeological sourcing studies

Abstract: Easter Island's geodynamic, volcanic, and geologic evolution is reviewed focusing on: 1) Rapa Nui's geomorphological formation and dating; 2) the island's main volcanoes (Poike, Rano Kau, and Terevaka) and their associated geological material; 3) Rapa Nui rock types, their locations in the landscape, and their ancient use to fabricate archaeological structures and artefacts; and 4) previous Rapa Nui geological and geoarchaeological research that has produced information relevant to this thesis. In turn, this review supports current archaeological and geochemical research on Rapa Nui interested in economic, ideological, and sociopolitical interaction during the pre–contact period.

Keywords: archaeological features and artefacts, geodynamics, geology, interaction studies, Polynesia, Rapa Nui (Easter Island), sourcing studies, volcanology

Introduction

While Rapa Nui is famous for its *moai* (statues) and *ahu* (platforms), the island's geodynamic, volcanic, and geologic evolution is what provided the stone necessary to materialise the ancient islander's economic, ideological, and sociopolitical systems. In this chapter, the robust records describing the island's geodynamic, volcanic, and geologic formation and evolution are reviewed. The location of stone sources and quarries used in the manufacture of archaeological artefacts, construction stone, and monoliths are mapped and described. Lastly, the various geological and archaeological sourcing studies conducted on Rapa Nui are reviewed and geochemical data recompiled. Geochemical data is essential for developing stone provenance databases for identifying unique geological sources, as well as assigning artefacts to sources. Overall, this chapter provides the necessary background for documenting ancient interaction using geoarchaeology and geochemical analyses on Rapa Nui (see Simpson 2014; Simpson and Dussubieux 2018; Simpson et al. 2017, 2018).

Rapa Nui: The land of rocky dreams

Rapa Nui volcanologists and geologists have set the stage for archaeologists interested in sourcing studies by highlighting the island's geodynamic activity, geomorphological formation and dating, and stone abundance (Baker 1967, 1993, 1998; Baker et al. 1974; Bandy 1937; Charola et al. [ed.] 1990; Chubb 1933; Déruelle et al. 2002; Fischer and Love 1993; Gioncada et al. 2010; Gonzalez–Ferran et al. 1974, 2004; Haase et al. 1997; Hamilton et al. 2011; Isaacson and Heinrichs 1976; Ray et al. 2012; Simpson 2014; Vezzoli and Acocella 2009).

Rapa Nui is an intra–oceanic volcanic island within the Nazca Plate, ~350km east from the East Pacific Rise bordering the Easter Microplate (Figure 1). It is the largest emerged part of the Easter Seamount Chain (ESC), an east–west trending alignment of volcanic seamounts which extends from the East Pacific Rise for ~2.500km until meeting the Nazca Ridge and South America (Fischer and Love 1993; Gonzalez–Ferran et al. 1974; Figure 1). Most of the activity that created the ESC was produced from the Sala and Gomez hotspot track (Ray et al. 2012), instead of a local mantle plume underneath Rapa Nui (Haase et al. 1997). Ray and colleagues (2012) established how this area experienced ~30 Ma years of geodynamic and hotspot activity, with the Easter Microplate forming ~5 Ma (Haase et al. 1997), and the creation of Rapa Nui representing the 'end–member' of this activity (Fischer and Love 1993; O'Connor et al. 1995; Vezzoli and Acocella 2009). Close to the island are multiple submarine volcanic fields and submerged seamounts (Moai, Umu, Ahu, Pukao, and Tupa; Figure 2) that are associated with the volcanic development of the island (Haase et al. 1997). Rapa Nui rests on the northeast–southwest Rano Kau ridge (Figure 2), 2800m above the oceanic floor, which was built–up during a submarine tholeiitic and calc–alkaline volcanism (Hagen et al. 1990; Haase et al. 1997). Subsequent volcanic activity caused the island to emerge above water in three formative stages (shield, caldera, and rifting). Radiometric dating indicates the original development of the island's three basaltic central volcanoes: Rano Kau, Poike, and Terevaka (Figure 3). However, unlike prior dating establishing the island's formation over three million years (Baker et al. 1974; Clark and Dymond 1977; Fischer and Love 1993; Gonzalez–Ferran et al. 1974), Vezzoli and Acocella (2009) specify that consistent (every 320–220 ka), coeval, but separate vent eruptions between the three principle volcanoes shaped Rapa Nui between <0.78 to 0.3 Ma (Figure 4). Palaeomagnetic evidence supports these refined dates, with all three principle volcanoes erupting in times of normal polarity within the Brunhes Epoch around 0.75 Ma (Brown 2002; Miki et al. 1998). The last phase of the island's geomorphological development occurred between 0.24 and 0.11 Ma, where vent rifting and eruption formed the island's current shape (Fischer and Love 1993; Gioncada et al. 2010; Vargas et al. 2006; Vezzoli and Acocella 2009; Figure 5). During this period, magma chamber depth and volume played a significant role in tributary eruptions (Stevenson et al. 2013; Vezzoli and Acocella 2009). For example, Terevaka's magma chamber was continuously replenished over time, allowing for more rifting volcanism. Conversely, underneath Poike and Rano Kau, crystal fractionation within post–shield forming lavas indicates that magma chambers had declining magma supply over time (Haase et al. 1997; Simpson et al. 2017). The result was five eruptive fissures from all three volcanoes which created distinct ancillary geological material. This included rhyolite and obsidian from Rano Kau, trachyte from Poike, and diverse scoria and basalts from Terevaka including hawaiite, benmoreite, and mugearite. Besides the three principle volcanoes, there are almost 100 monogenetic cinder and spatter cones and the two tuff cones of Rano Raraku and Maunga Toa Toa. Most cones radiate from the Terevaka summit, further demonstrating its replenished magma chamber volume and active volcanism over time (Figure 5). The last volcanic activity on Rapa Nui occurred in the Hiva Hiva and Rohio districts ~0.11 Ma (Fischer and Love 1993; Haase et al. 1997; O'Connor et al. 1995).

Volcanology and geology

The following reviews the geological evolution and physical characteristics of the principal volcanoes on Rapa Nui and demonstrates how they were responsible for producing the diversity of stone types that are found on the island. In turn, a detailed understanding of Rapa Nui's volcanic and geological contexts better informs archaeological studies as investigators can use data provided by volcanic and geological studies to better understand the use (or avoidance) of specific stone, from specific sources, to manufacture lithics, monoliths, and megalithics during Rapa Nui's pre–contact period.

Rano Kau

The shortest of the three principle volcanoes reaches 310m above sea level. An important water source (joining Rano Raraku and Rano Aroi) is located within the circular caldera (1.6km diameter) (Figure 6), which supported ancient habitation and ceremonial activities (Cristino et al. 1981; Fischer and Love 1993; Lee 1992; McCoy 1976, 2014; Mulloy 1995; Vargas et al. 2006). Vezzoli and Acocella (2009) estimated the area of Rano Kau at 50.2km^2 with a volume of ~5km^3. During the main shield formation stage, between 0.78 and 0.46 Ma, Rano Kau produced a 250m thick succession of 50 bedded lava flows consisting of aphyric and microporphyritic (plagioclase, olivine, and clinopyroxene) tholeiitic to alkalic basalts (Fischer and Love 1993; Ginocada et al. 2010; Haase et al. 1997). In the caldera–outflow stage, between 0.4 and 0.35 Ma, Rano Kau produced benmoreitic lava which is coarsely porphyritic, containing up to 20% plagioclase megacrysts and minor clinopyroxene phenocrysts (Vezzoli and Acocella 2009). Also during this phase, the eastern benmoreite part of the Maunga Orito relief was formed, while caldera lava flow created a tongue downslope towards Hanga Vinapu (Figure 7). During the final phase of Rano Kau's volcanism, between 0.24 and 0.11 Ma, multiple monogenetic vents, vitrophyric domes, and sub–volcanic intrusions of rhyolite were formed (Déruelle et al. 2002; Stevenson et al. 2013; Figure 7). This included: (1) Rapa Nui's three islets – Motu Kao Kao (monolithic neck), Motu Iti and Motu Nui (vitrophyric cryptodomes with the former containing obsidian; Figure 8); (2) a southern sheet intrusion at the base of Kari Kari (Figure 6); (3) a northern phreatomagmatic crater of Rano Kau containing obsidian (Figure 9); (4) the obsidian dome of Te Manavai (Figure 9); and (5) the western vitrophyric dome of Maunga Orito which is rich in high quality obsidian (Figure 9).

Poike

Rising 367m above sea level, Poike occupies ~15km^2 of Rapa Nui's land area (Figures 10–11). Vezzoli and Acocella (2009) reconstructed the volcano and estimated its area at ~28km^2 with a volume of ~3km^3. During the shield formation stage, between 0.78 and 0.41 Ma, an eastern summit vent produced aphyric or sparsely porphyritic (plagioclase and olivine) tholeiitic to transitional basalts (Fischer and Love 1993; Ginocada et al. 2010; Haase et al. 1997).

Eventually, the Poike shield collapsed and unlike Rano Kau, was subsequently filled in by the Puakatiki summit lava cone (Figure 12). This circular dry–crater is 175m wide, but only a few meters deep. At its eruption, around 0.36 Ma, Puakatiki emitted highly porphyritic and vesicular alkalic basalts which flowed towards the northern coast (Figure 12). The last phase of Poike's volcanic evolution includes three vitrophyric trachytic lava domes (Maunga Vai a Heva, Maunga Tea Tea, and Maunga Parehe; Figures 10 and 12) which are whitish and porphyritic with phenocrysts of anorthoclase, microphenocryst of olivine, and a groundmass of plagioclase, amphibole, and occasionally clinopyroxene (Baker 1967; Déruelle et al. 2002; Fischer and Love 1993; Ginocada et al. 2010; Haase et al. 1997).

Terevaka

The tallest point on Rapa Nui is found on Terevaka, 507m above sea level (Figures 13–14). As the largest of the island's three principle volcanoes (~14km wide), Terevaka's size attests to its very complex eruption history. This includes its shield formational stage from <0.77 to 0.24 Ma (Miki et al. 1988) until the last eruption in the Hiva Hiva district ~0.11 Ma (Fischer and Love 1993; Haase et al. 1997; O'Connor et al. 1995). Vezzoli and Acocella (2009) estimated its area at ~154km^2 with a volume of ~28km^3. During the shield formation stage, Terevaka's lower flanks were composed of aphyric lavas while upper areas were composed of plagioclase bearing porphyritic lava (Fischer and Love 1993; Gioncada et al. 2010; Vezzoli and Acocella 2009; Figure 15). Found on the north side of Terevaka is Hanga Oteo (Figures 15–16), a large embayment in the shape of an amphitheater that represents a landslide scarp (not an old volcanic crater [Vargas et al. 2006]) as shield lava in the embayment is surrounded by the younger shield porphyritic outflow (Vezzoli and Acocella 2009). Just like the other two principle volcanoes, Terevaka's shield caldera collapsed, forming an elliptic basin ~4km by 2.8km in diameter with a north–northeast orientation (Figure 15). The rim around this caldera is defined by shield lava scarps which were filled with younger lava, a variation of geomorphological intracaldera and outward lavas, and the later formation of a summit platform some 350m above sea level (Vezzoli and Acocella 2009). Later intracaldera activity included the formation of cinder cones on the western rim, phreatomagmatic breccias on the northern and western part of Rano Aroi, and stratified tuffs in the western section of the summit (Figure 17). In the last stage of summit activity, coarsely porphyritic benmoreitic lava with abundant plagioclase phenocrysts in a groundmass of highly vesiculated foam (*pahoehoe*) and tumuli structures, overfilled the caldera and flowed towards the northern coast (Ginocada et al. 2010; Haase et al. 1997). In addition, a lava flow tongue flowed 200m to the southeast (Figure 15).

In the final and most active stage of the Terevaka area, from 0.24 to 0.11 Ma, the southern and southeastern flanks were covered by younger lava flows and related cinder and spatter cones that were fed by some 100 fissure eruptions (Baker et al. 1974; Fischer and Love 1993; Gonzalez–Ferran et al. 1974, 2004; Figure 5). The composition of lava ranges between transitional and alkali basalt, scoria, hawaitte, mugearite, and benmoreite (Bandy 1937; Baker et al. 1974; Déruelle et al. 2002; Fischer and Love 1993; Haase et al. 1997; Gioncada et al. 2010; Gonzalez–Ferran et al. 2004; Simpson and Dussubieux 2018; Simpson et al. 2017). These latest flows, especially in the Tangaroa, Hiva Hiva, and Roiho districts (Figure 18), created numerous lava tubes and caves which were used for multiple purposes by the ancient Rapanui (Keirnan 1976; McCoy 1976; Fischer and Love 1993; Figures 19–20).

Tuff cones

Rano Raraku (Figure 21) and Maunga Toa Toa (Figure 22) are eroded tuff cones that were formed through sub– to shallow marine volcanic activity (hyalotuff). The exact date of Rano Raraku's formation is unknown, but a minimum age of 0.21 Ma is reported by Vezzoli and Acocella (2009). The northwest section of Rano Raraku contains reddish ash, while the southern flank contains sideromelane slightly altered to palagonite, and volcanic glass fragments (feldspatic microlites), crystals, and clasts. The youngest fragments are vesicular, scoriaceous basaltic lapilli with phenocrysts of olivine, clinopyroxene, plagioclase, and ilmenite (Ginocada et al. 2010; Simpson et al. 2018; Van Tilburg et al. 2008). This geological matrix was perfect for the Rapanui carvers, as ~96% of the *moai* were quarried from this tuff (Vargas et al. 2006; Van Tilburg et al. 1994). However, this did not stop the ancient *moai* carvers in experimenting with other stone types including scoria, basalt, and trachyte (Ginocada et al. 2010; Van Tilburg 1994; Van Tilburg et al. 2008; Vargas et al. 2006; Figure 23). This indicates that the ancient Rapanui were very active in exploring and experimenting with many types of stone found throughout the island to create megaliths, as well as artefacts and construction stone.

Geological and archaeological material

With a review of Rapa Nui's geodynamic, volcanic, and geological evolution, Table 1 lists the island's stone types, their geographic distributions, and their use in making archaeological features and artefacts. Figure 24 maps the spatial locations of known and/or documented stone sources and quarries throughout Rapa Nui. The proceeding section includes brief definitions and descriptions of Rapa Nui's geological types.

Basalt

Due to the final volcanic activity of Terevaka, surface basalt material is very common on Rapa Nui. Often found as flowing lava beds/crags or *papa* (Figure 25) and outcrops or *puku* (Figure 26), basalts have been described as having a nearly aphyric to slightly porphyritic texture with a finely crystallised groundmass. Multiple works have shown that the SiO_2 index of basalts covers the entire range of 45–52 wt%, but is mostly concentrated between 47–50 wt% (Baker et al. 1974; Clark and Dymond, 1977; Déruelle et al. 2002; Gioncada et al. 2010; Gonzalez–Ferran et al. 1974, 2004; Haase et al. 1997; Simpson and Dussubieux 2018; Simpson et al. 2017). As such, Rapa Nui's basalts can be separated between tholeiitic (quartz normative), transitional (hypersthene and olivine normative), and alkali (nepheline normative) textures. Transitional basalts show a range of petrology and mineralogy from fine–grained aphyric or slightly porphyritic texture with microphenocrysts of olivine, augitic, pyrozene and bytownite plagioclase to glomerophyres of plagioclase crystals with scarce olivine. Alkali basalts are less porphyritic, containing augite pyroxene and labradorite plagioclase phenocrysts with a coarser size than other basalts (Ayres et al. 1998; Déruelle et al. 2002; Haase et al. 1997; Gioncada et al. 2010; Vezzoli and Acocella 2009). Baker et al. (1974) report that Rapa Nui's basalt rocks tend to have low MgO contents but high Ti, Zr, and total iron, while Harper (2008) and Gioncada et al. (2010) note that porphyritic rocks contain relatively high levels of Sr and Al_2O_3. Using macroscopic analysis, Hamilton et al. (2011) noted that *panega* stone used for *ahu* on the north coast (e.g. Te Pito Kura) was comprised of local coarsely vesicular basalt, while *ahu* stone on the west coast (e.g. Maitaki te Moa) was comprised of local phenocrystalline material.

Hawaiite, mugearite, and benmoreite

Found mainly around the Terevaka, Tangaroa and Hiva Hiva areas, hawaiite is mostly aphyric and consists of olivine and calcic plagioclase with an established anorthite content between 50–70% (Déruelle et al. 2002; Van Tilburg et al. 2008). Hawaiitic groundmass (e.g. Rua Tokitoki quarry; Figure 27) exhibits microphenocrysts rich in Fe–oxides (Ayres et al. 1998; Baker et al. 1974; Haase et al. 1997; Gioncada et al. 2010; Simpson et al. 2017; Vezzoli and Acocella 2009). Mugearite and benmoreite are frequently described as having large and zoned plagioclase phenocrysts. They have a porphyritic texture with phenocrysts of labradorite to andesine plagioclase, augite pyroxene, and scarce olivine in a groundmass characterized by abundant plagioclase, minor clinopyroxene, and ilmenite (Baker et al. 1974; Haase et al. 1997; Gioncada et al. 2010; Vezzoli and Acocella 2009).

Trachyte and rhyolite

The most underrepresented rocks on Rapa Nui are trachytes and subaluminous to mildly peralkaline rhyolites with molar $(Na_2O+K_2O)/Al_2O_3$ slightly over 1 and low total FeO wt%, corresponding to comendites (Déruelle et al. 2002; Haase et al. 1997; Gioncada et al. 2010; Vezzoli and Acocella 2009). They have high concentrations of light Rare Earth Elements and Zr. Microscopically, trachytes from Poike show a finely crystallised groundmass and a modest abundance of microphenocrysts (Ginocada et al. 2010). Rhyolitic lavas from Rano Kau present obsidian facies with local development of spherulites with anorthoclase, fayalite, and aegirine microphenocrysts (Baker et al. 1974; Ginocada et al. 2010; Haase et al. 1997; Vezzoli and Acocella 2009). Obsidian geochemical results indicate that traces of Sc can be used to discriminate Motu Iti, Rano Kau and Orito/Te Manavai groups, while variation in Se and Zn can roughly separate Orito and Rano Kau groups (Beardsley et al. 1996, 2001; Mulrooney et al. 2014; Stevenson et al. 2013; Thomas 2009).

Pyroclastic tuff and scoria

This material characterises the deposits of the Terevaka and the Tangaroa regions. They are found as cinder cones with rarely welded scoria (e.g. Puna Pau; Figure 28). Their composition however, is mainly basaltic with lower Na_2O and K_2O levels compared to other rock types. Two notable tuff sources are Rano Raraku and Maunga Toa Toa where the established anorthite content of plagioclase phenocrysts is between 52–54% (Baker 1993; Ginocada et al. 2010; Van Tilburg et al. 2008). While three notable scoria sources are Puna Pau, O'Tuu, and O'Koro (Hamilton et al. 2011), Thomas (2014) thoroughly noted scoria sources and locations in the archaeological record where this stone has been quarried and used.

Stone characterisation research on Rapa Nui

Previous stone characterisation work on Rapa Nui can be divided into geological studies (Baker et al. 1974; Bandy 1937; Bonatti et al. 1977; Cheng et al. 1999; Clark and Dymond 1977; De Paepe and Vergauwen 1997; Fontignie and Schilling 1991; Hanan and Schilling 1989; Haase et al. 1997; Puzannkov and Bobrov 1997; White and Hofmann 1982) and geoarchaeological analyses (Table 2). Appendix A complies available geochemical data (major and trace elements) from these investigations, while Figure 29 plots TAS (total alkali versus silica) data for selected samples, identifying individual stone types in geochemical space (Vezzoli and Acocella 2009:87). This final section provides a review of both obsidian and non–obsidian sourcing studies conducted on Rapa Nui. In turn, this aids to identify and describe ancient economic, ideological, and sociopolitical interaction.

Obsidian sourcing studies

Regarding geoarchaeological provenance studies on Rapa Nui, more attention has focused on the island's four obsidian sources (Figure 24) and obsidian artefacts from ceremonial, habitation, and museum contexts (Mulrooney et al. 2014, 2015; Stevenson and Williams 2018; Stevenson et al. 1984; Thomas 2009). This is because the stone is ubiquitous at archaeological sites (McCoy 1976; Vargas et al. 2006), is datable by obsidian hydration (Stevenson 1984, 1986, 1997, 2000; Stevenson et al. 2015), and has diagnostic geochemical signatures which facilitate assigning artefacts to sources (Beardsley and Goles 1998, 2001; Beardsley et al. 1996; Cristino et al. 1999; Morrison and Dudgeon 2012; Mulrooney et al. 2014, 2015; Stevenson et al. 2013; Thomas 2009).

To document petrological and chemical characteristics of Rapa Nui obsidian, researchers have used a range of analytical techniques including: 1) macroscopic analysis (Baker et al. 1974; Bird 1988); 2) proton induced X–ray emission and gamma–ray emission (PIXE–PIGME; Bird 1988); 3) instrumental neutron activation analysis (INAA; Beardsley et al. 1996); 4) wavelength dispersive X–ray fluorescence (WDXRF; Baker et al. 1974); 5) energy dispersive X–ray fluorescence (EDXRF; Cristino et al. 1999; Stevenson et al. 2013); 6) portable X–ray fluorescence (pXRF; Mulrooney et al. 2014, 2015); and 7) laser ablation inductively coupled plasma–mass spectrometry (LA–ICP–MS; Morrison and Dudgeon 2012; Thomas 2009). These studies indicate that while it is possible to discriminate Motu Iti and Rano Kau obsidian, it is more difficult to separate Maunga Orito and Te Manavai due to their late period rhyolitic evolution and subsequent elemental propinquity (Bird 1988; Cristino et al. 1999; Mulrooney et al. 2014; Stevenson et al. 2013).

The importance of using precise and accurate geochemical data to fingerprint obsidian sources and artefacts to assign proper provenance is exemplified by Mulrooney et al. (2015). This investigation used pXRF analysis to demonstrate that a so–called *mata'a* (biface tool) found in the Bishop Museum Ethnology Collection (B.2195), originally attributed to Rapa Nui (Métraux 1940) and even to South America (Heyerdahl 1961), was actually from the Bismarck Archipelago. Further statistical analysis using elements Rb, Sr, Y, and Zr identified Mopir, New Britain, as the source quarry. Morphological reassessment of the artefact allowed Mulrooney and colleagues (2015) to conclude that not only a more complex set of social networks were operating in the Bismarck Archipelago prior to 3000 BP, but that any interpretation about Rapa Nui's past using B.2195 is erroneous. As such, this study highlights that by using precise and accurate geochemical analyses, like pXRF for obsidian, and appropriate statistical analyses, investigators can confirm the correct geological provenance for artefacts – especially those where the archaeological/museum context is assumed or unknown.

Distribution studies based on Rapa Nui geoarchaeological and geochemical data propose that obsidian from the four quarries was differentially utilised based on glass quality, geological location, and the different needs for obsidian between elite and non–elite Rapanui (Beardsley et al. 1996; Martinsson–Wallin 1994; Mulrooney et al. 2014; Stevenson et al. 2013). For example, in one of the most comprehensive investigation of obsidian geochemistry, Stevenson et al. (2013) used a 'Distributional Approach' (Hirth 1998), EDXRF on 331 archaeological samples, and Discriminant Function Analysis to conclude: 1) due its poor quality (small size, friable with more inclusions), Rano Kau obsidian was rarely used during the pre–contact period (see also Mulrooney et al. 2014), although opportunistic extraction and use may have existed; 2) although Te Manavai obsidian is flawed with perlitic inclusions (McCoy 1976), it was still usable for the production of flake tools and was represented in the majority of obsidian debitage found at inland domestic habitation sites (although Mulrooney et al. [2014] documented much less used of the Te Manavai source for *mata'a*). In addition, the low density of surface archaeological remains around Te Manavai, along with the lack of elite architecture (e.g. *moai–ahu* complex and homes such as *hare paenga*), suggest that access was open and/or negotiated with the members of the *mata* (Thomas 2009); 3) obsidian from Motu Iti constituted 14% of the artefacts analysed from ritual centres (*moai–ahu* complex) and crematoria, but only a 2% occurrence at interior habitation sites. Together, this evidence along with a single *ahu* on the adjacent Motu Nui, hints at a more elite controlled system of access, distribution, and use of the obsidian from Motu Iti. In addition, the higher frequency of Motu Iti's obsidian found at coastal caves and *ahu* (Beardsley et al. 1996), and the virtual absence from inland sites, suggests that obsidian from this off–shore location was most–likely acquired and delivered by elite members through canoe transfer; and 4) high quality obsidian from Orito (with almost no inclusions) was intensively extracted though surface pit mines and the production of cores and bifaces was conducted at the margins of the extraction pits (Stevenson et al. 1984). However, different from Rano Kau and Te Manavai, was the presence of a single *ahu* and a large *hare paenga*, suggesting that Orito's pits were monitored and/or managed by elite members of the *mata.* No evidence, however, is presented as to how elite managers (re)distributed obsidian to residential sites or *ahu*. While the details of obsidian exchange are incomplete, consequences of this process resulted in a pattern where 70% of all obsidian found at coastal sites and within crematoria, was from Orito. Arguably, ceremonial use of obsidian at *moai–ahu* complex required stone of the highest quality and/or desirability, and results show how Orito's obsidian served this purpose.

Therefore, results from Stevenson et al. (2013) illustrate how the more desirable Orito obsidian, used during ritual and death activities, flowed through the economy but was preferentially retained by elite members in the process. Mulrooney et al. (2014) however, argued that the chiefly control at Orito may instead have involved encouraging access to its high–quality obsidian as a means of building and maintaining prestige between chiefs and elite retainers from different *mata*. But, those Rapanui with lesser rank, living in centre portions of the island, acquired stone material via open (communal) access and down–the–line exchange (Renfrew 1975), arguably distributed from *tangata honui* through sociopolitical networks including *paenga* (family), *ure* (extended family), and *ivi* (lineage). Together, results from obsidian geochemical studies on Rapa Nui highlight that there were multiple means for the acquisition and the exchange of obsidian including: opportunistic, communal, and elite (re)distribution and redistribution efforts.

Non–obsidian sourcing studies

Figueroa and Sanchez (1965:171) were first to note that "without detailed petrographic analysis" it would be difficult to geographically source Rapa Nui's basalt adzes. Some 33 years later, the first systematic petrographic analysis of Rapa Nui adzes and quarry material was initiated at Rua Tokitoki, near Hanga Hoʻonu (Ayres et al. 1998; Métraux 1940; Simpson et al. 2017; Figure 24). Ayres et al. (1998:304) following Peterson et al. (1997), emphasised that exchange of basalt material on Rapa Nui represents multiple and contemporaneous interaction spheres including elite to elite and from elite to dependent or dependent to elite exchange relationships. Archaeological and source samples analysed by Ayres et al. (1998) came from locations within both Ko Tuʻu Aro Ko Te Mati Nui (high status northern clans) and Ko Tuʻu Hotu Iti Ko Te Mata Iti (low status southern clans) confederations which are divided by the Ko Te Mata Pipi O Moro line (Hotus et al. 1988; Stevenson 1986, 2002; Vargas et al. 2006). While some individual adzes had a wider geographic distribution, one adze group was predominantly found in the Rano Kau volcano complex. Ayres et al. (1998) conclude that patterns of ancient basalt adze exchange best fit into opportunistic and kin–based geographic categories (see Peterson et al. 1997).

Soon thereafter, Stevenson et al. (2000) used instrumental neutron activation analysis to detect 30 elements for 75 samples from five pit–mines (of a total of 37) found in the Hanga Hoʻonu region. Similar to the pit mines of obsidian, the authors found a similar pattern where basalt tools such as adzes and picks were prepared at pit margins, producing copious amounts of chipping debris and debitage. While Baker (1993, 1998) used TAS analysis to identify the area to be composed of hawaiite, Stevenson et al. (2000) concluded that the elemental uniqueness of basalt quarries and sources could not be differentiated on a micro–scale due to the chemical uniformity of the material extracted from the pit–mines. Notably, Stevenson et al. (2000) found minimum elite presence in their study area and hypothesised that the lack of domestic features associated with quarries and sources suggests that task groups, organised by corporate work strategies, visited quarry areas to extract basalt on a routine basis. Whether if this access was open to all *mata*, or directed through elite and specialist oversight, was not ascertained. However, similar to Orito, open access to this region's basalt may have assisted in the building and maintenance of prestige amongst chiefs and elite retainers, and may have fostered interaction between the island's confederations and *mata.*

Harper's (2008) used inductively coupled plasma–time of flight–mass spectrometry on basalt adzes (n=6) and *ahu* stones (n=12) and compared these findings to the geochemical profile of lava flows as identified by Gonzalez–Ferran et al. (2004). Previous geochemical research documented that the Rare Earth Elements (REE) were useful to distinguish unique basalt sources (De Paepe and Vergauwen 1997; Déruelle et al. 2002; Haase et al. 1997); however, Harper's (2008) work indicated that the period four transition metals (Sc, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn) appeared to be more useful. Results show adzes were provenanced from inside the Rano Kau area, while the *ahu* blocks were quarried from somewhere in the Terevaka volcanic complex, and then moved to *ahu* sites.

A study by Gioncada and colleagues (2010) used microscopic, macroscopic, and X–ray fluorescence analyses of 62 samples from 20 of the 29 volcanic units reported by Gonzalez–Ferran et al. (2004) to investigate the sources of *moai*, *pukao*, and *moai* pedestal stone for *ahu*. Contrary to Harper (2008), Gioncada et al. (2010) concluded that *paenga* stone for *ahu* came from opportunistic locations; that is, outcrops near the monuments (see also Hamilton et al. 2011).

The most recent geochemical analysis of Rapa Nui basalt adzes was conducted as part of the Easter Island Statue Project (Fischer and Bahamondez 2011). Non–destructive pXRF was used to analyse 170 adzes and picks, and Zr, Ca, K, Rb, and Ti appeared useful for discriminating the geochemical variability of these artefacts. Some 85% of the analysed *toki* were made from the same source of mugearite, with 13% of *toki* likely coming from a benmoreite source. These findings hint at possible centralised distribution (Peterson *et al.* 1997) from one or two main quarries outward to Rano Raraku, the *moai* quarry (see also Simpson et al. 2018).

Lastly, Hamilton et al. (2011) review Rapa Nui's principle stone types (e.g. flow lava, tuff, red scoria, trachyte, and *poro* beachstone) and their various ancient uses. They emphasise how stone provenance (i.e. volcano/land/sea contexts), colour, size, and shape influenced the use of particular stone to manufacture artefacts, construction stone, and monoliths. Hamilton et al. (2011:172) have also argued that:

"[c]omplete knowledge of [Rapa Nui's] complicated geological palimpsest is currently beyond archaeology's grasp, for a number of reasons. These include similarities between stone of the same broad type from different sources, the absolute number of outcrops of stone of utilisable type and the fact that many of the monuments are protected sites, which precludes close approach to, let alone systematic sampling of, the stones comprising them".

I disagree with this statement from Hamilton et al. (2011) as detailed geoarchaeologcial work, focused on the use of highly precise archaeometric sourcing methods, supported by anthropological archaeology theory, can indeed inform on and help to better understand the island's complicated geological and archaeological palimpsests.

Discussion

Many publications highlight Rapa Nui's geodynamic development, geomorphological formation and dating, geochemistry, and the rock types exploited and exchanged by the ancient Rapa Nui during the ~600–year sequence (Hunt and Lipo 2006; Mulrooney 2013; Stevenson et al. 2015; Weisler and Green 2011). In reviewing and synthesising these records, the following observations can be made. Rapa Nui is an intra–oceanic volcanic island located on the Nazca plate within the Easter Seamount Chain, 350km to the east of the East Pacific Rise. Starting 30 Ma, this area experienced geodynamic activity from the Sala and Gomez hotspot track, with the Easter Microplate forming ~5Mya, and the origination of Rapa Nui representing the end–member of this activity. The island rests on the northeast–southwest Rano Kau ridge, 2800m above the oceanic floor, that was built up during a period of enriched tholeiitic submarine volcanism. Subsequent volcanic activity, <.78 Ma to .10 Ma, caused the island to emerge above the water in three stages (shield, caldera, and rifting), forming the largest three volcanoes (Poike, Rano Kau, and Terevaka) and ~100 monogenetic cinder, spatter, and tuff cones. In turn, this prolific volcanism, influenced by magma chamber depth and refilling, created a variety of stone types including basalt (undifferentiated), hawaitte, mugearite, benmoreite, trachyte, rhyolite, tuff, and scoria. This diversity of multiple rock types provided the Rapanui with an almost endless amount of stone material to materialise the economic, ideological, and sociopolitical desires of the ancient culture, especially those of the island's elite classes (e.g. the *moai–ahu* complex, *paenga* and *pae* stone, and portable artefacts such as adzes, knives, and fishhooks).

While previous geoarchaeological research on Rapa Nui establishes that compositional differences amongst Rapa Nui's obsidian, basalt, scoria, and tuff can be determined using sourcing analyses, an emphasis has been placed on the investigation of obsidian as opposed to non–obsidian stone sources and artefacts. In turn, this has led to minimum reporting of non–obsidian stone geochemistry and the extraction and reduction techniques used by the ancient Rapanui. This includes major procedures within the *chaîne opératoire* (Sellot 1993) of extraction and reduction for artefacts and house and platform stones. Together, this overall lack of comprehensive geochemistry and detailed archaeological data for non–obsidian stone sources, artefacts, and construction stone has restricted the potential of Rapa Nui interaction studies. To address this issue, I, like Weisler (2008), suggest the need to work with geochemists and the use of comprehensive geochemical analyses to make objective connections between geological source and archaeological stone. This includes the use of in–depth geoarchaeological documentation and highly accurate and precise ICP–MS technologies to better describe Rapa Nui's basalt quarries and sources and their use to manufacture artefacts and construction stone. In turn, results and interpretations from these efforts will help to better recognise ancient economic, ideological, and sociopolitical interaction during Rapa Nui's pre–contact period (Simpson and Dussubieux 2018; Simpson et al. 2017, 2018).

Conclusion

From the multiple stone materials used to fabricate *moai*, shape *paenga*, form *pukao*, and make a multiplicity of archaeological features and artefact types, the Rapanui took full advantage of their Polynesian stone working ability and their island's unique geological landscapes. To better understand these archaeological and geological landscapes, in this chapter, I: 1) synthesised the geodynamic, volcanic, and geological evolution of Rapa Nui; 2) highlighted an updated model dating the island's three main volcanoes and secondary volcanic activity; 3) provided a review of Rapa Nui's volcanoes and their associated geological material; 4) described each island rock type, their geographic locations, and their use to make multiple archaeological structures and artefacts (Table 1); 5) spatially located and mapped known stone quarries used throughout Rapa Nui's pre–contact period (Figure 24); 6) recompiled geochemical data from previous investigations (Appendix A); and 7) reviewed Rapa Nui's obsidian and non–obsidian sourcing studies. These investigations demonstrate that ancient Rapanui exchange mechanisms included opportunistic, communal, kin–based, and elite (re)distribution means. Lastly, this chapter provides theoretical and methodological review of past investigations and findings, while taking the first steps towards building a comprehensive, highly accurate and precise geochemical database of fine–grained basalt sources on Rapa Nui. Subsequently, this database can be used to reconstruct patterns of interaction inferred from the transfer non–obsidian artefacts from unique geological sources to archaeological contexts such as habitation and ceremonial sites.

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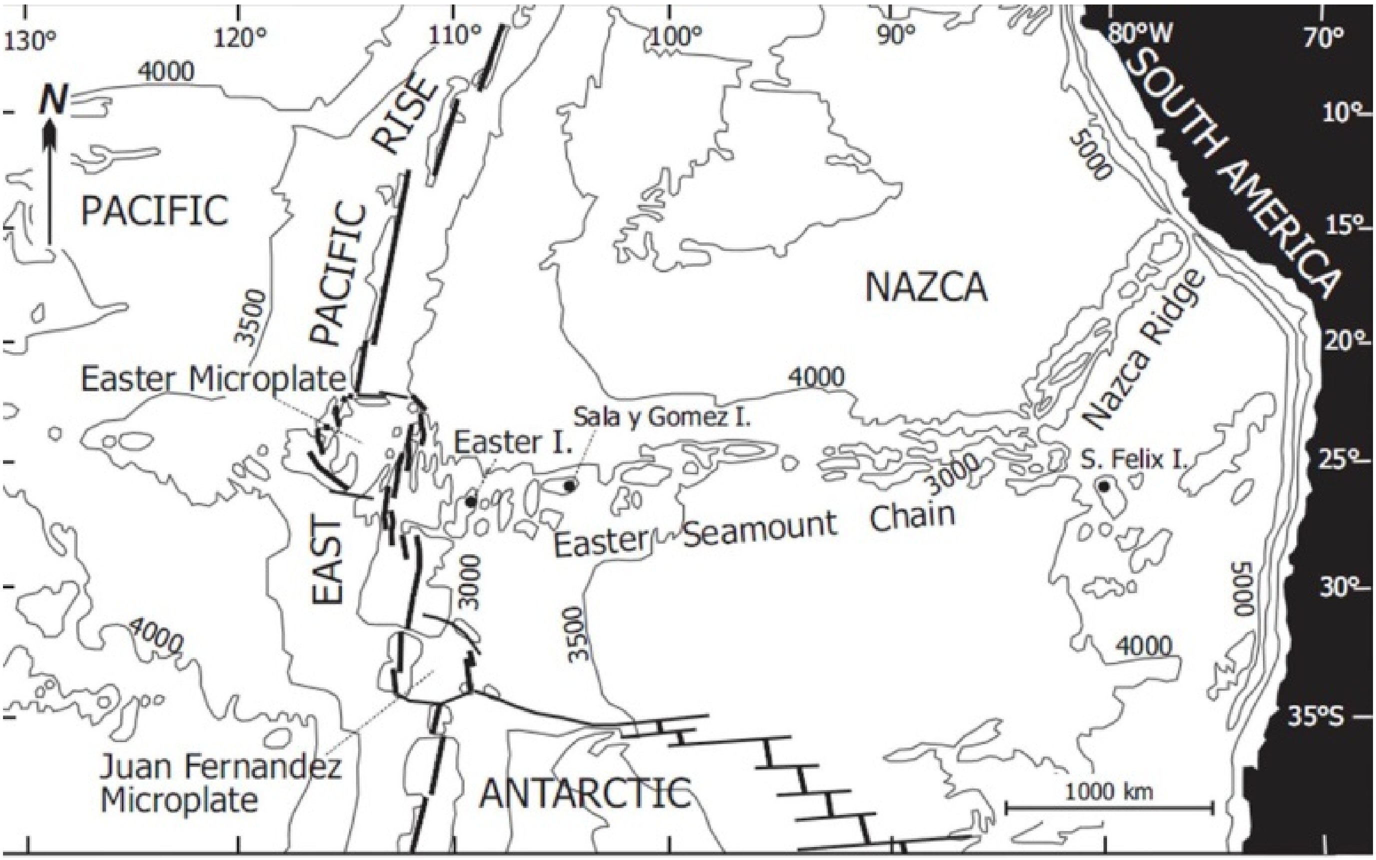

Figure 1. Geodynamic setting of Rapa Nui showing major plate and microplate boundaries and the Easter Seamount Chain–Nazca Ridge structure. Heavy lines indicate active spreading axis; thin lines indicate transform faults (Vezzoli and Acocella 2009:871; see also Hasse et al. 1997).

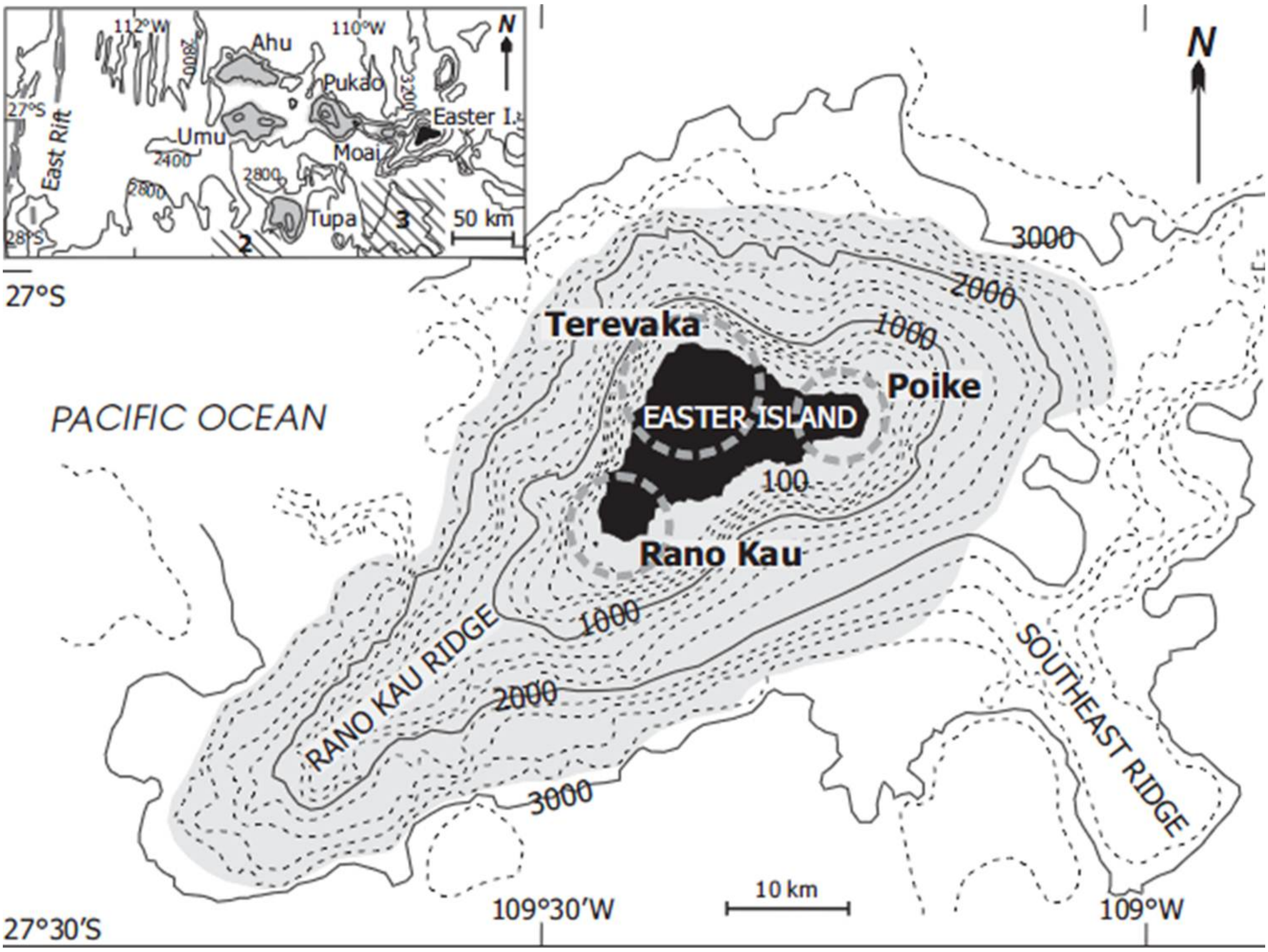

Figure 2. Submarine structure of the Easter volcanic complex with inset map of nearby volcanic fields and seamounts (Vezzoli and Acocella 2009:872; see also Hasse et al. 1997).

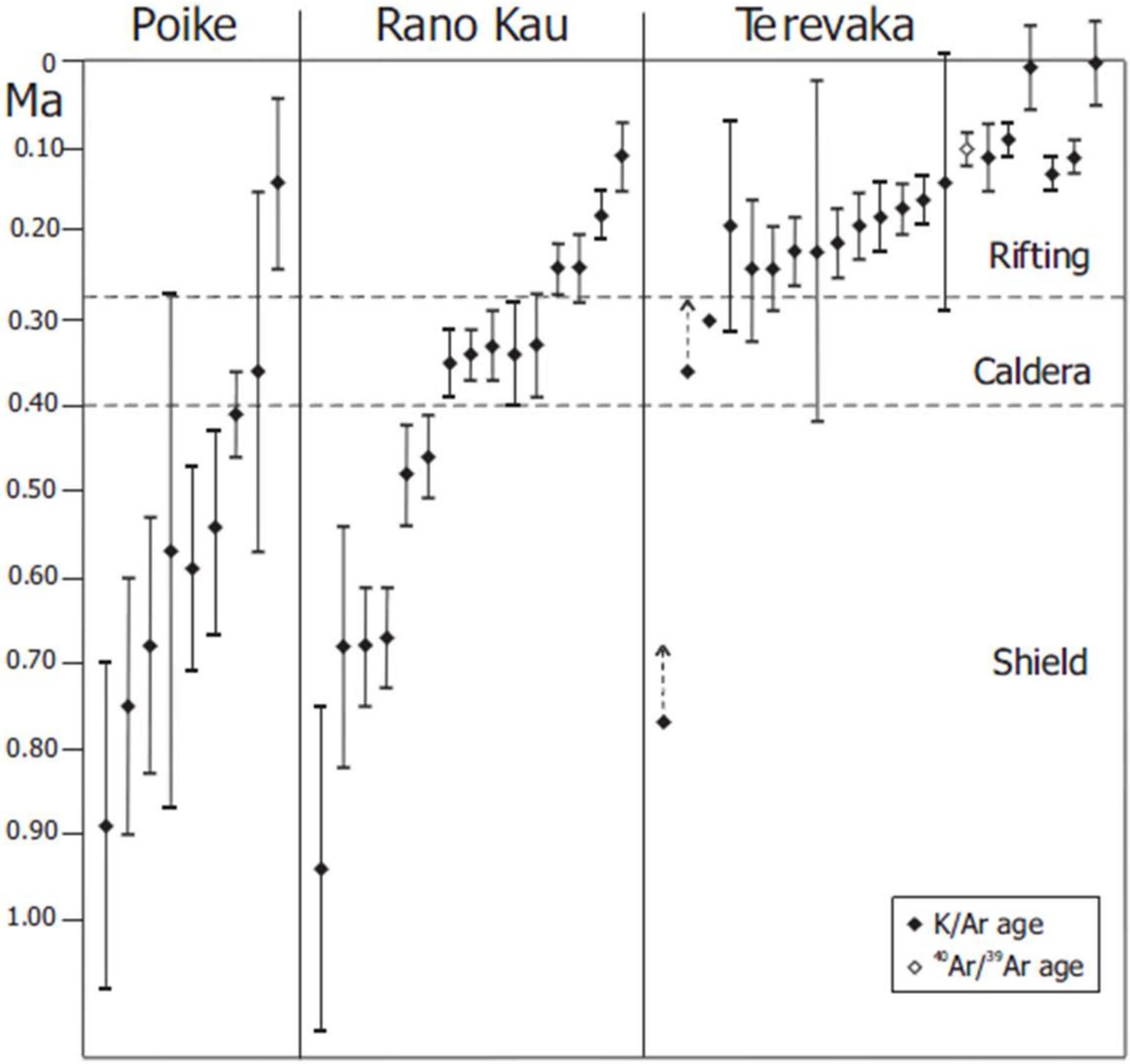

Figure 3. Radiometric dating of Rapa Nui's three volcanic centres (Vezzoli and Acocella 2009:872).

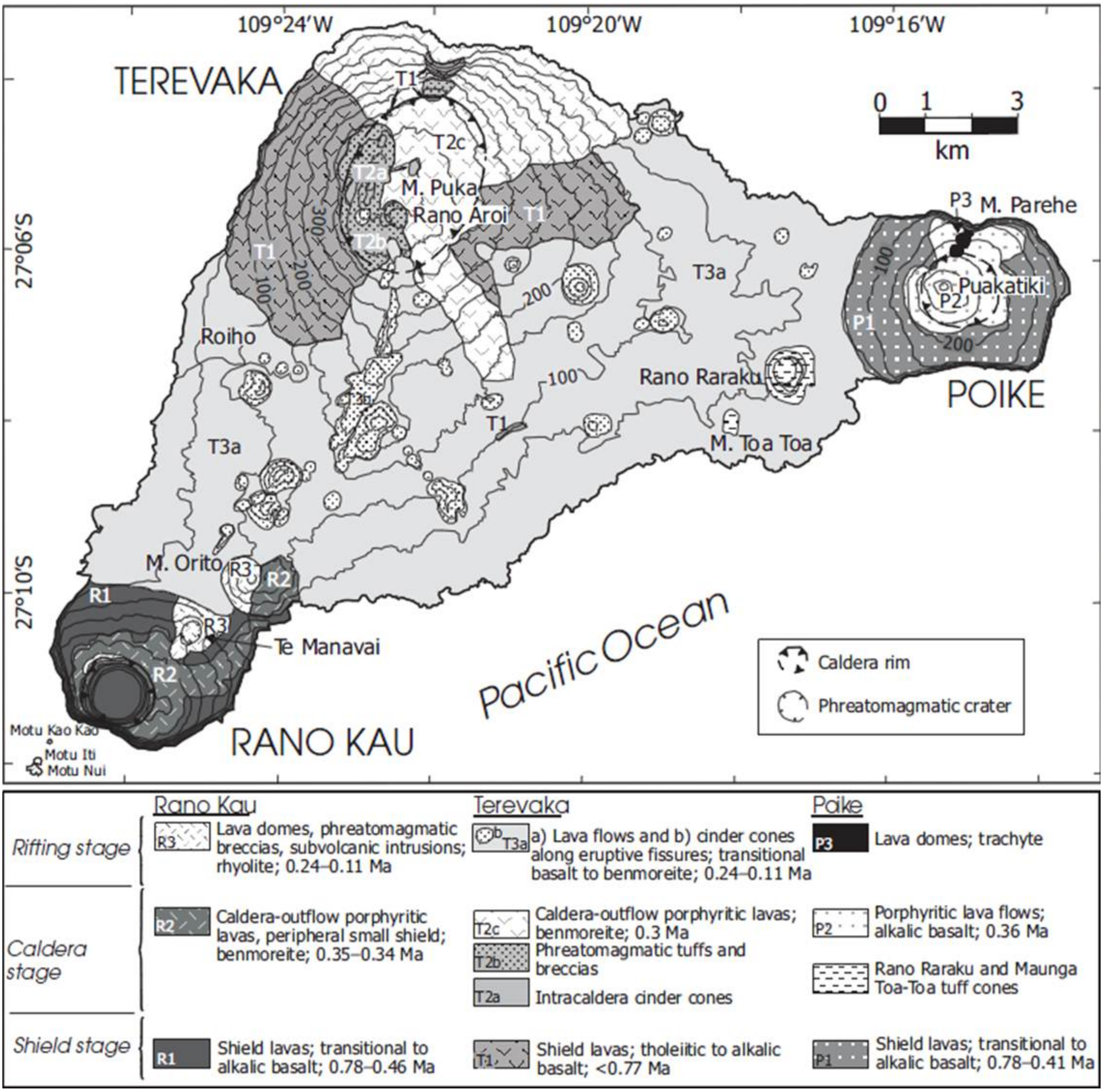

Figure 4. Volcanological evolution and geological material of Rano Kau, Poike, and Terevaka (Vezzoli and Acocella 2009:873).

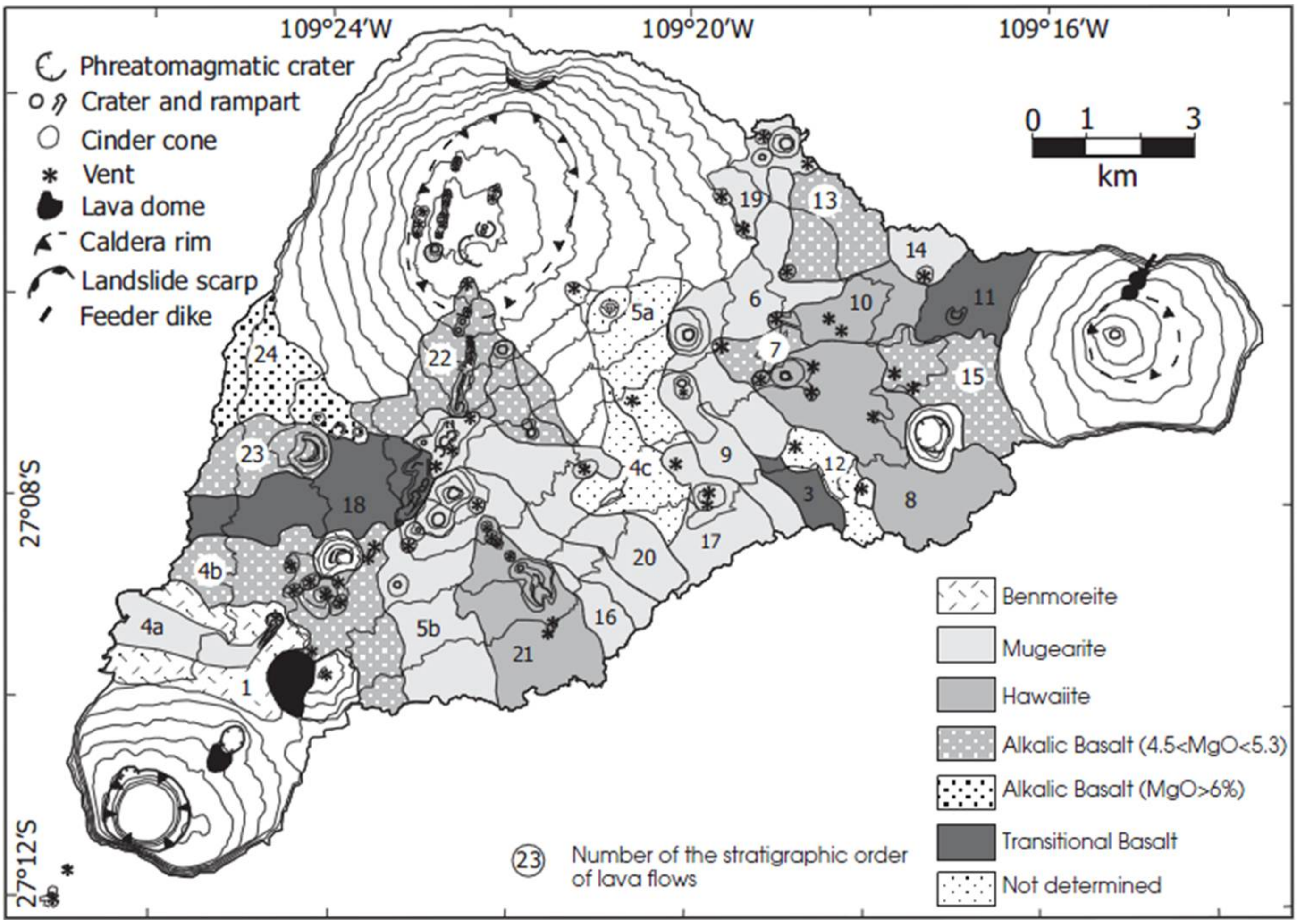

Figure 5. Rapa Nui's secondary volcanic eruptions and associated geological material (Vezzoli and Acocella 2009:879).

Figure 6. Rano Kau with Kari Kari (arrow) (photo by Simpson).

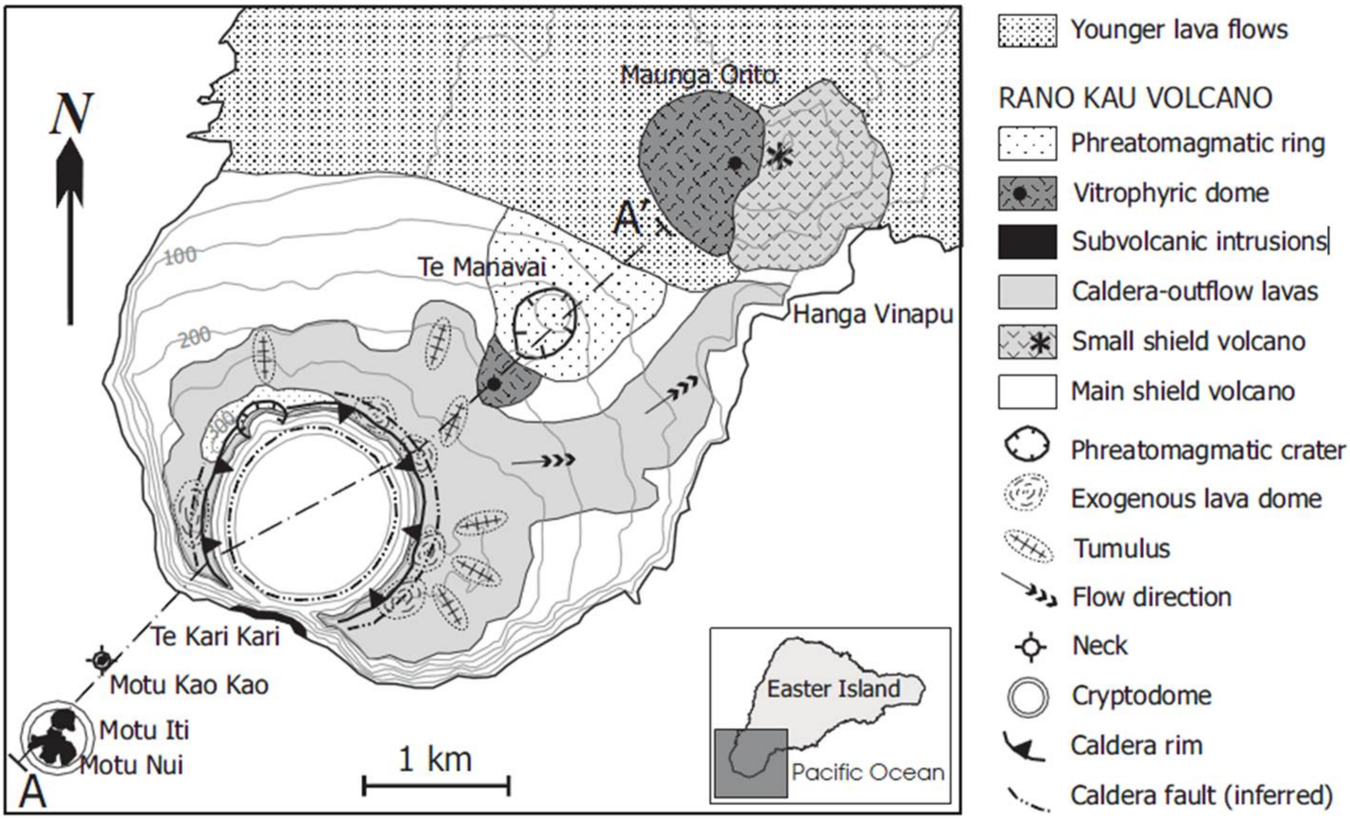

Figure 7. Volcanological evolution of Rano Kau (Vezzoli and Acocella 2009:876).

Figure 8. Motu Kao Kao (closest), Motu Iti (middle), and Motu Nui (farthest) (photo by Simpson)

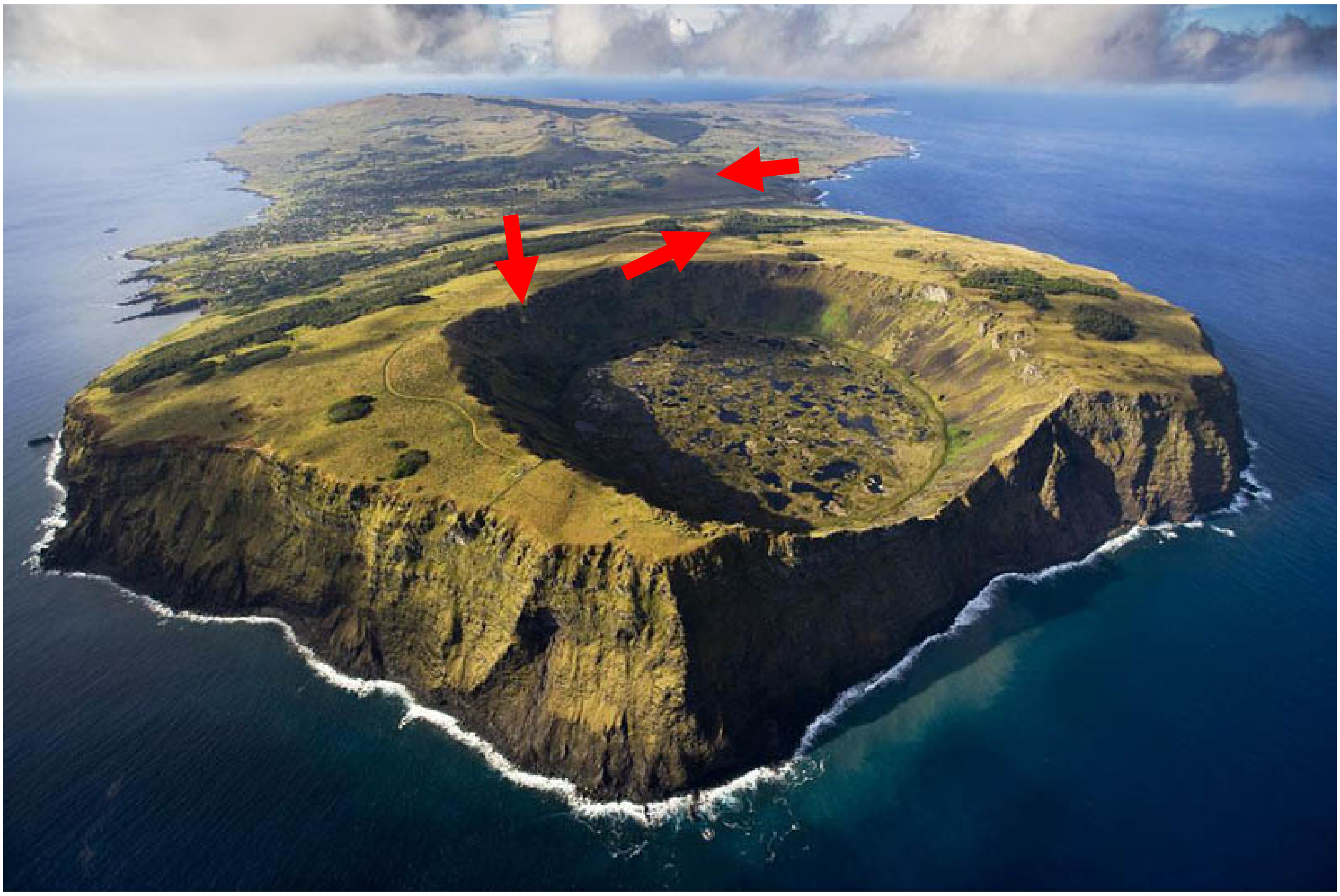

Figure 9. Phreatomagmatic crater of Rano Kau (left arrow), Te Manavai (middle arrow), and Orito (right arrow) (photo by Bertrand).

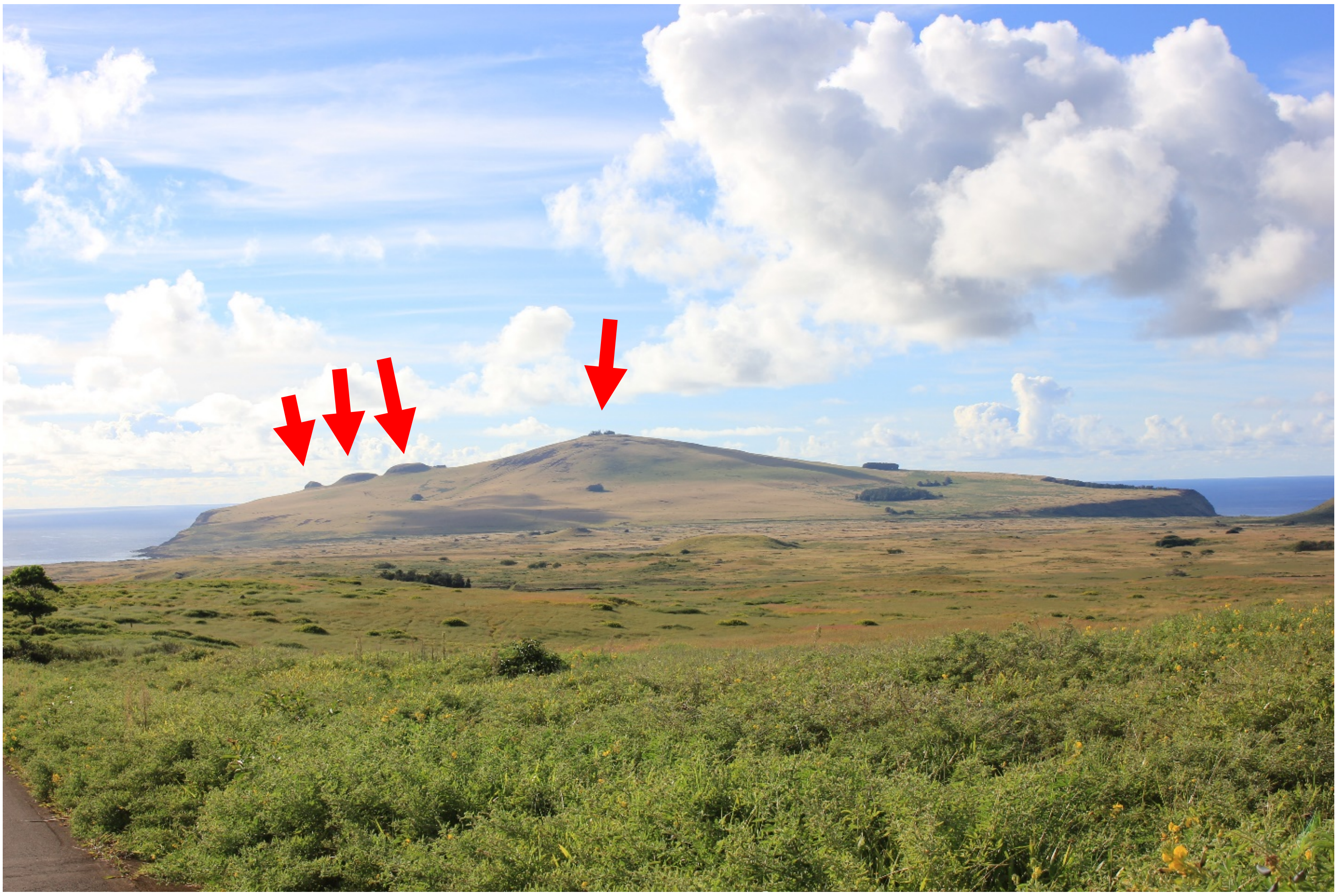

Figure 10. Poike with Maunga Parehe (first left arrow), Maunga Tea Tea (second left arrow), Maunga Vai a Heva (third left arrow), and Puakatiki summit lava cone (right arrow) (photo by Simpson).

Figure 11. Poike with Puakatiki summit cone (left arrow), Motu Marotiri (centre arrow), and Ahu Tongariki (right arrow) (photo by Simpson).

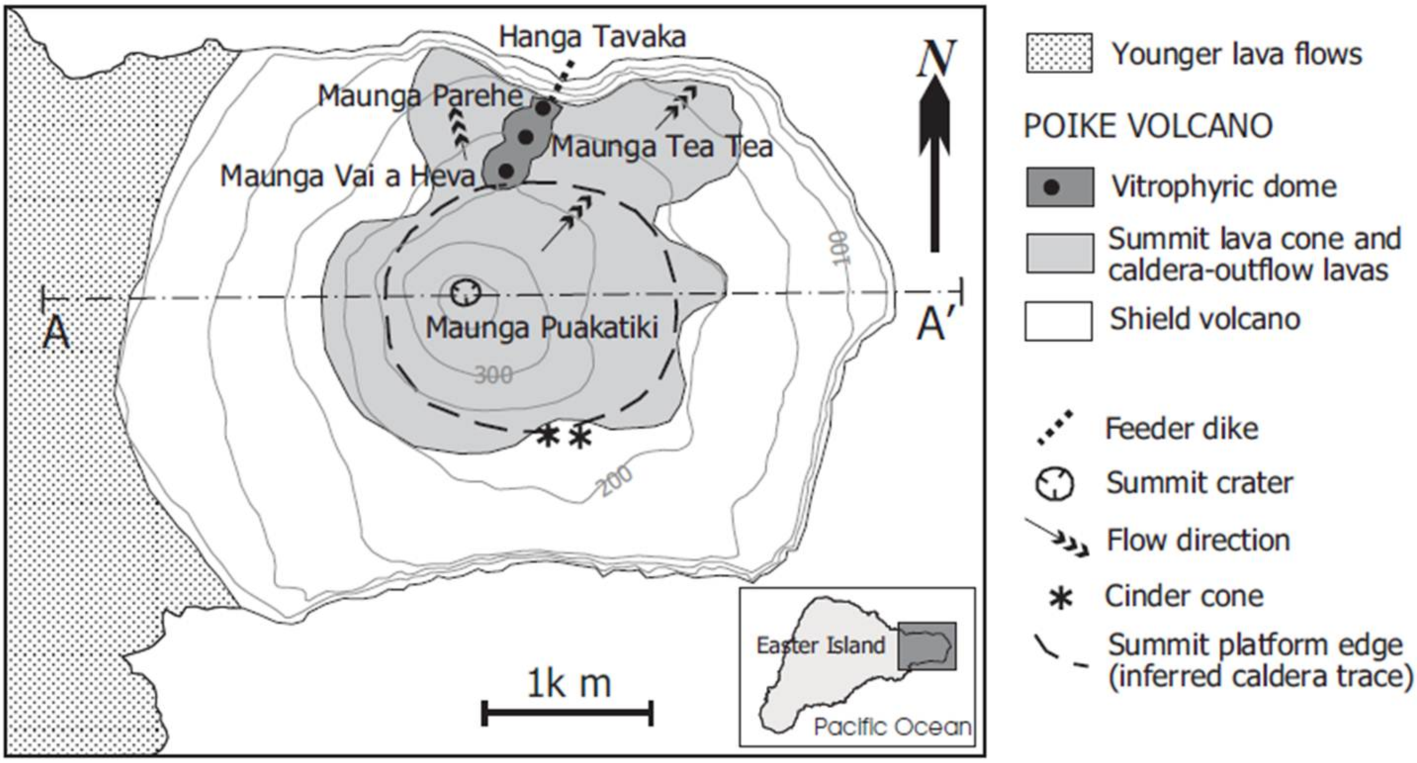

Figure 12. Volcanological evolution of Poike (Vezzoli and Acocella 2009:877).

Figure 13. Terevaka with Rano Aroi (arrow) (photo by Simpson).

Figure 14. Terevaka (right arrow) with Rano Kau (left arrow) (photo by Simpson).

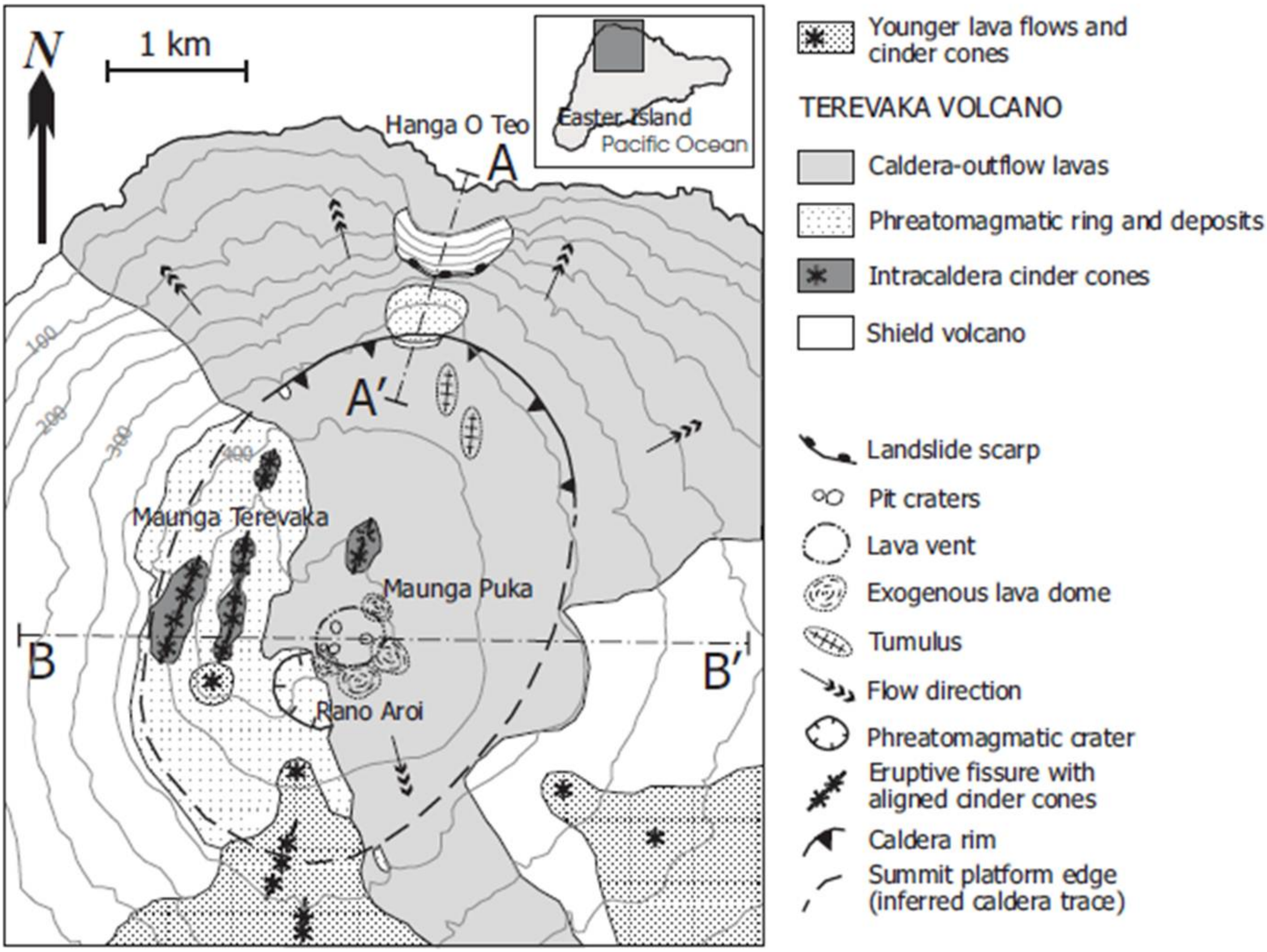

Figure 15. Volcanological evolution of Terevaka (Vezzoli and Acocella 2009:878).

Figure 16. Hanga O Teo (photo by Simpson).

Figure 17. Rano Aroi filled with *nga'atu* (totora – *Schoenoplectus californicus*) (Photo by Simpson).

Figure 18. Viewing Tangaroa, Hiva Hiva, and Roiho districts (arrow) with Rano Kau in the background (photo by Simpson).

Figure 19. Ana Tapairu with retention wall (photo by Simpson).

Figure 20. Ana Aharo with water retention (photo by Simpson).

Figure 21. Rano Raraku in foreground with Rano Kau to the left (photo by Simpson).

Figure 22. Toa Toa in foreground with Rano Kau in the background (photo by Simpson).

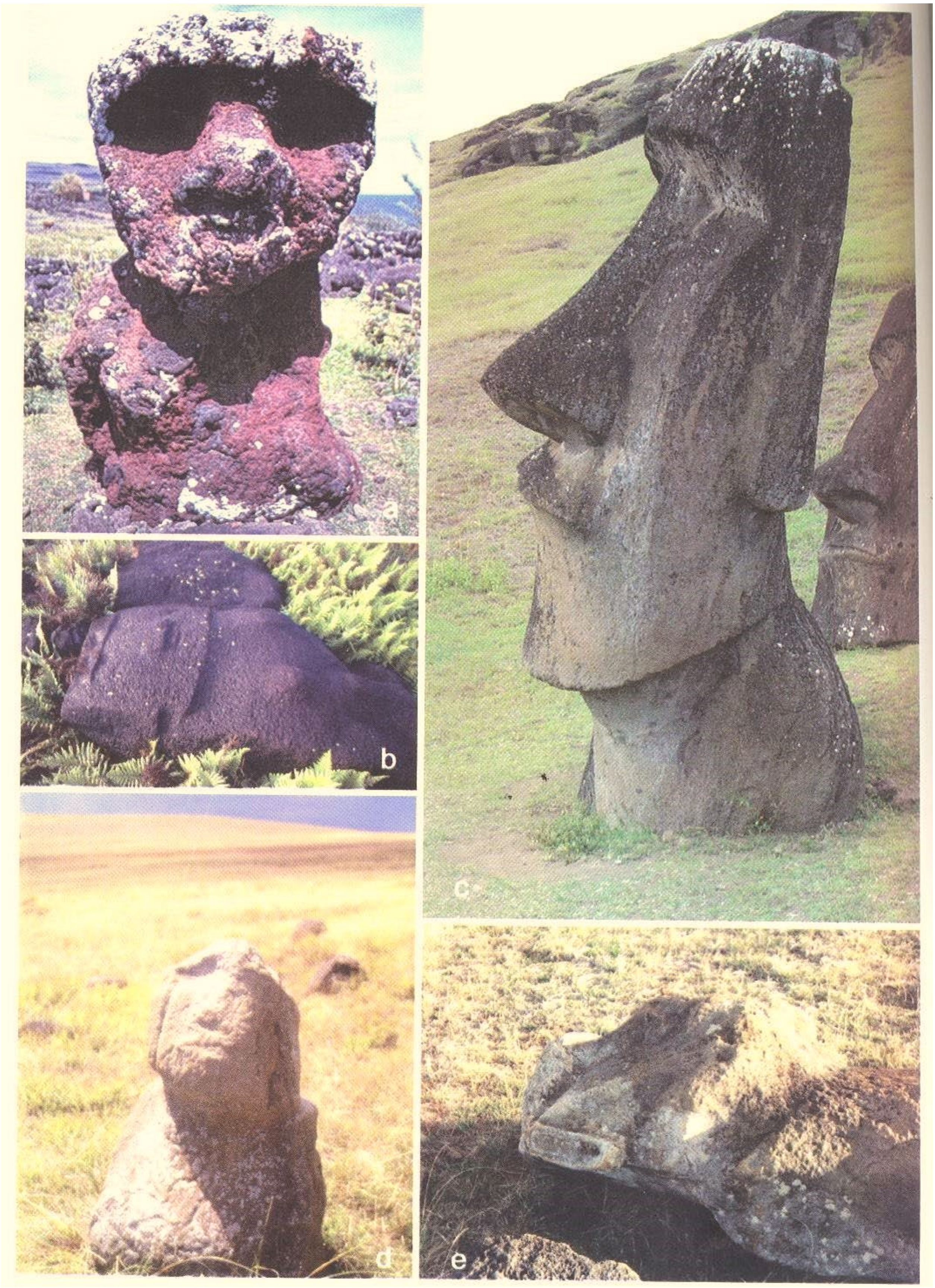

Figure 23. *Moai* made from multiple types of Rapa Nui stone: (a) scoria; (b) basalt; (c) toba; (d–e) trachyte (Vargas et al. 2006:166)

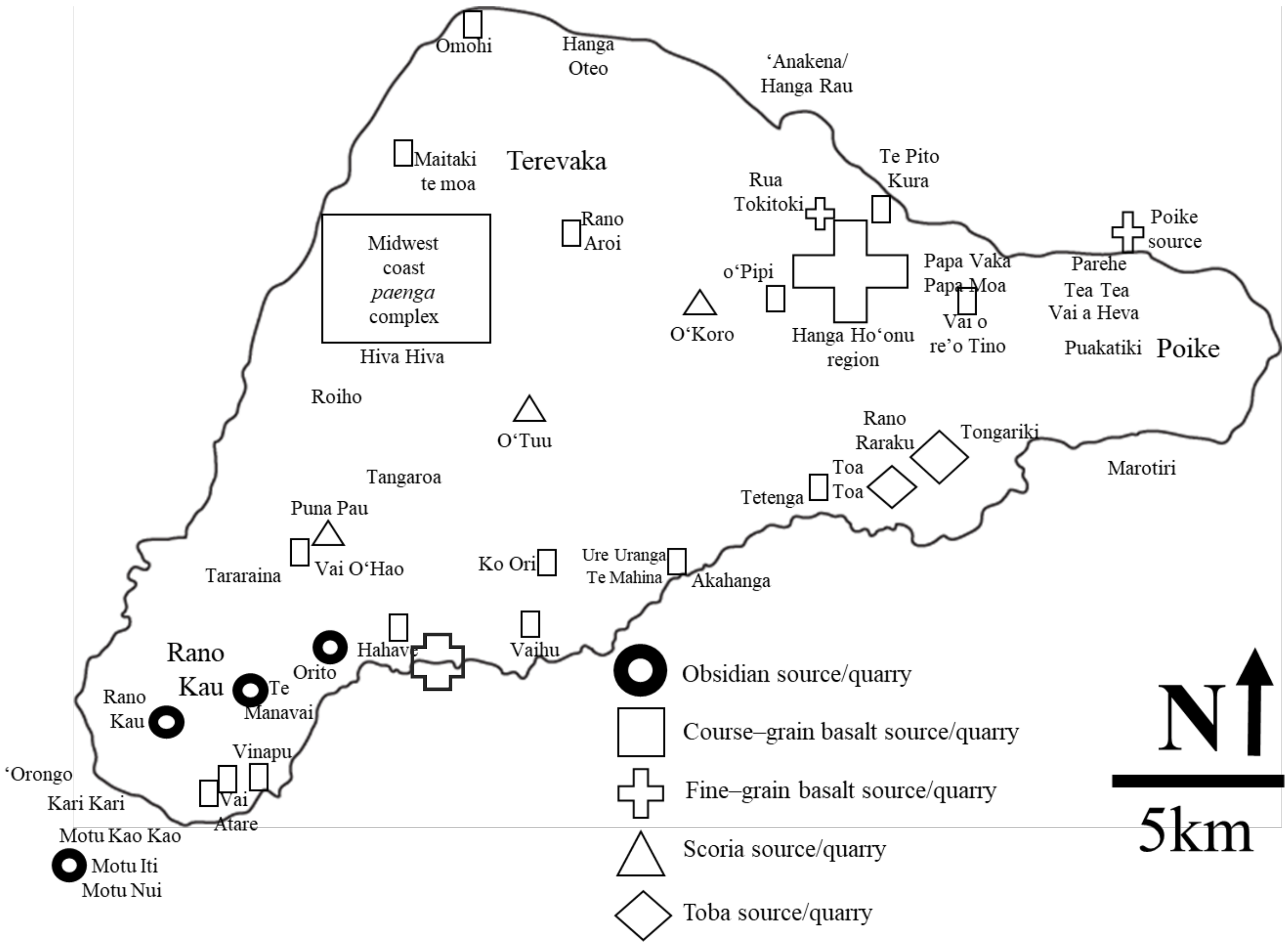

Figure 24. Documented stone sources and quarries and their geographic locations on Rapa Nui.

Figure 25. *Papa* with petroglyphs at Papa Vaka Papa Moa (photo by Simpson).

Figure 26. Worked *puku* with multiple extraction areas (photo by Simpson).

Figure 27. Rua Tokitoki adze quarry (photo by Simpson).

Figure 28. *Pukao* quarry at Puna Pau (photo by Simpson).

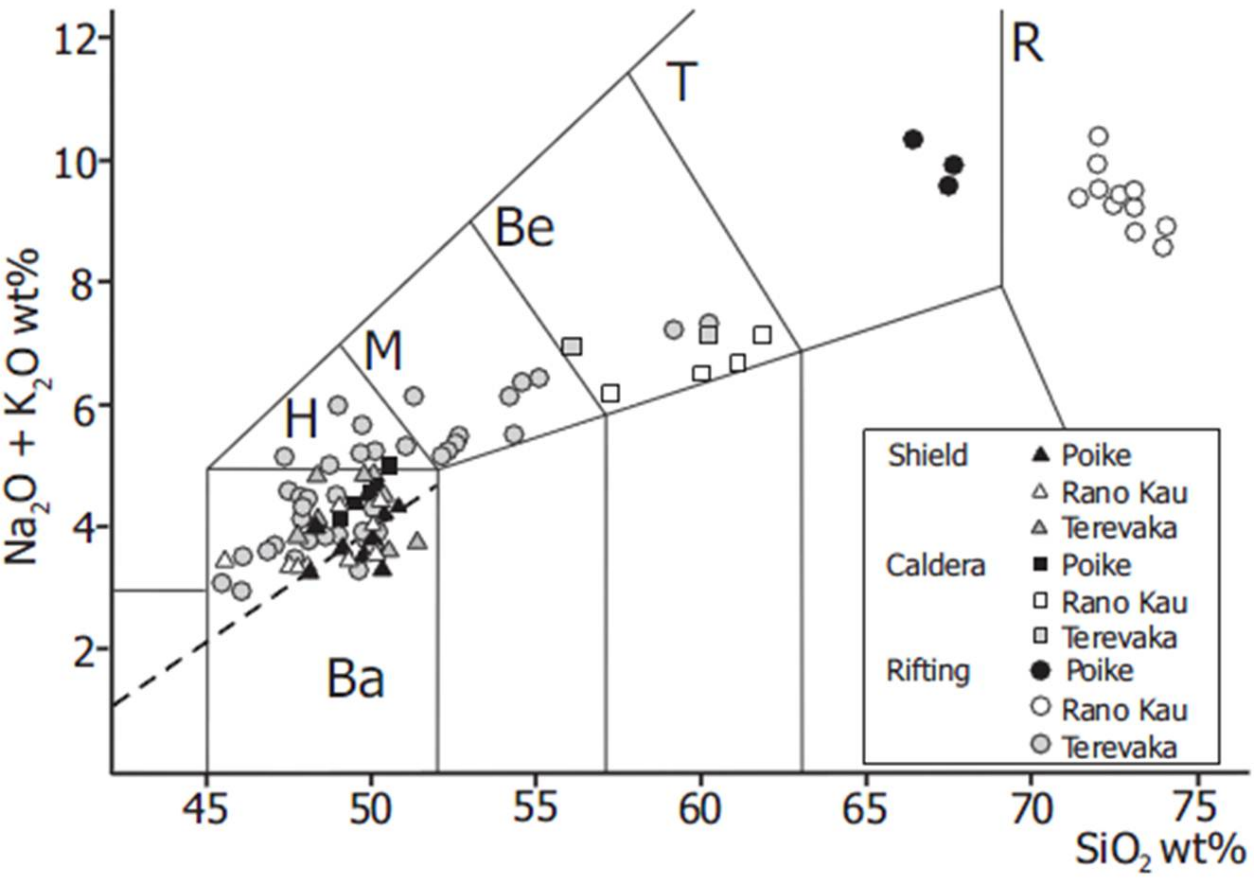

Figure 29. TAS diagram dividing shield, caldera–related, and fissure volcanic lava (Ba–Basalt; H–Hawaiite; M–Mugearite; Be–Benmoreite; T–Trachyte; R–Ryolite). The dashed line is the boundary separating tholeiitic and alkalic basalt (Vezzoli and Acocella 2009:871; see also Gonzalez–Ferran et al. 2004).

Stone Type	**Location**	**Ancient Use**
Basalt (undifferentiated)	Widespread: Terevaka, Rohio, Vaitea, coastal areas around Poike, Rano Kau, and Maunga Tararaina	*Ahu*, *moai*, *hare moa*, *paenga*, *pae*, *ana kionga*, *tupa*, structures (i.e. dwellings, tombs, walled reservoirs and channels for water), *manavai* (gardens), rock mulched (*kirikiri*) gardens, and *taheta* (water collectors/sharpeners).
Hawaiite and Intermediate Lava (mugearite and benmoreite)	Rano Kau, Orito, southwest coast, Rano Aroi, Ovahe, and La Pérouse	*Keho* roofs at Orongo, *ahu*, *toki*, *hoe*, *mangai mā'ea*, sharpeners, and *ngaru'a* or *turua* (stone pillows made from beach stones [*poro*]).
Trachyte	Poike	*Moai*, finely chiseled portable carvings, and Vai a Heva (carved feature found at Poike).
Rhyolite	Orito, Motu Iti, and Rano Kau	Obsidian tools: *mata'a* (stemmed bifaced), *hoe*, *toki*, *moai* eyes, scrapers, drills, and vegetable peelers.
Pyroclastic Tuff	Rano Raraku and Toa Toa	*Moai* and *toki* (pyroclastic).
Red Scoria	Puna Pau and Rohio area	*Pukao*, *paenga*, *moai*, *moai* eyes, *ahu* facia blocks, crematoria, and *ahu* fill, and funerary cists.

Table 1. Rapa Nui stone types, locations, and usage.

Reference	Lithic Type	Geological samples (n)	Archaeological samples (n)	Analytical technology
Baker et al. 1974	All types	n/a	n/a	Gravimetric; Atomic absorption; Flame photometry; XRF
Bird 1988	Obsidian	50	n/a	PIXE–PIGME
Baker 1993	All types	n/a	n/a	Microscopic; XRF
Beardsley et al. 1996	Obsidian	46	39	INAA
Ayres et al. 1998	Basalt	10	87	Micro– Macroscopic
Cristino et al. 1999	Obsidian	n/a	567	INAA; EDXRF
Stevenson et al. 2000	Basalt	75	n/a	INAA
Thomas et al. 2007	Obsidian	n/a	50 *mata'a*	TOF–LA–ICP–MS
Harper 2008	Basalt	130	18 *ahu* stone/*toki*	TOF–LA–ICP–MS
Van Tilburg et al. 2008	Tuff	39	2	Microscopic
Gioncada et al. 2010	Tuff	62	n/a	Microscopic; Macroscopic; XRF
Fischer and Bahamondez 2011	Basalt	n/a	170	pXRF
Hamilton et al. 2011	n/a	0	0	Visual proximity
Morrison & Dudgeon 2012	Obsidian	n/a	n/a	TOF–LA–ICP–MS
Stevenson et al. 2013	Obsidian	126	331	EDXRF
Mulrooney et al. 2014	Obsidian	115	332	pXRF
Mulrooney et al. 2015	Obsidian	115	1	pXRF

Table 2. Geoarchaeological analysis that has produced geochemical data.

CHAPTER 4: Archaeological documentation and geochemistry of the Rua Tokitoki adze quarry and the Poike fine–grain basalt source on Rapa Nui (Easter Island)

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Dale F. Simpson Jr., Marshall I. Weisler, and Emma J. St. Pierre
School of Social Science, The University of Queensland, St Lucia, Qld 4072 Australia.

Yuexing Feng
School of Earth Science, The University of Queensland, St Lucia, Qld 4072 Australia.

Robert Bolhar
School of Geoscience, The University of Witwatersrand, Johannesburg, South Africa.

Corresponding author: Dale F. Simpson Jr.
School of Social Science, The University of Queensland, St Lucia, Qld 4072 Australia.
Department of Anthropology, College of DuPage, Glen Ellyn, IL. U.S.A.
dfsj381@gmail.com

Archaeological documentation and geochemistry of the Rua Tokitoki adze quarry and the Poike fine–grain basalt source on Rapa Nui (Easter Island)

Abstract: Rapa Nui is famous for its *moai* (statues) and *ahu* (platforms), yet research into the island's many basalt quarries, sources, and workshops is limited. These geological and archaeological sites provided the raw materials for tools such as *toki* (adzes and picks), which facilitated the manufacture of Easter Island's iconic stonework. Other basalt tools such as *hoe* (knives), *ohio* (axes), and *mangai mā'ea* (stone fishhooks) served for resource acquisition and subsistence practices. However, little is known about the sources of these artefacts, the sequences of their manufacture, and their geochemical compositions. In this chapter, we provide archaeological site descriptions and geochemistry of source material from the Rua Tokitoki quarry and a fine–grain basalt locality on Poike. This information contributes towards an understanding of pre–contact quarrying, economic, ideological, and sociopolitical interaction, and elite oversight over valuable stone resources on this isolated East Polynesian outpost.

Keywords: basalt quarries, sources and workshops, elite political economy, geochemistry, ICP–MS, Polynesia, Rapa Nui (Easter Island)

Introduction

Throughout Polynesia, geochemical characterisation of quarry and source material linked to distant artefacts has been useful for reconstructing colonisation routes and spheres of interaction (Allen 2014; Allen and McAlister 2013; Ayres et al. 1998; Best et al. 1992; Clark et al. 2014; Collerson and Weisler 2007; Hermann et al. 2017; Rolett et al. 2015; Weisler 1998; Weisler [ed.] 1997; Weisler and Kirch 1996; Weisler and Walter 2017; Weisler et al. 2016a). On Rapa Nui (Figure 1), researchers have focused on geochemical analyses of the island's obsidian sources, artefacts, and debitage to better understand patterns of acquisition, control, distribution, and use (Baker et al. 1974; Beardsley and Goles 1998, 2001; Beardsley et al. 1996; Bird 1988; Cristino et al. 1999; Morrison and Dudgeon 2012; Mulrooney et al. 2014, 2015; Stevenson 2000; Stevenson et al. 1984, 2013; Thomas 2009). Fewer studies, however, have addressed the provenance and use of basalt, tuff, and scoria (Simpson 2014a; Simpson et al. 2017). In fact, up to this doctoral thesis, only three studies had focused on the geochemical analysis of the island's fine–grain archaeological basalts (Fischer and Bahamondez 2011; Harper 2008; Stevenson et al. 2000). Consequently, this lack of comprehensive geochemistry for non–obsidian stone sources has restricted the potential of Rapa Nui interaction studies, as investigators have reported multiple basalt sources, quarries, and workshops throughout the island (Table 1; Chapter 3, Figure 24). These basalt quarries, sources, and workshops provided the raw material for artefacts such as adzes, knives, axes and fishhooks, and for construction stone including *keho* (flat basaltic laminates), *pae* (non–dressed basaltic blocks), and *paenga* (dressed stone) (Table 2).

In this chapter, the *toki* quarry Rua Tokitoki and a fine–grain basalt source on Poike (Figure 1) are described to provide new information about basalt quarrying processes. Quarry and source geochemistry is reported including a comprehensive array of 10 fully quantitative major element concentrations, 43 trace element abundances, and high–precision strontium, neodymium, and lead (Sr–Nd–Pb) isotopic ratios obtained using Multi–Collector Inductively Coupled Plasma Mass Spectrometry (MC–ICP–MS, for Sr–Nd–Pb isotopes), quadrupole ICP–MS (for trace elements), and Inductively Coupled Plasma Optical Emission Spectrometry (ICP–OES, for major elements). Together, this geochemical data is useful to identify TAS (total alkali versus silica) rock types, to confirm the differences in petrogenesis between these types, and to identify isotopically different mantle sources for geoarchaeological samples under study. Lastly, using archaeological site data and inference from political economy theory, it is argued that monumental architecture found in proximity to the Poike source represents attempts by chiefly and elite Rapanui to control patchy, but valuable fine–grain basalt resources used to make adzes, knives, and fishhooks (Simpson et al. 2017).

Brief description of research design and geoarchaeological data set

Before archaeological fieldwork was conducted for this thesis, a collection of basalt samples from Rapa Nui was available for review and geochemical analysis. Held by the University of Queensland's (UQ) Archaeology Program (Weisler), this assemblage was collected by Roger Green in 1996. While he gathered 16 basalt samples from two distinct quarries on the island, he did not report geological collection protocol or site descriptions. Twelve specimens were selected at Rua Tokitoki from two separate extraction pits to determine the geochemical variability between pits, and to provide basic elemental data for the quarry. Four samples were selected from the *keho* (flat basaltic laminate) source near Ahu Kiri Reva on Poike, which Green believed was the stone used for making fishhooks. To evaluate the elemental variability of basalt between and within the two distinct locations, laboratories in the School of Earth and Environmental Sciences at UQ (St. Lucia) conducted a pilot analysis (Simpson et al. 2017). However, it is important to note, that later geochemical data generated by this thesis were produced at a different laboratory, namely, the Elemental Analysis Facility (EAF) at the Field Museum of Natural History (Chicago) (Simpson and Dussubieux 2018; Simpson et al. 2018). Using different analytical techniques for elemental analyses from different laboratories provides both issues and unique opportunities for this thesis. Issues include: 1) having different staff and personal between laboratories who were tasked with different responsibilities; 2) using different analytical protocols, samples, and blanks between laboratories; and 3) generating different datasets with UQ's labs producing isotopic, major, and trace elemental data, and the EAF producing only major and trace elemental data. However, an opportunity presents itself in the ability to examine the analytical accuracy and precision between different techniques; in this case, MC–ICP–MS, quadrupole ICP–MS, and ICP–OES used at UQ versus LA–ICP–MS (laser ablation inductively coupled plasma–mass spectrometry) used at the EAF (see Chapter Six).

Figure 1 notes the locations of Rua Tokitoki and the Poike source. Geologically speaking, the stone found around Rua Tokitoki is not associated to shield or caldera stage volcanic activity, but instead, the rifting activity of Terevaka (Chapter Three, Figure 4). Originating between 0.24–0.11 Ma (Vezzoli and Acocella 2009), the eruptions of Maunga o'Pipi created tumulus, or uplifted sections of *pahoehoe* lava crust which became deposits of hawaitte (Baker 1993, 1998). This is caused by the pressure from still fluid lava accumulating beneath hardening crust. Tumulus flows extend northeast from Maunga o'Pipi to the coast, ending between Te Emu O Hae and Hanga Ho'onu (Gonzalez–Ferran et al. 2004; Vezzoli and Acocella 2009; Figure 1). In their 2004 geological survey of Rapa Nui, Gonzalez–Ferran et al. label this flow RA6, noting that it is composed of olivine–poor mesocratic toleite and mugearite. Later investigation by Vezzoli and Acocella (2009:879; Chapter Three, Figure 5:13) noted the area consisted of alkalic basalt ranging between $4.5<MgO<5.3$.

The Poike source, according to Gonzalez–Ferran et al. (2004), is located within the juxtaposition of shield (PO1) and caldera stage volcanic activity (PO4), but is not related to the vitrophyric dome development of Maunga Parehe (TR) (Chapter 3, Figure 12). PO1 activity included some 60 flows which formed Poike's base and produced geological rock types such as alkalic and olivine basalts, hawaitte, and mugearite. Later PO4 flows, outward from Puakatiki, produced stone types such as olivine and toleite basalts. Using TAS (total alkali [$Na_2O + K_2O$] versus silica [SiO_2]) analysis, it should be possible to assign a geological provenance (PO1 and/or PO4) to the three samples from Poike.

Archaeological documentation of Rua Tokitoki and the Poike source

From 2014–2018, the lead author with many members of the Rapa Nui community, conducted four seasons of field research focusing on geological basalt deposits and artefactual material curated at the Father Sebastián Englert Anthropology Museum (MAPSE) (Simpson 2015c, 2016b; Simpson et al. 2017). While a total of 84 mines, quarries, sources, and workshops were documented within six study areas of the island (Simpson 2015a, b, c, 2016a, 2017, 2018a, b; Simpson and Dussubieux 2018; Simpson et al. 2018; Appendix B), additional attention was paid to Rua Tokitoki and the fine–grade basalt Poike source found north, and ~40m below, Ahu Kiri Reva (Figure 1).

Rua Tokitoki (*GPS WGS84 27.05.273S –109.18.860W*)

Located ~2km south of the Pekapeka camping area and 100m east of the north–south trending eucalyptus stand, Rua Tokitoki exhibits evidence for basalt stone tool manufacture. While archaeologically investigated (Ayres et al. 1998; Harper 2008; Simpson 2015b; Stevenson and Haoa 2008; Stevenson et al. 2000), little has been published about the quarry. Métraux (1940) believed it was a central quarry for adze production, while Ayres et al. (1998) reported that: 1) the site covers an area of approximately $0.4km^2$ and ranges in elevation to 60–75m a.s.l.; 2) Rua Tokitoki was possibly used to produce thousands of stone adzes and other artefacts; 3) the site was most likely used throughout the ancient period; 4) material from Rua Tokitoki was exchanged with other *mata* (clans) on the island, especially at group and/or kin–based sociopolitical levels; and 5) microscopic thin sections for Rua Tokitoki reveal slightly oriented plagioclase along with rare augite. Larger plagioclase crystals and rare olivine are also present. Stevenson et al. (2000:68) provide a physical description of the quarrying landscape around Rua Tokitoki:

"[c]oarse, but slightly better grade of basalt was present just below the surface. The surface outcrops [*puku*] of basalt tend to be vesicular as the result of small air bubbles in the matrix that developed during the release of volatiles in the lava as the pressure and temperature were lowered. However, just below the surface by about a meter, the quantity of vesicles decreases markedly forming basalt that is free from flaws, thereby possibly improving the knapping qualities and durability of the stone. This preferred material was most easily acquired at the margins of the elevated and exposed flows which are numerous within the Le Pérouse [Hanga Ho'onu]".

An outcrop and two archaeological features occur at Rua Tokitoki (Figure 2). The outcrop provides high quality stone (Figure 3). The archaeological features are stone pit–mines or repositories (called *pu* in Rapanui) and lithic reduction areas where boulders, cores, and dense debitage are located. However, complete *toki* and tool forms are not frequently present. To the south of the pits and workshop areas is an exposed outcrop (called *puku* in Rapanui) that measures 22m (N–S) by 4m (E–W). The stone from this flow is grey (Munsell colour 5YR 5/1 in the shade) and displays little to no mineral inclusions, depending on individual samples. It appears that the removal of stratigraphically younger flows of vesicular basalt and the cleaving and removal of boulders were the first steps in the lithic reduction sequence (Simpson 2015c, 2016b; Simpson and Dussubieux 2018; Simpson et al. 2018; Stevenson *et al.* 2000). Like *paenga* quarrying (Hamilton et al. 2011; McCoy 2014), angular wedges could have functioned to open and maintain space between holes and fractures found in the flow, while picks, hammer stones, and other boulders were used to remove workable nodules. It appears that knapping was not done near the outcrop, judging from the lack of worked cores and debitage around the source. This highlights that extracted boulders were moved from the exposed outcrop to Rua Tokitoki's pits, some 10m to the north for further reduction, highlighting a second portion of the operational sequence of basalt tool manufacture.

In total, the two storage pits and workshops at Rua Tokitoki measure 18.2m (E–W) by 14.2m (N–S). A small path divides the two areas. Comparing the local topography around the pits, they are found 2–3m lower in elevation, with total pit depth not exceeding 55cm, demonstrating how this area was quarried extensively. On the southern entrance to the two pits is a large flaked boulder (73cm maximum dimension) with associated debitage (Figure 4). The western pit measures 13.3m (N–S) by 10m (E–W) and is nearly 55cm deep. It is filled with more than 50 boulders with the largest measuring 90cm in maximum dimension. Many cobbles in the western pit exhibit evidence of large flake removal for future reduction. Around the rim of the western pit are debitage numbering in the hundreds to thousands (Figure 5). Many of these pieces show evidence of cortex removal. The eastern *pu* measures 14.2m (N–S) by 7.5m (E–W) and is 45cm deep. It contains *pae*, flaked boulders, and debitage. Areas around Rua Tokitoki were also used for gardening as mulched soils and planting surfaces (Baer et al. 2008) are located metres away from the pits. This pattern for horticultural production has been found throughout the La Pérouse area (Stevenson and Haoa 1998, 2008). The area around Rua Tokitoki does not present evidence for domestic activities (Stevenson and Haoa 2008; Simpson 2015b), nor an elite presence due to the lack of *ahu* and/or elite homes. This led Stevenson et al. (2000:68) to conclude:

"[a]n elite, or managerial, presence is often found in association with agricultural field system and suggests that the maintenance of agricultural productivity was a significant concern (Stevenson and Haoa 1998; Stevenson et al. 1999). However, [at Rua Tokitoki,] we find no such association, which implies that elite involvement, at least in the extraction process, was minimal".

Poike source (*GPS WGS84 27.05.652S–109.14.873W*)

A reconnaissance of Poike in 2014, especially below Ahu Kiri Reva (Figures 6–7), revealed a source of *keho*, which was extensively quarried, but not previously documented. While Ahu Kiri Reva was named by Routledge (1919) and described by Englert (1948), an excavation of the multi–tier platform was undertaken by Cauwe *et al.* (2010). In their report, the authors name the Poike *ahu* as Motu Toremo Hiva. However, careful historic and ethnolinguistic review finds this name to be an invention, and not supported by local Rapanui scholars (Moreno–Pakarati personal communication 2018). Further toponymic review of the Poike area finds a location named Te Toki to the west (Gonzalez–Ferran et al. 2004). Roughly translated to "of the *toki*", this name may represent a clue as to which types of tools were made from the Poike source, namely adzes.

The archaeological work by Cauwe et al. (2010) uncovered three construction events between 150±20 to 675±25 calBP. These events included the elaborate use, reuse, and recycling of many features including platforms, wings, ramps, *paenga*, *pae*, *poro*, and one *moai*. While the authors described the formation, use, and re–use of Ahu Kiri Reva, one important omission was the amount of *keho* stone found on the seaward side of the platform. This stone is durable, thin, and therefore conducive to manufacture *hoe* (knife) and *mangai mā'ea* (stone fishhook). Even though there are no observable *keho* quarries and/or sources at the 170m altitude of Ahu Kiri Reva, there is a surface scatter (or eroded fill from the *ahu*) trending downslope to the north for 10m, with pieces measuring 5–15cm in length. Descending further to about 130–140m a.s.l., a very steep pathway leads to a vein of *keho* stone. Outwards from this vein, and completely facing the ocean, is a 3m tall and 2m wide outcrop which contains high quality brown stone (Munsell colour 5YR 5/6 in the shade; Figure 8). This extensively quarried cliff is situated on a precarious ledge overlooking the ocean, where workers excavated the outcrops of the laminated *keho* stone. Due to the difficulty in reaching the source from the path, it may be that ropes and baskets were used to facilitate access, to mine material at the cliff face, and to raise quarried *keho* topside. But, ropes and baskets might have also been used to lower extracted stone to awaiting ocean canoes. This pattern would been akin to obsidian quarrying and procurement at Motu Iti, where canoes gathered and transferred stone materials to elite *moai–ahu* complexes throughout the island (Stevenson et al. 2013). In addition, similar to the distribution of a single *ahu* demarking the major obsidian deposits at Orito and Motu Iti, we contend that the close proximity between Ahu Kiri Reva and the Poike source (~40m) represents a purposeful attempt by Rapanui elite, including *tangata honui* who belonged to this *ahu* (Simpson 2008, 2009), to supervise access to this source (Simpson et al. 2017). As the location of the *ahu–moai* physically blocks the topside trail down to the source, any person trying to access this location would have required the proper rank/approval to pass by the sacred *ahu,* its deceased ancestor (*moai*), and most importantly, the living chiefs and elite retainers of Ahu Kiri Reva. This included *tangata honui* and possibly *tangata māori anga mā'ea*, who were expert stone tool makers. Furthermore, there are many large trachyte *pae* blocks within the *ahu*. As few *ahu* on Rapa Nui exhibit trachyte in their construction, the location of Ahu Kiri Reva may also represent an attempt to link the sacred *ahu* to the volcanic domes of Maunga Parehe, Maunga Vai a Heva, and Maunga Tea Tea (Chapter 3, Figure 12) and their sources of trachyte, further legitimising elite claim and control over desirable stone resources in the area (see Chapters Six and Seven).

Methods

From the 16 fine–grain basalt samples curated at UQ, ten were selected for the analyses of oxides, trace elements, and isotopes (Sr–Nd–Pb). Trace elements and isotopes were analysed at UQ's Radiogenic Isotope Facility (RIF), School of Earth and Environmental Sciences (SEES), while major elements were analysed in the Environmental Geochemistry Laboratory, SEES. Instrumentation, settings, and analytical procedures for trace elements and Sr isotope analyses are described in Collerson and Weisler (2007), but have been improved since to analyse smaller samples (Simpson et al. 2017; Weisler et al. 2013, 2016b). Nd and Pb isotopic ratio analyses followed methodology pioneered at UQ's RIF (Ma et al. 2011), using only 10mg of sample rock powder for ICP–OES and ICP–MS digestion. Reference standard material from US Geological Survey (USGS) BHVO–2 (basalt, Hawaiian Volcanic Observatory) was used for quality control and calibration. A diamond saw blade cut small pieces (~2cm^3) from the samples. Cut surfaces removed cortex to ensure only clean, unaltered material was analysed. Samples were manually crushed with a hardened steel mortar and pestle into 1–2mm chips, which were washed 3 times with milli–Q H_2O in an ultrasonic bath for 10 minutes and dried at 60°C. Subsamples of these chips were manually ground into a fine powder with an agate mortar and pestle for geochemical analyses. Major element concentrations were measured on a Perkin Elmer Optima 3300DV ICP–OES. Instrumental drift was monitored by introducing a known amount of internal standard (Lu, Sc, Y) with the samples, and for internal quality control, a monitor solution was re–analysed after every six samples to check the drift. Trace element abundances were measured on a Thermo X Series II quadrupole ICP–MS. Analytical procedures were modified from Eggins et al. (1997) and follow those outlined in Kamber et al. (2003). Isotopes were measured by using ion–exchange column chemistry techniques to separate strontium, neodymium, and lead from other elements. These techniques were modified from those outlined in Pin and Zaldueguil (1997), Deniel and Pin (2001), and Míková and Denková (2007). Pre–screening of Sr, Nd, and Pb concentrations were undertaken on the Thermo X Series II quadrupole ICP–MS to ensure proper concentrations of sample solutions for optimum data acquisition. Nd, Sr, and Pb isotope ratios were measured on a Nu Plasma HR MC–ICP–MS with DSN–100 nebulising system and a modified CETAC ASX–110FR autosampler. Instrument drift was monitored and corrected with standard–sample bracket technique. Nd isotopes were measured using a three–cycle dynamic procedure.

Results

The major element values are listed in Table 3. Figure 9 is a bivariate plot of total alkali versus silica (TAS) – sodium oxide (Na_2O) plus potassium oxide (K_2O) against silica oxide (SiO_2) – which is widely used to classify volcanic rocks (Cox et al. 1979; Le Maitre et al. 2002). It illustrates that the Rua Tokitoki quarry consists predominately of trachybasalt (hawaiite), except for sample number 584, while the Poike stone is (basaltic) trachyandesite with ~10% more silica oxide.

The trace element values are listed in Table 4, along with data for the reference material BHVO–2. Figure 10A plots chondrite–normalised REE while Figure 10B represents primitive mantle–normalised multi–trace element patterns. In the REE diagram, rock samples from the Rua Tokitoki quarry are almost indistinguishable in terms of trace element patterns and overall concentrations. The patterns are smooth, with light REE enriched over middle and heavy REE. Such patterns indicate either derivation from mantle sources that were enriched in incompatible trace elements (light REE [LREE] are more incompatible than middle [MREE] and heavy REE [HREE]), or small degrees of partial melting in the mantle, which tends to concentrate incompatible elements in the melt fraction (e.g. Hofmann 1997). Three samples from Poike display slightly higher concentrations of both LREE and HREE when compared to the Rua Tokitoki quarry samples. A subtle negative Eu anomaly in all three samples points to fractionation by feldspar during magma differentiation. When normalised to Primitive Mantle, Rua Tokitoki quarry samples are characterised by distinct negative anomalies for Sr and Ti, diagnostic for crystal fractionation involving feldspar and Ti–oxides, and conspicuous depletion of the most highly incompatible elements Rb, Ba, Th, and U. The Poike quarry samples (585, 586, and 587) show, in principle similar, multi–element patterns, with relative depletion of Sr and Ti, as well as relative depletion of Rb, Ba, Th, and U. Concentrations are somewhat higher when compared to the Rua Tokitoki quarry samples, especially for the highly (e.g. Rb) and moderately (e.g. Zr) incompatible trace elements, which is expected given their compositionally more evolved nature.

Coherent patterns, especially the similarity in relative and absolute concentrations of the highly mobile elements Rb, Ba, and U, suggest that effects arising from aerial weathering or submarine hydrothermal alteration were negligible. Overall, the similarity in trace element patterns, including elemental anomalies (Ti, Sr), for Rua Tokitoki and the Poike source imply that mantle sources and conditions of partial melting and subsequent (shallow level) fractional crystallisation were uniform for each location. Haase et al. (1997) reported that fractional crystallisation of basaltic and trachytic rocks on Rapa Nui was largely controlled by olivine, plagioclase, clinopyroxene, apatite, Ti–oxides, and spinel.

Neodymium, strontium, and lead isotopic ratios are listed in Table 5. In the $^{207}Pb/^{204}Pb$ vs $^{206}Pb/^{204}Pb$ plot (Figure 11A), all data define a relatively narrow range, and overlap compositionally with Pb isotopic data for volcanic rocks from the Easter Seamount Chain (Ray *et al.* 2012). Within the dataset of the present study, Poike samples 586 and 587 form a tight cluster in lead isotope space, while samples 585 (Poike) and 581 (Rua Tokitoki) have similar lead isotopic values and form a secondary cluster. All other Rua Tokitoki samples from the main cluster from this source. In the $^{143}Nd/^{144}Nd$ vs $^{87}Sr/^{86}Sr$ plot (Figure 11B), data define a narrow range and overlap compositionally with literature data for the Easter Seamount Chain (Ray et al. 2012). Samples from Rua Tokitoki and Poike display distinct clusters, which implies subtle differences in the mantle source compositions, as isotope ratios are not affected by igneous processes, such as partial melting or fractional crystallisation.

In summary, the Rua Tokitoki quarry and Poike source represent different rock types (trachybasalt vs trachyandesite), based on whole rock major and trace element geochemistry. Both normalised REE and multi–element patterns confirm differences in petrogenesis. In particular, subtle differences in Pb, Sr, and Nd isotope composition suggest that compositional differences between both rock types were controlled not only by variable degrees of partial melting and fractional crystallisation, but also involved isotopically different mantle sources.

Discussion

The Rua Tokitoki quarry and Poike's fine–grain basalt source on Rapa Nui include storage pits, knapping workshops, and trachybasalt (hawaiite), basaltic trachyandesite (mugearite), and trachyandesite (benmoreite) outcrops and deposits. At Rua Tokitoki, there is evidence for the intensive production of tools, including various stages in the operational sequence of artefact manufacture. Due to the superior quantity and quality of fine–grain hawaitte found at Rua Tokitoki (Baker 1993, 1998; Stevenson et al. 2000; Simpson 2015b; Simpson et al. 2017), it is argued that the quarry was an important place for stone acquisition, reduction, and artefact manufacture. Yet, for such an important place for basalt extraction, Rua Tokitoki has little archaeological evidence in the region to suggest that quarries, sources, and workshops were monitored by elite members of the Rapanui culture, including *ariki* and *tangata honui* (Simpson 2015b; Stevenson and Haoa 2008; Stevenson et al. 2000).

At Poike, 30–40m below Ahu Kiri Reva, a fine–grain basalt source was discovered and archaeologically recorded for the first time. TAS analysis reveals that stone from this source ranges between benmoreite and mugearite. Considering that two of these samples (Figure 9:P–586–587) are benmoreite, it is likely that the source was formed by Poike's PO1 eruption events, showing how the ancient Rapanui targeted and extracted stoned created by older volcanic activity. Due to the quality of stone from the Poike source, the difficulty in accessing this source, and the neighbouring location of Ahu Kiri Reva, it is likely that ropes, baskets, and even canoes were used to gather and transfer stone. Consequently, access and use of the Poike source may have been controlled by elite Rapanui members. Like important obsidian sources (Mulrooney et al. 2014; Simpson 2014a; Stevenson et al. 2013), the Poike source would have been under the direct supervision of *tangata honui* (elite retainers) where Ahu Kiri Reva helped play an important role in demarking an elite–controlled political economy and sociopolitical visualscape (Howard 2008; Simpson 2008, 2009, 2012; Simpson et al. 2017; Stevenson 1997, 2002; Stevenson and Haoa, 1998; Stevenson et al. 2005, 2013; Chapters Two and Seven). Lastly, toponymic and archaeological observations suggest that multiple tools could have been make from this fine–grain source including adzes and fishhooks. Geochemically analysing these artefacts types will help to identify which were sourced from Poike.

Therefore, evidence from both Rua Tokitoki and the source on Poike suggests two different means for the acquisition of fine–grain basalt. The former includes the extraction of basalt in a landscape which lacks *ahu*, elite homes, and residential activities. Inferring from this distribution, the quarries, sources, and workshops of Rua Tokitoki were not under the direct supervision of elite Rapanui. Instead, this area was visited by 'task groups' who had admittance into this 'commons' area (McCoy 2014) to access culturally valuable stone (Stevenson et al 2000; Simpson and Dussubieux 2018; Simpson et al. 2018; Chapter Seven). The latter includes an elite monitored and controlled basalt source where *tangata honui* and *tangata māori anga mā'ea* authorised and facilitated access and use. The physical location of Ahu Kiri Reva may have also been used by chiefly and elite retainers to control other valuable stone in the area, including trachyte from Maunga Parehe, Maunga Tea Tea and Maunga Vai a Heva (Simpson et al. 2017). Together, these two means for stone acquisition hint at diverse economic, ideological, and sociopolitical pathways that basalt was accessed, controlled, exchanged, and used during Rapa Nui's pre–contact period.

Findings at the quarry and the source under study support interpretations by McCoy (2014) who used archaeological and ethnographic data to demonstrate craft specialisation with regards to *paenga* manufacture. This specialisation included a division of labour where Rapanui elite such as *tangata māori anga hare paenga* (elite house building experts) directed labourers organised in task groups in the various stages of dressed stone manufacture, including one that solely focused on adding holes into which the roof rafters of the *hare paenga* were inserted (Englert 1948). Like *moai* carving (Van Tilburg 1994), McCoy (2014:18) contends that over time, *paenga* manufacture developed into a specialist "industry" involving skilled artisans (Helms 1993), who exchanged *paenga* for use in "public" or "political" economies (Earle 1987, 1997; Peebles and Kus 1977; Sahlins 1972; Simpson 2009). As dressed stone manufacture was related to chiefly rank and status, comparable to *moai* manufacture, *tangata māori anga hare paenga* participated in and at times directed the "consecrated enterprises" (Handy 1927:282) related to megalithic, monolithic, and artefact manufacture. As such, those engaged in directing quarrying and finishing *paenga* were "a privileged class, highly esteemed" and that the "profession was transmitted from father to son" (Métraux 1940:137). Though *tangata honui* rewarded *māori* elite with fish, lobsters, and eels, their protégée and lesser–ranked labourers were also given food in exchange for their skill and effort.

Similar to *moai* and *paenga* production, there was likely ritual protocol, specialisation, and elite oversight in the production of certain fine–grain basalt artefacts, especially considering that these artefacts were used to carve the sacred *moai, pukao*, and *ahu* stone, along with ocean going canoes. Portable tool making included elite specialist such as *tangata māori anga mā'ea* who directed the multiple stages of *toki, hoe, mangai mā'ea*, and *ohio* production. Yet, judging from the diversity in operational sequences for Rapanui fine–grain lithic tools, along with the prolific number of artefacts manufactured, there was probably a multiplicity of arrangements for raw material access and tool production (Chapter Seven). For example, at Rua Tokitoki, there is evidence of stages that included the removal of *in situ* trachybasalt boulders from an outcrop to storage pits. From the pits, multiple cobbles were further reduced into cores, blanks, and preforms. Inferring from shear density of boulders, cores, and debitage found at Rua Tokitoki, a considerable amount of stone was reduced there. At the Poike source, a specialised system of cliff mining developed to extract benmoreite laminates. This vertical extraction technique would have involved multiple stages from *keho* removal, to topside delivery, and lithic reduction around Ahu Kiri Reva. Or, laminates were lowered down to awaiting canoes and then transferred to other island locations similar to high–quality obsidian (Stevenson et al. 2013).

Future archaeological studies aimed at locating Rapa Nui's fine–grain basalt quarries should focus on areas with geological deposits of trachybasalt, basaltic trachyandesite, and trachyandesite from which artefacts were manufactured. Concurrently, cliffs, crags, outcrops, and gulches should be reviewed through field reconnaissance, preferably in the winter when the island's vegetation is minimal. This work may locate opportunistically used and/or less used quarries and sources. Once located, geologically sampled, and archaeologically documented, geochemical analysis of geoarchaeological basalt will be needed to create elemental baselines for Rapa Nui's quarries, sources, and workshops. Parallel geochemical analysis is needed to identify the elemental fingerprints of multiple tool classes including adzes, picks, knives, fishhooks and axes. Sampled artefacts should include locations from as many *mata kainga* (clan lands) as possible, and from both sides of Rapa Nui's ancient confederations.

Once accomplished, an assessment can be made as to which quarries were being used by which clans and by which groups (e.g. elite vs non–elite) to fashion basalt artefacts. Together, this information will help to better understand the archaeological use of Rapa Nui's basalt archaeological industries and ancient Rapanui economic, ideological, and sociopolitical interaction.

Conclusion

Regarding the Rapa Nui landscape, Stevenson (2002:214; see also Hunt and Lipo 2011) states that the "highly uniform archaeological record that reflects nearly a millennium of prehistory has hindered the identification of regional landscape patterns because of the high level of detail required for their characterisation". We believe that by attaining a high level of detail through archaeological survey and geochemical characterisation of Rapa Nui's non–obsidian sources and artefacts – especially fine– and course–grain basalts – we will be in a better position to understand the distribution of artefacts for documenting patterns of pre–contact cultural interaction and territoriality. We have initiated high–precision and comprehensive geochemical characterisation of Rapa Nui's fine–grain basalt quarries, sources, and workshops. This serves as a basis for understanding ancient stone acquisition, control, transfer, and use to model and better understand the island's ancient economic, ideological, and sociopolitical interaction and organisation.

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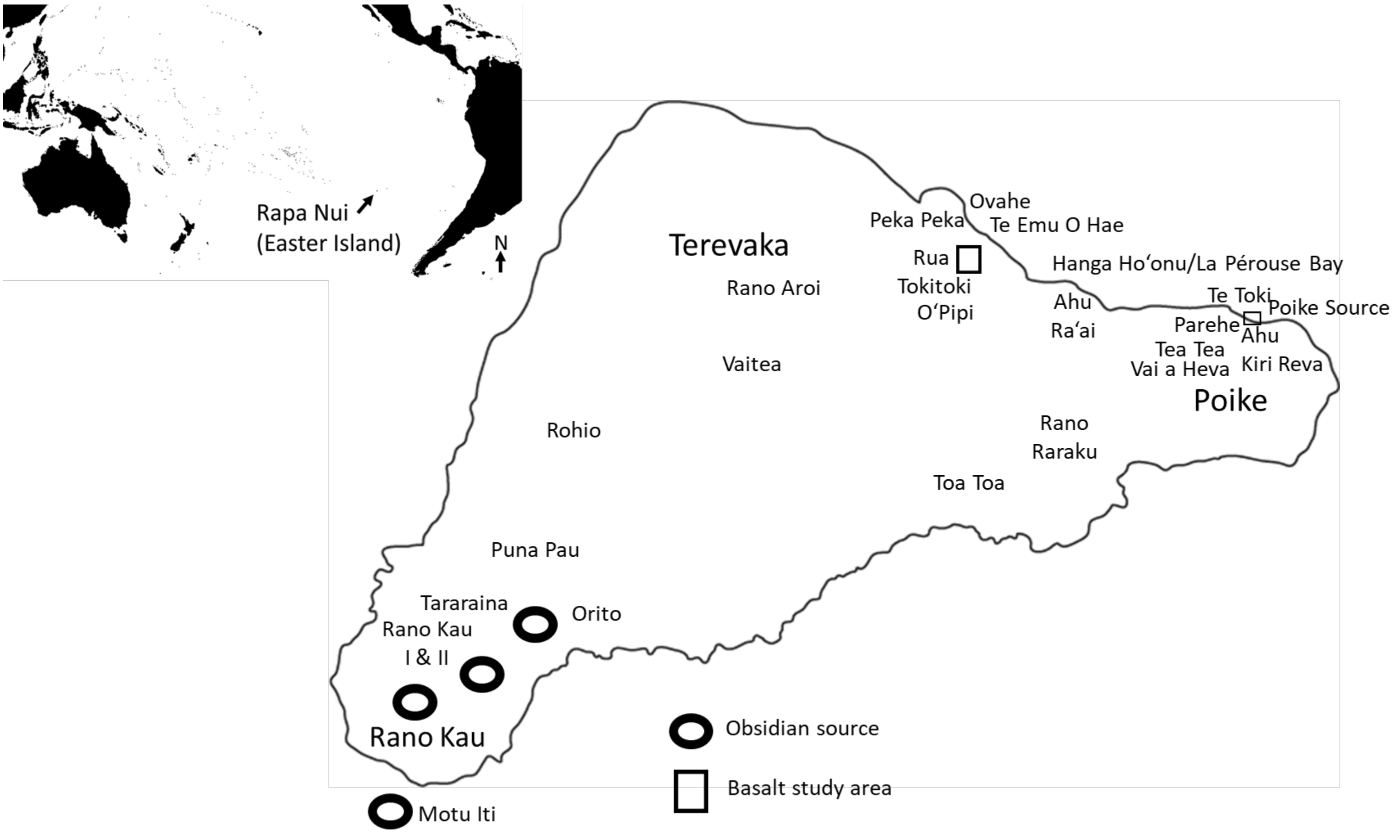

Figure 1. The location of Rapa Nui, stone quarries, and place names mentioned in the chapter.

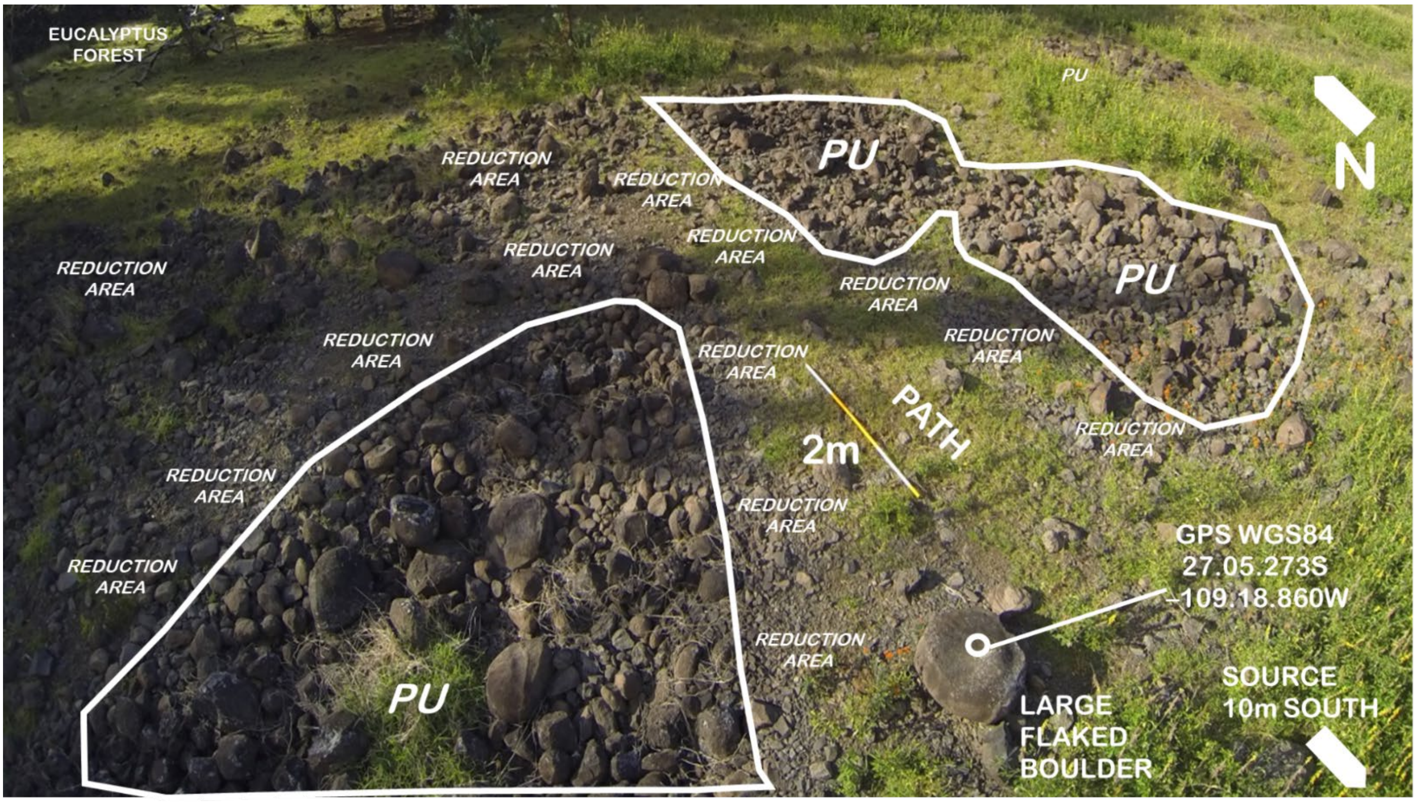

Figure 2. A drone view of Rua Tokitoki. Scale bar is 2m long (photo by Yancovic–Pakarati 2014; scale bar is 2m long).

Figure 3. Targeted flow south of Rua Tokitoki. Scale bar is 25cm (photo by Simpson 2014).

Figure 4. Large flaked boulder at Rua Tokitoki. Scale bar is 25cm (photo by Simpson 2014).

Figure 5. Debitage around the western pit of Rua Tokitoki. Scale bar is 25cm (photo by Simpson 2014).

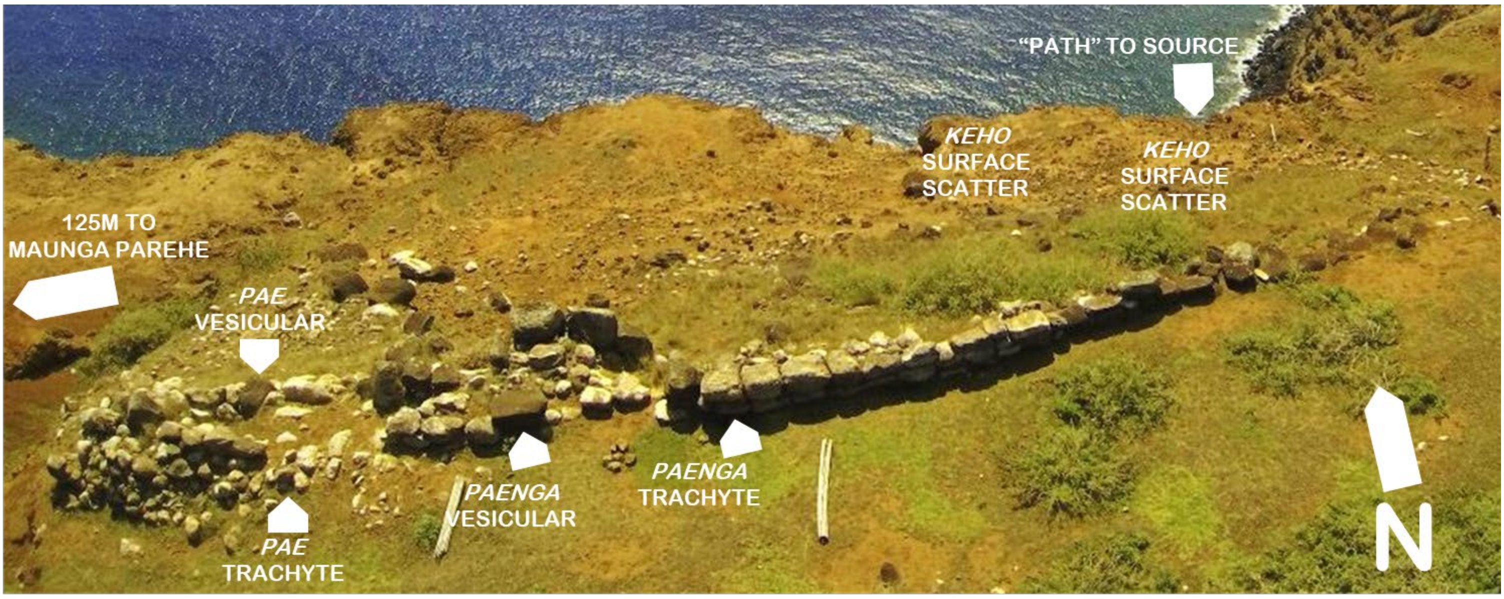

Figure 6. A drone view of the front of Ahu Kiri Reva (photo by Simpson 2014).

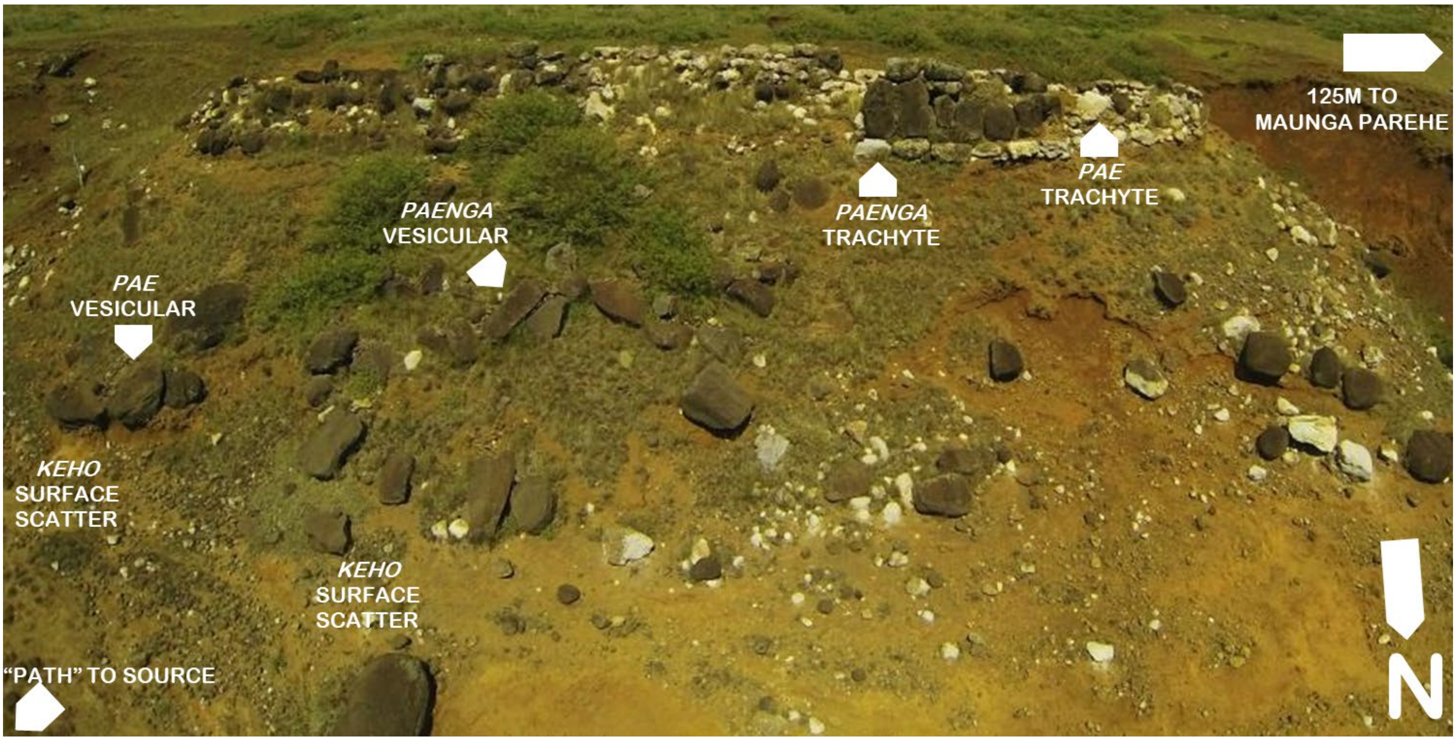

Figure 7. A drone view of the back of Ahu Kiri Reva (photo by Simpson 2014).

Figure 8. The trachyandesite (benmoreite) *keho* source on Poike. Scale bar is 50cm long (photo by Simpson 2014).

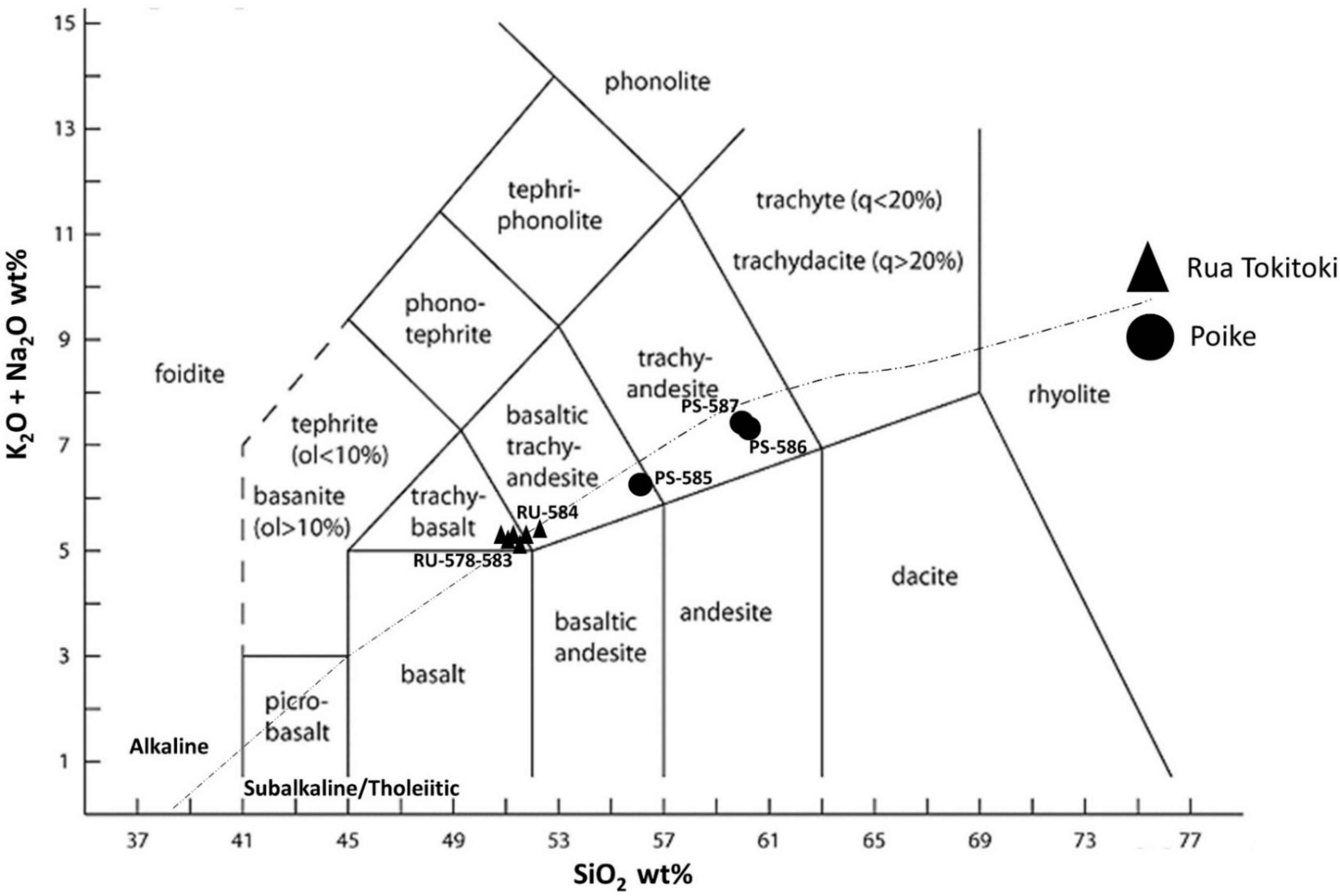

Figure 9. A bivariate plot of TAS total alkali ($Na_2O + K_2O$) versus silica (SiO_2), showing the rock types for the Rua Tokitoki quarry and the Poike source.

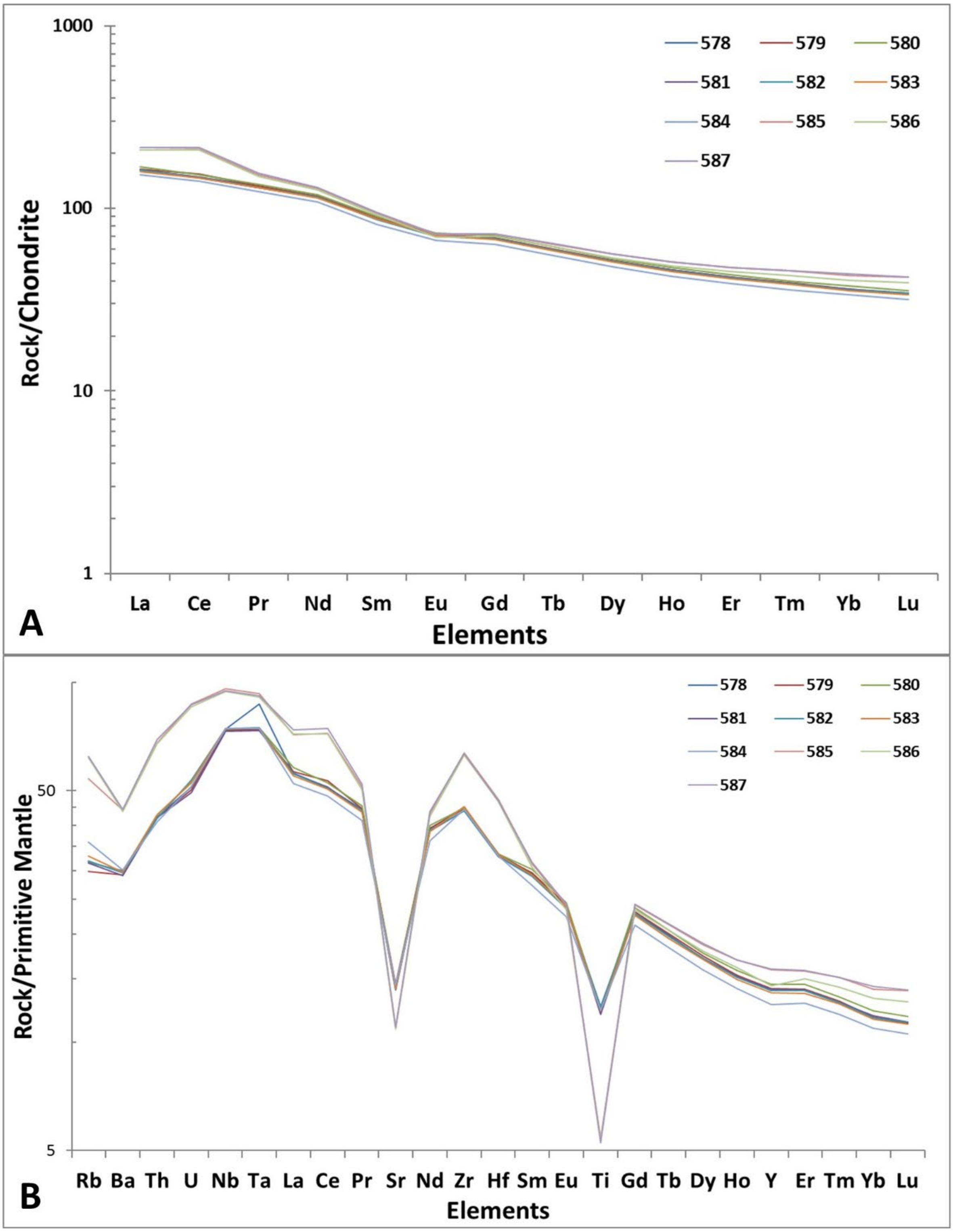

Figure 10. (A) REE patterns normalized to chondrite (McDonough and Sun 1995). (B) Multi–element patterns normalized to Primitive Mantle (Sun and McDonough 1989).

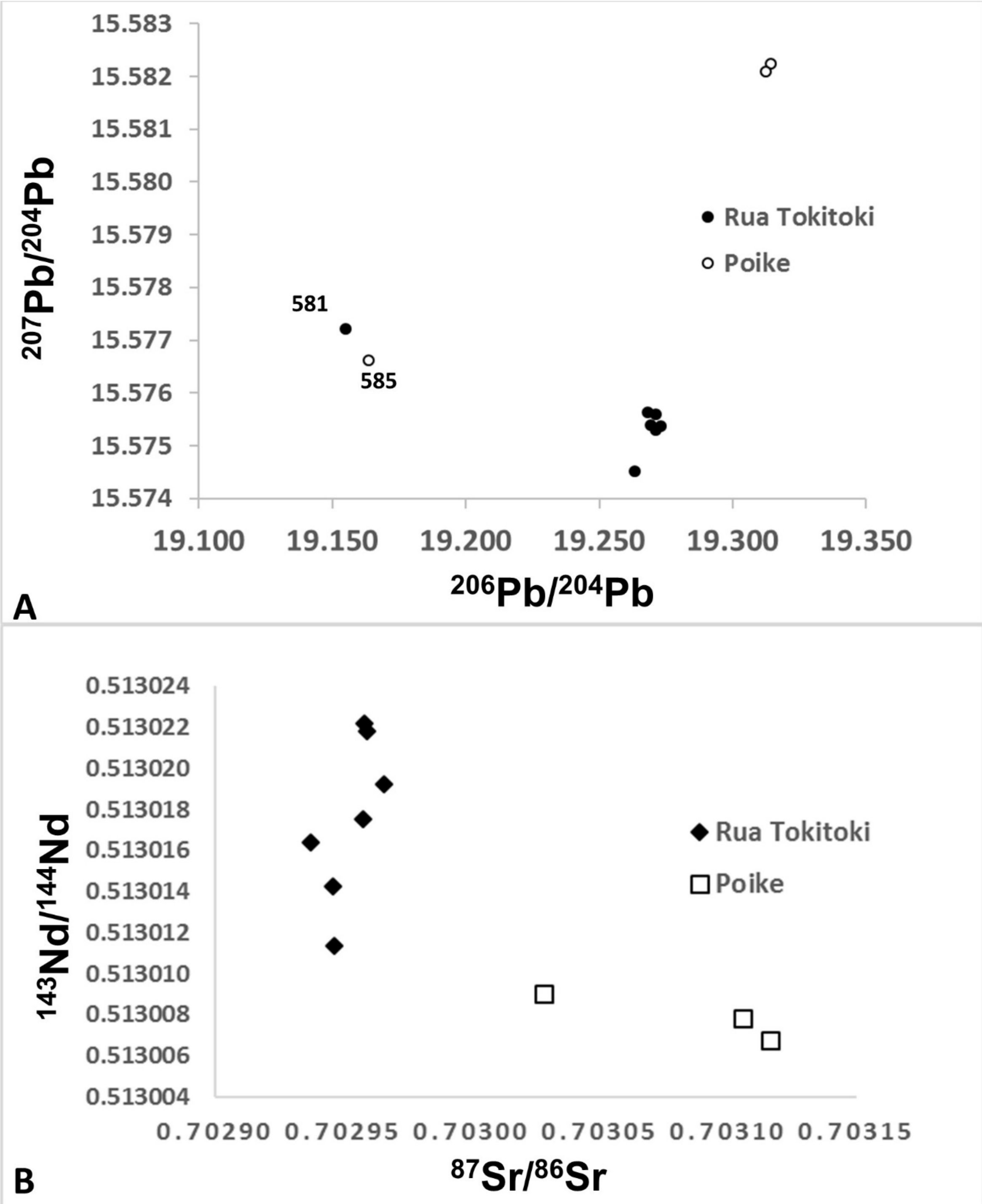

Figure 11. (A) $^{207}Pb/^{204}Pb$ versus $^{206}Pb/^{204}Pb$ and (B) $^{143}Nd/^{144}Nd$ versus $^{87}Sr/^{86}Sr$ isotopic values for Rua Tokitoki and the Poike source.

Investigator/Source	Site(s)	Location
Métraux 1940	*Paenga* (dressed basaltic blocks used in elite homes [*hare paenga*] and *ahu*) source *and toki* quarry	Rano Aroi and Rua Tokitoki
Englert (with Santiago Pakarati) 1948	Five *paenga* sources	Rohio's lava tubes (n=2), Te Pahu & Vai Taki Tiki, Omohi, Tetenga, o'Pipi
Ayres et al. 1998	Basalt quarry	Rua Tokitoki
Lee 2000	*Paenga* "factory"	Vai o re'o Tino (Ahu Ra'ai area)
Stevenson et al. 2000	37 pit–mines and workshops	Hanga Ho'onu region
Vargas et al. 2006	44 lithic sources, quarries and stone–knapping workshops (individual locations unknown)	Hanga O'Teo–Akahanga transect
Haoa et al. 2007	205 sources and quarry sites and 195 workshops (individual locations unknown)	West coast
Stevenson and Haoa 2008	More than 50 basalt sources, quarries, and workshops	Hanga Ho'onu region
Easter Island Statue Project (Fischer and Bahamondez) 2011	More than 15 basalt sources and quarries (individual locations unknown)	Between Maunga Toa Toa and Orito
McCoy (with Daniel Ika) 1976, 2014	Five *paenga* quarries	Rano Kau, Ko Ori, and Maunga Tararaina
Hamilton et al. 2011	Three *paenga* quarries	Rano Kau, Maitaki te Moa, and Te Pito Kura
Simpson 2015a, b, c, 2016a, b, 2017, 2018a, b; Simpson and Dussubieux 2018; Simpson et al. 2017, 2018	84 quarries, sources, and workshops	Poike, Ava o'Kiri, Poike, Pu Tokitoki, Rano Kau, Rua Tokitoki, southwest coast, Vai Atare
Stevenson et al. 2018	16 sources of coarse–grain construction stone for *paenga* and *pae.*	Hiva Hiva region

Table 1. Basalt sources, quarries, and workshops reported on Rapa Nui.

Stone Type	Location	Ancient Use
Basalt (undifferentiated)	Widespread: Terevaka, Rohio, Vaitea, coastal areas around Poike, Rano Kau, and Maunga Tararaina	*Ahu*, *moai*, *hare moa* (chicken house), *paenga, pae*, structures (i.e. dwellings, tombs, walled reservoirs and channels for water), *manavai* (gardens), *ana kionga* (protection caves), *tupa* (watchtowers), rock mulched (*kirikiri*) gardens, and *taheta* (water collectors/sharpeners).
Hawaiite and Intermediate Lava (mugearite and benmoreite)	Rano Kau, Orito, southwest coast, Rano Aroi, Ovahe, and La Pérouse	*Keho* roofs at Orongo, *ahu*, *toki*, *hoe*, *mangai mā'ea*, sharpeners, and *ngaru'a* or *turua* (stone pillows made from beach stones [*poro*]).
Trachyte	Poike	*Moai,* finely chiselled portable carvings, and Vai a Heva (carved feature found at Poike).
Rhyolite	Orito, Motu Iti, and Rano Kau	Obsidian tools: *mata'a* (stemmed bifaced), *hoe*, *toki, moai* eyes, scrapers, drills, and vegetable peelers.
Pyroclastic Tuff	Rano Raraku and Toa Toa	*Moai* and *toki* (pyroclastic).
Red Scoria	Puna Pau and Rohio area	*Pukao* (topknots), *paenga, moai, moai* eyes, *ahu* facia blocks, crematoria and *ahu* fill, and funerary cists.

Table 2. Rapa Nui stone types, locations and use (Baker 1993, 1998; Simpson 2014b; Simpson et al. 2017).

Sample #	RT -578	RT -579	RT -580	RT -581	RT -582	RT -583	RT -584	PS-585	PS -586	PS-587
SiO_2	50.9	50.9	51.3	51.7	51.8	51.4	52.3	56.5	60.3	60.0
Al_2O_3	15.0	15.2	15.0	14.9	15.1	14.8	14.7	15.2	15.8	15.8
TiO_2	2.7	2.6	2.7	2.6	2.7	2.6	2.7	1.8	1.2	1.1
Fe_2O_3	13.2	12.7	13.4	13.4	13.6	13.4	13.0	10.4	8.3	8.7
MnO	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.2
CaO	6.9	7.7	6.9	6.9	7.1	6.8	7.0	5.4	4.5	4.1
MgO	3.1	3.3	3.2	3.1	3.2	3.1	3.0	2.1	1.5	1.4
K_2O	1.2	1.2	1.2	1.2	1.2	1.3	1.3	1.8	2.3	2.2
MgO	3.1	3.3	3.2	3.1	3.2	3.1	3.0	2.1	1.5	1.4
Na_2O	4.0	4.1	4.0	3.9	4.0	4.1	4.1	4.5	4.9	5.1
P_2O_5	1.0	0.9	1.0	0.9	1.0	1.0	1.0	0.7	0.5	0.5
Total	98.0	98.8	98.8	98.9	99.9	98.6	99.3	98.2	99.5	99.0

Table 3. Major element analysis.

Sample #	RT-578	RT-579	RT-580	RT-581	RT-582	RT-583	RT-584	PS-585	PS-586	PS-587	BHVO-2
Li	9.7	8.5	9.9	9.6	9.4	10.8	8.4	8.0	5.6	11.4	3.4
Be	3.0	3.1	3.2	3.0	3.0	3.0	2.8	4.5	4.3	4.4	1.0
Mg	19579.5	19057.2	19901.4	19561.2	19127.8	19485.6	19500.9	8710.4	8881.9	8910.3	37433.0
P	4186.2	4038.2	4164.1	4007.6	4105.5	4146.1	4194.5	2115.4	2178.8	2153.1	1011.2
Ca	51199.0	51318.1	51230.4	50261.7	49971.5	50538.7	51722.4	29246.4	29307.6	30021.1	61762.7
Sc	25.2	25.1	25.6	25.3	24.7	24.5	22.9	14.3	11.9	15.1	30.4
Ti	16346.4	15789.2	16030.9	15565.5	16253.8	15883.6	15982.6	7032.4	6999.7	6827.2	12188.0
V	164.4	152.7	157.6	152.8	162.2	153.2	152.7	19.4	18.8	18.1	229.5
Cr	0.6	0.2	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.3	221.3
Mn	1713.3	1619.6	1717.2	1662.9	1706.0	1714.9	1660.7	1162.6	1163.1	1366.6	969.1
Fe	96701.6	91275.0	94201.0	94542.7	95553.2	95492.8	92041.0	58508.6	58195.4	62525.2	64121.5
Co	25.8	24.1	24.9	24.7	25.4	24.0	23.5	8.5	8.4	8.4	33.4
Ni	1.1	1.0	1.0	0.9	1.0	1.0	1.0	0.3	0.3	0.5	89.1
Cu	19.6	18.9	21.5	19.0	22.5	20.9	21.8	11.1	11.1	12.8	95.1
Zn	168.9	158.6	163.2	161.4	163.6	160.8	161.6	147.8	146.2	146.4	80.2
Ga	28.0	27.9	27.9	27.4	27.9	27.8	28.0	30.1	29.6	30.0	15.8
Sr	301.8	305.5	299.8	294.7	295.3	295.5	303.1	231.3	230.8	233.0	294.2
Rb	20.1	19.0	20.2	20.0	20.3	20.9	22.9	34.3	39.3	39.7	7.5
Y	63.2	64.1	65.9	63.8	63.3	62.4	57.8	72.5	65.4	72.9	21.6
Zr	503.1	499.2	500.9	492.2	493.8	505.5	496.8	713.0	705.2	711.5	130.3
Nb	52.8	52.7	52.8	52.2	53.2	53.1	53.2	68.5	67.3	67.7	13.6
Mo	2.4	2.2	2.3	2.7	2.3	2.1	2.7	3.0	2.9	4.1	2.6
Cd	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.2	0.1
Sn	4.1	4.0	4.2	4.0	4.2	4.2	4.0	5.8	4.3	6.3	1.4
Sb	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Cs	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1
Ba	209.6	204.2	208.0	203.2	206.5	207.8	210.6	309.5	305.9	309.9	100.3
La	38.5	38.8	39.9	38.3	38.4	37.8	36.0	49.2	49.4	50.8	13.5
Ce	90.6	94.7	93.3	91.0	89.9	89.8	85.8	128.5	127.8	132.3	32.6
Pr	12.2	12.3	12.5	12.1	12.1	12.0	11.4	14.1	13.9	14.4	4.6
Nd	53.1	53.3	54.3	52.3	52.5	52.2	49.3	58.6	57.4	59.2	20.5
Sm	13.1	13.1	13.4	12.9	12.9	13.0	12.1	13.9	13.6	14.0	5.1
Eu	4.0	4.0	4.1	4.0	4.0	4.0	3.7	4.0	3.9	4.1	1.7
Tb	2.1	2.2	2.2	2.1	2.1	2.1	2.0	2.3	2.2	2.3	0.8
Gd	13.7	13.7	14.1	13.6	13.5	13.4	12.6	14.3	13.9	14.4	5.2
Dy	12.6	12.8	13.0	12.6	12.6	12.5	11.7	13.8	13.2	13.9	4.4
Ho	2.5	2.5	2.6	2.5	2.5	2.5	2.3	2.8	2.6	2.8	0.8
Er	6.7	6.7	6.9	6.7	6.7	6.6	6.2	7.6	7.2	7.6	2.0
Tm	1.0	1.0	1.0	1.0	1.0	0.9	0.9	1.1	1.1	1.1	0.3
Yb	5.8	5.8	6.0	5.8	5.8	5.7	5.4	6.9	6.5	7.1	1.6
Lu	0.8	0.8	0.9	0.8	0.8	0.8	0.8	1.0	1.0	1.0	0.2
Hf	10.3	10.2	10.3	10.1	10.1	10.3	10.2	14.6	14.4	14.5	3.3
Ta	3.6	3.0	3.1	3.0	3.1	3.1	3.1	3.8	3.7	3.8	0.8
W	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.7	0.7	0.7	0.1
Tl	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.0
Pb	2.0	1.9	3.0	2.0	2.0	1.9	2.0	2.9	2.9	3.2	1.0
Th	3.6	3.6	3.6	3.6	3.6	3.6	3.5	5.8	5.7	5.9	1.1
U	1.1	1.1	1.1	1.0	1.1	1.1	1.1	1.8	1.8	1.8	0.3

Table 4. Trace element analysis.

Sample #	RT-578	RT-579	RT-580	RT-581	RT-582	RT-583	RT-584	PS-585	PS-586	PS-587	BHVO-2
$^{87}Sr/^{86}Sr$	0.702946	0.702958	0.702959	0.702947	0.702966	0.702937	0.702958	0.703106	0.703116	0.703028	0.703476
±2σ	0.000012	0.000012	0.000013	0.000012	0.000017	0.000012	0.000010	0.000010	0.000020	0.000015	0.000009
$^{143}Nd/^{144}Nd$	0.513014	0.513022	0.513022	0.513011	0.513019	0.513016	0.513018	0.513008	0.513007	0.513009	0.512980
±2s	0.000005	0.000005	0.000005	0.000006	0.000004	0.000004	0.000004	0.000006	0.000005	0.000004	0.000005
$^{208}Pb/^{204}Pb$	38.8690	38.8696	38.8642	38.9602	38.8589	38.8704	38.8674	38.9668	38.9385	38.9356	38.2031
±2s	0.0027	0.0030	0.0034	0.0039	0.0034	0.0017	0.0062	0.0023	0.0024	0.0028	0.0077
$^{207}Pb/^{204}Pb$	15.5756	15.5754	15.5754	15.5772	15.5745	15.5753	15.5756	15.5766	15.5823	15.5821	15.5317
±2s	0.0011	0.0011	0.0012	0.0014	0.0012	0.0019	0.0010	0.0009	0.0009	0.0010	0.0027
$^{206}Pb/^{204}Pb$	19.2712	19.2729	19.2691	19.1551	19.2634	19.2709	19.2683	19.1636	19.3141	19.3123	18.6190
±2s	0.0013	0.0012	0.0013	0.0016	0.0008	0.0019	0.0020	0.0011	0.0010	0.0011	0.0017
$^{208}Pb/^{206}Pb$	2.01694	2.01683	2.01697	2.03397	2.01715	2.01687	2.01710	2.03338	2.01603	2.01612	2.05169
±2s	0.00003	0.00004	0.00005	0.00004	0.00003	0.00003	0.00005	0.00005	0.00003	0.00004	0.00008
$^{207}Pb/^{206}Pb$	0.80823	0.80816	0.80832	0.81324	0.80845	0.80821	0.80828	0.81283	0.80677	0.80687	0.83411
±2s	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001

Table 5. Sr–Nd–Pb isotopic ratios.

CHAPTER 5: *Toki* (adze) and pick production during peak *moai* (statue) manufacture: Geochemical and radiometric analyses reveal pre–contact provenance, timing and use of Easter Island's fine–grain basalt resources

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Dale F. Simpson Jr.
School of Social Science, The University of Queensland, St Lucia, Qld 4072 Australia.
Department of Anthropology, College of DuPage, Glen Ellyn, IL. USA.

Jo Anne Van Tilburg
Cotsen Institute of Archaeology, University of California, Los Angeles, California, USA.
Easter Island Statue Project

Laure Dussubieux
Elemental Analysis Facility, Field Museum of Natural History, Chicago, Illinois, USA.

Corresponding author: Dale F. Simpson Jr.
School of Social Science, The University of Queensland, St Lucia, Qld 4072 Australia.
Department of Anthropology, College of DuPage, Glen Ellyn, IL. U.S.A.
dfsj381@gmail.com

Toki (adze) and pick production during peak _moai_ (statue) manufacture: Geochemical and radiometric analyses reveal pre–contact provenance, timing and use of Easter Island's fine–grain basalt resources

Abstract : Pacific and Rapa Nui (Easter Island) volcanologists, geologists, and geochemists have set the stage for archaeological lithic sourcing studies by providing practical data regarding the island's geodynamic activity, geomorphological formation and dating, and the macroscopic, microscopic, and elemental proprieties of Easter Island stone. Drawing upon this information, and the research collaboration between two active archaeological projects on Rapa Nui – the Easter Island Statue Project and the Rapa Nui Geochemical Project – we trace the movement of basalt resources from the Ava o'Kiri and Pu Tokitoki quarry complexes to the *moai* (statue) quarry at Rano Raraku between 1455–1645 AD. In this article, we report: 1) a synthesis of a five–metre deep field excavation of *moai* RR–001–156 in Rano Raraku; 2) a ^{14}C assessment which dates human presence around *moai* RR–001–156; 3) 31 basalt quarry and source site descriptions; and 4) archaeometric data using laser ablation–inductively coupled plasma–mass spectrometry **(**LA–ICP–MS) and principal component analyses of 21 archaeological and 117 geological samples. Our conclusions better highlight economic, ideological, and sociopolitical interaction during Rapa Nui's pre–contact period, while delineating the relationship between adze and pick production and *moai* manufacture.

Keywords: basalt artefacts, basalt quarries, geochemistry, *moai*, interaction studies, Polynesia, Rano Raraku, Rapa Nui (Easter Island)

Introduction

The geochemical study of artefacts, quarries, and sources is a focus of Pacific archaeological studies (Cochrane and Hunt 2018; Kirch and Weisler 1994; Kirch and Kahn 2007; Weisler 1997, 1998, 2002; Weisler [ed.] 1997; Chapter Two). This research has been invaluable by identifying the locations of stone sources and documenting the different lithic reduction strategies found within Polynesia's quarried landscapes (Bayman and Nakamura 2001; Clarkson et al. 2014; Hermann 2017; Jennings et al. 2018; Leach 1993; Leach and Leach 1980; McCoy 1990, 1999; McCoy et al. 2012; Turner 1992; Van Tilburg et al. 2008a; Weisler 2011; Winterhoff 2007). This research has also accented elite control over highly valued stone resources (Cleghorn 1986; Hamilton et al. 2011; Hermann et al. 2019; Kirch et al. 2011; Lass 1998; McAlister and Allen 2017; Rieth et al. 2013; Simpson et al. 2017; Stevenson et al. 2013), voyaging interaction spheres (Hermann et al. 2017; Weisler 1998; Weisler and Sinton 1997; Weisler and Walter 2017), and inter– and intra– island exchange networks in the Austral Islands (Hermann 2013; Rolett et al. 2015), in the Cook Islands (Allen and Johnson 1997; Sheppard et al. 1997; Walter and Sheppard 1996, 2001; Weisler et al. 1994, 2016a), in the Hawaiian Islands (Kahn et al. 2008; Kirch et al. 2011; Mills et al. 2010, 2011; Mintmier et al. 2012; Weisler et al. 2013), for Henderson, Mangareva, and Pitcairn Islands (Weisler 2002; Weisler et al. 2004), in the Marquesan Islands (Allen 2014; Allen and McAlister 2013; McAlister, 2011; McAlister and Allen 2017; Rolett et al. 1997; Weisler et al. 2016b), for New Zealand (Felgate et al. 2001; Lawrence et al. 2014; Phillips et al. 2016), for Samoa and Tonga (Best et al. 1992; Cochrane and Rieth 2016; Clark et al. 2014), in the Society Islands (Kahn et al. 2013; Hermann et al. 2019; Weisler 1998), and in the Tuamotu Islands (Collerson and Weisler 2007). This robust record of archaeological and geochemical investigation of artefacts, quarries, and sources has ultimately demonstrated how ancient Polynesians possessed a thorough knowledge of Pacific stone. This knowledge allowed them to extract, for example, obsidian, tuff, scoria, and basalt, from numerous quarries and sources throughout Remote Oceania (Green 1991; Chapter Two), to create a multiplicity of lithics and remarkable monoliths and megaliths.

Since European discovery of Rapa Nui in 1722 (Figure 1), the island and its stone archaeological remains significantly interested early international researchers (Englert 1948, 1970; Geisler 1882; Heyerdahl and Ferdon [eds] 1961; Knoche 1925; Métraux 1940, 1957; Palmer 1875; Routledge 1919; Thomson 1891). These researchers, along with later investigations, have studied the numerous *moai* statues (Shepardson 2013; Van Tilburg 1994; Vargas et al. 2006), *pukao* topknots (Hamilton 2007, 2013; Hixon et al. 2017, 2018; Martinsson–Wallin 1994; Shepardson et al. 2004; Thomas 2014), and *ahu* platforms that have been inferred to serve for ancestor worship, to represent aspects of sociopolitical organisation and economy, and to enforce resource and land ownership rights (Beardsley 1990; Martinsson–Wallin 1994; Simpson 2008, 2009; Simpson et al. 2017; Stevenson 2002).

Geochemical research on Rapa Nui has mostly focused on the island's four obsidian deposits (Motu Iti, Orito, Rano Kau, Te Manavai) and corresponding archaeological material to better understand ancient access, control, distribution, and use of stone resources (Beardsley et al. 1996; Beardsley and Goles 1998, 2001; Bird 1988; Cristino et al. 1999; Mulrooney et al. 2014, 2015; Stevenson et al. 1984, 2013; Thomas 2009). Yet, up to 1998, few studies provided archaeological description of Rapa Nui's fine–grained basalt quarries, sources, and workshops, addressed the major procedures within the *chaîne opératoire* (Sellot 1993) of extraction and reduction for artefacts, and reported accurate and precise geochemical data. Since then, several authors have published archaeological site and archaeometric data for Rapa Nui's basalt deposits and lithics (Ayres et al. 1998; Fischer and Bahamondez 2011; Harper 2008; Simpson and Dussubieux 2018; Simpson et al. 2017, 2018; Stevenson et al. 2000; Stevenson and Haoa 2008; Vargas et al. 2006).

Accordingly, these investigations and subsequent elemental profiles for basalt industries have demonstrated the valuable contributions geochemistry offers for Rapa Nui interaction studies. This includes providing evidence for the transfer of material from geological sources to habitation, ceremonial, and/or other quarrying sites, and for how this movement perhaps represented opportunistic, communal, kin–based, and/or elite (re)distribution pathways (Ayres et al. 1998; Simpson and Dussubieux 2018; Simpson et al. 2017, 2018).

Our current research provides further archaeological and geochemical descriptions of Rapa Nui's fine–grained basalt artefacts, quarries, sources, and workshops by joining the efforts of two on–going projects, the Easter Island Statue Project (EISP) and the Rapa Nui Geochemical Project (RNGP). The EISP has produced multiple archaeological assemblages with associated temporal contexts, extensive spatial databases and mapping resources, and integrated previously unpublished field notes along with the field notes from other archaeological researchers (Van Tilburg 1994; Van Tilburg and Pakarati 2012, 2014; Van Tilburg et al. 2008a, 2015a,b). The RNGP aimed to expand its research by geochemically analysing other known collections of archaeological basalt from Easter Island to better understand how the archaeological acquisition, exchange, and use of this stone may highlight spatial and temporal patterns of sociopolitical, ideological, and economic interaction (Simpson 2014; Simpson and Dussubieux 2018; Simpson et al. 2017, 2018).

This chapter: 1) provides EISP excavation syntheses and a radiocarbon dating corpus for human activity around *moai* RR–001–156 found in Rano Raraku; 2) reports RNGP site descriptions for 31 basalt quarries, sources, and workshops from five study areas of the island; and 3) presents LA–ICP–MS (laser ablation–inductively coupled plasma–mass spectrometry) results, including major, minor, and trace elements, for 117 quarry and source samples and 21 stratigraphically recovered specimens from Rano Raraku. Conclusions from our combined EISP and RNGP research delineate the relationship between Rapa Nui's basalt sources and archaeological materials, while illustrating the manufacture, timing, transfer to, and use of basalt artefacts in Rano Raraku. In turn, our results elucidate economic, ideological, and sociopolitical interaction on Rapa Nui during the pre–contact period.

Easter Island Statue Project

Founded in 1982 as a collaboration with the *Universidad de Chile* archaeological team then established on Rapa Nui (Cristino et al. 1981; Vargas et al. 2006), the EISP had as its central goal documenting *moai* in all of their locations and situations. At the initiation of the Rapa Nui island–wide archaeological survey (1968–1976), 16 site categories were defined, one of which was designated as "unclassified" (McCoy 1976:14–15, Table 1). Categories were described structurally but also interpreted functionally in the field, with function being defined largely by Rapanui terminology as applied by field workers. The survey goal was to create a matrix of localised and identified archaeological sites and features. However, of the 11,913 archaeological features constituting 6,927 sites that were identified, only 11 of the original 16 taxonomic categories are available (Cristino et al. 1981; Vargas et al. 2006). Consequently, this has demanded resurvey and reclassification. Although data are frequently summarised by counts and percentages, they cannot be employed in analytical research unless taxonomic definitions are attached to survey points and symbolised on maps. While *ahu*, *moai*, and *pukao* are part of the original taxonomic list, "quarries" and "sources", and the interpretive differences between these site classes (see Weisler and Sinton 1997), are not. Therefore, the EISP expanded its inventory and taxonomy to include these latter categories, along with the broader complexities of other archaeological, geological, and palaeoecological data. Thus, the data compilation between the EISP and the RNGP presented a unique opportunity for both projects.

Rano Raraku – The *moai* quarry

Rano Raraku was an important site for stone quarrying on Rapa Nui, serving as the major focal point for the ancient island culture to fabricate *moai*. The volcano is one of the many satellite cones that developed from Terevaka's secondary and tertiary volcanic activity (Baker 1967; Gonzalez–Ferran et al. 2004). It is an eroded tuff cone, presently filled with freshwater, the level of which has varied significantly during 2018. The cone formed through shallow marine volcanic activity and primary magmatic fragmentation creating hyaloclastites and hyalotuffs (Drief and Schiffman 2004; Dunn et al. 2015; Gioncada et al. 2010; Honnorez and Kirst 1975). The exact date of formation is unknown, but a minimum age of 0.21Ma is reported by Vezzoli and Acocella (2009). The northwest section of Rano Raraku contains fine reddish ash, while the southern skirt contains tuff of sideromelane slightly altered to palagonite that includes volcanic glass fragments (felspathic microlites), crystals, and clasts (Charola et al. 1994; Ginocada et al. 2010; Dunn et al. 2015; Van Tilburg et al. 2008b; Vezzoli and Acocella 2009; Wender et al. 1996). The youngest fragments of Rano Raraku are vesicular, scoriaceous basaltic lapilli that are embedded into the layers of hardened volcanic ash. Tuff deposits at Rano Raraku also include augites, phenocrysts of olivine with some alteration to iddingsite, clinopyroxene, plagioclase lath, apatite, Fe–Ti oxides, and opaques (Ginocada et al. 2010; Simpson 2014; Van Tilburg 1994; Vezzoli and Acocella 2009).

Regarding the monolithic sculptures carved from Rano Raraku's workable tuff, EISP mapping and excavations build directly upon previous mapping by Routledge (1919), Cristino et al. (1981), and Vargas et al. (2006), but add original digital and spatial information about *moai* and their production. This georeferenced database includes new records for 304 complete *moai*, 68 heads only, 15 torsos, and 22 sculptural fragments (Van Tilburg et al. 2015a). This does not include shaped blocks, which are often *moai* in early carving stages. Therefore, with so much activity focused at Rano Raraku, we argue that the volcano served as a continuously evolving ideological, sociopolitical, and economic focal point for the ancient culture, as well as a richly productive horticultural sub–zone. Despite issues centred on the colluvial nature of the soil deposits due to deforestation and the intense industrial activity focused on the upper slopes (Dunn et al. 2015), Rano Raraku is one of the more significant archaeological landscapes having potential to better understand interactive human use patterns and archaeological basalt materials from Easter Island.

***Moai* crater excavation (RR–001–156 and RR–001–157)**

To establish the history of human use in Rano Raraku, the EISP survey team conducted high–resolution digital mapping of the quarried bedrock surface and subsurface excavation (Van Tilburg et al. 2008a; Van Tilburg and Pakarati 2012, 2014). The decision to re–excavate two standing statues (RR–001–156 and RR–001–157; Figure 2) in Quarry Section 02 of Rano Raraku's inner basin was based on the poor documentation of earlier excavations (Routledge 1919), the significant iconographic data (rock art) on both statues, and the probable presence of additional quarries downslope (Skjølsvold 1961). The geological composition of Quarry Section 02 is a cross–bedded lapilli hyalotuff (Van Tilburg et al. 2008a). While the episodic depositional history remains to be fully analysed, it appears that a 2m layered colluvium was deposited due to upslope soil disturbance caused by deforestation and *moai* quarrying (Dunn et al. 2015). Thus, this excavation also addresses the history of erosion and deposition in the inner crater basin.

The EISP excavated a series of 1 x 1m foci (squares) to a depth of 5m and the complete stratigraphy associated with *moai* RR–001–156 (Figure 3) was exposed for lithostratigraphic sampling and morphological description including: Munsell colour, texture, structure, and the nature of contacts and clasts (Van Tilburg and Pakarati 2014; Van Tilburg et al. 2015a,b). Of central interest was the 1624 complete *toki* (adzes from prepared blanks) or *toki* fragments and picks (flaked boulders) found around both statues. Using these artefacts, Fischer and Bahamondez (2011) conducted a non–destructive portable X–ray fluorescence analysis (pXRF) of 170 *toki* and picks to illustrate that elements Zr, Ca, K, Rb, and Ti appeared useful for discriminating the geochemical variability of basalt artefacts. Results also uncover the existence of at least two main raw material sources of the *toki* and picks used in Rano Raraku. This includes 85% of analysed artefacts which were reportedly made from a source of mugearite and 13% of artefacts likely coming from a benmoreite source (Fischer and Bahamondez 2011). While Fischer and Bahamondez (2011) report the existence 15 basalt quarries located through field survey, no geochemical results were reported from these sites. Therefore, to build upon previous work, we can now compare the geochemical profiles of EISP archaeological samples with the elemental signatures attained from RNGP quarries and sources under study. This, in turn, will facilitate identification of the stone material used to make the adzes and picks found at Rano Raraku to carve *moai*.

Archaeological dataset

Table 1 presents the basalt archaeological samples (n=21) geochemically analysed in this investigation. They include specimens that were recovered in excavation of RR–001–156 squares seven and nine at depths from 0–5m. Four complete picks recovered around *moai* RR–001–156 were also elementally characterised. Table 1 also displays object trait measurements including recorded depth, length, width, and weight. A brief description defines the artefact type. Appendix C provides a scaled photo for each EISP sample.

Radiocarbon samples

Radiocarbon determinations were achieved from materials recovered during EISP excavations in Rano Raraku. We report here a selected set, achieved on *Broussonetia papyrifera* (paper mulberry) materials collected in the front of RR–001–156 in squares 1–4, 6 at depths reaching to 420cm (Figure 2). Radiocarbon dating was conducted at a Beta Analytic commercial laboratory.

Rapa Nui Geochemical Project

As basalt adzes, chisels, and picks were necessary tools for woodworking, canoe building, *moai*, *pukao* and *ahu* stone sculpting (Simpson et al. 2017, 2018; Van Tilburg 1994), understanding their manufacture and distribution can inform on ancient economy and social interaction through time (Best et al. 1992; Duff 1959; Emory 1968; Weisler 1997, 1998; Weisler 1997 [ed.]). Therefore, the goals of the RNGP are to: 1) locate and archaeologically document Easter Island's basalt quarries and sources; 2) demonstrate how the ancient Rapanui were expert geological miners who developed multiple basalt reduction sequences to make portable artefacts; and 3) identify patterns of economic, ideological, and sociopolitical interaction inferred through the transfer of basaltic material (Simpson 2014, 2015a, 2016a, 2017a, 2018; Simpson and Dussubieux 2018; Simpson et al. 2017, 2018).

Over four field seasons between 2014–18, the RNGP, along with many Rapanui, surveyed, documented, and geoarchaeologically sampled 84 fine–grained basalt mines, quarries, sources, and workshops in six study areas (Figure 1; Appendix B). These study areas were chosen as they contained the most surface evidence for the operational sequence of basalt artefact manufacture on Easter Island (Stevenson et al. 2000). Site locations were provided by past publications (Chapter Four, Table 1), local informants and officials, and reconnaissance survey. Our documentation process included identifying the operational sequence of basalt tool making, measuring geological quarry, source, and workshop areas, noting GPS coordinates with a Garmin eTrex 20x Worldwide, and taking photos and videos with a Nikon D3400/AF–S DX NIKKOR SLR camera fitted with a 16–85mm f/3.5 lens and a DJI Phantom drone quadcopter fitted with a Hero GoPro4 digital video camera. Our geological sampling procedure extracted between one to seven geological samples per site (<20g in total), depending on overall size (see Weisler et al. 2016b for an improved sampling protocol based on Marquesan basalt geochemistry). Ten grams were curated in the island's Sebastián Englert Anthropology Museum (MAPSE) for future analysis, while the other 10g were brought to The University of Queensland (UQ) and The Field Museum of Natural History (TFM) for review and geochemical analyses. For LA–ICP–MS examination, we selected the 31 largest quarries and sources that exhibited the most complete evidence for basalt stone procurement, reduction, and artefact manufacture, especially sites that contained extensive *in situ* remains including: worked outcrops, cores, blanks, preforms, and extensive debitage (Table 2; Appendix D)

Ava o'Kiri and Pu Tokitoki complexes (Figure 4)

Ava o'Kiri and Pu Tokitoki study areas share the same volcanic flow, RA6, which was the result of Maunga o'Pipi's volcanic activity, originating between 0.24–0.11 Ma (Vezzoli and Acocella 2009). Tumulus flows which originated from Maunga o'Pipi moved north, and northeast, ending at the coastline between Te Emu O Hae and Hanga Ho'onu (Gonzalez–Ferran et al. 2004). Both areas are composed of alkalic basalt including hawaiite–mugearite ranging between 4.5–5.3% MgO (Baker 1993, 1998; Simpson et al. 2017; Simpson and Dussubieux 2018; Vezzoli and Acocella 2009). Ava o'Kiri and Pu Tokitoki study areas have significant evidence for the intensive production of fine–grained basalt tools (Ayres et al. 1998; Simpson 2015a,b,c, 2016b; Simpson and Dussubieux 2018; Simpson et al. 2017, 2018; Stevenson et al. 2000; Stevenson and Haoa 2008). In Pu Tokitoki alone, there are more than 42 documented surface features over ~3km^2, representing the largest tool quarry and source complex on Rapa Nui. This study area contains multiple quarries, sources, and workshops, including the largest of these sites found to date (RNGP#48; Figure 5). Sites in the Pu Tokitoki region are normally focused around certain features: 1) *puku* (outcrops) that were mined for their different stone; 2) *pu* (pit repositories) that held cobblestones used in the stone reduction sequence; and 3) stone reduction areas which contain hammer stones, cores, blanks, preforms, and very thick distributions of debitage, attesting to the intensive production of basalt artefacts. At Ava o'Kiri, there are at least seven sites that are found within the *ava* (gully). These sites display indication for both fine– (tool grade) and coarse–grained basalt stone extraction and reduction.

Southwest coast mining complex (Figure 6)

The southwest coast is located within the TA1 flow (Gonzalez–Ferran et al. 2004), which is composed of alkalic basalt ranging between 4.5<MgO<5.3 (Baker 1993, 1998; Simpson et al. 2017; Simpson and Dussubieux 2018; Vezzoli and Acocella 2009). The TA1 flow is related to the 12 volcanic events of Maunga Tangaroa, Puna Pau, and Vai O'Hao. Flows of hawaitte and olivine basalts moved from the three northern volcanoes, to the southern coast, ending between Hanga Hahave and Hanga Poukura (Gonzalez–Ferran et al. 2004). The TA1 also rests on top of earlier volcanic activity in the area, namely shield lava (tholeiitic to alkalic basalt). Numerous basalt mines, quarries, and sources are found on Rapa Nui's southwest coast between Hanga Poukura and Hanga Hahave (Simpson, 2015a, 2016b; Simpson and Dussubieux 2018; Simpson et al. 2018). In total, there are 21 sites that very in size from small *keho* (flat basaltic laminates) chipping stone workshops (1m in length), to large *keho* mines (15m in depth). While the presence of complete tools is not common, there is dense debitage in many caves and at cliff sites, highlighting the amount of stone removed from, and reduced at the southwest coast mine complex (Figure 7). Most sites are found from 2–3m to 60m above sea level. They appear to be concentrated around exposed *keho* slab deposits (between 2–50cm of width) that run horizontally as stratigraphic lenses throughout the southwest coast study area. Instead of focusing on *puku* that exhibited multiple stone types as in Ava o'Kiri and Pu Tokitoki, the Rapanui at the southwest coast targeted specific geologic stratigraphy that contained fine–grained, tabular *keho* stone. These basaltic laminates are ideal sized to create *toki, hoe* (knife), and *mangai mā'ea* (stone fishhook). There are also easily accessible linear deposits of *kie'a* (mineral pigment) and beach stone (*poro*) deposits. The latter could have been used as hammerstones for *keho* reduction, flaked into picks, and/or utilised as wedges for other stone reduction sequences including *paenga* and *pae* (McCoy 2014) and *moai* (Simpson et al. 2018). In short, the geological resources found with the southwest coast study area make the location an important location for the acquisition of stone and mineral pigment raw material (Figure 7).

Rano Kau and Vai Atare complexes (Figure 8)

The volcano of Rano Kau and the area of Vai Atare located on the south–eastern flank have been considered "storied place[s]" for Rapa Nui's past (McCoy 2014:10). Not only are there oral traditions about this area which relate to the islander's founder Ariki Mau Hotu Matu'a (Englert 1948, 1970; Routledge 1919), but there also exists information about basalt stone quarrying in the area. For example, while Van Tilburg (1992) proposed the famous *moai* Hoahakananai'a, located in the British Museum, may have been quarried from this area's geological deposits, Lee (1992), who documented a number of petroglyphs around Vai Atare, suggested that the rock art in this area was connected to the practice of stone quarrying. Archaeological work by McCoy (2014, 1976) regarding *paenga* and *pae* quarrying found three main sources in Rano Kau (Sites 2–83, 85, 112) and two isolated, semi–finished *paenga* (Sites 2–41, 113). Sites in Rano Kau were considered sources, as there existed little evidence for pits and/or mining of basalt raw material. Evidence for the production of *paenga* and *pae* include whole and broken *poro* (used as wedges) and adze fragments that were likely used as manufacturing tools for percussion strikes. Some *paenga* sources have *in situ* stone that measure 90cm long, 50cm by 50cm, whereas the *paenga* at Site 2–41 measures 2.45m long, 70cm wide, and 35cm thick. Most likely, these large *paenga* were to be used in *moai–ahu* complex construction (perhaps Ahu Tahira, Vinapu) including being used for sea walls wings, platforms, and other *ahu* features.

Rano Kau and Vai Atare complexes are located within the RK2 flow (Gonzalez–Ferran et al. 2004), created by the volcanic activity of Vai Atare Runga. These study areas also contain porphyritic lavas from caldera outflow of Rano Kau (Vezzoli and Acocella 2009) with benmoreite as the most common TAS class type (Chapter Three). Areas within Rano Kau and Vai Atare show substantial evidence for stone extraction and reduction (Simpson, 2015a, 2016b; Simpson and Dussubieux 2018; Simpson et al. 2018). In Vai Atare, 11 locations were documented, while in Rano Kau, one considerable stone extraction site was recorded. Unlike the evidence from other fine–grained tool quarries and sources, hammer stones, adze blanks, preforms, and pockets of debitage (smaller than 20cm) are rarely found. There is also a lack of *pu* in both areas, with many mining sites taking advantage of surface and cliff benmoreite flows. *Keho* slabs at both Rano Kau and Vai Atare range from very large (~2m) to smaller 20cm blocks, with many sources showing large voids, suggesting intensive stone extraction (Figure 9). While it is evident that a great amount of *keho* stone was removed within the Rano Kau and Vai Atare study areas, we hypothesise that most of this stone was used to build the house walls and cantilever ceilings at the ceremonial village of 'Orongo (Figure 1). This includes the reconstruction of 'Orongo in the 1970s, which used local material from the Rano Kau area (Mulloy 1975). In short, we find little physical evidence at these sources to suggest that stone from these two study areas was used *in situ* to manufacture portable artefacts.

Analytical methods and results

LA–ICP–MS analysis at TFM's Elemental Analysis Facility (EAF)

LA–ICP–MS was chosen over other analytical methods (including XRF) as this technology "is generally highly sensitive and can achieve high–precision results for trace elements, [and] has been widely used to trace the provenance of ancient stone artefacts for reconstructing patterns of interaction" (Ma et al. 2011:890). Our methodology followed Carter and Dussubieux (2016) and Simpson and Dussubieux (2018). Analyses were conducted at TFM's EAF using a Thermo ICAP–Q ICP–MS connected to a New Wave UP213 laser for direct introduction of solid samples. The parameters of the ICP–MS are optimised to ensure a stable signal with a maximum intensity over the full range of elemental masses and to minimise oxides and double ionised species formation (XO^+/X^+ and X^{++}/X^+ <1 to 2%). For that purpose, the flow of argon, the radio–frequency power, the torch position, the mirror, lenses, and detector voltages are adjusted using an auto–optimisation procedure (see Dussubieux et al. [eds] 2016 for further discussion regarding ICP–MS operating procedures).

Laser ablation parameters not only influence the sensitivity of the method and the reproducibility of the measurements, but also the amount of damage to the sample. For better sensitivity, helium was used as the gas carrier in the laser. To determine elements with concentrations in the range of ppm while leaving surface traces invisible to the naked eye, the single point analysis mode was used. This mode employs a laser beam diameter of 100µm, operating at 80% of the laser energy (0.2mJ) and at a pulse frequency of 20Hz. A pre–ablation time of 20 seconds was set to eliminate the transient part of the signal, and to be sure that possible surface contamination did not affect the results of the analysis. For each basalt sample, the average of 10 measurements of 45 elements, corrected from the blank, was considered for the calculation of concentrations. The relatively large number of measurements insured that a representative volume of material was sampled despite the heterogeneity of the basalt. To improve the reproducibility of measurements, the use of an internal standard, Si^{29}, corrected for possible instrumental drifts or changes in ablation efficiency. Concentrations for major elements, including silica, are calculated assuming that the sum of their concentrations (weight % of oxides) is equal to 100% (see Gratuze 1999).

Fully quantitative analyses are possible by using external standards. To prevent matrix effects, the composition of standards must be as close as possible to that of the samples. Two different types of standards are used to measure major, minor, and trace elements. Ideally, we should have used a basalt standard (e.g. USGS standard BHVO–2) but we did not have such a standard in our possession, and in the past, we successfully used glass standards to analyse silica–rich rocks such as carnelian (Carter and Dussubieux 2016). SRM 610, a soda–lime–silica glass doped with trace elements in the range of 500ppm was used as an external standard. Because certified values are available for a very limited number of elements, concentrations from Pearce et al. (1997) were also used. A second series of standards included Corning Glass B and D which match compositions of ancient glass (Brill 1999; Vicenzi et al. 2002; Wagner et al. 2012). We assessed accuracy and precision using Corning Glass B and D and found appropriate agreement of values for the major and minor elements (<5%); however, trace element concentrations for these two glasses have never been published (Table 3). Precision is generally more than 10%, but degrades when concentrations are less than 100ppb (0.1ppm) as these elements are getting close to the limits of detection. In addition, there is no guarantee that the elements are homogeneously distributed in the standards. It is important to note that trace element concentrations in the basalts are generally higher than in the Corning samples. Among the elements selected for statistical analysis, those with RSD better than 10% were used.

Complete major, minor, and trace element values for RNGP and EISP basalt samples, including 17 oxides and 45 elements, are listed in Appendix E. Using this data, we present a principal component analysis of elements and oxides which geochemically defines Rapa Nui's basalt mines, quarries, sources and workshops, allowing the assignment of a provenance to EISP samples.

Principal component analysis (PCA)

The approach used here relies on the provenance hypothesis, which implies that "the variation [of the elemental or isotopic compositions] between sources is greater than that within them" (Wilson and Pollard 2001:508). In order to examine multivariate patterning in the data, principal component analysis was conducted (Baxter 2003:73–89). This approach has been used in archaeology for heterogeneous materials including basalt (e.g. Di Piazza and Pearthree 2001). Some elements and oxides (Na_2O, MgO, K_2O, CaO, Be, B, V, Ni, Co, Sr, Zr, Nb, Sn, Ba, Ta, Mo, Th) have significantly different averages when comparing the five sources and therefore were subsequently selected for statistical analysis (Table 4). Before principal components were calculated using JMP 13 statistical software[2], 17 oxides and elements were converted into base–10 logarithms as the different elements have concentrations that can vary by several orders of magnitude (Baxter 2003). Principal component 1 accounts for 64.5% and Principal component 2 for 13.7% of the total variance in the data (Figure 11). Results demonstrate that Ava o'Kiri and Pu Tokitoki have more Sr and CaO compared to the other sources. The southwest coast stone is enriched in Na_2O but depleted in Co, V, and Ni. At Rano Kau and Vai Atare, measurements of Mo, Ta, and Sn are higher compared to the other sources (Table 4).

Figure 12 plots the five study areas in their elemental space. Notably, elements and oxides used for statistical analysis establish that Ava o'Kiri and Pu Tokitoki, that are found in the same area of the plot, are geochemically similar. This is likely because both study areas are found in the same volcanic flow and include similar geological and total alkali versus silica compositions (Gonzalez–Ferran et al. 2004; Simpson and Dussubieux 2018; Simpson et al. 2017; Vezzoli and Acocella 2009), making elemental discrimination difficult (see also Stevenson et al. 2000). Rano Kau and Vai Atare study areas exhibit similar geochemistry, with samples from Rano Kau less variable in elemental space. Geochemically, the southwest coast study area separates from other RNGP study areas, exhibiting a more homogeneous elemental fingerprint.

Figure 13 plots the PCA analysis of EISP archaeological material versus RNGP study areas. Although many artefacts are sourced to Ava o'Kiri and Pu Tokitoki and less to the southwest coast, there are some artefacts which plot outside PCA probability ellipses. This detection may indicate that our analyses have not completely captured the geochemical variability of RNGP study areas, or more likely, they have identified quarries and sources that the RNGP has not located and/or analysed. Possible settings for these unknown quarries and sources include locations in the archaeological "*corrales*" (enclosures) found in the centre of the island (Stevenson et al. 2005; Vargas et al. 2006), or on unsurveyed cliff faces as found on Poike (Simpson et al. 2017).

Contradicting the proposition by McCoy (2014) and geoarchaeological sourcing results of Ayres et al. (1998) and Harper (2008), not one adze under study was provenanced to Rano Kau or Vai Atare. This result, along with the limited archaeological site evidence for *in situ* tool making (i.e. cores, blanks, preforms, and debitage), suggests the limited use of Rano Kau and Vai Atare basalt for portable artefact making.

Radiocarbon dating

B. papyrifera samples returned dates between 1455–1640 AD (Simpson et al. 2018). While Bayesian probabilities for all radiocarbon determinations is in preparation, Figure 10 presents ^{14}C radiometric results, plotting: Beta/sample ID, square location, sample level (cm), and calibrated date (calAD) for the activity around *moai* RR–001–156. Table 5 provides basic data for each radiocarbon age determination. While these ^{14}C dates are the first ever reported for inside the Rano Raraku crater, other radiometric dates have been reported from excavations conducted outside the crater, around the southern skirt of the *moai* quarry. This includes three dates at 750 ±250 BPcal., 550 ±70 BPcal., and 480 ±100 BPcal. (Martinsson–Wallin and Crockford 2002). Considering that these ^{14}C dates are earlier than the dates presented in his chapter for the interior crater, it is likely that *moai* carving on the exterior of Rano Raraku took place sometime before *moai* carving began inside the volcanic crater. A larger corpus of ^{14}C dating from the inside of the Rano Raraku, however, would be needed to confirm this.

Discussion

Schiffer's publications (1976, 1987) encourage archaeologists to consider the various cultural and natural transforms that create the archaeological record and how post–depositional processes affect site formation and influence archaeological interpretations. Thus, endeavouring to better understand both the geomorphological formation of Rano Raraku and human use at the tuff crater to make Easter Island's iconic statuary, a 5m–deep excavation in Quarry 02 focused on the morphological recording of lithostratigraphic units around the area of *moai* RR–001–156 (Dunn et al. 2015; Van Tilburg and Pakarati 2014; Van Tilburg et al. 2015a,b). This fieldwork revealed a 2m deposit of colluvium that formed after the initial use of the *moai* quarry. Under this colluvium deposition, a further 3m was removed until reaching the base of *moai* RR–001–156. Multiple specimens and artefact raw material types were recovered within and from under the colluvium during excavation. *B. papyrifera* provided samples for radiometric determination, resulting in five statistically identical calibrated dates between 1455–1645 calAD. Also around *moai* RR–001–156 and 157, 1624 basalt *toki*, picks, and fragments were found in association with cores, flakes, and debitage. Portable XRF analysis of the *toki* and picks revealed that at least two unidentified basalt sources were exploited to obtain the raw material used to manufacture the 170 *toki* and picks under study (Fischer and Bahamondez 2011).

Our current study reports more accurate and precise LA–ICP–MS elemental data for EISP samples including four complete picks along with 17 recovered specimens (*toki* and pick fragments, flakes, and cores). This elemental data was compared to the geochemical signatures of 31 mines, quarries, sources, and workshops from five study areas as determined by the RNGP using PCA. Results highlight that each of the four picks found around *moai* RR–001–156 were sourced to the Ava o'Kiri and Pu Tokitoki complexes, establishing a link from these study areas and their basalt resources to the statue quarry at Rano Raraku. This result supports ethnographic observations by Métraux (1940) and geochemical results by Simpson and Dussubieux (2018) and Simpson et al. (2018) who also identified Ava o'Kiri and Pu Tokitoki as the major sources for the stone used in adze and pick manufacture. Of the 17 EISP specimens that were recovered and elementally analysed, four samples were from within the colluvium's 0–199cm depth. All four of these samples were found to be geochemically distinct, unknown to the RNGP. It may be that the geologic origin(s) of these specimens was from the same Rano Raraku region, and their inclusion into the 2m colluvium was due to later cultural and natural transform processes after statue carving has ceased.

The geochemical analysis of 13 archaeological specimens recovered from 2–5m provides insight to stone material selection and use to fabricate artefacts found in Rano Raraku. More than 60% of all EISP's basalt samples were elementally sourced to Ava o'Kiri and Pu Tokitoki. Only five samples were found from outside these study areas, with two samples originating from the southwest coast mining complex, and three samples sourced from locations unknown to the RNGP. This pattern, again, shows the preferential use of Ava o'Kiri and Pu Tokitoki stone to make tools to carve *moai* at Rano Raraku. In addition, with a consistent grouping of samples originating from Ava o'Kiri and Pu Tokitoki and the southwest coast, it appears that there were at least two main locations that produced stone for *toki* and pick manufacture. These results support conclusions made by Fischer and Bahamondez (2011), where two sources of basaltic material for *toki* and picks were identified thought pXRF analysis. Yet, Ava o'Kiri and Pu Tokitoki appear to be the principle location for the basalt used to make the artefacts recovered around *moai* RR–001–156.

The five radiocarbon dates reported here are from the area around RR–001–156 and are statistically identical at 1455–1645calAD. While it should be noted that the dated charcoal is not in direct association with the archaeological material examined, we suggest that basalt material coming out of the Ava o'Kiri and Pu Tokitoki quarry complex, the southwest coast, and the unknown sources still unidentified by the RNGP, may be bracketed between 1455–1645 AD. As this time period has been suggested by other researchers as a possible peak of *moai* carving (Fischer 2005; Hamilton et al. 2011; Van Tilburg 1994; Vargas et al. 2006), results from this chapter support this interpretation, and confirm that during this period, Rano Raraku acted as a major economic, ideological, and sociopolitical focal point for the pre–contact culture.

Overall, the evidence in the interior region of Rano Raraku demonstrates that multiple statues were being carved, but not necessarily finished at the same time, creating a necessity to have a quantity of stone carving tools on hand. Additionally, the oldest surveys of Rano Raraku documented the quarry as being littered with numerous deposits of *toki* and picks (Pinart 1878; Routledge 1919; Skjølsvold 1961). This pattern for the purposeful caching of finished tools has also been documented on Rapa Nui for other stone artefacts including obsidian *mata'a* (bifaced tool) and handheld figure carvings (Heyerdahl 1975; Heyerdahl and Ferdon 1961; McCoy 1976; Vargas et al. 2006). We maintain that this purposeful caching of *toki* and picks – including the 1624 specimens recovered around *moai* RR–001–156 – does not represent a dramatic abandonment of *moai* carving as has been proposed and linked to the island's alleged "collapse" (Bahn and Flenley 1992; Diamond 2005), but instead highlights that *tangata māori anga moai* (ancient statue carvers) and their task groups, supported by *tangata honui*, were well organised and planned ahead by having a surplus of necessary materials on hand and ready to use. In turn, this made Rano Raraku a highly productive megalithic quarry, hence the production of ~1000 *moai* (see also Hamilton 2007; Hamilton et al. 2011; Simpson et al. 2018; Chapter Seven). We believe that the need for large quantities of *toki* and picks may have been the reason for such intensive quarrying at Ava o'Kiri and Pu Tokitoki. Judging from the size of these complexes, and the sheer amount of stone extraction and reduction that took place, these basalt quarries and sources were likely in use from a much earlier time than 1455 AD, more so if the island was colonised by 1100–1200 AD (Hunt and Lipo 2006; Mulrooney 2013; Stevenson et al. 2015; Weisler and Green 2011). However, further dating and geochemical analysis is needed to confirm this.

Like Rano Raraku for *moai* and Puna Pau for *pukao*, Ava o'Kiri and Pu Tokitoki likely served as major focal points for stone tool manufacture for generations, with great labour and organisational effort focused on extracting and reducing stone to produce basalt artefacts. This effort produced nearly 50 documented sites dedicated to the production of stone tools. The acquisition of this basalt may have been the work of specialised 'task groups' who visited the area to extract stone on an on–going basis (Stevenson et al. 2000). In turn, the intensive use of Ava oʻKiri and Pu Tokitoki by Rapa Nui's stone tool artisans created an anthropogenic landscape by mining *puku* with multiple geologic deposits, excavating *pu* to make pit repositories, and reducing basalt into cores, blanks, preforms, and arguably finished tools. As such, we maintain that like other skilled experts (McCoy 2014; Simpson et al. 2017, 2018; Simpson and Dussubieux 2018), *tangata māori anga māʻea* (experts in stone tool manufacture) were recognised as a highly–privileged sociopolitical class and were rewarded for their specialised labour with luxury resources (Métraux 1940). Once artefact manufacture by these experts was nearly complete and/or finished at Ava oʻKiri and Pu Tokitoki, and to a lesser degree from the southwest coast, tools such as *toki* and picks were transferred to Rano Raraku. At this impressive Polynesian megalithic quarry, these travelled tools were then used to carve the iconic symbol of Easter Island and its people, the *moai*.

Conclusion

This joint EISP and RNGP investigation used multiple data sets to better understand the provenance and timing of use for basalt material found in Rano Raraku. The synthesis of this data confirms a major ancient connection between the Ava oʻKiri and Pu Tokitoki basalt stone complexes and the *moai* quarry during 1455–1645 AD. Further chronological refinement awaits a Bayesian analysis of the other radiocarbon age determinations. Our results suggest that basalt stone tool makers played a substantial role in manufacturing the tools required for the efflorescence of *moai* statuary, especially during the peak production period on Easter Island. We argue that this specialised class of master tool makers, along with task groups, where responsible for the creation of Rapa Nui's basalt industries that were used to produce the adzes and picks for *moai* carving. Our work shows that by better delineating basalt tool operational sequences – from stone acquisition at Ava oʻKiri and Pu Tokitoki to artefact use for statue carving at Rano Raraku – we can better appreciate the specialisation of Rapa Nui stone tool manufacture and *moai* fabrication.
Lastly, the collaboration between the EISP and RNGP provides an example of how the integration of multiple datasets, by projects with different personnel, research designs, and goals, serves to better understand the ancient Rapa Nui culture. We hope our example of collaboration is enough to join other island projects in larger synergetic investigations interested in uncovering and better appreciating Easter Island's past (see also Larsen and Simpson 2014).

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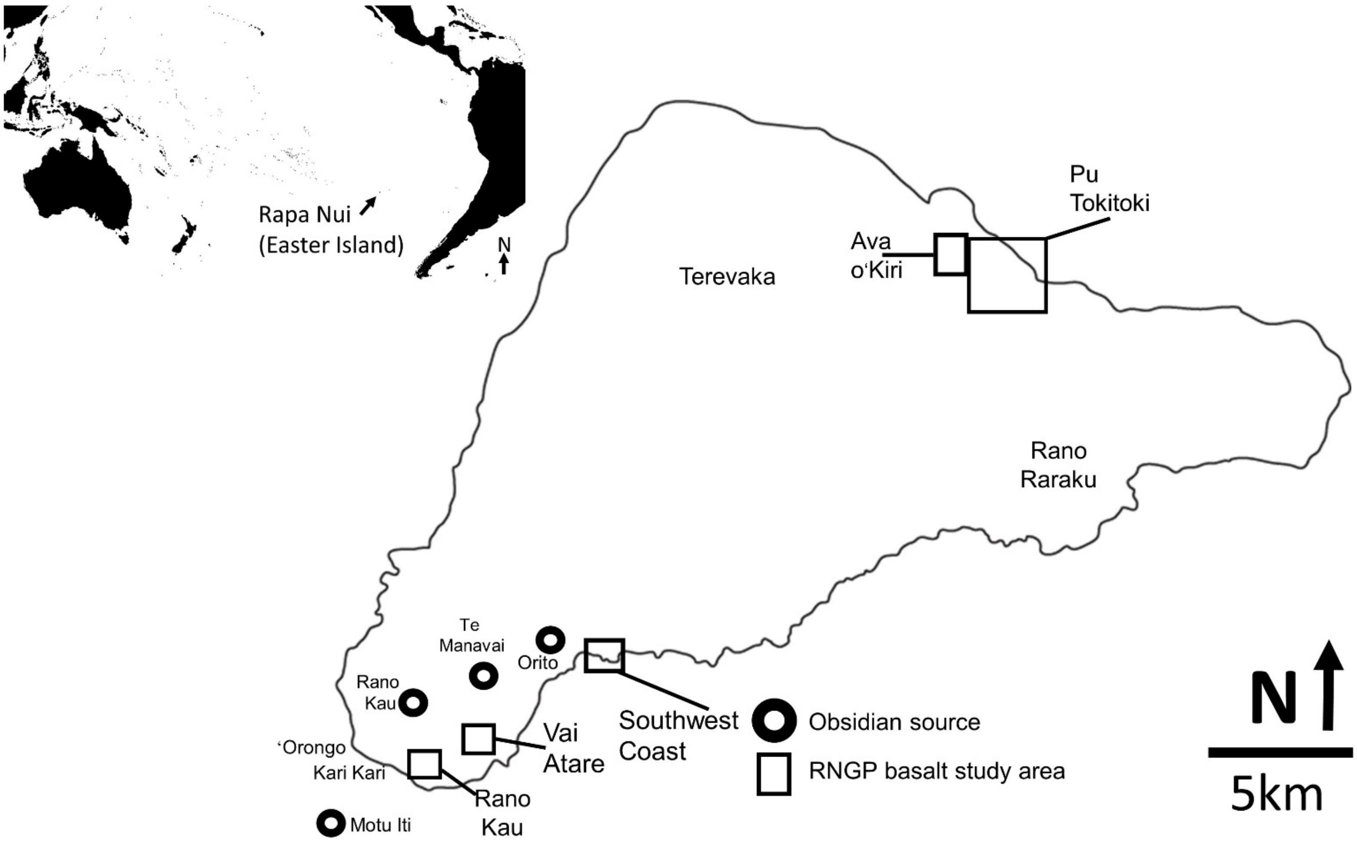

Figure 1. Rapa Nui, obsidian sources, basalt study areas, and locations mentioned in the chapter.

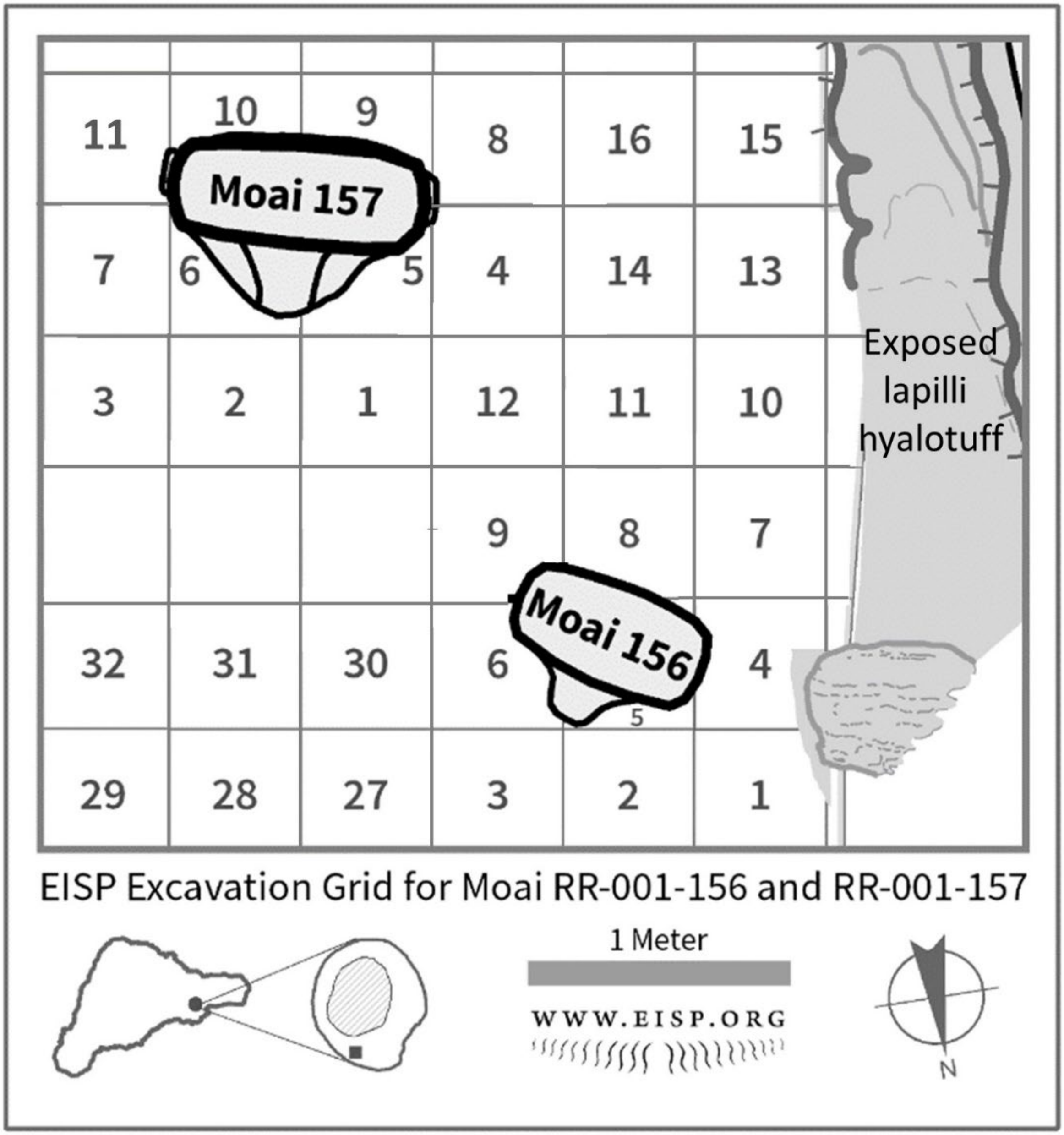

Figure 2. EISP excavation grid for RR–001–156 and RR–001–157 (Cartography by A. Hom/EISP).

Figure 3. Excavated *moai* RR–001–156 (Photo by B. Tuki Haoa/EISP).

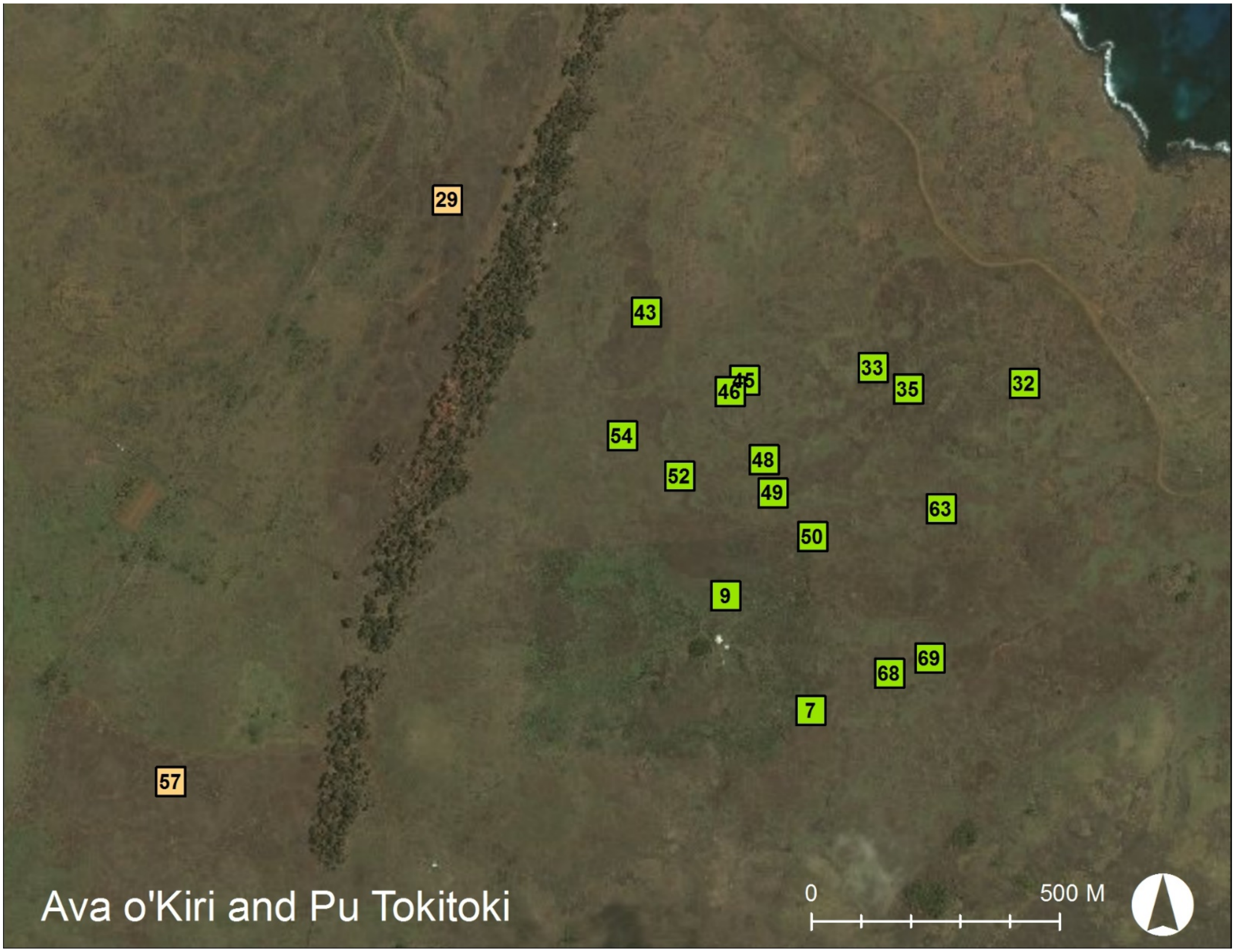

Figure 4. RNGP sites in Ava o‘Kiri and Pu Tokitoki under geochemical analysis (Photo courtesy of ESRI, Digital Globe; Cartography by A. Hom/EISP; Simpson 2017b).

Figure 5. RNGP#48 Rapa Nui's largest fine–grain basalt quarry with multiple *puku,* seven *pu*, numerous adze forms, artifacts, and extensive debitage (Photo by Simpson).

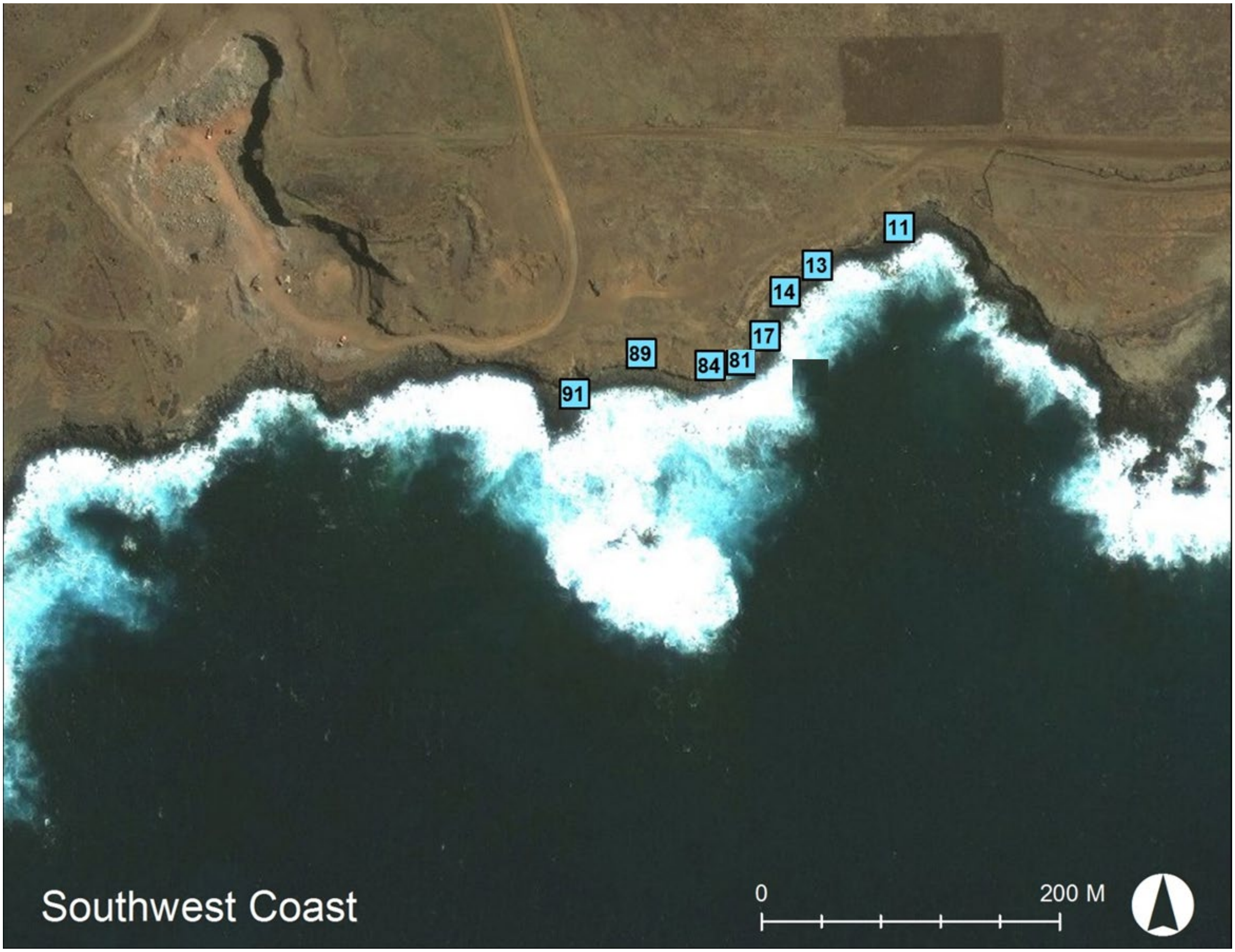

Figure 6. RNGP sites in the southwest coast under geochemical analysis (Photo courtesy of ESRI, Digital Globe; Cartography by A. Hom/EISP; Simpson 2017b).

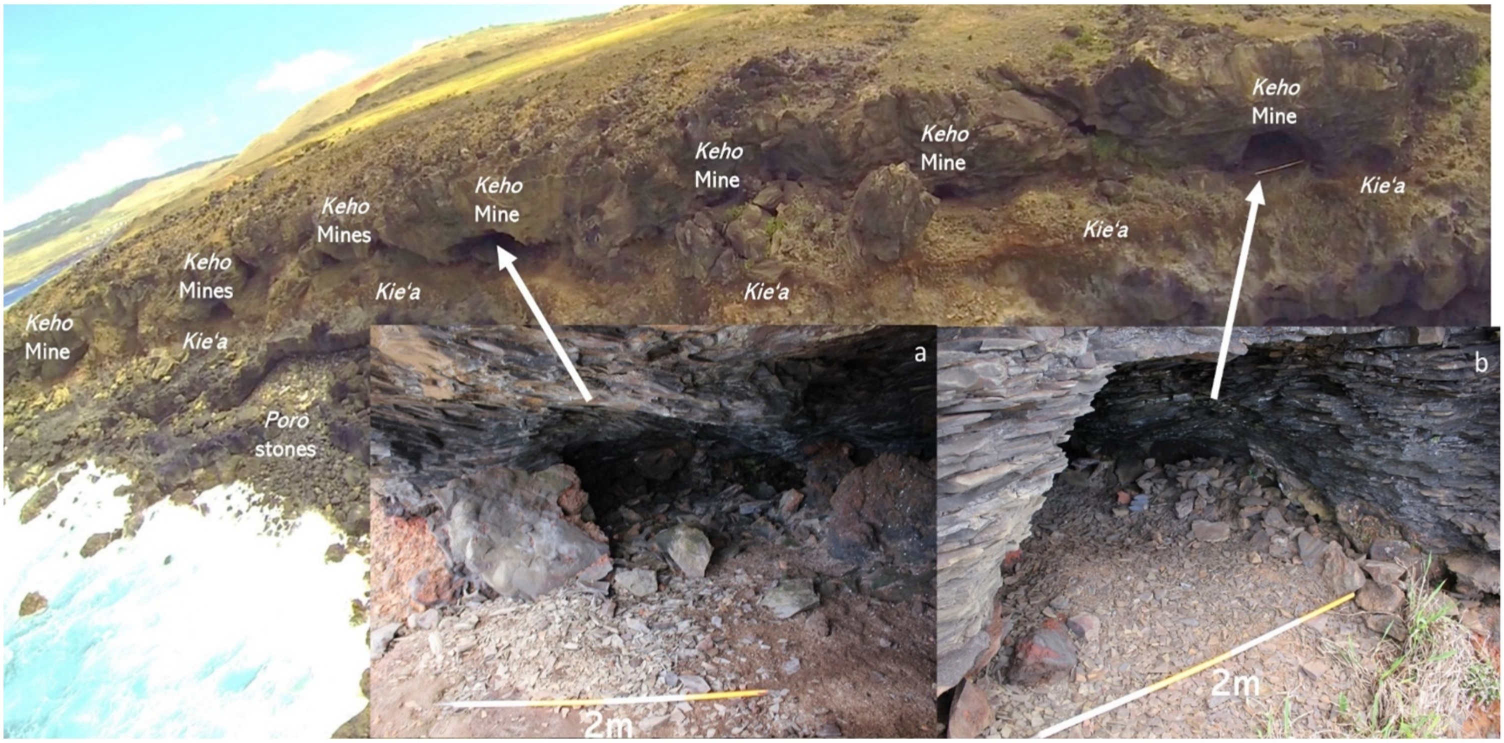

Figure 7. RNGP#11 Southwest coast mine complex with RNGP sites #11(a) and #13(b) (Photo by Simpson).

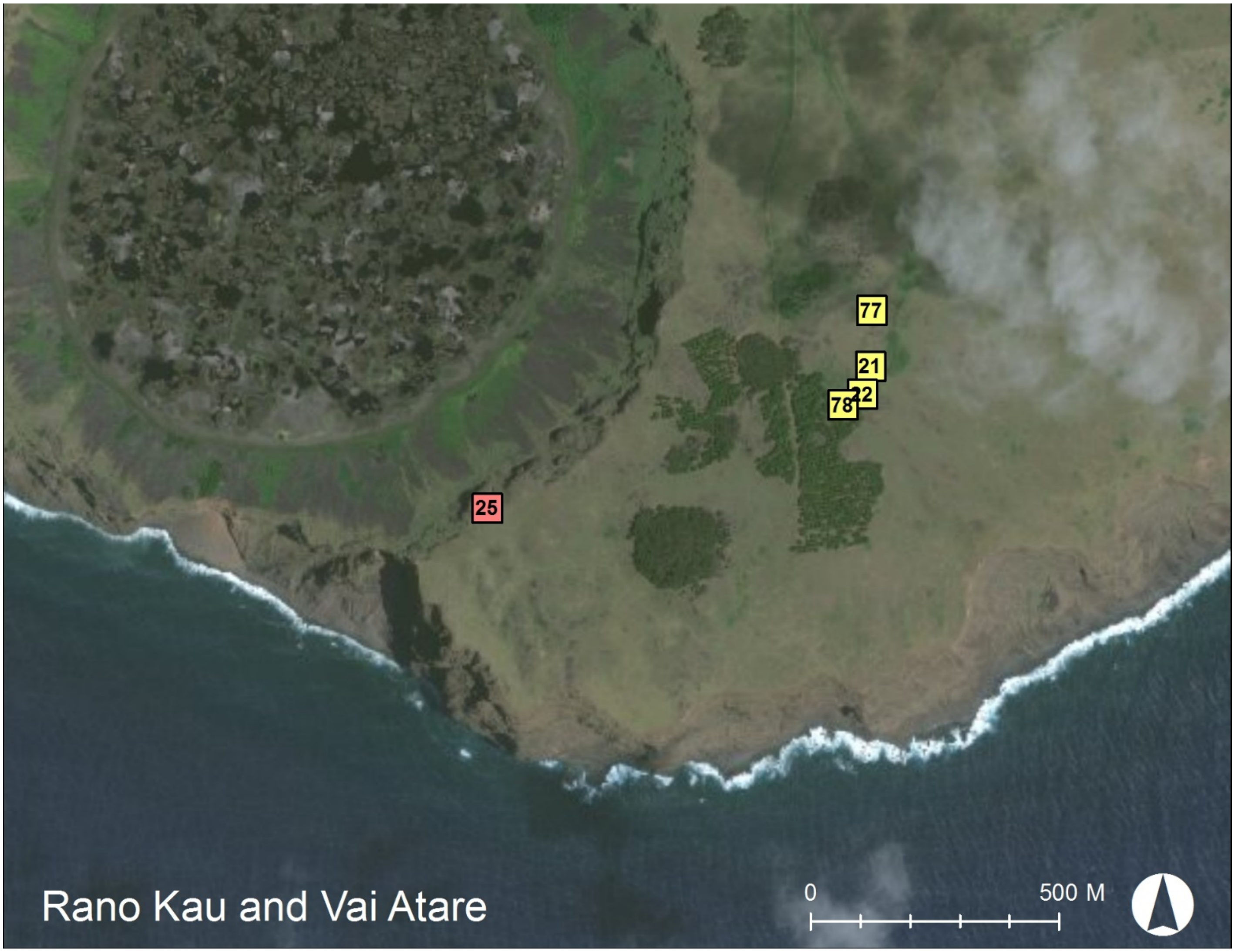

Figure 8. RNGP sites in Rano Kau and Vai Atare under geochemical analysis (Photo courtesy of ESRI, Digital Globe; Cartography by A. Hom/EISP; Simpson 2017b).

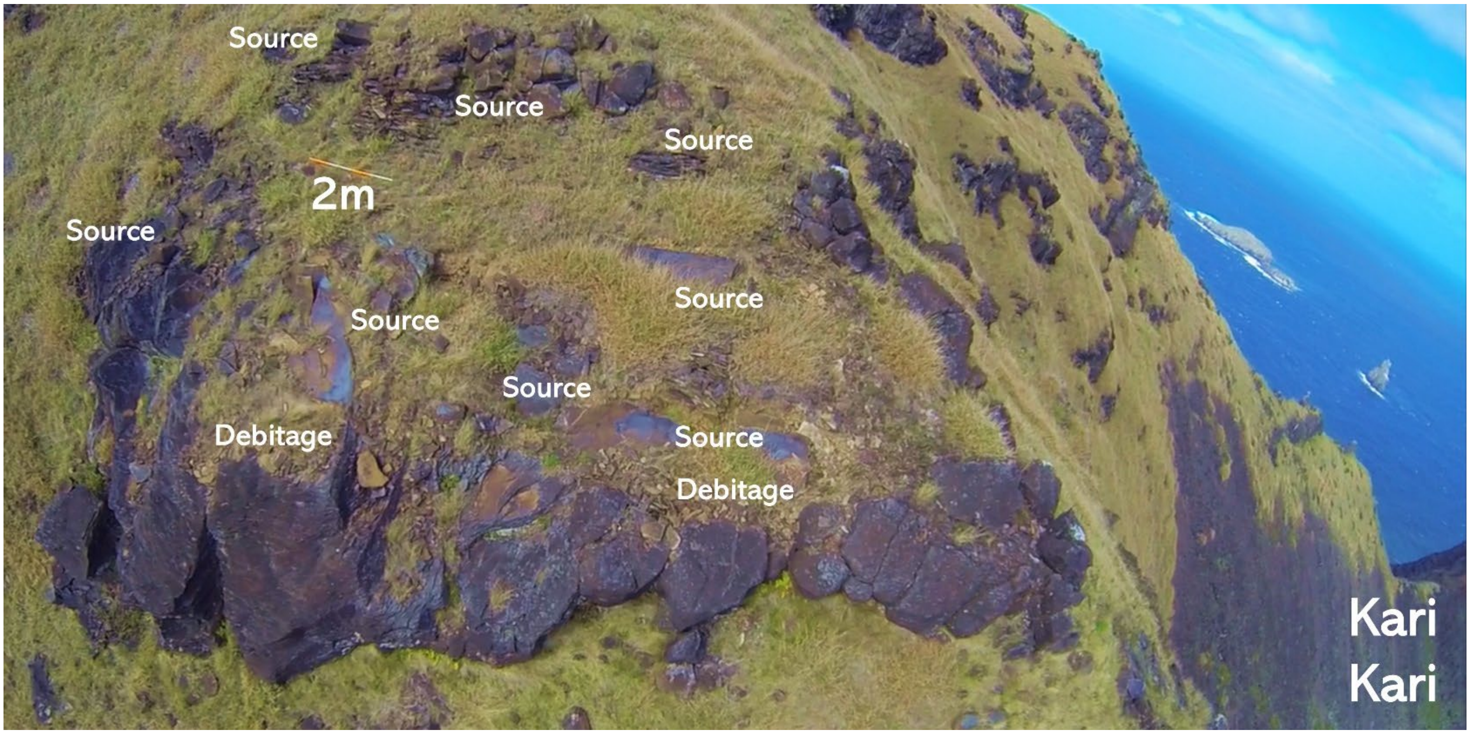

Figure 9. RNCG#25: *Keho* quarry in Rano Kau (Photo by Simpson).

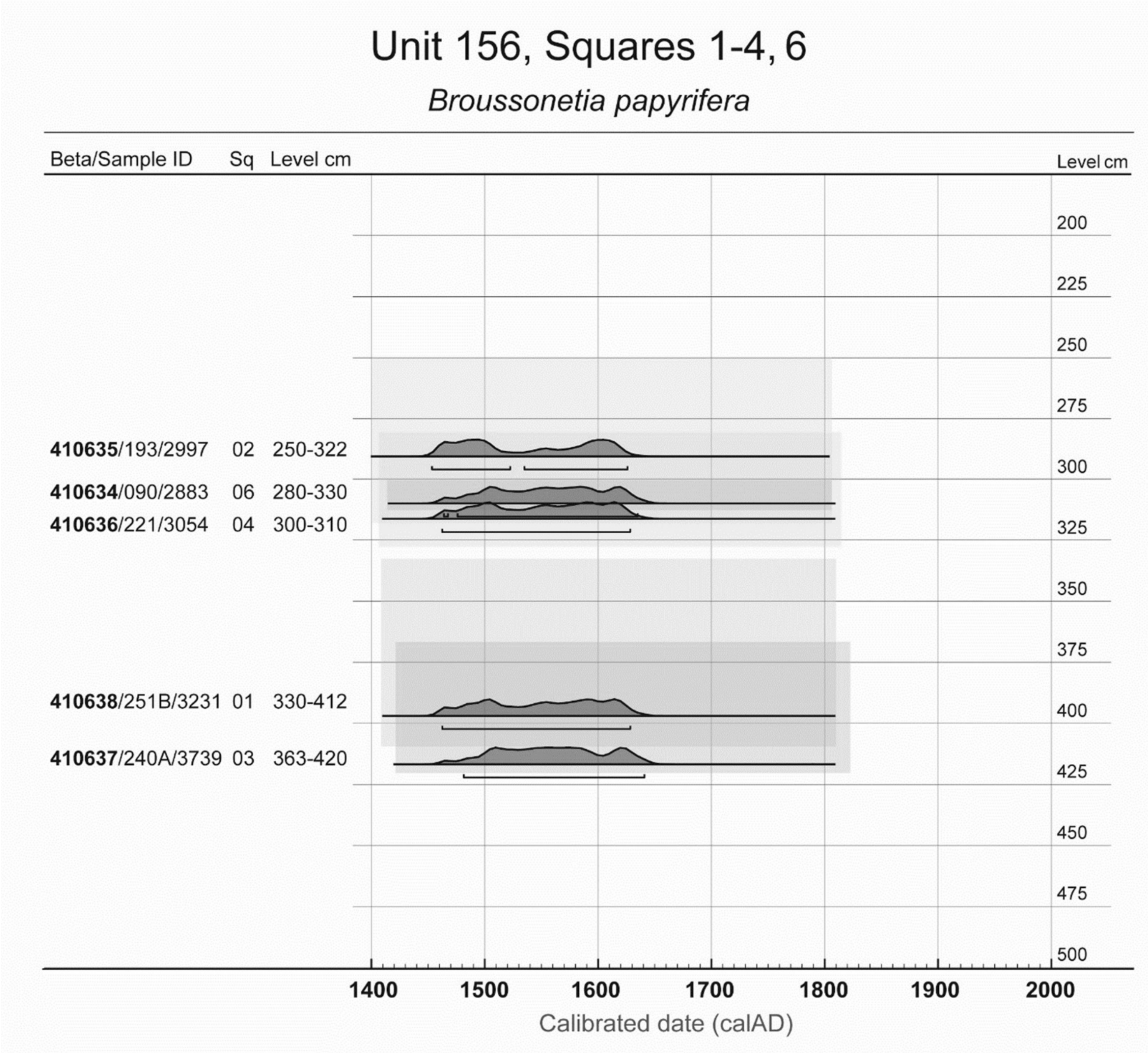

Figure 10. Radiometric data from *B. papyrifera* samples at RR–001–156 plotting beta/sample ID, square location, level cm, and calibrated date (calAD).

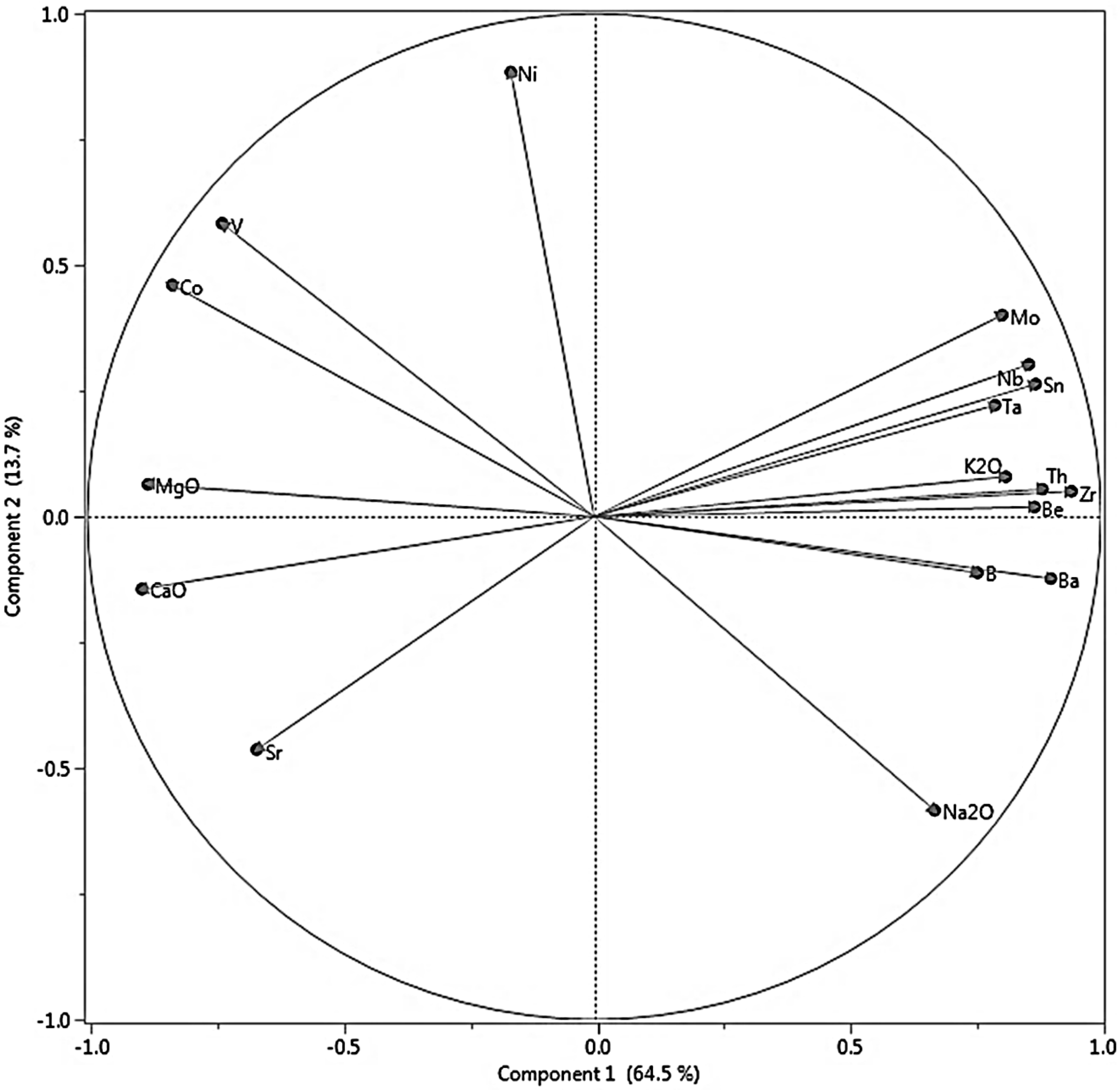

Figure 11. Component loadings by elements included in the PCA.

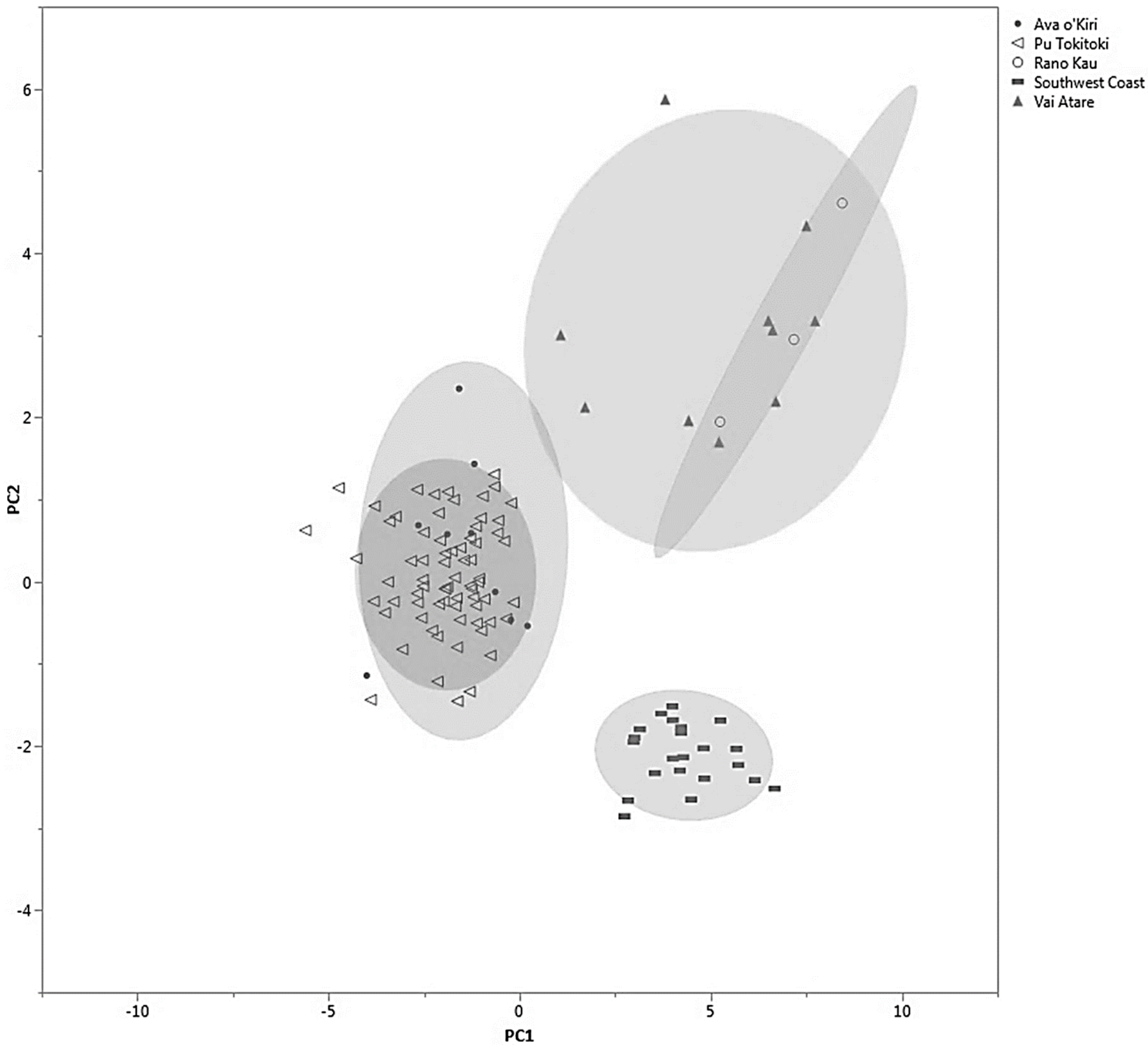

Figure 12. PCA analysis of RNGP study areas (ellipses represent 90% confidence probability).

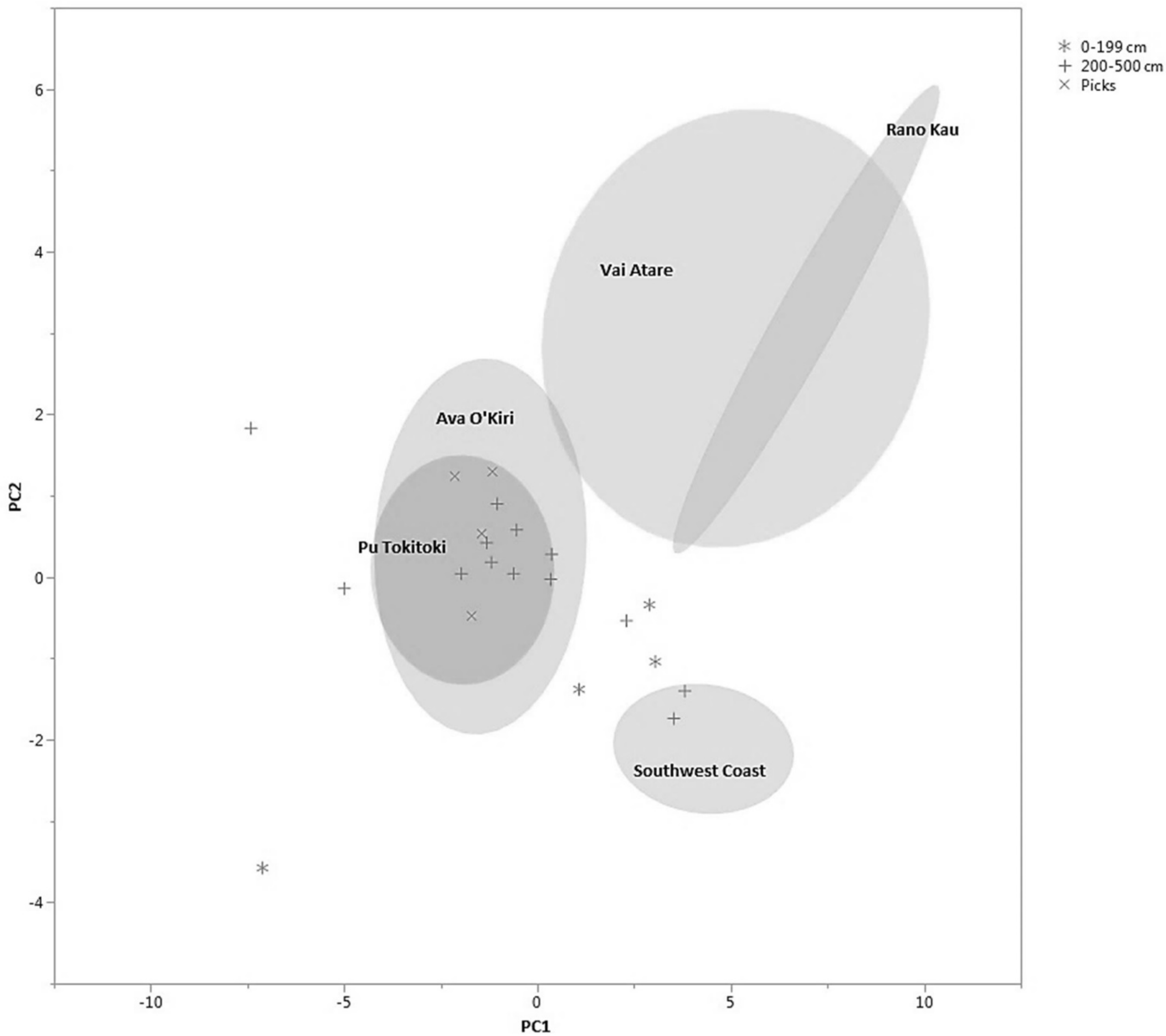

Figure 13. PCA analysis of EISP archaeological samples and RNGP study areas (ellipses represent 90% confidence probability).

RNGP #	EISP #	*Moai* #	Square #	Depth (cm)	Length (cm)	Width (cm)	Weight (g)	Specimen description
RR 1	RR-001-156-183	156	7	120	7.5	4.5	52.05	Polished flake/debitage
RR 2	RR-001-156-200	156	7	200	7	5.1	93.74	Flake/debitage with platform
RR 3	RR-001-156-132	156	7	220-320	8.5	5.1	102.28	*Toki*/pick fragment with cortex
RR 4	RR-001-156-038	156	7	320	4.8	3.1	13.88	*Toki* fragment/debitage with reduction scars
RR 5	RR-001-156-052	156	7	375-424	6.2	3.9	37.27	Flake/debitage
RR 6	RR-001-156-049	156	7	373-425	8.1	5	65.85	Flake/debitage with reduction scars
RR 7	RR-001-156-117	156	7	475-500	7	3.7	36.84	*Toki* or pick fragment/debitage with reduction scars and cortex
RR 8	RR-001-156-023	156	9	0-25	9.6	5.9	131.05	Pick fragment/debitage with reduction scars
RR 9	RR-001-156-106	156	9	100-200	6.3	2.6	11.81	Polished *toki* fragment
RR 10	RR-001-156-055	156	9	180	12	6.7	249.75	Pick fragment with cortex
RR 11	RR-001-156-216	156	9	200	4.9	3.9	17.68	Core/pick fragment
RR 12	RR-001-156-216	156	9	200	7.3	6.2	247.42	Polished fragment
RR 13	RR-001-156-206	156	9	220	5.1	3.4	28.97	Polished fragment/*poro* (beach stone)
RR 14	RR-001-156-062	156	9	220-320	5.9	4	18.92	*Mata'a* (biface)/debitage
RR 15	RR-001-156-062	156	9	220-320	3.4	3	35.23	*Toki* fragment
RR 16	RR-001-156-153	156	9	434	7.6	6.2	68.53	Polished flake/scraper with retouching

RR 17	RR-001-156-169	156	9	434-496	6.94	5.1	38.26	Debitage/*poro* (beach stone) fragment
RR 18	n/a	156	n/a	n/a	858	16	9	Complete pick
RR 19	n/a	156	n/a	n/a	>1kg	19	9	Complete pick
RR 20	n/a	156	n/a	n/a	810	15	8.5	Complete pick
RR 21	n/a	156	n/a	n/a	560	15.5	7	Complete pick

Table 1. EISP archaeological samples from the excavation of *moai* RR–001–156 subjected to geochemical analysis.

RNGP site number	Study Area	Type	Area m^2
29	Ava o‘Kiri	Quarry/Workshop	264
57	Ava o‘Kiri	Quarry/Workshop	420
7	Pu Tokitoki	Quarry/Workshop	800
9	Pu Tokitoki	Quarry/Workshop	660
32	Pu Tokitoki	Quarry/Workshop	609
33	Pu Tokitoki	Quarry/Workshop	500
35	Pu Tokitoki	Source/Workshop	182
43	Pu Tokitoki	Quarry/Source/Workshop	195
45	Pu Tokitoki	Quarry/Workshop	180
46	Pu Tokitoki	Quarry/Workshop	110
48	Pu Tokitoki	Quarry/Source/Workshop	1000
49	Pu Tokitoki	Quarry/Workshop	420
50	Pu Tokitoki	Quarry/Workshop	360
52	Pu Tokitoki	Quarry/Workshop	660
54	Pu Tokitoki	Quarry/Workshop	198
63	Pu Tokitoki	Quarry/Workshop	102
68	Pu Tokitoki	Quarry/Source/Workshop	700
69	Pu Tokitoki	Quarry/Workshop	156
25	Rano Kau	Quarry/Source/Workshop	1200
11a–b	Southwest Coast	Quarry/Workshop	33
13	Southwest Coast	Quarry/Workshop	68
14	Southwest Coast	Quarry/Workshop	123
17	Southwest Coast	Quarry/Workshop	38
81	Southwest Coast	Quarry/Workshop	40
84	Southwest Coast	Source/Workshop	90
89	Southwest Coast	Quarry/Workshop	33
91	Southwest Coast	Source/Quarry/Workshop	49
21	Vai Atare	Source/Workshop	16
22	Vai Atare	Source/Workshop	84
77	Vai Atare	Quarry/Workshop	21
78	Vai Atare	Quarry-workshop	45

Table 2. RNGP quarries, sources, and workshops under geochemical analysis.

	CORNING B				CORNING D			
	Brill 1999	Dussubieux et al. 2009	Average this study	RSD this study	Brill 1999	Dussubieux et al. 2009	Average this study	RSD this study
SiO_2	61.6%	61.5%	62.5%	0.5%	55.24%	55.60%	55.5%	1%
Na_2O	17.0%	17.6%	16.6%	1.1%	1.20%	1.46%	1.3%	1%
MgO	1.03%	1.01%	1.04%	1.5%	3.94%	3.95%	4.0%	2%
Al_2O_3	4.36%	4.38%	4.35%	1.2%	5.30%	5.36%	5.2%	2%
P_2O_5	0.82%	0.81%	0.91%	7.7%	3.93%	3.94%	3.8%	4%
K_2O	1.00%	1.06%	1.11%	2.7%	11.30%	11.40%	11.4%	1%
CaO	8.56%	8.95%	8.69%	3.7%	14.80%	15.00%	15.1%	6%
MnO	0.25%	0.25%	0.25%	2.3%	0.55%	0.56%	0.6%	2%
Fe_2O_3	0.34%	0.37%	0.36%	3.0%	0.52%	0.53%	0.5%	3%
CuO	2.66%	2.63%	2.54%	6.7%	0.38%	0.37%	0.4%	6%
TiO_2	0.09%	0.10%	0.10%	4.5%	0.38%	0.34%	0.3%	7%
PbO	0.61%	0.53%	0.61%	1.4%	0.48%	0.28%	0.3%	3%
Li	5		11	4%	23		27	6%
Be			0.1	37%			0.08	46%
B	62		97	3%	311		311	5%
Sc			6	21%			5	24%
V	224	168	187	2%		95	93	3%
Cr			60	4%	21		19	5%
Ni	786	707	712	2%		369	361	2%
Co	362		330	2%	180		141	2%
Zn	1527	1607	1698	9%	803	803	831	7%
As			18	6%			235	5%
Rb	9		12	5%	46		42	6%
Sr	161	161	163	8%	482	490	460	4%
Zr			166	3%			87	3%
Nb			0.5	49%			0.7	15%
Ag			63	3%			27	4%
In			1	13%			3	8%
Sn	315	242	191	7%	787	787	614	3%
Sb	3843		2378	7%	8103		5092	10%
Cs			0.1	61%			0.22	55%
Ba	1075	627	662	2%	4568	2508	2284	5%
La			0.4	27%			0.76	15%
Ce			1	52%			0.79	44%
Pr			0.1	66%			0.11	68%
Ta			0.2	38%			0.29	8%
Au			0.1	97%			0.10	55%

Y			1	19%			0.50	27%
Bi			41	6%			12	7%
U			0.4	42%			0.23	19%
W			0.2	98%			0.15	68%
Mo			1.7	8%			3.16	10%
Nd			0.2	47%			0.25	40%
Sm			0.07	52%			0.08	53%
Eu			0.07	41%			0.15	43%
Gd			0.07	41%			0.08	54%
Tb			0.03	68%			0.02	68%
Dy			0.09	33%			0.07	33%
Ho			0.04	53%			0.03	50%
Er			0.08	23%			0.06	40%
Tm			0.03	61%			0.02	58%
Yb			0.1	21%			0.08	22%
Lu			0.04	52%			0.03	41%
Hf			4.3	3%			2.28	3%
Th			0.94	8%			0.77	7%

Table 3. Compared average compositions for Corning Glass B and D. The averages are calculated from 15 compositions measured over the course of the project. Table 2 includes compositions published by Brill et al. (1999) and Dussubieux et al. (2009) using different ICP–MS. The relative standard deviation (divided by the average concentration for a given element) is calculated giving an indication of measurement precision.

	Ava o'Kiri (9)		Pu Tokitoki (71)		Rano Kau (3)		Southwest Coast (22)		Vai Atare (10)	
SiO2	56.7%	4%	55.3%	4%	63.9%	1%	61.7%	3%	64.1%	8%
Na_2O	**3.71%**	**16%**	**3.89%**	**10%**	**4.53%**	**8%**	**5.1%**	**6%**	**4.12%**	**19%**
MgO	**2.81%**	**33%**	**3.01%**	**29%**	**0.68%**	**87%**	**0.7%**	**45%**	**0.62%**	**85%**
Al_2O_3	14.8%	14%	15.0%	10%	16.1%	11%	15%	7%	16.6%	18%
P_2O_5	0.90%	19%	0.83%	15%	0.37%	39%	0.33%	18%	0.29%	50%
K_2O	**1.28%**	**20%**	**1.32%**	**16%**	**3.0%**	**14%**	**2.0%**	**8%**	**2.63%**	**20%**
CaO	**6.75%**	**7%**	**7.4%**	**10%**	**2.2%**	**61%**	**3.1%**	**28%**	**2.09%**	**59%**
MnO	0.23%	27%	0.24%	25%	0.18%	36%	0.19%	38%	0.12%	38%
Fe_2O_3	10.7%	21%	10.9%	21%	7.9%	11%	10%	20%	8.12%	30%
TiO_2	2.17%	29%	1.95%	30%	0.98%	15%	1.0%	14%	1.20%	57%
Li	7.8	39%	8.84	25%	20	35%	9.7	34%	15	41%
Be	**2.1**	**24%**	**2.2**	**15%**	**5.1**	**23%**	**3.9**	**41%**	**4.2**	**15%**
B	**3.4**	**29%**	**3.9**	**24%**	**8.5**	**26%**	**6.5**	**28%**	**6.0**	**32%**
Sc	30	20%	30.3	20%	25.4	23%	29	11%	22	16%
V	**122**	**25%**	**148.9**	**29%**	**41.6**	**25%**	**0.97**	**34%**	**71**	**127%**
Cr	0.67	62%	1.59	41%	5.2	32%	1.3	72%	3.5	84%
Ni	**0.65**	**30%**	**0.87**	**49%**	**6.5**	**86%**	**0.17**	**33%**	**4.7**	**81%**
Co	**20**	**33%**	**22**	**27%**	**7.5**	**2%**	**2.8**	**40%**	**8.7**	**44%**
Cu	13	21%	18	30%	19	49%	6.7	34%	18	34%
Zn	175	23%	165	18%	183	3%	182	15%	166	36%
As	0.30	61%	0.65	48%	2.1	70%	1.1	70%	1.1	55%
Rb	21	36%	21	22%	50	36%	35	36%	56	40%
Sr	**240**	**20%**	**283**	**12%**	**130**	**29%**	**208**	**9%**	**117**	**23%**
Zr	**436**	**16%**	**409**	**11%**	**883**	**13%**	**716**	**9%**	**830**	**20%**
Nb	**63**	**16%**	**60**	**11%**	**129**	**13%**	**83**	**10%**	**108**	**17%**
Ag	0.14	18%	0.20	48%	0.71	43%	0.27	20%	0.34	52%
In	0.19	15%	0.25	52%	0.55	51%	0.25	28%	0.34	32%
Sn	**3.7**	**20%**	**3.5**	**17%**	**8.2**	**21%**	**4.9**	**16%**	**7.0**	**27%**
Sb	0.48	56%	1.04	155%	1.2	31%	0.35	71%	1.2	151%
Cs	0.23	36%	0.30	32%	0.67	37%	0.21	55%	0.4	36%
Ba	**190**	**13%**	**174**	**14%**	**328**	**3%**	**265**	**8%**	**273**	**20%**
La	39	18%	39	16%	40	48%	40	31%	33	42%
Ce	96	16%	94	17%	84	49%	86	39%	73	37%
Pr	14	16%	14	18%	13	47%	13	29%	10	39%
Ta	**4.4**	**17%**	**3.8**	**19%**	**8.3**	**11%**	**5.1**	**11%**	**6.0**	**31%**
Au	0.02	14%	0.04	98%	0.10	39%	0.04	31%	0.1	160%
Y	61	16%	65	14%	75	35%	72	21%	66	33%
Pb	2.4	13%	2.9	61%	5.4	21%	3.4	80%	4.0	42%
Bi	0.01	37%	0.07	137%	0.38	98%	0.04	170%	0.12	94%
U	1.1	22%	1.2	32%	3.5	24%	2.0	14%	2.1	34%

W	0.6	18%	0.6	38%	1.5	41%	0.91	36%	1.2	34%
Mo	**2.8**	**18%**	**2.8**	**15%**	**5.5**	**4%**	**3.6**	**18%**	**5.4**	**18%**
Nd	49	16%	49	15%	42	51%	50	29%	37	39%
Sm	12	15%	12	15%	11	46%	13	27%	9.5	37%
Eu	3.7	13%	3.9	15%	3.6	15%	4.9	17%	3.3	27%
Gd	13	16%	13	15%	11	46%	13	25%	9.5	36%
Tb	2.5	15%	2.3	17%	2.4	35%	2.4	22%	1.9	34%
Dy	12	15%	12	15%	12	33%	14	22%	11	32%
Ho	3.0	16%	2.7	17%	3.2	29%	3.2	20%	2.6	31%
Er	6.2	16%	6.3	15%	7.6	27%	8.1	23%	6.3	30%
Tm	1.1	16%	1.0	18%	1.5	26%	1.3	20%	1.1	31%
Yb	5.5	17%	5.7	16%	7.9	19%	7.8	22%	6.5	30%
Lu	1.0	16%	1.0	18%	1.5	27%	1.3	22%	1.2	31%
Hf	11	17%	10	16%	26	14%	18	12%	19	31%
Th	**4.2**	**21%**	**3.8**	**21%**	**10**	**14%**	**6.0**	**11%**	**6.9**	**34%**

Table 4. Average compositions with relative standard deviations for the different areas investigated in this study. The number of samples is indicated with the name of the study area. Bold and underlined elements represent those used in statistical analysis.

Provenience	Lab No.	$^{13}C/^{12}C$ Ratio ($^{0}/_{00}$)	Conventional Radiocarbon Age (BP)	Calibrated 2 σ age range (BP)
410635/193/2997 Square No. 2 250–322cm	Beta-410635	-25.7	400+/-30BP	Cal AD 1455 to 1630
410634/090/2883 Square No. 6 280–330cm	Beta-410634	-25.7	380+/-30BP	Cal AD 1460 to 1635
410636/221/3054 Square No. 4 300–310cm	Beta-410636	-26.1	370+/-30BP	Cal AD 1460 to 1640
410638/251B/3231 Square No. 1 330-412cm	Beta-410638	-26.9	380+/-30BP	Cal AD 1460 to 1635
410637/240A/3739 Square No. 3 363-420cm	Beta-410637	-25.9	360+/-30BP	Cal AD 1465 to 1645

Table 5. Radiometric data from five *B. papyrifera* samples at RR–001–156.

CHAPTER 6: A collapsed narrative? Geochemistry and spatial distribution of basalt quarries and fine–grained artefacts reveal elite bottlenecking efforts, confederation (re)distribution, and communal use of stone on Rapa Nui (Easter Island)

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Dale F. Simpson Jr.

School of Social Science, The University of Queensland, St Lucia, Qld 4072 Australia.

Department of Anthropology, College of DuPage, Glen Ellyn, IL. USA.

Laure Dussubieux

Elemental Analysis Facility, Field Museum of Natural History, Chicago, Illinois, USA.

Corresponding author: Dale F. Simpson Jr.

School of Social Science, The University of Queensland, St Lucia, Qld 4072 Australia.

Department of Anthropology, College of DuPage, Glen Ellyn, IL. U.S.A.

dfsj381@gmail.com

A collapsed narrative? Geochemistry and spatial distribution of basalt quarries and fine–grained artefacts reveal elite bottlenecking efforts, confederation (re)distribution, and communal use of stone on Rapa Nui (Easter Island)

Abstract: Many publications document Easter Island's famous *ahu* (platform), *moai* (statue), *pukao* (topknot), and almost millennium–long culture. Yet, few investigations have been dedicated to basalt resources, artefacts, and their geochemistry. As part of the Rapa Nui Geochemical Project, we conducted comprehensive fieldwork and material culture and archaeometric analyses focused on Easter Island's archaeological basalt industries. Our results highlight that the Rapanui were sophisticated Polynesian stone workers, led by experts, who developed multiple tool reduction sequences for several types of fine–grain basalt, creating unique anthropogenic landscapes in the process. Using results from LA–ICP–MS geochemistry from 209 geological and archaeological samples, we argue that similar to other culturally valuable stone (e.g. obsidian, scoria, and tuff), there was communal access to and confederation (re)distribution efforts of specific basalt resources during the pre–contact period. We also document that elite Rapanui bottlenecked a patchy, but valuable fine–grain basalt deposit, highlighting chiefly influence over certain valuable stone resources. Together, communal access, confederation (re)distribution, and elite control over culturally valuable stone hint at patterns of economic, ideological, and sociopolitical interaction on this extreme eastern Polynesian outpost. Overall, the spatial and temporal distributions of basalt artefacts casts doubt on Easter Island's collapse narrative.

Key Words: basalt artefacts, mines, quarries, sources, and workshops, societal collapse, geochemistry, LA–ICP–MS, Polynesia, interaction studies, Rapa Nui (Easter Island)

Introduction

The earliest investigations conducted on Easter Island (Figure 1) addressed the islander's mining operations that included the *moai* (statue) quarry at Rano Raraku and the *pukao* (topknot) quarry at Puna Pau (Englert 1948, 1970; Geisler 1882; Heyerdahl and Ferdon [eds] 1961; Knoche 1925; Métraux 1940; Routledge 1919; Thomson 1891). Such large–scale undertakings at these megalithic quarrying sites highlight how mining for stone required an understanding of geology, a familiarity with engineering, and labour organisation and specialisation. Other raw materials exploited by the ancient Rapanui included obsidian from four sources (Motu Iti, Orito, Rano Kau, and Te Manavai), trachyte from Poike, *hani hani* (red scoria) from the Vai O'Hao and Puna Pau region, and *kie'a* (mineral pigment) from the island's rocky coasts (Arredondo 2003; Beardsley and Goles 1998, 2001; Beardsley et al. 1996; Hamilton 2007, 2013; Hixon et al. 2017; Simpson 2014; Simpson et al. 2017; Stevenson et al. 2013; Vargas et al. 2006).

In more recent years, selected archaeological investigations have focused on how the Rapanui obtained and worked fine– and coarse– grained basalt materials (McCoy 2014; Simpson et al. 2017). Basalt was used to fabricate: 1) *keho* – flat laminates used for construction purposes (e.g. 'Orongo) and tool manufacture (e.g. knives and adzes); 2) *paenga* – dressed vesicular blocks used in *ahu* (platform), *hare nui* (community house), *hare paenga* (elite home), *ana kionga* (refugee cave), and *umu* (stone slab–lined oven) construction; 3) *pae* – non–dressed vesicular blocks used in *ahu*, *ana kionga*, *umu*, *hare vaka* (boat–shaped house), *hare oka* (circular house), *manavai* (rock–walled garden), *tupa* (observation tower), and *pipi horeko* (land marker) construction; and 4) artefacts including *toki* (adze and pick), *kauteki* (composite adze), *ohio* (axe), *hoe* (knife), and *mangai mā'ea* (fishhook). Thus, it is important to document the archaeological evidence for the acquisition, use, and exchange of basalt, given the vast role that it played in many aspects of ancient life.

In recent publications (Simpson and Dussubieux 2018; Simpson et al. 2017, 2018), the Rapa Nui Geochemical Project (RNGP) reported archaeological site descriptions and basalt archaeometric data using inductively coupled plasma–mass spectrometry (ICP–MS). This included 117 geological samples from 31 quarries, sources, and workshops from six study areas, 21 basalt artefacts from a dated context (1455–1645 AD) in the *moai* quarry (Rano Raraku), seven geological samples from the adze quarry Rua Tokitoki, and three geological samples from a fine–grained source on Poike (Figure 1). This combined research permitted the development of geochemical baselines to assign artefacts to geological sources. Outcomes from Simpson and Dussubieux (2018) and Simpson et al. (2017, 2018), combined with results from this chapter, can now be used to further trace the movement of artefacts from geological sources to archaeological sites. In turn, this forms a basis to infer differential access to and use of basalt resources during Rapa Nui's past. In other words, a better understanding of how basalt raw materials and finished artefacts circulated within the ancient Rapa Nui society, will help to evaluate previous interpretations of economic, ideological, and sociopolitical interaction and organisation (Hotus et al. 1988; Hunt and Lipo 2011; Lee 1992; Métraux 1940; Routledge 1919; Simpson 2008; Stevenson 2002; Van Tilburg 1994; Vargas et al. 2006).

In this chapter, we: 1) highlight 31 fine–grained basalt mines, quarries, sources, and workshops found within five study areas on Rapa Nui (Figure 1); 2) document 61 Sebastián Englert Anthropology Museum (MAPSE) artefacts from 14 archaeological contexts using SLR photography, 3D scanning, portable X–ray fluorescence, and an online datashare (http://www.terevaka. net/toki/index.html); 3) report major, minor, and trace element compositions for 31 fine–grained basalt mines, quarries, sources and 61 MAPSE artefacts obtained by ICP–MS; 4) join and compare this ICP–MS data to existing RNGP geochemical databases to discuss the implications of basalt access, control, exchange, and use during Rapa Nui's pre–contact period; 5) document multiple pathways for the exchange and the (re)distribution of basalt; and 6) refute economic, ideological, and sociopolitical interpretations espoused by the collapse narrative for Easter Island (Bahn and Flenley 1992; Diamond 2005).

Cultural Context

Since European discovery of Rapa Nui in 1722, the island and its stone archaeological remains have attracted international attention. Most researchers have studied the numerous *moai* (Shepardson 2013; Van Tilburg 1994; Vargas et al. 2006), *pukao* (Hamilton 2007, 2013; Hixon et al. 2017; Martinson–Wallin 1994; Thomas 2014), and *ahu* (platforms) that have been inferred to serve ideological purposes, represent aspects of sociopolitical organisation and economy, and used in the demarking of elite–controlled landscapes (Beardsley 1990; Martinson–Wallin 1994; Simpson 2008, 2009; Stevenson 2002; Chapter Two). The construction of these megalithic features was thought to represent the manifestation of ancient Polynesian ancestor worship, to ensure fertile harvests and successful fishing campaigns, and to enforce freshwater, staple resource, and land ownership rights (Earle 1997, 2002; Earle and Spriggs 2015; Emory 1943; Firth 1967; Graves and Sweeny 1993; Kirch 1984, 1990, 2000; Kolb 1991, 1994). This latter point is of importance, because unlike the multiple islands and vast valleys and peaks of the Marquesas, Hawaii, and Tahiti, Rapa Nui's broad gently rising plains prescribed a cultural system which directly demarcated land, resources, and inhabitants.

According to oral traditions and ethnolinguistic and ethnographic sources (Englert 1948, 1970; Hotus et al. 1988; Métraux 1940; Routledge 1919), the island's first chief, Hotu Matu'a, divided the island among each of his six sons, forming the first *mata* (clans) and *mata kainga* or land divisions. But, by European colonisation, the island was divided into 10–18 *mata*, with two major confederations forming, Ko Tu'u Aro Ko Te Mata Nui (high–status northern clans) and Ko Tu'u Hotu Iti Ko Te Mata Iti (low–status southern clans), which are divided by the Ko Te Mata Pipi O Moro line (Hotus et al. 1988; Vargas et al. 2006; Figure 1). As such, each Rapanui *mata* was afforded access to coastal and inland resources (Stevenson 2002), like in *ahupua'a* organisation in Hawaii (Handy and Pukui 1989; Kirch 1984). Control over staple (horticultural crops) and luxury (pelagic fish, dolphins, turtles, lobsters, and eels) resources, however, was mostly reserved for the Rapanui elite (Englert 1948; Métraux 1940, 1957). This included the Miru (the most ranking *mata*), *ariki mau* (paramount chief), and *ariki paka* (secondary chiefs) found at Hanga Rau ('Anakena), along with *tangata honui* (local chiefs and elite) who held position over *paenga* (families), *ure* (extended families), and *ivi* (lineages) throughout the island (Sahlins 1958; Simpson 2008; Stevenson 2002). Using elite architecture, first–fruit ceremonies, and corporate work strategies, elite Rapanui oversaw and controlled the political economy, and rechannelled labour to invest in landesque capital intensifications (Kirch 1990) such as the *moai–ahu* complex that ultimately legitimised and broadcasted *Miru* and *tangata honui* control over *mata kainga*, *mata* inhabitants living inland (commoners), and the staple resource economy (Howard 2008; McCoy 2014; Simpson 2008, 2009; Simpson et al. 2017; Stevenson 1997; Stevenson and Haoa 1998; Chapter Two).

Yet, although a rigid system of social stratification, territoriality, and staple–resource control existed in ancient times, not one *mata* had all the required raw stone material in their own *mata kainga* needed to fabricate the *moai–ahu* complex (basalt, scoria, and tuff) and to manufacture lithics (basalt and obsidian) (Hamilton et al. 2011; Simpson and Dussubieux 2018). For example, 96% of all *moai* come from only one tuff quarry (Rano Raraku), but finished statues are found in every *mata kainga* (Shepardson 2013; Van Tilburg 1994). *Pukao*, mainly carved from Puna Pau's red scoria, are also distributed in most *mata kainga* (Hixon et al. 2017; Martinson–Wallin 1994).

In short, while staple resources were under the direct management and control of the elite Rapanui, especially the *ariki* and *tangata honui* (Howard 2008; Simpson 2008, 2009; Simpson et al. 2017; Stevenson 1997; Stevenson and Haoa 1998; Stevenson et al. 2000), the access to and subsequent utilisation of valuable stone material to produce megaliths, construction stones, and portable tools appear to follow different patterns for acquisition, distribution, and use. As there were relatively few quarries throughout the island producing preferred stone (see also, Weisler 1990 for a similar discussion about Hawaii), was it possible that Rapa Nui's *mata*, led by *tangata honui*, adopted economic, ideological, and sociopolitical arrangements to allow for the communal access to and confederation (re)distribution of similar stone to manufacture nearly identical *moai–ahu* complexes and lithics? Concurrently, did Rapanui elite reserve and bottleneck patchy, but valuable stone for chiefly consumption and utilisation, especially for *moai* carving and boat manufacture? This chapter focuses on how basalt quarries and sources were accessed and subsequently used to make artefacts during the pre–contact period. It also answers these two important questions, helping to fill in gaps in the archaeological record regarding Rapa Nui's ancient basalt industries.

Materials

Geoarchaeological fieldwork

RNGP geoarchaeological fieldwork methodology and study areas (Ava o'Kiri and Pu Tokitoki, Poike, Rano Kau, southwest coast, and Vai Atare) were discussed in Chapter Five (see also Simpson 2015a, 2015b, 2015c, 2017; Simpson and Dussubieux 2018; Simpson et al. 2017, 2018). Table 1 lists the 31 sites under geochemical investigation including their RNGP number, study area, site type, and area (m^2). While Appendix B provides site descriptions, Appendix D includes photos of each mine, quarry, source, and workshop under study.

Archaeological dataset

We selected 61 specimens with known provenance from previous archaeological excavations, recovery, and restoration projects (n=14) curated at the Rapanui Museum (MAPSE). Samples were selected from multiple areas around the island including coastal *ahu* (elite) and inland site (commoners) contexts, at locations within multiple *mata* territories from both Rapa Nui confederations (Figure 2). Recorded artefact traits included functional type (e.g. adze, axe, knife, etc.) and measurements of length, width, thickness, and weight. High–resolution photos of each artefact were produced using a Nikon D3400/AF–S DX NIKKOR SLR camera fitted with a 16–85 mm f/3.5 lens (Appendix C). These photos were used to record each artefact and to denote locations where portable X–ray fluorescence (non–destructive) and LA–ICP–MS (destructive) samples were taken for MAPSE conservation reports. Collaborating with Terevaka.net, an online datashare was created at http://www.terevaka.net/toki/ (Simpson 2016c). This datashare includes the RNGP number for each MAPSE artefact; high–resolution photographs of each artefact; a map denoting the archaeological location of each artefact; individual artefact information including MAPSE number and physical location within the museum's storehouse; artefact class; if it is a complete artefact; who was responsible for its recovery (researcher); maximum and minimum lengths; and weight. A preliminary elemental analysis was conducted at TFM using portable X–ray fluorescence. While the machine and analytical methodology for this pilot study are discussed below, the following elements, in parts per million (ppm), are included for each RNGP artefact on the Terevaka.net datashare: Al, Ba, Bi, Ca, Cl, Cr, Cs, Cu, Fe, K, Mg, Mn, Mo, Nb, Ni, P, Pb, Rb, S, Sb, Sc, Si, Sn, Sr, Te, Ti, V, W, Y, Zn, and Zr. The reason for the creation of this datashare and publishing artefact traits and pXRF results online, is the hope that other museum/research facilities that possess similar pXRF technology, and have access to basalt archaeological collections from Rapa Nui, could collaborate together to gather multiple, but mutually intelligible datasets for larger compilation, comparison, and interpretation. However, up–to–date, no further analysis has been conducted with this ppm dataset (although see Simpson 2017). Lastly, using a portable ScanStudio HD scanner and desktop software, selected artefacts were laser–scanned in three dimensions. The additional morphological, experimental, and statistical analyses of these scans may well be used to identify patterns in the production of Polynesian adzes (see Clarkson et al. 2014; Shipton et al. 2016; Weisler et al. 2013).

Methods

PXRF analysis at TFM's Elemental Analysis Facility (EAF)

Portable XRF analysis was conducted in the EAF at TFM. Prior to pXRF analysis, all samples were scrubbed under hot ultra–clean water and placed in an ultrasonic bath with distilled water for 20 minutes and later dried for 30 minutes. Three relatively flat, homogenous points (void of phenocryst, inclusions, and decomposition [Mills et al. 2010]) on each geological and archaeological sample were selected and noted in the specimen's documentation photo. These points were then analysed using a non–destructive ThermoFisher Scientific Niton XL3t GOLDD+ portable X–ray Fluorescence Spectrometer, equipped with a high–performance Geometrically Optimised Large Area Drift Detector (GOLDD). Between days of use, we performed a Total Machine Calibration, while between every 20 samples run, we analysed two EAF laboratory standards (CRB2005 and ELC001) to evaluate the pXRF's elemental readings, precision, and accuracy. According to radiation safety protocol, the Niton was connected to a stationary fully–shielded benchtop test stand, where it was securely mounted underneath, directing four beams upward to the specimen platform. The XL3t GLODD+ is fitted with an Ag anode (50kV and 200μA) tube and has an analytical range of 30 elements from magnesium (Mg) to uranium (U). However, adding a helium (He) vacuum purge allows the recognition of even lighter elements that escape older silicon drift detectors (SSD). There are three program Application Modes including alloy, plastic, and bulk, where each analysis varies in the elements that are targeted and detected, beam frequency, and length of run time. Samples were run for 120 seconds live time per sample under the Total Geology Mode, as longer run–times offer no measurable improvement in performance (Charleux et al. 2014). The main filter runs at 40kV and 100 µA, the high filter runs at 50 kV and 100 µA, the low filter at 25kV and 100 µA, and the light filter at 15 kV and 200 µA. In total, we preformed 459 individual analyses for 153 objects (57 archaeological and 96 geological). Elemental data was downloaded using the Niton Data Transfer (NDT) PC program through a USB cable into Microsoft Excel for data visualisation, assessment, and quantification. After purging elements (n=8) that were under the limits of detection, and after following the findings and interpretations from previous basalt pXRF geochemical studies in the Pacific (see Charleux et al. 2014 for the Marquesas; Fischer and Bahamondez 2011 for Rapa Nui; Kahn et al. 2008, 2013 for the Society Islands; Mills et al. 2010 for Hawaii; Weisler 1993 for Polynesia), we found that the mid–Z elements could usefully discriminate the geochemical variability of Rapa Nui's basalts (Simpson 2017). This especially included yttrium (Y), zirconium (Zr), strontium (Sr) and rubidium (Rb). All pXRF results can be found at http://www.terevaka.net/toki/ (Simpson 2016c).

LA–ICP–MS analysis at TFM's Elemental Analysis Facility (EAF)

Geochemical analysis methodology and results were discussed in Chapter Five (see also Carter and Dussubieux 2016; Dussubieux et al. [eds] 2016; Simpson and Dussubieux 2018; Simpson et al. 2018). Complete major, minor, and trace element values for RNGP samples, including 17 oxides and 45 elements, are listed in Appendix E. Using this data, we present the results of total alkali versus silica classification and principal component analysis of elements which geochemically define Rapa Nui's basalt mines, quarries, sources, and workshops, allowing the assignment of a provenance to MAPSE artefacts. In turn, this data can be added to and compared with prior RNGP results to provide a more robust sampling of Rapa Nui basalt archaeological industries, leading to the possibility of more accurate interpretations about ancient economic, ideological, and sociopolitical interaction and organisation.

Results

Total alkali versus silica classification (TAS)

Figures 3 and 4 are bivariate plots of total alkali versus silica – sodium oxide (Na_2O) plus potassium oxide (K_2O) against silica oxide (SiO_2) – which is widely used to classify volcanic rocks (Cox et al. 1979; Le Maitre et al. 2002). Figure 3 illustrates the TAS analysis for RNGP artefacts, showing the diversity of rock types used by the ancient Rapanui to manufacture artefacts including basaltic trachyandesite, basaltic andesite, trachyandesite, andesite, trachydacite, and dacite. Figure 4 illustrates the TAS for RNGP quarries and sources, showing a variety of rock types available within the five study areas. TAS plots indicate that stone from Ava o'Kiri and Pu Tokitoki is predominantly basaltic trachyandesite, basaltic andesite, and andesite. Southwest coast stone is mostly trachyandesite while Rano Kau stone is typically trachydacite. The Vai Atare study area is composed of both trachydacite and dacite.

Principal component analysis (PCA)

PCA calculations and results were discussed in Chapter Five (see also Simpson and Dussubieux 2018; Simpson et al. 2018). Using these results, Figure 5 plots RNGP study areas with defined artefact types and Figure 6 plots RNGP study areas and artefacts from coastal *ahu* versus inland site contexts. While many artefacts are sourced to Ava o'Kiri and Pu Tokitoki, and less to the southwest coast, there are several artefacts which plot outside all five PCA probability ellipses. This detection highlights artefacts (n=15) that are not provenanced to one of the five study areas. Attempting to assign provenance to these unsourced artefacts, we merge our empirical ICP–MS results from this chapter with other RNGP geochemical data, namely major and trace elemental compositions from Simpson et al. (2017; Chapter Four). This includes seven specimens from Rua Tokitoki, which is located within the Pu Tokitoki study area, and three samples from a fine–grain source on Poike, below Ahu Kiri Reva. Considering that Rua Tokitoki is an outstanding example of a well–worked basalt source, quarry, and workshop found within the Pu Tokitoki complex, we hypothesise that Rua Tokitoki should have nearly identical geochemistry to sites found throughout Pu Tokitoki. We also hypothesise that the geochemistry of the Poike source should discriminate itself from other study areas, as it is a unique source and TAS rock type.

Figure 7, which plots PCA results using data from this chapter and from Simpson et al. (2017), confirms both of our hypotheses. The stone from Rua Tokitoki is geochemically comparable to that of samples from Pu Tokitoki, and the Poike source is indeed elementally unique, with its geochemical properties plotting between all five sources (Figure 7). These results are notable, because they demonstrate that by using highly accurate and precise elemental data obtained from only ICP–MS, even if the data comes from different laboratories (e.g. UQ versus TFM), they can be used together to elementally evaluate geological and archaeological stone gathered by the RNGP.

As such, by adding MAPSE artefacts to the geochemical baseline provided in Figure 7, four previously unsourced artefacts can be assigned a provenance to the elite–controlled Poike source at Ahu Kiri Reva (Figure 8). These four artefacts (A02 [adze], A07 [knife], A53 [knife], and A57 [adze]) were archaeologically recovered from two important elite centres on Rapa Nui, ‘Anakena and Ava Ranga Uka A Toroke Hau (ARU). This pattern suggests that chiefly centres like ‘Anakena and ARU had access to the elite–controlled basalt from the Poike source (see below). Unlike the proposition by McCoy (2014:10) and geoarchaeological sourcing results of Ayres et al. (1998) and Harper (2008), not one adze under study was provenanced to Rano Kau or Vai Atare. This result, along with the limited archaeological site evidence for *in situ* tool making (e.g. blanks, preforms, and debitage), suggests the limited use of Rano Kau and Vai Atare basalt for portable artefact making. Moreover, lithics geochemically analysed from the Vai Atare region were not even made from the locally sourced basalt, but were provenanced to Ava o‘Kiri and Pu Tokitoki and to unknown quarries and sources.

Discussion

Table 2 lists RNGP findings, while Figure 8 maps the movement of basalt material as identified by this thesis. Geochemical results demonstrate the wide access to and use of stone material from Ava o‘Kiri and Pu Tokitoki with 13 of 14 archaeological locations having basalt materials from these complexes. This evidence is similar to the concentrated use of other stone quarries on Rapa Nui (e.g. Rano Raraku, Puna Pau, and Orito), where multiple *mata* had access to and used these preferred resources to construct the *moai–ahu* complex and manufacture portable artefacts. Simpson and Dussubieux (2018) argued that this pattern for extensive use of these preferred quarries, sources, and workshops represented a form of ‘communal’ access and use where multiple *mata* throughout the island, representing both confederations, accessed and used basalt from Ava o‘Kiri and Pu Tokitoki (see Chapter Seven).

Three artefact locations (Orito, Oroi, Puku Nga Aha Aha) within the Ko Tu‘u Hotu Iti Ko Te Mata Iti confederation establish how stone from the southwest coast mining complex was used to manufacture *toki* and *hoe.* Judging from the fact that basalt artefacts from the southwest coast were only provenanced within the southern Ko Tu ‘u Hotu Iti Ko Te Mata Iti confederation, including at Rano Raraku (Simpson et al. 2018), this pattern likely reflects local reciprocity and (re)distribution efforts between *tangata honui* and *mata* members of the southern coast confederation*.* Similar to the exchange of obsidian (Mulrooney et al. 2014; Stevenson et al. 2013) and coarse–grain basalt (McCoy 2014), the redistribution of southern coast fine–grain stone (amongst other raw materials such as *kie‘a* pigment and *poro* stones) may represent attempts by chiefly retainers from the Ko Tu‘u Hotu Iti Ko Te Mata Iti confederation to build and maintain prestige between elite Rapanui from different southern coast *mata* (see Chapter Seven).

In addition to the more open access to stone at Ava o'Kiri and Pu Tokitoki, and the localised use of stone within the southwest coast, results from this chapter demonstrate how basalt from the Poike source was accessed and utilised by elite Rapanui members. Hard evidence for the relationships between the elite–controlled Poike source and chiefly and elite retainers includes the geological provenance of four artefacts from 'Anakena (n=2) and ARU (n=2). At 'Anakena – the homeland for the most sacred and ranking individuals of the ancient Rapa Nui culture – stone from Poike was used to manufacture an adze (A02) and a knife (A07). This indicates that a relationship existed between the fine–grain basalt found at the Poike source and the island's most elite affiliates, including members of the Miru and their *ariki*. The exchange of Poike's basalt by *tangata honui* to the *ariki* at 'Anakena might highlight patterns of reciprocity and/or (re)distribution efforts between elite members of the Rapa Nui culture, where luxury resources such as tuna were exchanged for materials such as high–quality basalt. The result of this exchange would have increased the prestige of Poike's *tangata honui*, while providing access to high–quality basalt for the Miru living at 'Anakena.

Referred to by Vogt and Moser (2010) as a 'sacred landscape', ARU is an inland complex defined by activities and features related to water management and collection, including dams and channels. As water was one of the most important resources for survival during ancient times (Brosnan et al. 2018; DiNapoli et al. 2019; Hixon et al. 2019; Englert 1948; Trush 2016), it seems quite obvious that chiefly and elite retainers would want to oversee valuable sites and features which collected and bottlenecked water. Examining the presence of a single *ahu* with *moai* (Ahu Hanua Nua Mea) and the sporadic occurrence of *paenga* stones (to make dams and retention pools) found throughout the ARU area, Vogt and Moser (2010) argued for not only an elite presence at ARU, but also, their control over the area. Further evidence for the involvement of elite Rapanui (e.g. *ariki paka* from 'Anakena) at ARU comes in the form of nearly 40 coral fragments recovered during excavation. Vogt and Moser (2010:22) believe that the appearance of multiple coral within ARU "represent[ed.] a kind of sacrificial offering which may refer to a water cult or – more precisely – to the worship of the rain god Hiro. Métraux (1957:110) refers to cult practices in times of drought when the ariki's priest prays for rain and buries wet seaweed and corals in the hills". If the coral found during excavation accurately represents the presence of *ariki* at ARU, it supports ethnographic evidence which highlights how *ariki paka* visited sites throughout the island, ensuring rain and the fertility of plantations and chickens (Routledge 1919; Métraux 1940, 1957).

Geochemical results from this chapter indicate that two artefacts from ARU (A53 [knife] and A57 [adze]) were sourced to Poike. As high–ranking members from ‘Anakena were also using basalt form Poike, and their presence has been suggested within ARU, it is not surprising that chiefly and elite retainers at ARU used similar basalt for adzes and knives. Perhaps, the very use of basalt from Poike indicated high–status and rank, and the very activities the artefacts made from this basalt were reserved for. Therefore, evidence from ‘Anakena and ARU argues that elite Rapanui not only controlled and bottlenecked valuable, but patchy fine–grain basalt resources, but also, valuable, but patchy water management and collection systems (see Chapter Seven).

To better highlight and sythnesise the various modes of economic, ideological, and sociopolitical interaction which existed during Rapa Nui’s pre–contact period as discussed throughout this chapter and overall thesis, I have applied Renfrew’s (1975) ten modes of procurement and exchange transaction that could be identified archaeologically for Rapa Nui. Table 3 appropriates these modes and considers mechanisms for stone access, control, exchange, and use. I have also applied Plog’s (1977) variables to better define and document Rapanui exchange networks. Table 4 appropriates these variables and considers mechanisms for basalt stone access, control, exchange, and use during Rapa Nui’s pre–contact period. These efforts help to highlight the diversity of economic, ideological, and sociopolitical interaction that existed during the island pre–contact period.

Lastly, while this thesis uses the movement of archaeological basalt to highlight the diversity of exchange mechanisms which existed during ancient times, our archaeometric work could not identify the provenance of 11 MAPSE artefacts. In this situation, we could merge past geochemical work (Appendix A) with RNGP data to better identify the geological origins of unsourced artefacts. However, as only one prior geoarchaeological study of Rapa Nui’s basalt used highly precise and accurate ICP–MS technology for analysis (Harper 2008), and this study did not obtain major elements (which are used to calculate TAS types), we, along with other geochemical researchers (see Ferguson 2012; Riebe et al. 2018), do not agree with the merging of multiple non–ICP–MS geochemical datasets, especially those from Rapa Nui. The reasoning for this is that every elemental analytical technique is unique with regards to sampling procedures, equipment, operating procedures, blanks and standards, and statistical and quantifying methods. As such, the merging of basalt datasets, outside RNGP’s ICP–MS data, may not be best practice because of the lack of precision and accuracy between multiple analytical technologies and their methods.

To better geographically locate the quarries which provided stone for the 11 unsourced artefacts, a further literature review, along with a more detailed examination of elemental similarities and differences between artefacts (including TAS types), provide insight and suggestions for future research directions. Prior geoarchaeological literature hints at probable settings for basalt materials that were used to manufacture the unsourced artefacts. These include locations in the archaeological "*corrales*" (enclosures) found in the centre of the island (Stevenson et al. 2005; Vargas et al. 2006), on unsurveyed cliff faces as found on Poike, and/or around locations of Rano Kau (Simpson and Dussubieux 2018; Simpson et al. 2017, 2018).

Figure 9 pinpoints four groupings of unsourced artefacts (1–4). In general, Group 1 contains more Zr, but less V, Group 2 contains more MgO, CaO, V, Ni, and Co, but less Na_2O, K_2O, Be, Sr, Zr, Nb, Sn, Ba, Ta, Mo, and Th, Group 3 contains more CaO, but less Sr, Zr, Nb, Sn, Ba, Ta, Mo, and Th, and Group 4 contains more B and Mo, but less Co. Therefore, elemental differences between these groups suggest that at least four unique basalt sources exist that the RNGP has not yet located/analysed.

Group 1 artefacts include A08 (axe) and A14 (adze made from a retouched flake), which were both recovered from Ahu Tongariki. Considering that these artefacts were found together during excavation and restoration efforts, and they both share comparable geochemistry, it is very possible that they were sourced from the same location. TAS analysis supports this interpretation, with both artefacts being made from a similar basaltic andesite. Altogether, this evidence suggests that a quarry or source near Ahu Tongariki was opportunistically accessed (as no other RNGP artefact used this specific basaltic andesite) by Rapanui who lived around the island's largest *moai–ahu* complex to produce artefacts such as axes and adzes. Thus, to locate the source of A08 and A14, future RNGP survey should target areas immediately around Ahu Tongariki, including PO1, RA3, and RA8 geologic events (Gonzalez–Ferran et al. 2004).

Group 2 is a lone artefact numbered A23 (debitage) which was recovered from Vai Atare. According to the TAS plot, A23 is made from dacite, a unique stone type for Rapa Nui. Considering that this piece is a far outlier in the PCA plot (i.e. no other sample, either geological or archaeological, shares A23 geochemistry), it may represent a less–used source not yet located by the RNGP, or an opportunistic use of stone from an unsurveyed area. This area may occur in Rano Kau, especially within RK2, as multiple stone types were produced by this volcanic activity (Gonzalez–Ferran et al. 2004). Thus, further survey for basalt sources in the Rano Kau area is recommended.

Group 3, plotting between the confidence probability ellipses of Ava o'Kiri and Poike, is the most diverse cluster of unsourced artefacts. TAS and tool types in this group include a trachyandesite knife (A06) from Tahai, an andesite adze (A15) and a trachyandesite adze (A17) from ‘Anakena, an andesite adze (A27) and a dacite adze (A29) from Tautira, a trachyandesite flake (A40) from Oroi, a trachyandesite or andesite axe (A43) from Orito, and a trachydacite adze (A52) and a trachydacite or dacite adze (A56) from Ava Ranga Uka A Toroke Hau. Judging from these results, the following observations can be made. Group 3 consists of unsourced artefacts from six archaeological locations. Three of these locations are found within the Ko Tu‘u Aro Ko Te Mata Nui confederation (‘Anakena, Tahai, Tautira) and three of these locations are found from inland sites (Ava Ranga Uka A Toroke Hau, Orito, Oroi) within the Ko Tu‘u Aro Ko Te Mata Iti confederation. Group 3 is composed of only four TAS rock types (andesite, trachyandesite, dacite, trachydacite); however, there is elemental intra–variation between these types. PCA analysis indicates that of all Group 3 artefacts, A6 (knife from Tahai) and A17 (adze from ‘Anakena) share the most elemental propinquity. They are also both made from trachyandesite, suggesting that they were sourced from a similar geological context. This pattern arguably highlights that both of these important *moai–ahu* complexes, within the upper class Ko Tu‘u Aro Ko Te Mata Nui confederation, had access to another valuable source of fine–grain basalt still not yet located by the RNGP. This pattern is similar to geochemical results presented earlier in this discussion, where elite groups from both ‘Anakena and ARU had access to and used stone from Poike to make adzes and knives. In short, Group 3 appears to be a cluster of unique basalt stone types, which, in the least, represents a minimum of four different quarries and/or sources. Thus, future RNGP efforts will need to locate a minimum of four basalt quarries that were used during Rapa Nui’s pre–contact period.

Plotting between the confidence probability ellipses of Poike and the southwest coast, Group 4 has two artefacts which may be more related to Poike, and one artefact that discriminates itself from the cluster. This artefact, numbered A26, is a dacite adze from Tautira. Considering that another unsourced dacite adze (A29) was also recovered from Tautira, perhaps a more localised quarry around this *ahu* was accessed to produce both A26 and A29. However, as Tautira is found within Hanga Roa, and as Hanga Roa has experienced intense coastal and land development in the last 100 years, it may be that this quarry and/or source has been destroyed, and no longer exists. Regardless, further RNGP survey around Tautira is suggested to find the source for artefacts A26 and A29.

Conclusion

For almost six years, the principle goals of the Rapa Nui Geochemical Project have been to document the capabilities of the island’s ancient stone tool workers and to define patterns of pre–contact economic, ideological, and sociopolitical interaction and organisation. RNGP research design included: 1) archaeological documentation and sampling of 84 fine–grain basalt mines, quarries, sources, and workshops; 2) artefact documentation of 61 basalt tools from MAPSE; and 3) ICP–MS analysis of 33 RNGP sites and 78 artefactual samples to determine major, minor, and trace elements for geochemical and statistical analyses (TAS and PCA). These results formed a basis to infer differential access to and use of basalt resources, helping to evaluate ancient economic, ideological, and sociopolitical interaction.

While the outcomes of our research do not provide direct evidence for interaction networks on Rapa Nui as suggested by Thomas (1999), Stevenson et al. (2000), and McCoy (2014), they do demonstrate that Ava o'Kiri and Pu Tokitoki were key focal points for manufacturing basalt tools. As there is almost no monumental architecture and elite homes associated with basalt quarries and sources in Ava o'Kiri and Pu Tokitoki (see also, Stevenson et al. 2000; Stevenson and Haoa 2008), we do not detect the elite bottlenecking of tool–grade basalt from Ava o'Kiri and Pu Tokitoki. This suggests minimum elite oversight and competition for this significant basalt resource between members of different *mata*. This less–monitored use of basalt parallels the access to and use of other culturally valuable stone (e.g. obsidian, scoria, and tuff), which were not available to all *mata* in their *kainga*, but were still used by each major district *ahu* throughout the island (Hixon et al. 2017; Martinson–Wallin 1994; Simpson 2008; Stevenson 2002; Stevenson et al. 2013).

Geochemical results also highlight how basalt from the southwest coast study area was only used within the lower ranked Ko Tu'u Aro Ko Te Mata Iti confederation. Perhaps mining and the use of southwest coast stone represented attempts by the southern *mata* to have an alternative to Ava o'Kiri and Pu Tokitoki stone. Additionally, the extensive extraction of southwest coast stone could signify local reciprocity and (re)distribution efforts of basalt between *tangata honui* of the southern coast confederation to build and maintain prestige between elite Rapanui from different southern coast *mata*.

Lastly, geochemical results from this chapter provide hard evidence for the use of Poike stone by chiefly and elite members. Fine–grain basalt from the elite–controlled Poike source was used by affiliates of the Miru at 'Anakena and ARU to manufacture adzes and knives.

Therefore, while it has been well documented that staple–resources (e.g. horticultural and chicken husbandry produce) were under the direct oversight and management by elite members of the Rapanui culture, the access to and the use of valuable stone resources – including basalt – follow different patterns for acquisition, control, and use. Pathways for acquisition and usage, as proposed from results of this thesis, include: opportunistic and communal means, confederation (re)distribution, and elite oversight over patchy, but valuable basalt resources. Arguably, these pathways facilitated economic, ideological and sociopolitical interaction within and between clans and confederations of the ancient Rapa Nui culture (see also Tables 3 and 4).

Overall, our archaeological interpretations paint a different picture of Rapa Nui's pre–contact period than is portrayed within the 'collapse narrative' (Bahn and Flenley 1992; Diamond 2005; Chapter Seven). This research suggests that Easter Island's ancient inhabitants knowingly participated in unsustainable cultural competition and megalithic development, leading to the island's reported ecocide and cultural collapse. Adjoined with overpopulation, warfare, deforestation, and ecological and sociopolitical change, the island was transformed from a complex culture dominated by elite polities (Kirch 1984, 2000; Simpson 2008, 2009; Stevenson 1997, 2002), to fragmented clans fighting for limited resources and prestige through the 'Orongo centred *tangata manu* (birdman) competition (Drake 1992; Lee 1992; Ramírez–Aliaga 2016; Van Tilburg 1994). Although there exists the popular narrative that identifies Easter Island as the *cause célèbre* of a failed society, many explanations of the collapse narrative have more recently been questioned though empirical, systematic, and multi–disciplinary investigation (Haoa et al. 2018; Hunt and Lipo 2011; Jarman et al. 2017; Lipo et al. 2016; Mulrooney 2012, 2013; Rull et al. 2013, 2016; Simpson and Dussubieux 2018; Stevenson et al. 2015).

Interpretations by these researchers, along with other publications, establish the following: 1) there is little evidence to suggest rapid island deforestation, in addition to the fact that slash–and–burn horticultural systems co–existed with palm dominated forests (Gossen 2011; Hunter–Anderson 1998; Hunt 2006; Hunt and Lipo 2010; Mieth and Bork 2004, 2005, 2010; Mann et al. 2008; Orliac 2000; Orliac and Orliac 1998); 2) that the Pacific rat (*Rattus exulans*) and the possible appearance of fungus, insect infestations, and tree and plant diseases played notable roles in preventing tree regeneration (Hunter–Anderson 1998; Mieth and Bork 2010; Hunt and Lipo 2007; Shepardson 2013); 3) that the island's isolated and unpredictable geo–ecological environment, which included pressure from global phenomenon (*El Niño*–Southern Oscillation, Little Ice Age, Pacific volcanism, and sea level changes) and threats from local events (droughts/fires, earthquakes, flooding, tsunamis), acerbated social and ecological transformation (Dickinson 2003; Goff et al. 2012; Hunt and Lipo 2001; McCall 1993; Nunn 2000; Sáez et al. 2009); 4) that traditional narrative interpretations for Rapa Nui artefact, land, and resource use, along with claims for extensive warfare and cannibalism, are empirically invalid (Hunt 2006, Hunt and Lipo 2001, 2010; Mulrooney et al. 2009, 2010; Rainbird 2002;

Simpson 2010; Thromp and Dudgeon 2015); and 5) that the catastrophic impact brought to the island by early visitors and colonisers, in the form of social change, disease, blackbirding, and murder, undoubtedly played the largest catalysts for Rapanui cultural change (Métraux 1957; Peiser 2005; Chapter Two). Synergistically, these five aspects played more of a detrimental role to the Rapa Nui environment and the Rapanui community, than the community played on itself.

Other critiques of Easter Island's collapse narrative were made by Larsen and Simpson (2014), who argued that more than palaeoecological data and selective archaeological evidence are needed to support island–wide interpretations of ecological and anthropogenic collapse. These authors suggest the involvement of more scientific fields (including geochemistry), using synergetic research methods, would better help to demonstrate that the ancient Rapanui never truly collapsed through economic, ideological, and sociopolitical competition, ecological overexploitation, and megalithic overproduction, but was thriving at time of contact in 1722 (Chapter Two).

Thus, to further destabilise the collapse narrative and argue that its descriptive frameworks are not sufficient to elucidate Easter Island's past, we take aim at explanations made by the narrative and use RNGP results and interpretations to present an alternative discussion of Rapa Nui's past. We argue that during the pre–contact period, there was more economic, ideological, and sociopolitical interaction and integration between Rapanui *mata* and the two ancient confederations than has been previously detailed in the anthropological archaeology literature. Principally, this connectivity was created by the needs of multiple *mata* to have access to similar stone to construct the *moai–ahu* complex, as well as to manufacture portable tools. Our interpretation that there was more cultural interconnection and affinity between Rapanui clans – based on the empirical evidence for the acquisition and use of basalt and other stone resources – is fundamentally opposed to explanations offered in the collapse narrative which argues that, there was mostly "competition between chiefs commissioning to outdo each other" (Diamond 2005:98). Or, that *mata* were "likely…in competition with each other, trying to outdo their neighbours in the scale and grandeur of their religious centres and ancestor–figures…" (Bahn and Flenley 1992:121). While we do believe that competition and conflict existed and undoubtedly influenced the ancient culture (i.e. the *tangata manu*), solely portraying Rapanui's *ariki* and *honui* as simple competitors, bent on building larger *ahu* which were embellished with more grandiose *moai* over time, overshadows the fact that there was common interaction and connectivity between *mata* and the island confederations. Simply, we conclude that it was this very interaction and connectivity between *mata* that supported and allowed for Rapa Nui's ancient cultural development. In other words, the very exchange of archaeological stone between the Rapanui could have been the very mechanism that allowed the island's culture to be so successful in producing tens of thousands of archaeological features, for more than 500–years of the pre–contact period. Therefore, like other research that has more recently critiqued explanations of the collapse narrative, results from this RNGP investigation cast doubt on economic and sociopolitical explanations provided by Bahn and Flenley (1992) and Diamond (2005), disparage against portraying the ancient island culture as one with only chiefly and elite competition and opposition, and highlight the existence of greater ancient interaction between clans and confederations during Rapa Nui's pre–contact period.

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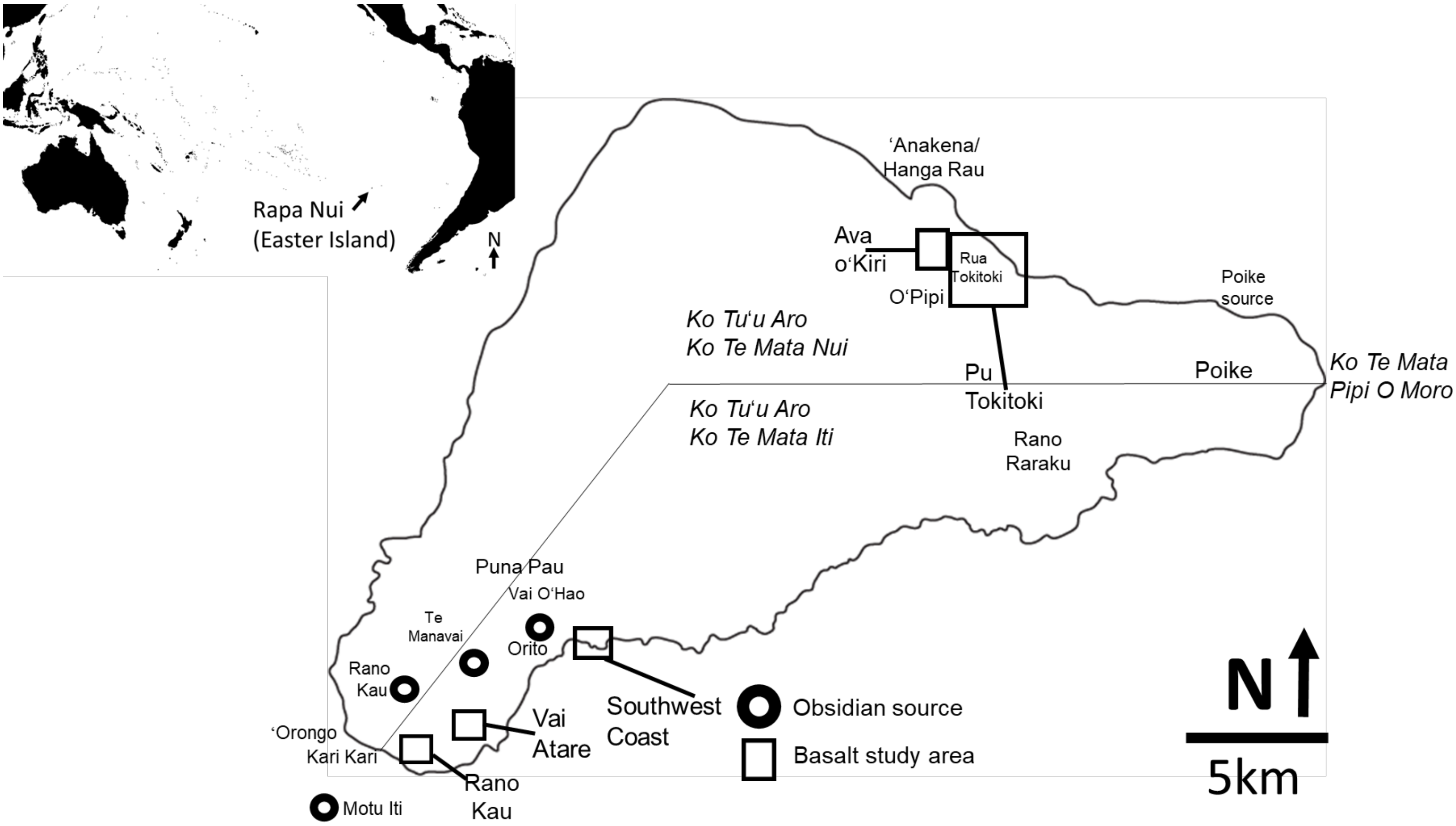

Figure 1. Geographic location of Rapa Nui, stone quarries, and place names mentioned in the chapter.

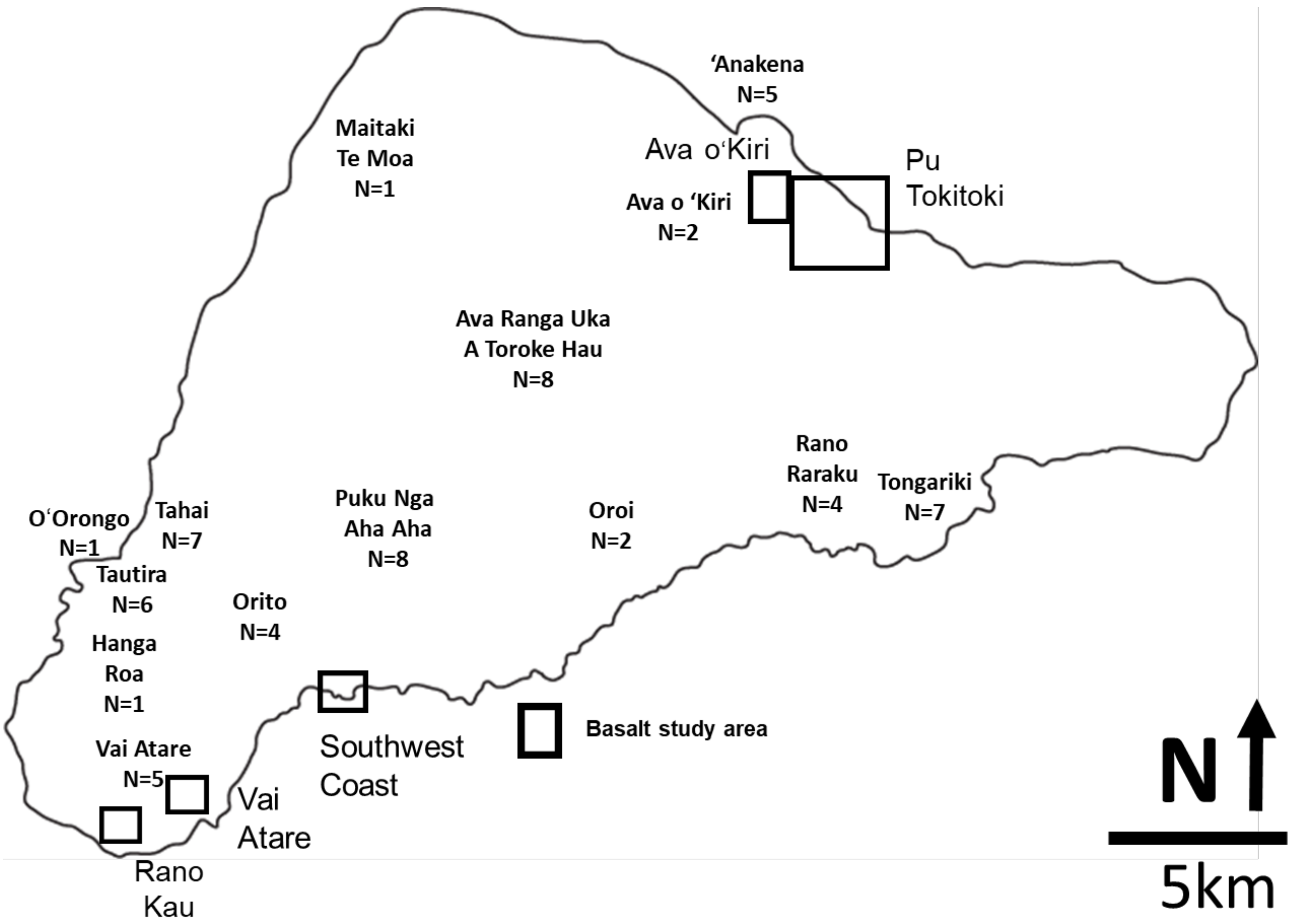

Figure 2. Location and number of RNGP artefacts under geochemical analysis.

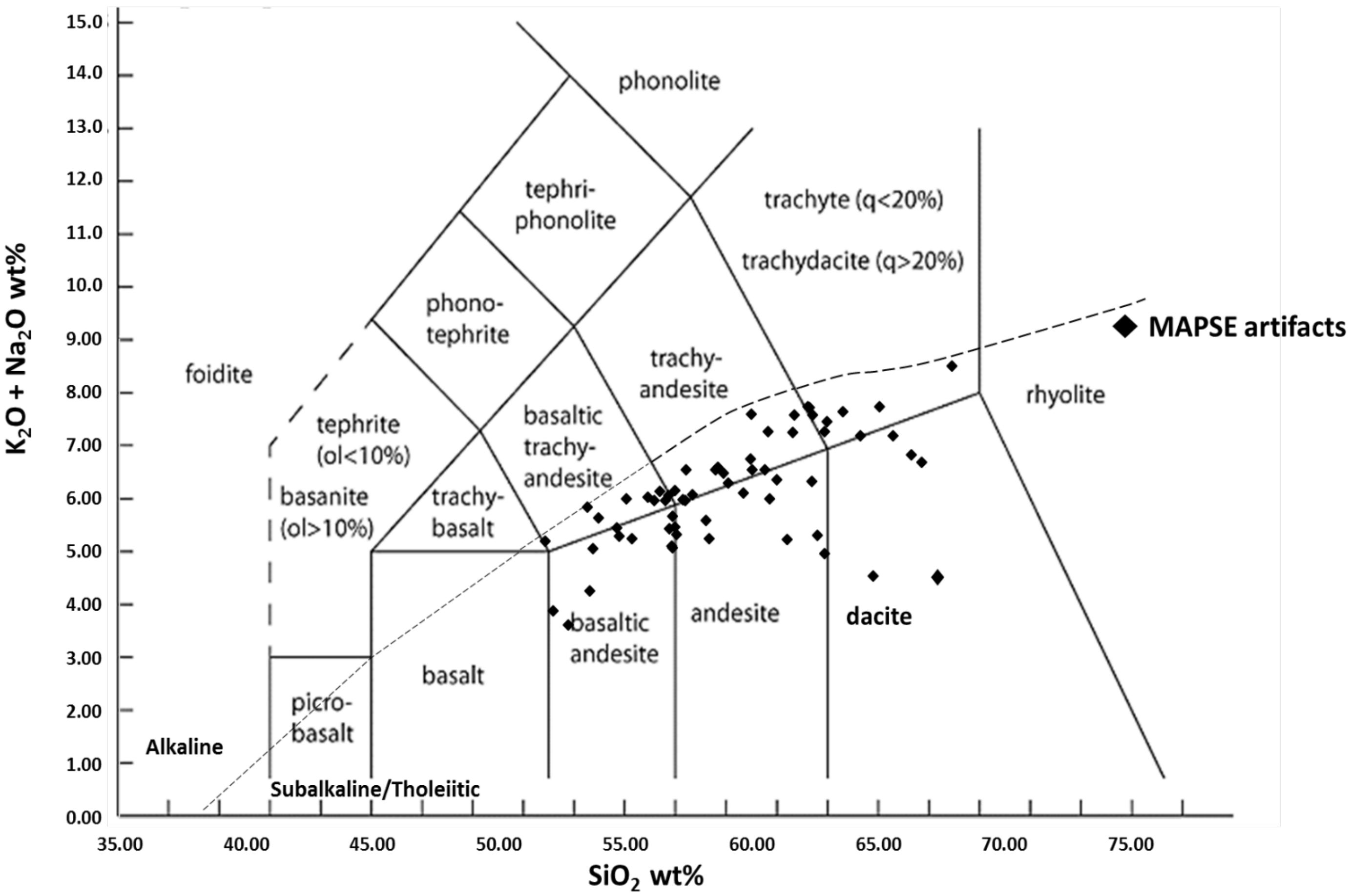

Figure 3. A bivariate plot of TAS total alkali (Na_2O + K_2O) versus silica (SiO_2) (data normalized to 100%), showing the rock types for RNGP artefacts. The dotted line represents the division between alkaline and subalkaline/tholeiitic rock (following Cox et al. 1979; Le Maitre et al. 2002).

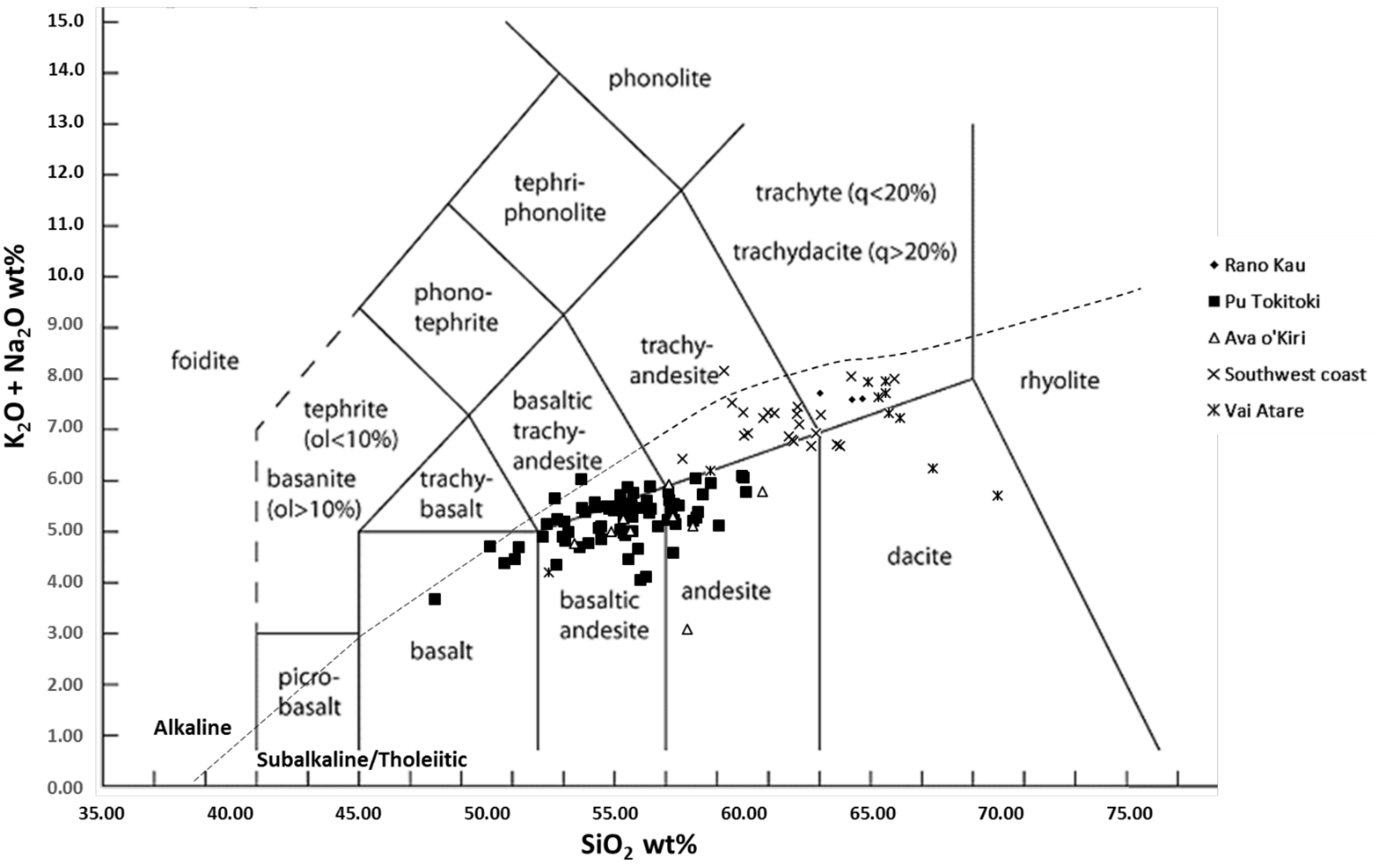

Figure 4. A bivariate plot of TAS total alkali (Na_2O + K_2O) versus silica (SiO_2) (data normalized to 100%), showing the rock types for RNGP study areas. The dotted line represents the division between alkaline and subalkaline/tholeiitic rock (following Cox et al. 1979; Le Maitre et al. 2002).

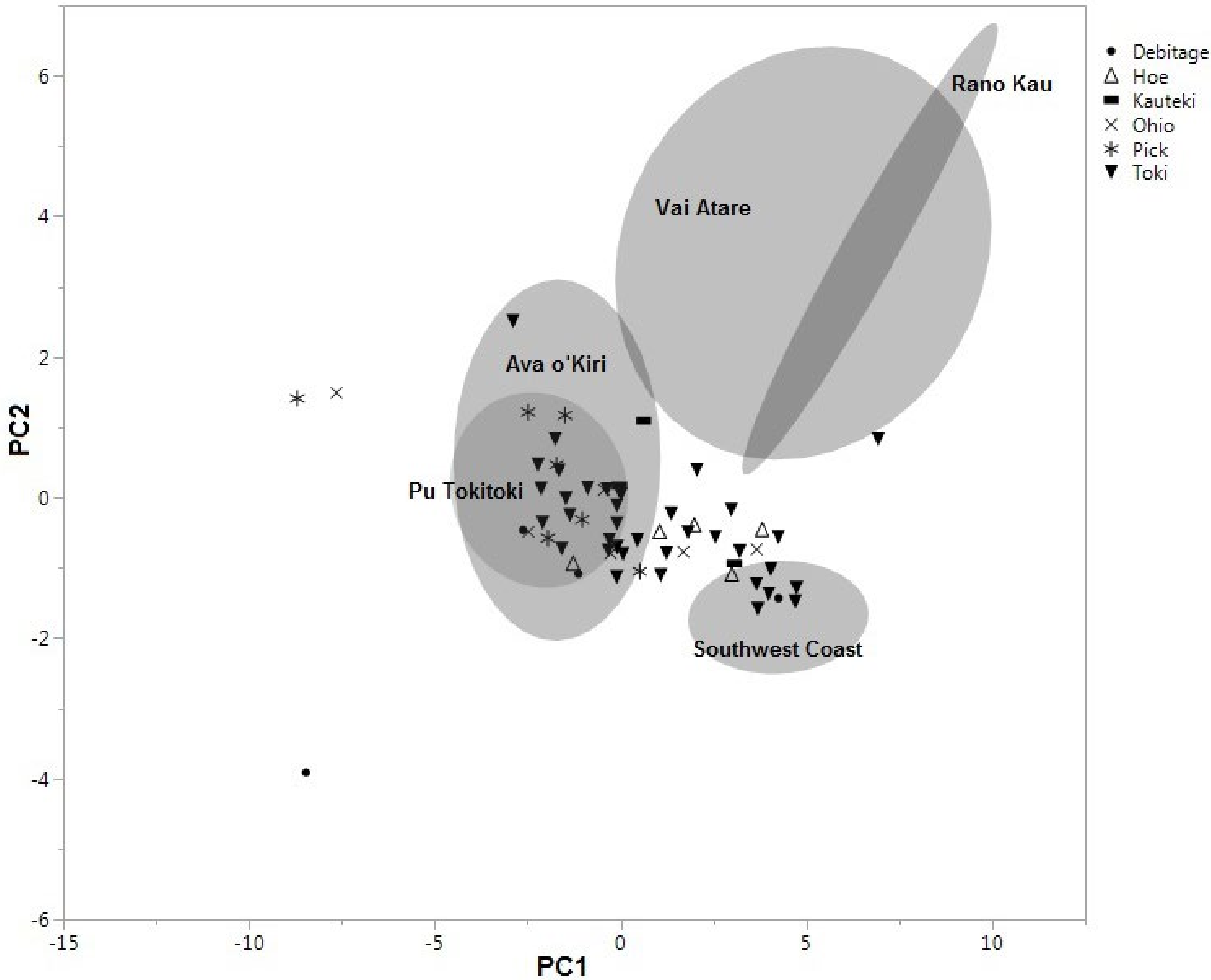

Figure 5. PCA analysis of RNGP study areas and artefact types (ellipses represent 90% confidence probability).

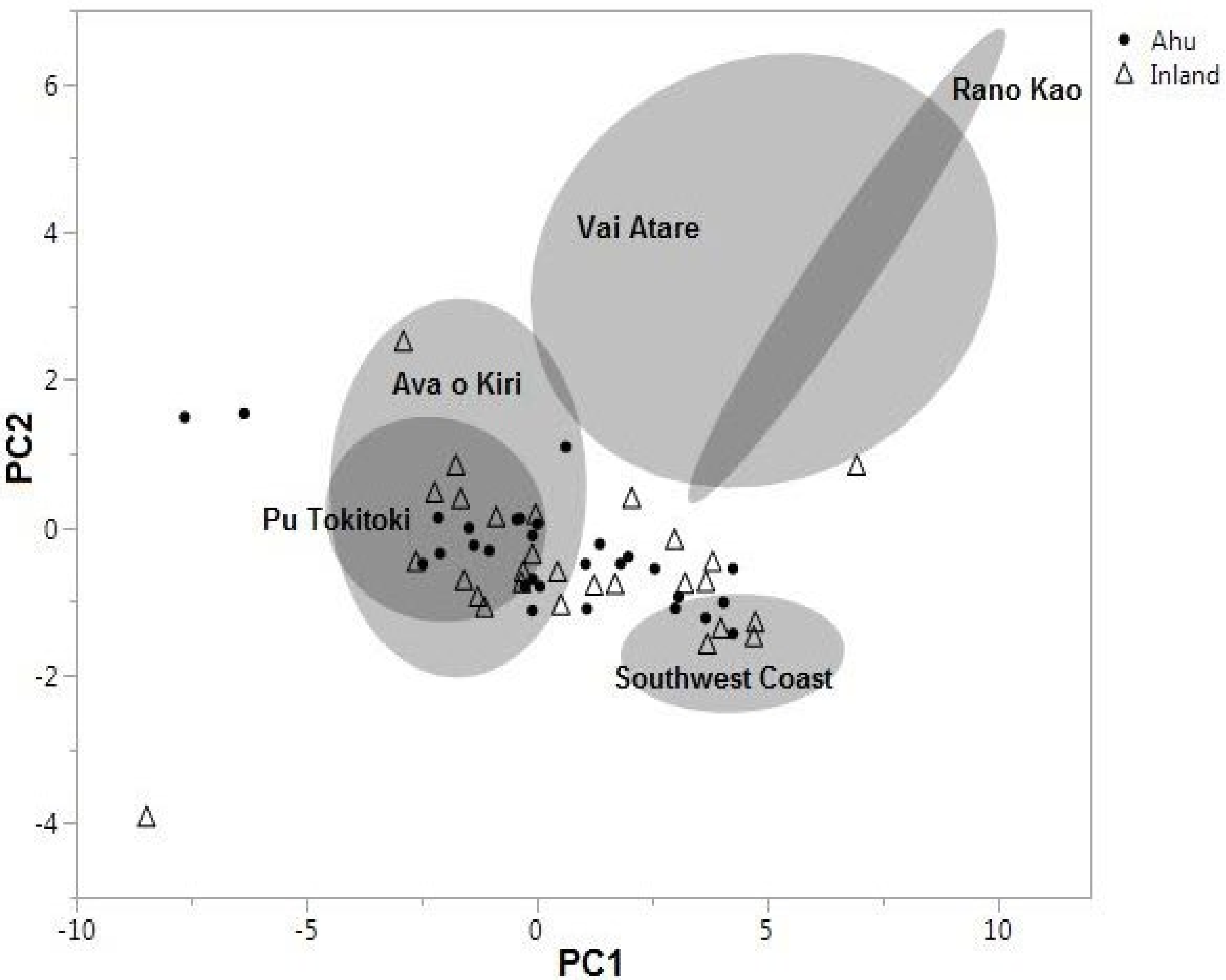

Figure 6. PCA analysis of RNGP study areas and artefacts from coastal *ahu* versus inland sites (ellipses represent 90% confidence probability).

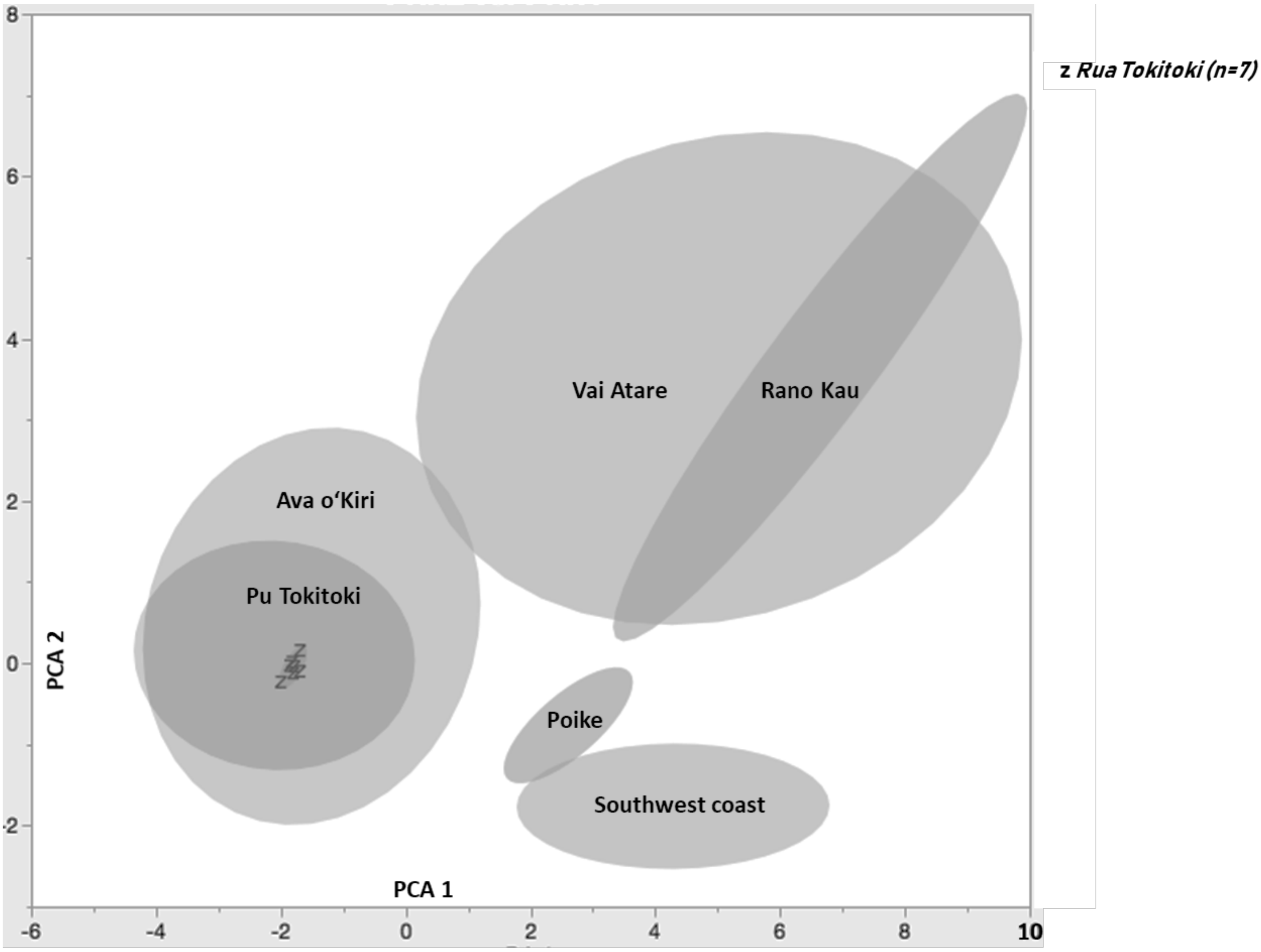

Figure 7. PCA analysis of RNGP study areas including samples from Rua Tokitoki (n=7) and the Poike source (n=3) (ellipses represent 90% confidence probability).

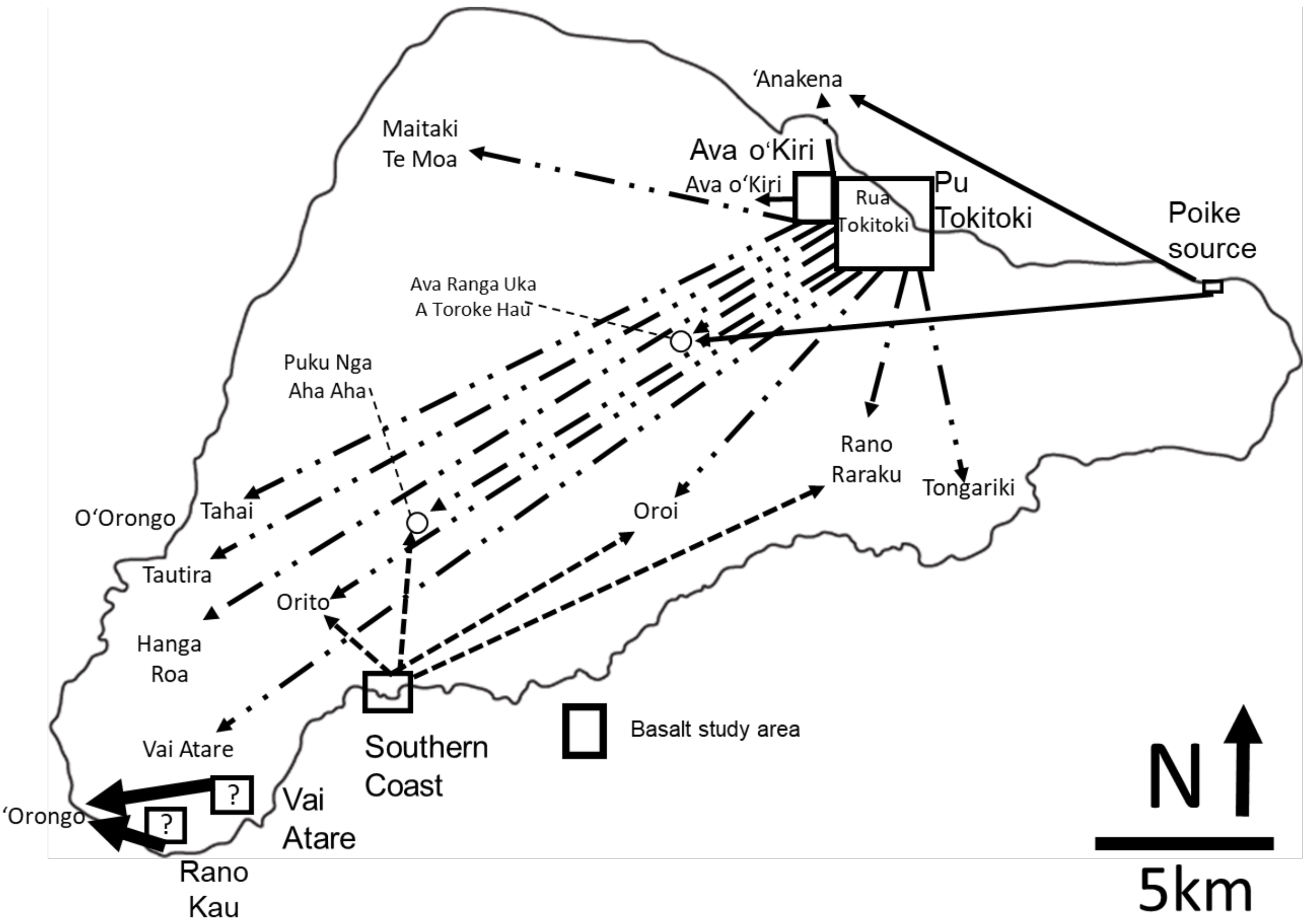

Figure 8. Movement of basaltic material as identified by the RNGP

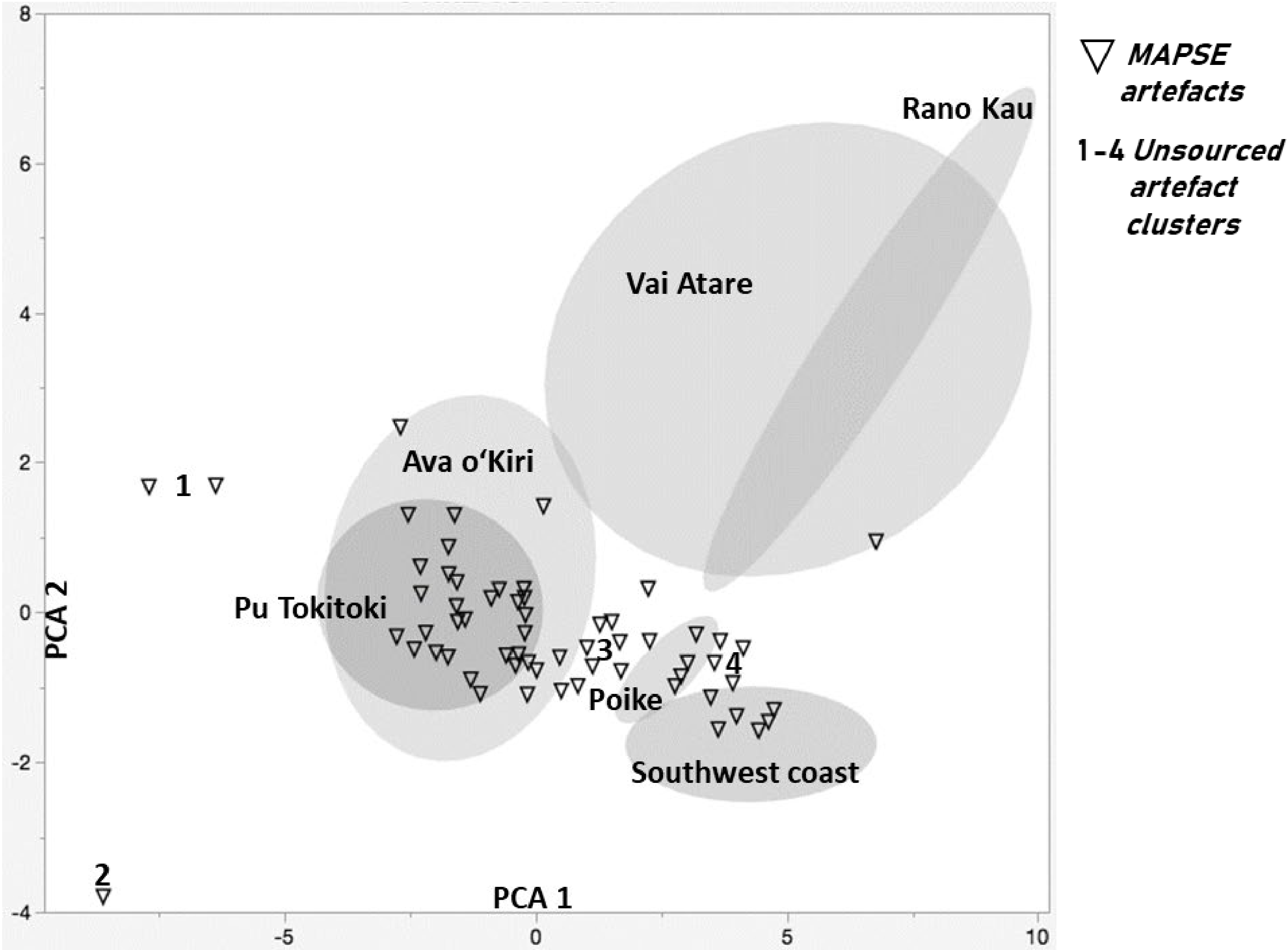

Figure 9. PCA analysis of RNGP study areas (including Poike), MAPSE artefacts, and unsourced artefact clusters 1–4 (ellipses represent 90% confidence probability).

RNGP site number	Study Area	Type	Area m^2
29	Ava o‘Kiri	Quarry/Workshop	264
57	Ava o‘Kiri	Quarry/Workshop	420
7	Pu Tokitoki	Quarry/Workshop	800
9	Pu Tokitoki	Quarry/Workshop	660
32	Pu Tokitoki	Quarry/Workshop	609
33	Pu Tokitoki	Quarry/Workshop	500
35	Pu Tokitoki	Source/Workshop	182
43	Pu Tokitoki	Quarry/Source/Workshop	195
45	Pu Tokitoki	Quarry/Workshop	180
46	Pu Tokitoki	Quarry/Workshop	110
48	Pu Tokitoki	Quarry/Source/Workshop	1000
49	Pu Tokitoki	Quarry/Workshop	420
50	Pu Tokitoki	Quarry/Workshop	360
52	Pu Tokitoki	Quarry/Workshop	660
54	Pu Tokitoki	Quarry/Workshop	198
63	Pu Tokitoki	Quarry/Workshop	102
68	Pu Tokitoki	Quarry/Source/Workshop	700
69	Pu Tokitoki	Quarry/Workshop	156
25	Rano Kau	Quarry/Source/Workshop	1200
11a–b	Southwest Coast	Quarry/Workshop	33
13	Southwest Coast	Quarry/Workshop	68
14	Southwest Coast	Quarry/Workshop	123
17	Southwest Coast	Quarry/Workshop	38
81	Southwest Coast	Quarry/Workshop	40
84	Southwest Coast	Source/Workshop	90
89	Southwest Coast	Quarry/Workshop	33
91	Southwest Coast	Source/Quarry/Workshop	49
21	Vai Atare	Source/Workshop	16
22	Vai Atare	Source/Workshop	84
77	Vai Atare	Quarry/Workshop	21
78	Vai Atare	Quarry-workshop	45

Table 1. RNGP quarries, sources, and workshops under geochemical analysis.

Location & number of artefacts under study	Site type	Provenance
Tahai (n=7)	*Ahu*	Pu Tokitoki and Ava o'Kiri; unknown source(s)
Tongariki (n=7)	*Ahu*	Pu Tokitoki and Ava o'Kiri; unknown source(s)
'Anakena (n=5)	*Ahu*	Pu Tokitoki and Ava o'Kiri; Poike; unknown source(s)
Tautira (n=6)	*Ahu*	Pu Tokitoki and Ava o'Kiri; unknown source(s)
Oroi (n=2)	*Ahu*	Pu Tokitoki and Ava o'Kiri; southern coast
Maitaki te moa (n=1)	*Ahu*	Pu Tokitoki and Ava o'Kiri
O'Orongo (n=1)	*Ahu*	Unknown source(s)
Vai Atare (n=5)	Inland	Pu Tokitoki and Ava o'Kiri; unknown source(s)
Puku Nga Aha Aha (n=8)	Inland	Pu Tokitoki and Ava o'Kiri; southwest coast; unknown source(s)
Orito (n=4)	Inland	Pu Tokitoki and Ava o'Kiri; southwest coast; unknown source(s)
Ava o'Kiri (n=2)	Inland	Pu Tokitoki and Ava o'Kiri
Ava Ranga Uka (n=8)	Inland	Pu Tokitoki and Ava o'Kiri; Poike; unknown source(s)
Hanga Roa (n=1)	Inland	Pu Tokitoki and Ava o'Kiri
Rano Raraku (n=4)	Quarry	Pu Tokitoki and Ava o'Kiri

Table 2. Summary of locations, site type, and geochemical assignment.

Procurement and exchange type	Procurement and exchange definition	Rapa Nui
Direct access	User travels directly to the source of the material.	Task groups from multiple *mata* led by *tangata māori anga mā'ea* entered Ava o'Kiri and Pu Tokitoki to procure and reduce basalt for lithic manufacture. This material was then brought back to multiple *mata kainga* (clan land) for distribution, exchange, and use. Task groups led by *tangata māori anga mā'ea* entered Rano Kau and Vai Atare to procure and reduce *keho* stone used for house construction at 'Orongo.
Home–base redistribution	User travels to partner's home–base to exchange material	*Paenga* (family), *ure* (extended family), and *ivi* (lineage) exclusively exchanged southwest coast basalt between individual *mata* of the lesser ranked Hotu Iti Ko Te Mata Iti confederation. These cross *mata* relationships, within the southern confederation, were most likely created and legitimised through *tumu* marriage interactions, feasting and ceremony (e.g. *koro*), and the need for stone exchange.
Boundary reciprocity	Users travel to common boundary area to exchange material.	Interactions between *tangata honui* from different *mata* included meeting and conducting ceremonies at boundaries between *mata kainga*. Perhaps these interactions included the exchange of stone amongst other staple and luxury resources and marriage partners.
Down–the–line	Commodities flow across successive territories through repeated reciprocal exchanges.	Similar to the exchange of Maunga Orito obsidian, where elite members vied to create prestige through reciprocal interactions, *tangata honui* within the Ko Tu'u Hotu Iti Ko Te Mata Iti confederation exclusively exchanged southwest coast basalt within the *mata* of the lesser ranked confederation to build prestige amongst its most elite members. From there, individual *tangata honui* would distribute acquired stone to their lesser ranked *paenga*, *ure*, and *ivi*.
Central place redistribution	Geographically diverse goods are appropriated from the members of a group by a central	On an island–wide scale, *ariki mau* did appropriate luxury maritime resources such as *kahi* (tuna) and other pelagic fish given his control over the ocean and canoes. After

	organisation or political leader then re–divided within the group.	his minimum consumption, he would (re)distribute these resources to the lesser ranked *tangata honui* for their consumption and redistribution. However, there is little evidence to suggest that at any time the *ariki mau* and the Miru at Hanga Rau acted as nodes for island–wide centralisation and redistribution of staple resources, including fine–grain basalt. Instead, each individual *mata* was its own economic, ideological, and sociopolitical unit where non–local stone resources, including basalt, were acquired through communal, opportunistic, confederation, and elite (re)distribution means.
Central place market exchange	Involves bargaining and price–fixing at a centralised location for commercial transactions.	No evidence for Rapa Nui.
Middleman trading	A freelance trader exchanges with various people but is not under their control.	Possible on Rapa Nui, however, there exists no known evidence that this economic and sociopolitical station existed within the prehistoric culture.
Emissary trading	A leader or group sends a representative to exchange goods with another group on their behalf.	Possible on Rapa Nui, however, there exists no known evidence that this economic and sociopolitical station existed within the prehistoric culture.
Colonial enclave	A leader or group sends emissaries to establish a base in or near the territory of a foreign group in order to engage in trade with them.	No evidence for Rapa Nui.
Port–of–trade	A place which specialises in trading activities, outside of the traders' jurisdiction, where traders from a wide variety of political units can freely meet.	Not present during Rapa Nui prehistory, but the island did act as a port–of–trade from initial contact in 1722 until today (Chapter 2).

Table 3. Economic, ideological, and sociopolitical mechanisms for stone access, control, exchange, and use during Rapa Nui prehistory following Renfrew's (1975) modes.

Variable	Descriptive Summary
Content	Fine–grain basalt from six areas of the island. Basalt ranges from tool grade material (adzes, axes, picks, and knives) to construction stone (*keho*, *pae*, and *paenga*).
Magnitude	Artefacts manufactured from Ava o'Kiri and Pu Tokitoki stone found throughout the island. Artefacts manufactured from Southwest coast stone found only within one confederation and within limited *mata*. Artefacts manufactured from Poike stone found at elite centres ('Anakena and ARU). Stone from Rano Kau and Vai Atare likely used at 'Orongo for house construction. Other undocumented fine–grain basalt quarries and sources still exist and need to be located, registered, and geochemically sampled.
Diversity	High import diversity as no individual *mata* had all of the raw stone resources, including basalt, needed to construct the *moai–ahu* complex and manufacture portable artefacts. Thus, most *mata* needed to import a diversity of stone including basalt (both fine– and coarse–grain), obsidian, *poro*, and *kie'a* within their individual *mata kainga*.
Network Size	Network using Ava o'Kiri and Pu Tokitoki stone – Large (island–wide) Network using southwest coast stone – Medium (confederation–wide) Network using Rano Kau and Vai Atare stone – Small (localised use) Network using Poike stone – Small (Elite use)
Directionality	Stone from Ava o'Kiri and Pu Tokitoki was found at ceremonial, habitation, and other stone quarrying sites. Stone from southwest coast was found at ceremonial, habitation, and other quarrying sites. Stone from Rano Kau and Vai Atare was not found at any ceremonial, habitation, and other quarrying sites. Stone from Poike was found at ceremonial sites.
Time Span	>200 years
Centralisation	Besides stone from Poike, fine–grain basalt quarries and sources were not under control and appropriated through centralised acquisition and (re)distribution.
Complexity	Not simple with multiple means for the transfer of basalt including communal, opportunistic, confederation and elite (re)distribution means.

Table 4. Economic, ideological, and sociopolitical mechanisms for stone access, control, exchange, and use during Rapa Nui prehistory following Plog's (1977) variables.

CHAPTER 7: Conclusion

Introduction

Understanding human interactions, both ancient and historic, across time and space, has been a focus for anthropological archaeologists (Bauer and Agbe–Davies 2011; Baugh and Ericson [eds] 1994; Caldwell 1964; Dillian and While [eds] 2010; Erlandson 2008; Finnegan 2002; Gamble 2007; Knappet 2011, 2013 [ed.]; Kristiansen and Larsson 2005; Mignon 1993; Mills 2017; Schortman and Urban 1987, 1992; Stein 2002; Weisler 1997). This work is important because it documents and interprets the variety of ways *Homo sapiens* have networked in a myriad of nodes, scales, and spheres for some 200,000 years. Interaction studies in Oceania have revealed how humans have interacted within and between islands, from the Pleistocene to the early Holocene; during the period of the Lapita Cultural Complex of the mid–Holocene; and during *Ma'ohi* exploration, expansion, and development in the late Holocene (Cochrane and Hunt 2018; Earle 1997a; Hunt and Graves 1991; Kirch and Kahn 2007; Kirch 1991, 2000; Kirch and Weisler 1994; Terrell 1986; Weisler [ed.] 1997; Chapter Two). On Rapa Nui, research regarding pre–contact interactions has been informed by numerous archaeological theories (e.g. diffusionism, culture–history and culture–ecology, settlement pattern studies, and evolutionary, interpretive, and political economy) and methods (e.g. lithic sourcing studies), resulting in various interpretations and conclusions (Chapters Two and Three).

Based on political economy theory (Chapter Two), and using a multiplicity of anthropological archaeology techniques (literature review, field archaeology, drone and SLR photography and videography, 3D scanning, ^{14}C dating, an online datashare [http://terevaka.net/toki/], artist's reconstructions, and educational outreach) and geochemical analyses (laser ablation inductively coupled plasma–mass spectrometry), this thesis has documented economic, ideological, and sociopolitical interactions during Rapa Nui's past, especially regarding the access, control, exchange, and use of archaeological basalts (Chapters Four, Five, and Six). This final chapter draws together the results of research presented throughout the thesis to present a unified explanatory framework for understanding Rapa Nui's ancient political economy and addresses the main research findings as they relate to the six research questions posed in Chapter One. It concludes with an outline of proposed future research objectives that result from the thesis and provides a final report from the Rapa Nui Geochemical Project (2013–2019).

Main findings

RQ1: What types of economic, ideological, and sociopolitical interactions were evident during Rapa Nui's pre–contact and historic/contact periods?

Chapter Two reviewed how early explorers, missionaries, ethnographers, anthropologists, and archaeologists provided insight into Rapanui cultural interactions (e.g. between the Rapanui and visitors and between the Rapanui themselves). An important observation is that the vast majority of early ethnohistoric records indicate that the Rapanui culture did not experience a socio–ecological collapse before European contact (Bahn and Fleney 1992; Diamond 1995, 2005; see also Chapter Six and RQ6). On the contrary, many early records suggest the island's culture was thriving at the time of contact. For example: 1) the island's population was more than 3000 upon the first interaction with the outside world in 1722 and its population did not drop to the low of 110 until 1877 after the dramatic effects of disease and blackbirding (Altman [ed.] 2004; Englert 1970; Fischer 2005; Hunt 2007; Larsen and Simpson 2014; Métraux 1957; Peiser 2005; Pinart 1877); 2) multiple *moai–ahu* complexes were still in place (including standing statues with topknots on platforms) and in use for ceremonies (Cook 1777; DuPetit–Thouars 1841; Forster 1777; Kotzebue 1821; Roggeveen 1722); 3) new houses were being constructed (La Pérouse 1797); 4) copious amounts of horticultural and fowl staple resources were transferred between the Rapanui and visitors, suggesting that ancient farming and chicken husbandry were still being practised. This is also supported by first–hand accounts witnessing extensive gardens and plantations by early visitors (Behren 1722; Foerster 2012; Foerster and Lorenzo 2016; Gale as cited by Richards 2008; Heyerdahl 1961, 1975; Knoche 1921, 1925; La Pérouse 1797; Métraux 1940; Peard as cited by Gough 1973; Roggeveen 1722; Smith 1844); and 5) chiefs and elites were still present in the society, overseeing and directing exchange activities between visitors – similar to their roles in earlier periods of the island's culture (Agüera 1770; Cuming as cited by Richards 2008; DuPetit–Thouars 1841; Englert 1948, 1970; Gale as cited by Richard 2008; Geiseler 1882; La Pérouse 1797; Loti as cited by Altman [ed.] 2004; Métraux 1940, 1957; Peard as cited by Gough 1973; Roggeveen 1722; Roussel 1869; Routledge 1919; Smith 1844; Thomson 1891; Wolf as cited by Richards 2008). As such, an argument is made here that since the Rapanui culture had not collapsed before contact, early records have much to inform researchers about patterns of economic, ideological, and sociopolitical interaction. Therefore, using a review of 50 historic visits (from Captain Roggeveen in 1722 to Father Sebastián Englert in 1935) and multiple ethnographic, ethnohistoric, and archaeological interpretations, the following modes for interaction are evident during Rapa Nui's ancient and historic periods: reciprocity, redistribution, exchange, connectivity, and trade. Over time, however, it is quite apparent that modes of interaction evolved to become more adaptable to the issues faced at the time, particularly after the island's contact with the outside world.

Reciprocity, *redistribution*, *and exchange*

Reciprocity was evident in the way that the Rapanui transferred materials between themselves, suggesting one individual was not the owner of a specific item, and artefacts such as fishing lines, nets, and bone needles were communally used (e.g. Agüera 1770; Knoche 1925; Heyerdahl 1961, 1975; Richards 2008). Yet, although some Rapanui gifted items and resources to early visitors without looking for an immediate reciprocal return within the same interaction (e.g. DuPetit–Thouars 1841; Gough 1973; Métraux 1940), other exchanges included the purposeful manipulation of the weight of baskets/barrels by the Rapanui (who added rocks instead of produce) to fool trading partners about their contents and maximise their returns (Richards 2008). Altogether, these actions may be related to practices of generalised and balanced reciprocity (*umanga* in Rapanui), and perhaps even negative reciprocity, which linked individuals, families, lineages, and chiefly elites to materials and resources. Thus, whereas reciprocity was the traditional base for Rapa Nui's economy and sociopolitical interaction, reciprocal linkages between the Rapanui and members of the outside world were possibly created to foster relationships with visitors for their exotic goods, to increase levels of prestige amongst individual Rapanui through contact with visitors, and to generate new forms of interaction within the island's culture.

Redistribution is apparent in the way first–fruits (yams) and tuna were originally acquired by the *ariki mau* (paramount chief) through chiefly *tapu* (restriction) and then transferred to *tangata honui* (local chief) for further *mata* (clan) reallocation (Eyraud 1864; Roussel 1869; Routledge 1919; Métraux 1940). On lower sociopolitical levels, families and linages, and workers such as *kio* (lowest ranked individuals) and *tangata henua henua* (farmers), provided corporate labour (McCall 1979) to produce a variety of horticultural and fowl produce (Englert 1970; Fischer 2005; Stevenson 1997; Stevenson and Haoa 1998). In turn, *tangata honui* oversaw production and appropriated the very best produce through first–fruit ceremonies (Howard 2007; La Pérouse 1797; Roussel 1869; Simpson 2008, 2009; Stevenson 1997, 2002; Stevenson and Haoa 1998; Stevenson et al. 2005). Using control over the staple resource economy, Rapanui elite were subsequently able to: supply *hatu* (for singular *mata*) and *koro* (for multiple *mata*) festivals, which were further means for interaction including the exchange of personnel, materials, and information; finance corporate work groups; expand horticultural plots and plantations; and to fund monumental construction projects such as *moai–ahu* complexes (see RQ2). These examples highlight elite to elite redistribution (*ariki mau* to *tangata honui*), elite to commoner redistribution (*tangata honui* to *paenga* [family], *ure* [extended family], and *ivi* [lineage]), and commoner to elite distribution (*paenga*, *ure*, and *ivi* to *tangata honui*).

Multiple forms of Rapanui exchange have been documented during the pre–contact period (1100–1722 AD), as well as during historic, ethnohistoric, and ethnographic periods. Regarding the former period, exchange was conducted: 1) within an individual *mata*; 2) between the island's individual *mata*; and 3) within and between the island's two confederations (Ayres et al. 1998; Hunt and Lipo 2011, 2017; McCoy 2014; Mulrooney et al. 2014; Simpson and Dussubieux 2018; Simpson et al. 2017; 2018; Stevenson et al. 2013; Thomas 2009). Under the direction of the *tangata honui*, staple horticultural and fowl resources were mostly exchanged within each *mata* and amongst its various polities including *paenga*, *ure*, and *ivi*. Under the direction of the *tangata honui* of each *mata*, non–local stone resources (i.e. basalt, obsidian, scoria, and tuff) and marriage partners were exchanged between individual *mata kainga* (except for the Miru at Hanga Rau) and between and within the two island confederations (see Chapter Two). These exchanges (possibly facilitated through *hatu* and *koro* festivals), in turn, allowed access to culturally important stone materials not found locally in each *mata kainga* (Simpson and Dussubieux 2018). They also provided marriage partners between *mata* to ease genetic bottlenecking during the island's isolated prehistory (Dudgeon 2008; Gill 1988, 2000; Gill et al. 1983; Routledge 1919). Altogether, internal and external exchange assisted individual chiefs in the establishment of power strategies to increase their prestige and authority over their particular *mata* (see RQ2), and helped to formulate and maintain economic, ideological, and sociopolitical interaction within the ancient island culture (see RQ5).

Regarding the latter periods, Rapanui exchanged both staple and luxury resources with visitors to the island. This includes exchanging horticultural crops, chickens, nets, wooden carvings, chiefly cloaks, stone artefacts, and *moai* for visitor's hats, handkerchiefs, cloth, fishhooks, metal, mirrors, tobacco, wood, and whaling products (Altman [ed.] 2004; Behren 1722; Brown 1924; Cook 1777; DuPetit–Thouars 1841; Fischer 1997, 2005; Foerster 2012; Foerster and Lorenzo 2016; Forster 1777; Gale 1810 as cited by Richards 2008; Geisler 1882; Heyerdahl

1961, 1975; Knoche 1925; Kotzebue 1821; Métraux 1940; Peard as cited by Gough 1973; Pinart 1877; Richards 2008; Roggeveen 1722; Routledge 1919; Smith 1844; Thomson 1891; Van Tilburg 2004; Wolf as cited by Richards 2008). Means for the transfer of these items between the Rapanui and visitors included the offering of gifts and women (reciprocity), bartering for foreign materials (requesting specific material returns for items presented), and the ceremonial exchange of chickens and cloaks (during rituals with visitors). Arguably, the consistency whereby specific staple and luxury resources were exchanged between the Rapanui and their visitors shadowed economic, ideological, and sociopolitical mechanisms for exchange used during the pre–contact period. Therefore, reciprocity, redistribution, and exchange were major arrangements whereby the prehistoric and historic Rapanui interacted between themselves and, after contact, with the outside world.

Connectivity and trade

One of the main catalysts for putting economic value on Rapanui material culture came from the actions of Ariki Alexander P. Salmon (Fischer 2005; Heyerdahl 1975; Métraux 1940; Routledge 1919). He was the first visitor/resident to Rapa Nui who stimulated mass artefact production after witnessing the great desire for *kohau rongorongo* (proto–language tablets), *moai miro* (wood statues), *mangai mā'ea* (stone fishhooks), and featherwork by visitors. As a result of the hyper–production of artefacts encouraged by Salmon, along with the annexation of the island by Chile in 1888, Rapanui material cultural began to be collected and traded between individuals and institutions from around the world, including, for example, the U.S., Great Britain, Germany, Russia, France, New Zealand, and Chile (Brown 1924; Chauvet 1934; Heyerdahl 1975; Simpson 2010). This diffusion of objects and raw material served to create connectivity with one of the world's most isolated islands, not only with other islands in Polynesia (e.g. early wood figures were brought to Tahiti by Mahine), but also to a globalised network (Fischer 2005). Today, Rapa Nui material culture, including *moai*, lithics, wood/stone carvings, and *tapa* artefacts, can be found in museums throughout the world.

RQ2: What are the characteristics of Rapa Nui's chiefly and elite controlled ancient political economy?

Chapter Two presented frameworks, definitions, and case studies of political economy (PE) theory in archaeology. It particularly highlighted PE investigations conducted in Polynesia and on Rapa Nui, revealing the multiple ways that power strategies and bottlenecking efforts were used by ancient *Ma'ohi* chiefs and elites to come into power and to maintain control over prehistoric political economies (Earle 1997b, 2002; Earle and Spriggs 2015). In turn, this power and control allowed successful chiefs to influence cultural development and change throughout ancient Polynesia (Dow and Reed 2013; Earle 1997b, 2002; Earle and Spriggs 2015; Firth 1967; Goldman 1970; Graves and Sweeny 1993; Hommon 2013; Kirch 1984, 1990, 2000; Kirch et al. 2011; Kolb 1991, 1992, 1994; Lass 1998; Sahlins 1958; Younger 2012).

Chapter Two also established that the ancient Rapa Nui society was economically, ideologically, and sociopolitically complex, exhibiting a highly stratified culture with multiple cultural positions, each with its own role and responsibilities (Chapter Two, Table 3A–C). These included: *ariki* (*mau* and *paka*), *tangata honui*, *ivi atua*, *māori*, *matato'a* and *paoa*, and *kio*. Each of these individual classes played a role in the evolution of the ancient society and in the development of the island's political economy; however, it was the Rapanui chiefly and elite classes that were most responsible for the management and direction of economic, ideological, and sociopolitical interaction. Table 3A–C in Chapter Two synthesises the roles and responsibilities of each of these cultural positions within the ancient culture. Drawing upon this synthesis, along with the frameworks, definitions, and interpretations that are provided by the PE theoretical orientation in archaeology, I identify three power strategies (and associated bottlenecking efforts) used by ancient Rapanui chiefs and elites during the pre–contact period: control over land, freshwater, seascapes, labour, and staple resource production systems; control over redistribution systems; and control over the ideological domain and landscapes.

Power gained from control over land, freshwater, seascapes, labour, and staple resource production systems

Two effective means for *tangata honui* to gain power and acquire surplus staple resources were to demark, oversee, and control land (*mata kainga*), water (e.g. wells, seeps, and access to the ocean), and productive features (e.g. *manavai* gardens and chicken houses) and to direct corporate work strategies for many types of clan projects – from constructing *ahu* platforms and transporting *moai* statues, to expanding gardening land and constructing new chicken husbandry features. One way *tangata honui* bottlenecked access to land, freshwater sources, and land and sea resources, was in the careful spatial positioning and construction of *moai–ahu* complexes, elite homes (*hare paenga*), *pipi horeko* (stone towers), and petroglyphs (Howard 2007; DiNapoli et al. 2019; McCoy 1976; Simpson 2008, 2009; Stevenson 2002; Stevenson et al. 2005, 2013; Vargas et al. 2006). Inland, elite retainers carefully marked individual plantations farmed by lesser ranked *paenga*, *ure*, and *ivi*, by using carefully placed rock field markers and elite homes (Behrens 1722; Howard 2007; La Pérouse 1797; Roussel 1869; Thomson 1891; Stevenson et al. 2005). This demarcation undoubtedly served *tangata honui* who could use these structures to organise corporate labour around specific plots and to monitor staple horticultural resource production (i.e. taro, sweet potato, yams, and bananas) from seeding through harvest to redistribution (McCall 1979; Simpson 2008, 2009; Stevenson 1986, 1997; Stevenson and Haoa 1998; Van Tilburg 1994).

Regarding the production of fowl, the *hare moa*, or chicken house, was a physical means of staple resource bottlenecking because its stone construction allowed the protection and restriction of chickens (Geisler 1882; Palmer 1875; Vargas et al. 2006). Consequently, *hare moa* greatly assisted in the pooling of fowl staple resources including meat, eggs, feathers, and bones for elite *tangata honui* (Simpson 2008, 2009). Moreover, as some chicken houses were blessed by members of the Miru (*ariki paka*), especially before *koro* ceremonies, *hare moa* and the elite *puoko moa* (incised skulls) found within them, created an influential connection between specific chicken houses, deceased elite individuals, and the most powerful *mata* on Rapa Nui – the Miru and their supreme chiefs (Métraux 1940; Roussel 1869; Routledge 1919). By protecting chickens, and aiding in the limiting of access to chickens, especially those owned by the *tangata honui*, chicken houses acted as one of the most critical means of staple resource bottlenecking during the pre–contact period.

Therefore, successful chiefs and elites were those who restricted access to land, freshwater, and the sea, controlled corporate labour task groups, and used the *hare moa* to cache and pool staple resources created by elite–legitimised fowl husbandry.

Power gained from control over redistribution systems

As mentioned in the discussion of RQ1, there are multiple forms of redistribution noted in historic, ethnohistoric, ethnographic, and archaeological records during Rapa Nui's pre–contact and historic periods. The most prestigious form of chiefly redistribution (enforced through *tapu*) was found in the exchange of *kahi* (tuna) from the *ariki mau*, caught in his royal *vaka vero* canoe, to individual *tangata honui* throughout the island (Eyraud 1864; Métraux 1940, 1957; Roussel 1869). This luxury resource, and its consumption, was certainly one way individual *tangata honui* could be directly connected to the Miru and the *ariki mau* from Hanga Rau at 'Anakena. This connection to the paramount chief would have increased the prestige, status, and *mana* of *tangata honui*, allowing them to increase their prestige and *mana* within their individual *mata*, as well as between *tangata honui* from other *mata* (see also McCoy 2014 and Mulrooney et al. 2014 for a similar discussion regarding archaeological stone redistribution). This would be especially true during the winter months, when only the *ariki mau* had access to tuna. Thus, consumption of tuna during *tapu* periods would have elevated elite status even further and would have allowed those *tangata honui* with access to tuna to bottleneck, control, and redistribute this important protein source and luxury resource.

Regarding the redistribution of staple horticultural resources, one of the most important bottlenecking strategies used by the *tangata honui* (and other chiefly elites throughout Polynesia; for example, see Gifford 1929; Handy and Handy 1972; Oliver 1974) was the first–fruit ceremony (La Pérouse 1797; Métraux 1940; Roussel 1869; Simpson 2008, 2009). After overseeing the horticultural process from seeding to harvest, first–fruit ceremonies allowed elite Rapanui to appropriate the best and largest produce to be used to fund individual and collective agency. Remaining produce, not selected by *tangata honui*, was used to supply local *hatu* festivals, which helped to redistribute staple resources to lower ranked *paenga*, *ure*, and *ivi*.

Additional bottlenecking efforts over redistribution systems can be found in the way *tangata honui* directed the installation of *umu pae* (ovens) and *hare umu* (oven houses) to be intervisible with an *moai–ahu* complex and the associated elite coastal settlement pattern (Simpson 2008, 2009). Consequently, this intervisibility helped living chiefs and elite retainers (backed by deceased ancestors – *tupuna*) to keep a panoptic eye over valuable (cooked) food resources that were used in redistribution efforts to feed corporate members, as well as to fund chiefly activities of individual *tangata honui*. These included, for example: the obtaining of body decoration (*tatau* and *takona*); the funding of larger *koro* festivals which were held between different *tangata honui* from distinct *mata*; the production and acquisition of specialised crafts and luxury resources (feathered hats, cloaks, wood artefacts); the intensification of horticultural (*manavai* and rock gardens) and fowl husbandry (*hare moa*) production; and the construction of monumental works and political landscapes (see below).

Therefore, successful chiefs and elites during pre–contact times on Rapa Nui were those who bottlenecked access to valuable luxury resources, used first–fruits ceremonies to claim ownership over the island's best horticultural staple resources, and installed ovens and oven houses within the visibility of living and deceased ancestors to help oversee the consumption of (cooked) staple resources. In turn, both luxury and staple resources would have been used by *tangata honui* to finance a variety of activities which further legitimised chiefly control over the island's ancient political economy and promoted elite hegemony during Rapa Nui's pre–contact period.

Power gained from control over the ideological domain and landscapes

One of the most important aspects that drove ideological interaction throughout Polynesia and during Rapa Nui's past was elite ancestor worship and its connection to *mana* (Fischer 2005; Kirch 1984, 2000; Métraux 1940, 1957; Shore 1989). Accordingly, relationships between the living and the dead, and elite and non–elite individuals (indicated by ascribed *mana*), were major elements within the ideological domains of ancient Rapanui existence.

Other ideological domains created and manipulated by the elite Rapanui included *kohau rongorongo*. This proto–writing script and its cryptic meanings was likely utilised by the Miru, and its most elevated *ariki*, to code messages used between elites, and to inscribe and safeguard myths, traditions, and sacred genealogies (Englert 1970; Fischer 2005; Métraux 1940, 1957; Routledge 1919; Thomson 1891). This information could then be recited to non–readers during ceremonies, by certain chiefs, which ultimately promoted elite hegemony, the dominance of a singular cultural creation myth, and an exclusive genealogy. Starting with Hotu Matu'a and continuing through his six sons and their descendants, including later *tangata honui*, the island's many archaeological remains, especially the *moai–ahu* complex, were created to broadcast this royal lineage and to memorialise later chiefly and elite genealogies (Goldman 1970; Englert 1970; Martinsson–Wallin 1994; Sahlins 1958; Simpson 2008, 2009; Stevenson 2002).

It was in the most elite lineage (the six sons of Hotu Matu'a), whose members were specifically relocated throughout the island depending on their birth order, that the most sacred ascribed *mana* resided (Englert 1970; Métraux 1940, 1957; Routledge 1919; Roussel 1869; Thomson 1891). From these six primogenitures each *mata* and *mata kainga* was established, and successive generations of chiefs and elite retainers continued through the *atariki* (first born son). With island colonisation between 1100–1200 AD, and with little evidence for secondary *Ma'ohi* migrations to Rapa Nui before European contact in 1722 AD, Rapanui elite classes arguably controlled and manipulated the island's ideological domains for more than 500 years.

To help materialise an ideology of Rapanui elite rule, chiefs and specialists focused on building a physical landscape that would constantly remind all *mata* members of their economic, ideological, and sociopolitical roles and responsibilities (Chapter Two, Tables 3a–c). This so–called political landscape used *moai*, *ahu*, elite homes, petroglyphs, rock towers and markers to assist chiefs and elites to oversee *mata kainga* and seascapes, to direct the behaviour and stimulate the labour of lesser ranked sociopolitical units, to carefully monitor staple resource production, to legitimise allocation rights over the staple resource economy during first–fruits, *hatu*, and *koro* ceremonies, and to administer the redistribution of cooked staple resources and luxury resources (Howard 2007; DiNapoli et al. 2019; Simpson 2008, 2009; Simpson et al. 2017; Stevenson 1997, 2002; Stevenson and Haoa 1998; Stevenson et al. 2005, 2013).

Thus, the political landscape gave multiple generations of *tangata honui* the ability to promote hegemony by controlling their *mata kainga*, lower ranked *mata* inhabitants and their labour efforts, and production and redistribution systems. Furthermore, successful chiefs and elites during Rapa Nui's pre–contact era were those who celebrated and maintained elite ideological domains including chiefly genealogies traced to the island's founder, Hotu Matu'a, and his six sons, who used *kohau rongorongo* to code and protect chiefly and elite scripture, and who constructed political landscapes that bottlenecked the bodies and minds of all *mata* inhabitants.

In summary, Rapa Nui exhibited a very interactive and complex economic, ideological, and sociopolitical system during pre–contact times, and into the historic period in certain circumstances. This complexity can be observed by identifying the various interactions, roles, and responsibilities of each cultural position recognised during the island's prehistory, from the *ariki mau* to *kio*. Yet elites, including the Miru and *tangata honui*, were in firm control of the ancient island culture – especially its ancient political economy. But, the most successful chiefly and elite retainers were those who used and combined sources of power gained from the overseeing of land, freshwater, seascapes, labour, and staple resource production systems, the bottlenecking of redistribution systems, and the use of ideological domains and landscapes, to promote individual and collective agency. Therefore, Rapa Nui's archaeological record may be interpreted as evidence for a system that highlights the successes and failures of individual Rapanui chiefs, clans, and confederations throughout the island's past.

RQ3: What fine–grain basalts are found in the Rapa Nui Geochemical Project study areas and what types of basalt were used to manufacture portable artefacts according to total alkali versus silica (TAS) analysis? What were the geological formation processes that created tool grade basalt? What elements should geochemists use to better discriminate Rapa Nui's basalt sources in the future?

While this thesis is archaeological in nature, this specific research question is focused on describing the varied geological landscapes found throughout Rapa Nui and within the RNGP study areas. The reason for this line of enquiry is that, by determining which specific types of basalt were targeted by the ancient Rapanui, a more detailed understanding of ancient stone selection and use than has been presented by past archaeological research can be attained. To support this enquiry, in Chapter Three I synthesised the robust records concerning Easter Island's geodynamic, volcanic, and geologic evolution and previous archaeological sourcing studies (see also Simpson 2014; Simpson et al. 2017). This review has offered background and context to my research by providing geological data to situate my findings of archaeological patterning of basalt exploitation in an explicit identification of prehistoric stone selection, distribution, and use.

Rapa Nui's complex geodynamic formation and its more than 100 volcanic events provided the island's inhabitants with a relativity high diversity of geological rock types, including: hawaitte, mugearite, benmoreite, rhyolite, tuff, and scoria. The diverse range of available materials is also reflected in the many types of archaeological basalt that were identified during investigations for this thesis. For example, using TAS analysis, which plots total alkali versus silica content, Chapters Four and Six documented a variety of rocks that were available in the RNGP study areas, including basaltic trachyandesite, basaltic andesite, trachyandesite, andesite, trachydacite, and dacite (Simpson and Dussubieux 2018; Simpson et al. 2017).

Regarding RNGP sources and quarries, Simpson et al. (2017) demonstrate that the Rua Tokitoki quarry consists predominately of trachybasalt, while the Poike source stone is trachyandesite. Both normalised Rare Earth Elements and multi–element patterns confirm differences in basalt petrogenesis between Ava oʻKiri and Pu Tokitoki (Rua Tokitoki) and Poike. Simpson and Dussubieux (2018) establish that Pu Tokitoki and Ava o'Kiri are predominantly basaltic trachyandesite, basaltic andesite, and andesite. Southwest coast stone is mostly trachyandesite while Rano Kau stone is typically trachydacite. The Vai Atare study area is composed of both trachydacite and dacite. (Simpson and Dussubieux 2018; Simpson et al. 2018).

Future elemental and statistical analyses used in sourcing studies should focus on the following major and minor elements – Na_2O, MgO, K_2O, CaO, Be, B, V, Ni, Co, Sr, Zr, Nb, Sn, Ba, Ta, Mo, Th – as they appear to be the most appropriate to discriminate the elemental differences in Rapa Nui's basalt deposits.

RQ4: What are the spatial distributions, physical characteristics, and timing of use for Rapa Nui's fine–grain basalt mines, sources, quarries, and workshops?

The advantage of investigating geoarchaeological quarries and sources is that they are often highly localised and distributed unevenly in archaeological landscapes, allowing researchers to document patterns of raw stone access, control, exchange, reduction, and use. This information, in turn, can provide information about past economic, ideological, and sociopolitical interaction and organisation for Rapa Nui, and for Polynesian islands in general.

Over four field seasons, the RNGP documented six locations where the ancient Rapanui extracted basalt to fashion portable artefacts and construction stones: Poike, Pu Tokitoki, Ava o'Kiri, the southwest coast, Rano Kau, and Vai Atare (Simpson and Dussubieux 2018; Simpson et al. 2017, 2018).

Poike

While the northern area of Poike (near Ahu Kiri Reva) contains one difficult–to–access fine–grain basalt source (ranging between benmoreite and mugearite), other sources and quarries, as yet undocumented by the RNGP, may exist in the northern Poike area, requiring future survey (see below). Toponymic and archaeological observations, along with geochemical evidence, demonstrate that adzes, fishhooks, and knives were all made from this source (Gonzalez–Ferran et al. 2004; Simpson et al. 2017; Chapter Six). The operational sequence for these artefacts may have begun by climbing (or rappelling) down Poike's cliffs using ropes, removing raw material, and then using baskets to bring quarried material up to Ahu Kiri Reva, or down to awaiting canoes, like obsidian quarrying at Motu Iti (Stevenson et al. 2013). The Poike source is unique in terms of other fine–grain sources on Rapa Nui in that it was under the oversight of elite retainers, especially through its associated spatial association with Ahu Kiri Reva. This *ahu* and others in the area (e.g. on top of Maunga Tea Tea) may have been used to demark other stone sources in the area, including trachyte (Simpson et al. 2017). As such, material from Poike was geochemically traced to elite inhabited areas including 'Anakena and Ava Ranga Uka A Toroke Hau, representing a pattern of chiefly control over patchy fine–grain basalt resources (Chapter Six; see also RQ5).

Ava o'Kiri and Pu Tokitoki complexes

These areas include the largest fine–grain basalt quarry complex on Rapa Nui, as well as more than 50 quarries, sources, and workshops spread over 3km^2 (including Rua Tokitoki). Results from TAS analyses demonstrate that trachybasalt, basaltic trachyandesite, basaltic andesite, and andesite were removed from geological deposits by the ancient Rapanui (Simpson and Dussubieux 2018; Simpson et al. 2017). Ethnographic observations and archaeological and geochemical evidence all demonstrate that picks, adzes, knives, and axes were made from stone quarried from this area (Ayres et al. 1998; Harper 2008; Simpson and Dussubieux 2018; Simpson et al. 2017, 2018; Stevenson and Haoa 2008; Stevenson et al. 2000).

The operational sequence for the manufacture of these artefacts begun with the creation of *pu* (pits) to extract fine–grain boulders from *puku* (outcrops). This process likely used wedges to remove targeted stone (McCoy 2014). Around *puku* and *pu* there is normally ample evidence of blanks, preforms, and very thick deposits of debitage. Few finished artefacts and polishing stones are found at quarrying sites. Unlike the Poike source, there is little evidence for elite monitoring and control in this area due to the lack of *ahu*, *hare paenga*, and rectangular homes (Simpson and Dussubieux 2018; Simpson et al. 2017; Stevenson et al. 2000).

Material from Ava o'Kiri and Pu Tokitoki was traced to both coastal (elite) and inland (non–elite) sites including: Tongariki, Rano Raraku, Oroi, Puku Nga Aha Aha, Orito, Vai Atare, Hanga Roa, Tautira, Tahai, Ava Ranga Uka, Maitaki te Moa, Ava o'Kiri, and 'Anakena. This pattern suggests that multiple clans throughout the island had communal access to basalt found in the Ava o'Kiri and Pu Tokitoki complexes (see RQ5).

Southwest coast complex

Representing the second largest fine–grain basalt quarry complex on Rapa Nui, the southwest coast includes 21 trachyandesite mines, quarries, sources, and workshops spread over 1.2km^2. There are also locations, found next to mining sites, which produced *kie'a* (mineral pigment) and *poro* (beach stone), making the southwest coast a very important location for raw material acquisition. Geochemical evidence demonstrates that adzes and knives were made from this quarry complex (Simpson and Dussubieux 2018; Simpson et al. 2018).

The operational sequence for these artefacts started by targeting specific geologic formations that contained fine–grain, tabular *keho* stone. Once selected, intensive mining operations were initiated, creating multiple entry points to access trachyandesite. Like Ava o'Kiri and Pu Tokitoki complexes, little evidence for elite monitoring and control in the area exists, based on the lack of *ahu*, *hare paenga*, and rectangular homes (although Ahu Hanga Poukura is found 250m to the east of the main complex). However, unlike the widespread distribution of archaeological basalt from Ava o'Kiri and Pu Tokitoki throughout the island, material from the southwest coast was traced only to locations within the lower–class Ko Tu'u Hotu Iti Ko Te

Mata Iti confederation: Orito, Oroi, Puku Nga Aha Aha, and Rano Raraku. This pattern suggests that only one confederation, and selected clans, had access to basalt from the southwest coast (see RQ5).

Vai Atare

There are 11 quarries, stone sources, and workshops with trachydacite and dacite rocks found within the larger Rano Kau volcanic complex, spread over 1km^2. However, unlike the other fine–grain basalt deposits in other RNGP study areas, there is little evidence of small debitage (<20cm), and an overall lack of *pu*, hammer stones, adze blanks, preforms, and finished artefacts. In fact, lithics geochemically analysed from the Vai Atare region were not even made from the locally sourced basalt, but were provenanced to Ava o'Kiri and Pu Tokitoki complexes and an unknown source(s) (Simpson and Dussubieux 2018; Simpson et al. 2018). While this would suggest portable artefacts were not made in the area, Vai Atare was an important location for *keho* extraction and fabrication. In turn, this *keho* was most likely used to construct homes found at the nearby ceremonial village of 'Orongo (Mulloy 1975). As there is little evidence for elite monitoring and control in the area, based on the lack of *ahu*, *hare paenga*, and rectangular homes, stone from Vai Atare may have been opportunistically used by all clans to construct individual houses located at 'Orongo (see below).

Rano Kau

While there are multiple *keho* quarries around the Rano Kau rim (outside the study area), the RNGP identified and documented a large singular source spread over 0.5km^2. Like Vai Atare, the site in Rano Kau does not show evidence for the production of portable artefacts, but instead, the selection and fabrication of large *keho* stones (Simpson and Dussubieux 2018; Simpson et al. 2018). Considering that this site produced the largest laminates of trachydacite on the island, stone from Rano Kau could have been used opportunistically to produce the cantilever ceilings of houses found at 'Orongo; however, this should be tested with future geochemical studies (see below).

Timing of use for Rapa Nui's basalt mines, quarries, sources, and workshops

Using five ^{14}C determinations from a 5m excavation around the area of *moai* RR–001–156 in Rano Raraku (Van Tilburg and Arévalo 2015), it appears that basalt, in the form of *toki* and picks, was brought into the interior of the *moai* quarry between 1455 and AD 1645 (Simpson et al. 2018). The provenance for many of these artefacts and fragments was traced to the largest quarrying complexes for fine–grain basalt on Rapa Nui, Ava o'Kiri and Pu Tokitoki and the southwest coast (Simpson and Dussubieux 2018). This result is supported by other geochemical analyses conducted in Rano Raraku that also identified two raw material types used to make the adzes and picks recovered during Easter Island Statue Project excavations (Fischer and Bahamondez 2011). While further chronological refinement awaits a Bayesian analysis of other radiocarbon age determinations, these five dates from the interior of Rano Raraku suggests that the quarries, sources, and workshops at Ava o'Kiri and Pu Tokitoki and the southwest coast were in operation no later than AD 1455, and were possibly in use for no less than 200 years. This would imply that there were multiple generations of master craftsmen and tool makers who continued to acquire stone to produce lithics, which in turn were used to carve ~1000 *moai* statues, ~100 *pukao* topknots, and numerous construction stones including *pae* and *paenga.* Yet, considering that *moai* carving at Rano Raraku began on the outside southern margin crater before carving moved inside the inner crater, it is very possible that adzes and picks sourced from Ava o'Kiri and Pu Tokitoki and the southwest coast were also used there to carve *moai*, pushing the initial operation of these complexes before AD 1455. Further geochemical analysis of archaeological basalt from the outside flank of Rano Raraku, found in association with *moai*, could verify this.

Using four ^{14}C determinations from uncharred nutshells recovered from excavations in Ava Ranga Uka A Toroke Hau, human activity in the area was dated between 1458 and 1642 AD (Vogt and Moser 2010; Vogt and Kühlem 2018; Vogt et al. 2018). Also found in association with these nutshells were some 250 modified obsidian and basalt artefacts. Of the latter raw material, eight artefacts were geochemically analysed by the RNGP, and two, an adze and a knife, were sourced to the elite controlled source on Poike underneath Ahu Kiri Reva (Simpson et al. 2017).

Furthermore, considering that basalt from Poike was being used to manufacture artefacts at nearly the same time as basalt from Ava o'Kiri and Pu Tokitoki and the southwest coast was being used (Simpson and Dussubieux 2018; Simpson et al. 2018), this suggests that multiple fine–grain basalt quarries and sources were in operation and in use at the same time, especially from 1455 to 1642 AD. Moreover, this timing has also been suggested for coarse–grain basalt quarrying in the Hiva Hiva district (Stevenson et al. 2018).

Thus, multiple basalt quarries, of both fine– and coarse–grain materials, were being accessed at the same time throughout the island. Further radiometric and obsidian hydration dating and geochemical analyses of basalt materials from ceremonial and habitation sites, along with materials found in association with *moai* on the outside margins of Rano Raraku, could help to verify this.

RQ5: What were the economic, ideological, and sociopolitical mechanisms that facilitated the access to and use of archaeological stone, including fine–grain basalt, during Rapa Nui history?

This thesis is the most comprehensive study, so far, of fine–grain basalt sourcing on Rapa Nui. However, conclusions made for RQ5 would benefit from further field survey and geochemical analyses to increase sample sizes. Yet, evidence presented in this final chapter, as well as throughout this thesis, suggests that there were multiple pathways for economic, ideological, and sociopolitical interaction during Rapa Nui's past. Using terminology provided by Renfrew (1975), the following procurement and exchange types were present during Rapa Nui prehistory: direct access; home–base redistribution; boundary reciprocity; down–the–line exchange; and central place redistribution (Chapter Six, Table 5). These terms help with understanding the ancient procurement and exchange strategies used on Rapa Nui. In addition, results from the research reported in this thesis further support the adoption of four general terms to identify and describe economic, ideological, and sociopolitical interaction during Rapa Nui's pre–contact period: opportunistic, communal, confederation and elite (re)distribution.

Opportunistic

For this research, opportunistic use includes making an artefact/construction stone utilising a geological source whose location is within the borders of the *mata kainga* where the artefact/construction stone was recovered in the archaeological record. In other words, localised opportunistic use would not require stone exchange with elite members from other *mata* and/or confederations. For instance, considering coarse–grain basalt was used to manufacture construction stone and *moai* pedestals, some *ahu* around the island were erected with material from quarries that are in proximity to *moai–ahu* complexes. This includes, for example, Maitaki te Moa, Te Pito Kura, Tepeu, Mahatua, and Moa te Eru Eru, where local *papa* and *puku* were quarried to create *pae* and *paenga* to construct nearby platforms, sea walls, wings, ramps, and other *ahu* features (Gioncada et al. 2010; Hamilton 2013; Hamilton et al. 2011; McCoy 2014). However, there were some *moai–ahu* complexes where *pae* and *paenga* were imported from some distance away (Harper 2008), as occurred at Vinapu, and for the construction of the platforms at Vaihu and Akahanga (McCoy 2014). I argue that the former example highlights an instance of opportunistic basalt acquisition, where *mata* inhabitants focused on the production and use of construction stone from quarries that were confined within their *mata kainga*.

Concurrently, clans that were rich in one stone resource not abundant throughout the island could have used this material for exchange within/between the two confederations and/or within/between other *mata*, creating microeconomies for unique stone types within/between the island's numerous clans and two confederations. For example, McCoy (2014) argued that one specific clan, the Marama, may have had exclusive rights to five sources of localised basalt found in Rano Kau, Maunga Tararaina, and Ko Ori which were utilised to make *paenga* and *pae*. Using this valuable basalt, *tangata honui* not only used this material within their own *mata kainga* (e.g. Vaihu), but also exchanged it within/between other *mata* and/or within the confederation (see below). This, in turn, would have raised the prestige and power of individual chiefs and elite retainers and fostered economic, ideological, and sociopolitical interaction between the island clans and confederations.

The best evidence for opportunistic use of fine–grain basalt is two RNGP artefacts (A08, A14) from Ahu Tongariki which were sourced from an undocumented quarry or source likely found around the same *moai–ahu* complex (perhaps located in the volcanic flows PO1, RA3, and RA8 [Gonzalez–Ferran et al. 2004]). As these two adzes have outlying geochemical signatures when compared to other RNGP specimens, in addition to their unique basaltic andesite composition, this suggests that not all adzes and picks were made from stone extracted from the largest fine–grain basalt complexes on Rapa Nui (i.e. Ava o'Kiri and Pu Tokitoki and the southwest coast), and that some tools were also made from localised stone sources. This could have included the opportunistic use of coastal *poro* boulders to fashion artefacts such as adzes and picks, in addition to wedges and hammer stones used for a multiplicity of purposes.

Communal

Communal use is deemed to be extraction of stone from a resource shared by all members of a community, in common use. An example of communal use of basalt comes from McCoy's (2014) archaeological work involving *paenga* and *pae*. McCoy argued that one pathway to acquire coarse–grain basalt from Rano Kau was through so–called 'commons' areas, where basalt was accessed by members of different clans (see also Mulrooney et al. 2014 for a similar interpretation about archaeological obsidian). On a larger scale, geochemical fingerprinting studies undertaken for this thesis revealed that most *mata* throughout the island used Ava o'Kiri and Pu Tokitoki stone (Simpson and Dussubieux 2018; Simpson et al. 2018). Stone from this area was used to manufacture a variety of tools including adzes, axes, picks, and knives. Artefacts sourced from the island's largest fine–grain basalt quarrying complex were used in a variety of archaeological contexts including habitational, ceremonial, and in other stone quarries (i.e. Rano Raraku). With the island–wide utilisation of Ava o'Kiri and Pu Tokitoki stone, I argue that this pattern is an example of communal use of fine–grain basalt Moreover, this pattern for the communal use of quarries by all the island's *mata* is also evident for other archaeological stone (e.g. obsidian, toba, and scoria) (see also Simpson and Dussubieux 2018)..

Communal use of stone from Ava o'Kiri and Pu Tokitoki was likely directed by the island's individual *tangata māori anga mā'ea* who led task groups, organised by corporate strategies (directed by *tangata honui*), into commons areas to acquire and reduce stone to manufacture artefacts. Through this process, *tangata māori anga mā'ea* earned prestige and luxury resources such as lobsters, eels, and certain pelagic fish from their local *tangata honui*, elevating their economic, ideological, and sociopolitical status (Van Tilburg 1994). For this reason, they were considered an elite class that earned prestige through their achieved actions, passing their legacy and specialist knowledge from father to son (Métraux 1940).

Judging from the fact that quarries, sources, and workshops at Ava o'Kiri and Pu Tokitoki were in use for hundreds of years, there were probably multiple generations of master tool makers who made a variety of artefacts for use in both every day and sacred activities. Many of these master tool makers were motivated individuals who were seeking honour, status, and prestige (Goldschmidt 1990). As such, *tangata māori anga mā'ea*, when combined with the individual motivation and agency of *tangata honui*, formed a powerful economic, ideological, and sociopolitical unit that undoubtedly influenced and directed the development and evolution of their individual *mata*, as well as the overall ancient island culture.

Confederation (re)distribution

Rapa Nui society comprised two confederations: the northern Ko Tu'u Hotu Iti Ko Te Mata Nui and the southern Ko Tu'u Hotu Iti Ko Te Mata Iti (Hotus et al. 1988; Stevenson 1986, 2002; Vargas et al. 2006). As the northern confederation was a higher ranking confederation, due to the location of the Miru and *ariki* within Ko Tu'u Hotu Iti Ko Te Mata Nui territory, there may have been a necessity for the southern confederation to create intra–confederation interaction to acquire materials not easily attained by exchange with the Ko Tu'u Hotu Iti Ko Te Mata Nui. Therefore, confederation (re)distribution includes the exclusive use of stone by an exclusive confederation. McCoy's (2014:18) work on the southwest coast, investigating the sourcing and manufacture of coarse–grain *pae* and *paenga*, argued for a pattern of confederation (re)distribution where the Marama *mata* "had proprietary right to the summit region, but granted access to other groups [of the southern confederation] in exchange for some unknown product or service".

A similar example of a confederation (re)distribution network is seen in archaeological stone from the southwest coast study area, used to make adzes and knives. This stone has been traced to sites within the Ko Tu'u Hotu Iti Ko Te Mata Iti (Chapter Six, Figure 21). Judging from the facts that: 1) stone from the southwest coast complex was not used by the northern Ko Tu'u Hotu Iti Ko Te Mata Nui confederation; and 2) RNGP artefacts from Orito, Oroi, Puku Nga Aha Aha and Rano Raraku were mainly provenanced to the southwest coast complex (Simpson and Dussubieux 2018), I argue that this pattern reflects local (re)distribution efforts of basalt between members of the Ko Tu 'u Hotu Iti Ko Te Mata Iti confederation, including *tangata honui* and their lesser ranked *paenga*, *ure*, and *ivi*. Additional staple resources such as obsidian, *poro*, and *kie'a* could have also been exchanged through these confederation (re)distribution networks, connecting multiple southern *mata* through the exchange and use of similar, but spatially localised stone materials. This transfer of materials would have allowed the southern coast confederation to interact economically, ideologically, and sociopolitically within the confederation and between its individual *mata*.

Elite (re)distribution

Investigation into elite access, control, distribution, and use of stone resources during Rapa Nui prehistory has been a focus for interaction and provenance studies (Ayres et al. 1998; Harper 2008; Mulrooney et al. 2014; Simpson and Dussubieux 2018; Simpson et al. 2017, 2018; Stevenson et al. 2000, 2013). This work has analysed both obsidian and non–obsidian lithics and construction stone, documenting how elite Rapanui bottlenecked the access to stone quarries and utilised preferred stone material around the sacred *moai–ahu* complex and within the elite coastal settlement pattern.

The definition of elite (re)distribution includes the exclusive acquisition and use of archaeological stone by elite Rapanui – especially the Miru and *tangata honui*. For example, Stevenson et al. (2013) demonstrated how obsidian from the elite monitored sources of Maunga Orito and Motu Iti, used during elite ritual and death activities conducted at the *moai–ahu* complex, flowed through the prehistoric economy, but was preferentially retained by chiefly members in the process. Meanwhile, lower ranked Rapanui, living in upland and centre portions of the island, acquired stone material via communal access and down–the–line exchange (Renfrew 1975), arguably redistributed from *tangata honui* to *paenga*, *ure*, and *ivi*. However, Mulrooney et al. (2014) posited that the chiefly control at Orito may instead have involved encouraging communal access (and/or confederation [re]distribution) to the higher quality obsidian as a means of building and maintaining prestige between chiefs and elite retainers from different *mata*, including those within the northern Ko Tu'u Hotu Iti Ko Te Mata Nui confederation, which lacks obsidian deposits in its territory.

For coarse–grain basalt, Stevenson et al.'s (2018) investigation from Hiva Hiva concluded that *moai–ahu* complexes, several *hare paenga*, concentrated feature complexes, and specialised quarries to produce construction stone represented chiefly and specialist oversight over *paenga* and *pae* manufacture. Organised and sponsored by *tangata honui*, *tangata māori anga hare paenga* directed specialised task groups who were fed by localised staple resource production. Surplus industry from this system of *paenga* and *pae* production, overseen by chiefly and elite retainers, was arguably (re)distributed to other *tangata honui* from other clans and perhaps even to the southern Ko Tu'u Hotu Iti Ko Te Mata Iti confederation. This system for coarse–grain stone extraction and *pae* and *paenga* dressing seems to be quite prolific, as Stevenson et al. (2018) found 16 basalt sources in the region, while Haoa et al. (2007) found more than 200 sources in the entire Hiva Hiva and Roiho district.

The most apparent indication for elite (re)distribution of fine–grain basalt during Rapa Nui prehistory comes from the use of stone from the elite monitored source on Poike, under Ahu Kiri Reva, to manufacture artefacts found at 'Anakena and Ava Ranga Uka A Toroke Hau (Chapter Six). At 'Anakena, the homeland for the Miru and the *ariki*, the most sacred and highest–ranking individuals of the pre–contact Rapa Nui culture, stone from Poike was used to manufacture an adze (A02) and a knife (A07). Arguably, these tools were used for boat construction, which was regulated by the *ariki mau.*

In another elite controlled area of the island, Ava Ranga Uka A Toroke Hau, an archaeological complex that was dedicated to the collection and maintenance of water (Vogt and Moser 2010; Vogt et al. 2018), two artefacts – a knife (A53) and an adze (A57) – were also sourced to Poike. As the presence of elite retainers such as *ariki paka* has been identified in both 'Anakena and Ava Ranga Uka A Toroke Hau (Routledge 1919; Métraux 1940; Vogt and Moser 2010; Vogt et al. 2018), perhaps it was these very individuals who were responsible for using the elite controlled stone from Poike at these locations. Conceivably the use of basalt from Poike indicated high–status and rank, and the activities for which the artefacts made from this basalt were reserved, included elite–controlled canoe making (see Chapters Two and Six).

In summary, while elite Rapanui controlled access to two sources of obsidian (i.e. Orito and Motu Iti) and one source of fine–grain basalt (i.e. Poike), there is more evidence to argue that the Miru and *tangata honui* did not bottleneck/inhibit the access to the majority of the island's mines, quarries, and sources in the past. In other words, there is little evidence to suggest that overall control of the island's stone resources was used as a power strategy by Rapanui elite to come to/maintain power and to sustain control over the island's ancient political economy. With other prehistoric pathways to access stone – opportunistic, communal, and confederation (re)distribution – interpretations from this thesis are paralleled by results from obsidian characterisation studies on Hawai'i Island, were there was little chiefly involvement in the distribution of volcanic glass from the Pu'u Wa'awa'a source (McCoy et al. 2011). This indicated that alternative exchange systems, based upon reciprocity between related individuals or more formalised exchange partnerships from different lineages, existed.

This result prompted Stevenson et al. (2013:109) to ask: "are [Rapanui] elite members of society involved in the management of everyday exchange activities that involve basalt and obsidian cores, flakes, and finished tools? Is such micromanagement on an island–wide level feasible or even desirable to higher ranking individuals"? The answer to this question, as highlighted by the results presented in this thesis, is 'no'. Instead, operating under the umbrella of a chiefly and elite controlled political economy, there were other independent exchange networks in place. Arguably, it was this diversity of pathways to stone that allowed room for island–wide economic, ideological, and sociopolitical interaction within clans, between clans, and within and between the island's two confederations.

RQ6: What do the overall results from this thesis suggest about cultural interpretations put forward by proponents of the 'ecocide' or 'collapse' narrative?

Mulloy (1974; Mulloy and Figueroa 1978) was the first archaeologist to suggest that Rapa Nui's fragile environment was overexploited through the process of *moai–ahu* complex construction. In turn, this inferred overexploitation created drastic landscape and ecological change, motivating violent actions towards elite Rapanui including the toppling of the *moai–ahu* complexes by lower class Rapanui. This activity, plus resource depletion, warfare, cannibalism, and subsequent societal collapse within the 16th or 17th centuries, before the arrival of Europeans, became the main explanation for prehistoric interaction and cultural change during Rapa Nui's past.

Six years after Mulloy and Figueroa's 1978 monograph regarding the reconstruction of Ahu Akivi (Atio a Runa Runa), Flenley and King (1984), and later Flenley et al. (1991), presented palaeoecological evidence regarding late Quaternary pollen records from Rapa Nui. These records revealed that an extensive palm forest once existed on the island, but after Polynesian colonisation, the island's forests were cut down by slash–and–burn horticultural practices and for the procurement of lumber for cremation, canoe manufacture, *ahu* and house construction, and *moai* carving, transport, and installation.

Using Mulloy's hypothesis, along with the newly acquired palaeoecological data for Rapa Nui, the seminal *Easter Island Earth Island* was published by Bahn and Flenley in 1992. Later updates and reprints of this book have been issued, which advocate the hypothesis that through a 'synergy of impacts' initiated by human (and rat) arrival to Rapa Nui, the island was overpopulated, deforested, eroded, and later plagued by warfare, food shortage, and cannibalism (Flenley and Bahn 2003). The main evidence for these human impacts, and the timing for Rapa Nui's socio–ecological collapse, was based on palynological reconstruction and ^{14}C dating of organic material from core samples recovered from the island's freshwater sources. Results indicated the island was heavily forested at 1000 BP, but was completely deforested through human actions by 1680 AD. This date of 1680 AD then became the benchmark year for when the island's ancient culture had entirely denuded the island, leading the Rapanui culture towards their pre–contact collapse.

Yet, the largest impact of Bahn and Flenley's research was their notion that what happened during Rapa Nui's pre–contact times is similar to how humans are behaving on planet Earth today. Using Rapa Nui's alleged 'ecocide' as a microcosm for global environmental degradation and equating this to cultural and environmental actions of humans on planet Earth generally, Bahn and Flenley's (1992) present 'overshoot and crash' models for both Rapa Nui and planet Earth. This model argues that populations exponentially increase over time, then at some point, experience demographic collapse (see also Tainer 2006). For Rapa Nui, collapse was calculated at 1680 AD; for planet Earth and humanity, collapse is calculated at 2050 AD. For both models, cultural collapse is ultimately tied to the decrease and degradation of natural resources and the increase in pollution and populations above carrying capacities.

Two years after *Easter Island Earth Island* was published, the movie *Rapa Nui* (1994) visually portrayed the collapse narrative. Throughout the movie, triggers for the island's collapse such as deforestation, civil conflict, overpopulation, and overconsumption to support *moai* carving and transport are presented. Also detailed in the film is the final crash of the ancient society, which included the cutting down of the last palm tree, warfare between the 'long' (elite) and 'short' (non–elite) ears for power, battles for authority, dwindling resources, and vivid scenes of cannibalism. With these sensationalised images of the island's socio–ecological downfall, the collapse narrative became the main trope with which to discuss Rapa Nui palaeoecology, prehistory, and history.

One year after *Rapa Nui*, Diamond (1995) published *Easter's End*, an article that synthesised selected, but now outdated, archaeological, palynological, and paleontological data to offer further discourse supporting the island's collapse narrative (see Lipo [2018] for an updated rebuttal of Diamond [1995]). This interpretation was furthered in Diamond's 2005 book entitled *Collapse: How Societies Choose to Fail or Succeed*, where Rapa Nui, along with examples of other 'failed' societies, was served up as a cautionary tale for contemporary human populations.

Archaeological evidence for the collapse narrative has been offered (Diamond 2005; Kirch 2000; Mieth and Bork 2004, 2005, 2010; Mulrooney et al. 2009; Stevenson 1997). This has included, for example, the later and prolific appearance of the *mata'a* (obsidian bifaces), which are believed to have been used during island–wide warfare campaigns between the two confederations and their *mata*. Clan warfare, directed by the island's warriors, priests, and the activities of the *tangata manu* (birdman) competition, was presumed to have been prompted by the lack of staple horticultural resources and consequent hunger, which ultimately led to raiding, skirmishes, and cannibalism. According to this narrative, with the overthrow of elite classes that represented the *moai–ahu* complex, their *hare paenga* were destroyed, and *paenga* were reused to create *ana kionga* (protection caves) that kept islanders safe during conflict.

Other evidence often given in support for collapse consists of explicit changes in mortuary, settlement, and landscape use patterns during later prehistory. These included the shift from cremation in earlier periods to the later use of *ahu* and *avanga* for human burial, the complete abandonment of inland areas, a desanctification of coastal areas, and the degradation of soils after deforestation was complete by 1680 AD – 42 years before European colonisation of Rapa Nui.

However, not all archaeologists have supported Rapa Nui's collapse narrative. Early critiques were voiced by Hunter–Anderson (1998) and Rainbird (2002). While the former asked if the ancient Rapanui 'really cut down all those trees' and presented a geoclimatic model that provided frameworks to explain the island's deforestation (see also Orliac and Orliac 1998), the latter argued that Rapa Nui's 'ecodisaster' transpired after the post–contact period and as a result of Polynesian and outside world interactions. Other authors have supported conclusions presented by these early sceptics, highlighting how many aspects of the Rapa Nui culture radically changed after contact and colonisation, conversion to Catholicism, blackbirding and slavery, and disease and murder (Hunt 2007; Larsen and Simpson 2014; Peiser 2005; Simpson and Dussubieux 2018).

The most voiced critique against Rapa Nui's pre–contact collapse narrative has been made by Hunt, Lipo, and their colleagues (Hunt 2007, Hunt and Lipo 2006, 2007, 2010, 2011; Jarman et al. 2017; Lipo 2018; Lipo et al. 2013, 2016). Using evolutionary theory and a variety of archaeological science techniques and methods (see Chapter Two), they have systematically questioned Rapa Nui's collapse narrative using empirical data gained from field, laboratory, and experimental research over the last 20 years. Interpretations of these data indicate that the island was colonised no earlier than AD 1100–1200 (not AD 400–800 as held by the collapse narrative), giving much less time for drastic population growth (Hunt, Lipo, and their colleagues argue for a peak pre–contact population of only a few thousand, not 20,000 as held by the collapse narrative). Hunt and Lipo et al. also stress the significant impact the introduced Polynesian rat (*Rattus exulans*) played in palm and forest deforestation. In addition, statues were 'walked' to the *moai–ahu* complexes (using ropes and organised work groups) and not rolled and transported on palm trunks (thus, deforestation was not a product of producing log rollers for *moai* transport). Lastly, like other scholars, Hunt and Lipo et al. conclude that interactions after European contact, for example blackbirding and imported disease, were the real reasons behind the island's drastic socio–ecological collapse.

Hunt, Lipo, and their colleagues' interpretations have been supported by other recent work in palaeoecology, palaeodemography, climatology, archaeology, biological anthropology, history, and mathematics (Cañellas–Boltà et al. 2013; Gossen 2011; Larsen and Simpson 2014; Mann et al. 2008; Mulrooney 2012, 2013; Mulrooney et al. 2009; Owsley et al. 2016; Rull et al 2013, 2016; Sáez et al. 2009; Simpson and Dussubieux 2018; Stevenson et al. 2015; Thromp and Dudgeon 2015). Much of this recent research has also demonstrated that arguments supporting the island's prehistoric socio–ecological downfall are often misguided. While

Chapter Six synthesised specific deficiencies of the narrative as revealed by this corpus of so–called 'anti–collapse' research, the following synthesises data and results from this thesis to further destabilise the collapse narrative. This includes using literature review and archaeological and geochemical interpretations to argue that the collapse narrative's descriptive frameworks and interpretations are not adequate to elucidate Rapa Nui prehistory and history.

Literature review

As revealed through ethnographic, ethnohistoric, and historic record review in Chapter Two, it is apparent that many traditional Rapanui economic, ideological, and sociocultural systems were still in place at the time of European contact and had not yet deteriorated. Living in these systems were thousands of islanders (Hunt 2007) who lived under confederation and *mata* organisation, controlled by elite Rapanui such as the Miru and *tangata honui* (Agüera 1770; DuPetit–Thouars 1841; Englert 1948, 1970; Gale as cited by Richards 2008; Geiseler 1882; La Pérouse 1797; Loti as cited by Altman [ed.] 2004; Métraux 1940; Peard as cited by Gough 1973; Roggeveen 1722; Roussel 1869; Routledge 1919; Smith 1844; Thomson 1891; Wolf as cited by Richards 2008). While early records indicate that *moai–ahu* complexes were still standing and in use during the ethnographic present (Cook 1777; DuPetit–Thouars 1841; Forster 1777; Kotzebue 1821; Roggeveen 1722), and new houses were being built (La Pérouse 1797), other visitors noted that Rapa Nui was exceedingly fruitful, having great fertility and robust vegetation and gardening plots (Behren 1722; Gale as cited by Richards 2008; Heyerdahl 1961, 1975; Knoche 1921; La Pérouse 1797; Métraux 1940; Peard as cited by Gough 1973; Roggeveen 1722; Smith 1844). Horticultural staple resources, in great quantities, were often used by the Rapanui to barter with the early visitors. At times, the islanders offered innumerable baskets and bushels of sweet potatoes, bananas, taro, and yams, along with valuable artefacts such as *moai miro*, nets, cloaks, featherwork, and *rongorongo* tablets for visitor's hats, handkerchiefs, cloth, fishhooks, metal, mirrors, tobacco, wood, and whaling products. (Altman [ed.] 2004; Behren 1722; Brown 1924; Cook 1777; DuPetit–Thouars 1841; Fischer 1997, 2005; Forster 1777; Gale 1810 as cited by Richards 2008; Geisler 1882; Heyerdahl 1961, 1975; Knoche 1925; Kotzebue 1821; Métraux 1940; Peard as cited by Gough 1973; Pinart 1877; Richards 2008; Roggeveen 1722; Routledge 1919; Smith 1844; Thomson 1891; Van Tilburg 2004; Wolf as cited by Richards 2008).

Thus, the data presented in Chapter Two, along with the discussion in this chapter, support Richards' (2008) conclusion that pre–contact and contact Rapanui were not so impoverished, nor so hungry, that they would not trade valuable staple resources in large quantities, for the curiosities offered by early visitors (see also Foerster 2012; Foerster and Lorenzo 2016). Most likely, the source for such great quantities of fruits and tuber crops came from the numerous inland horticultural plots and plantations that were under the oversight of the island's elite classes and that were worked by lesser ranked Rapanui. These spatially organised plots and plantations included *manavai*, rock gardens, rock mulched gardens, and terracing (Baer et al. 2008; Stevenson and Haoa 1998, 2008). Together, these features likely provided the copious quantities of produce and surpluses that were traded with foreigners (Foerster 2012; Foerster and Lorenzo 2016; Richards 2008).

As such, extensive literature review does not support the notion of a pre–contact collapse narrative that argues for great famine and a lack of staple resources at the time of European arrival. Not only is this explanation not based in any data, but careful review of available records shows that economic, ideological, and sociocultural systems were still in place at the time of contact, with islanders still venerating the ancestors, building homes, and producing large quantities of staple resources through intensive horticultural practice.

Archaeological data

Prehistoric material culture caching on Rapa Nui first gained attention through the work of Heyerdahl and his desire to uncover Rapa Nui's hidden artefact caves (Heyerdahl and Ferdon et al. 1961). In finding these caves, and the multiple types of material and artefacts therein, Heyerdahl convinced many people that these caves were from a period of conflict and warfare, where valuable material culture had to be gathered, concealed, and protected against raiding and thievery during the so–called Huri Moai Phase.

Obsidian *mata'a* have also been found in caching contexts, being found in large numbers in multiple locations throughout the island (McCoy 1976; Vargas et al. 2006). This prolific appearance in prehistory prompted the interpretation that they were used during warfare campaigns, where many *mata'a* were needed at once (Bahn and Flenley 1992; Diamond 1995, 2005). Warfare, as it is argued in the collapse narrative, was a product of the island's socio–ecological disintegration, and cached *mata'a* represented evidence of armed conflict between the island's confederations and *mata*.

Basalt tools, such as adzes and picks, have also been found in a caching context in Rano Raraku. While the oldest surveys of the *moai* quarry documented numerous deposits of *toki* and picks (Pinart 1878; Routledge 1919; Skjølsvold 1961), excavation by the Easter Island Statue Project found 1624 adzes, picks, and tool fragments associated around two inner crater *moai* (Simpson et al. 2018; Van Tilburg and Arévalo 2015). Following the logic of the collapse narrative, this prolific appearance of *toki* and picks in Rano Raraku represented a dramatic instant after collapse, when *moai* carvers abandoned their carving and collectively discarded their sculpting implements. This is also the reason, as proposed by the narrative, for why there are so many *moai* still within Rano Raraku, as they were never finished due the island's pre–contact collapse and the termination of the so–called Ahu Moai Phase.

For all three of these examples, reviewing the existing literature and using evidence presented in Chapter Five provides alternative explanations for the caching of material culture during Rapa Nui's past. Regarding artefact caves, Heyerdahl offered to buy many of the monolithic pieces found in caves, therefore prompting Rapanui to recover old pieces and to carve new artefacts to sell to Heyerdahl (Conniff 2002). In short, it would seem that the idea of artefact caves may not have been a pre–contact phenomenon at all, but instead, represented a new pattern to cache and display material culture, one instigated by Heyerdahl and his desire to purchase Rapa Nui material culture.

Regarding obsidian *mata'a*, residue and use–wear research has shown that Rapa Nui's obsidian bifaces were used mainly for tuber processing, weeding, and wood, shell, and bone working (Bollt et al. 2006; Church and Rigney 1994; Church and Ellis 1996; Lipo et al. 2016; Stevenson and Williams 2018; Torrence et al. 2018). Therefore, obsidian caching may be more related to the processes of obsidian reduction and specific use patterns than for warfare.

Regarding the high–volume of basalt adzes and picks from Rano Raraku, I argue that the purposeful caching of 1624 specimens recovered around *moai* RR–001–156 does not represent a dramatic socio–ecological collapse, where *moai* sculpting simply ended one day (Simpson et al. 2018). Instead, it may be more useful to posit that *tangata māori anga moai* and their task groups were well organised and planned ahead by having a surplus of necessary materials on hand and ready to use. This would not only include finished basalt *toki*, picks, and wedges from Ava o'Kiri and Pu Tokitoki and the southwest coast, but also other economic, ideological, and sociopolitical resources (e.g. labour, food, blessings, etc.) needed to complete a statue from its inception until installation at its designated *moai–ahu* complex. This ability to be highly organised and prepared may explain why Ava o'Kiri and Pu Tokitoki and the southwest coast where so extensively quarried; to produce a surplus of stone tools which were used to carve more than 1000 *moai* during the island's occupation.

Geochemical data

Those who support the collapse narrative have painted a picture of constant aggressive tribalism and intense competition between chiefs, determined to outdo their neighbours in the scale and grandeur of their megalithic centres (Bahn and Flenley 1992; Diamond 1995, 2005). In turn, this competition facilitated and encouraged overconsumption, overpopulation, warfare, and pre–contact cultural collapse. While competition and conflict existed and undoubtedly influenced the ancient Rapanui culture (e.g. the activities of the *tangata manu* or birdman competition; Drake 1992; Lee 1992; Ramírez–Aliaga 2016; Van Tilburg 1994), the collapse narrative simply portrays Rapanui's *ariki* and *tangata honui* as superfluous competitors, bent on building larger *ahu* with more grandiose *moai* over time, to display their and their ancestors' dominance over adjacent neighbours. Unfortunately, this interpretation of intense competition between clans, which ultimately promotes their alleged collapse, belies the fact that there was indeed cultural co–operation within and between *mata* who developed economic, ideological, and sociopolitical mechanisms to share, exchange, and control culturally valuable stone (Simpson and Dussubieux 2018; Simpson et al. 2017, 2018).

From geoarchaeological fieldwork (2014–2018) and the results of ICP–MS analyses of stone tools, the RNGP demonstrated the prehistoric timing and transfer of basalt material from geological sources to archaeological sites from 1455 to 1645 AD (Simpson and Dussubieux 2018; Simpson et al. 2017, 2018; RQ4). Results and interpretations reported in this thesis suggest four types of stone resource exchange: opportunistic; communal; and confederation and elite (re)distribution (see RQ5). These interpretations, based on rigorous archaeological assessment, indicate that there were far more economic, ideological, and sociopolitical interactions on this East Polynesian outpost than has been identified in the collapse narrative. Principally, interactions were created by the need for multiple *mata* to have access to identical stone to construct the *moai–ahu* complex, as well as to manufacture portable tools, indicating a shared tradition possibly started by the Miru (Goldman 1970; Englert 1970; Martinsson–Wallin 1994; Sahlins 1958; Simpson 2008, 2009; Stevenson 2002).

As there were relatively few quarries throughout the island producing high–quality stone, and there were only three stone sources that were supported by elite bottlenecking efforts (see RQ5), clans, led by *tangata honui*, adopted multiple social arrangements (i.e. opportunistic, communal and confederation [re]distribution) to allow access to, and use of, similar and culturally valuable stone within *mata*, between *mata*, and within/between the two island confederations. These arrangements resulted in information sharing and a system of maximum use for a minimum number of mines, quarries, sources, and workshops throughout the island (e.g. Rano Raraku, Puna Pau, Orito, Ava o‘Kiri and Pu Tokitoki). In turn, this pattern allowed for and stimulated economic, ideological, and sociopolitical interaction and may have been the very reason for the prolific archaeological development of Rapa Nui for more than 500 years.

Future Objectives for Enhancing Research Outcomes

Future research can include the following:

1. Additional field survey is needed to locate and record the remaining mines, quarries, and sources.
According to the TAS analyses of unsourced artefacts, geological locations with the following rock types should be targeted first: basaltic trachyandesite, basaltic andesite, trachyandesite, andesite, trachydacite, and dacite. Two areas in particular that may contain these rock types are locations around the *corrales* (enclosures) found in the centre of the island (Stevenson et al. 2005; Vargas et al. 2006) and on cliff faces as found on Poike (Simpson et al. 2017).

In addition, further field survey and documentation in Rano Kau is needed, especially in the Kari Kari region, as more *keho* sources and quarries were identified by the RNGP, but not formally recorded or geologically sampled (Simpson 2015b; Simpson and Dussubieux 2018).

I also propose a geochemical examination of the construction stone used at ‘Orongo – including both house walls and cantilever ceilings – to confirm that *keho* stone used for construction was indeed from Rano Kau and Vai Atare.

Adequacy of sample sizes for geochemical analysis should also be demonstrated (e.g. Weisler et al. 2016) in the future.

2. To better recognize the operational sequence of basalt lithic manufacture, I suggest the future application of a *chaîne opératoire* documentation approach (Sellot 1993).

More specifically, the analysis of hammer stones, cores, blanks, preforms, and debitage will help to improve understanding the stages of lithic reduction that were used at quarries. This, in turn, would help to identify the reduction sequences of basalt tools (e.g. adzes, axes, picks, and knives).

3. Archaeological excavation of basalt quarries and sources should be undertaken.

As no archaeological excavation has ever been conducted on basalt mines, quarries and/or sources on Rapa Nui, preliminary excavations of the largest sites (along with surface collection and analyses) should provide additional information about the *chaîne opératoire* of basalt tools, generate site formation evidence, and provide material for ^{14}C radiometric dating and obsidian for hydration dating. Together, these data would provide more detailed timing of basalt quarry, source, and workshop use during the past.

4. There is a need for more sampling of archaeological collections.

Since the RNGP has now created a baseline for the further comparison of basalt geoarchaeological samples, I suggest the need for more sampling from other archaeological collections found on the island and in collections held elsewhere. Sampling design should include different artefact types, especially fishhooks, axes, knives, flakes, and cores. Ideal basalt material to analyse would include those collections with known spatial and temporal contexts to build understanding of when basalt materials were being quarried, reduced, and used throughout the island. This information would also help to determine if certain quarries were used to make specific artefacts and/or used in specific exchange networks.

5. There needs to be increased engagement with local peoples through outreach programs.

One of the most rewarding aspects of the RNGP was working with various heritage institutions and programs on Rapa Nui. This included collaborating with the Sebastián Englert Anthropology Museum, Chilean Heritage Council, Terevaka Archaeological Outreach, Hotel Explora, and Manu Iri Heritage Guardians to offer archaeological outreach, public archaeology, and educational opportunities for the Rapanui community (Shepardson et al. 2014; Torres and Hereveri 2015; Torres et al. 2015; Appendix G). In working with some of these institutions for more than 15 years, I encourage all archaeologists to incorporate educational programs into their research designs (Simpson 2015a, 2016, 2019), as co–ordinating archaeology and outreach education has already proven to have very positive effects for the local community and has stimulated local Rapanui youth to study archaeology (Shepardson 2013; Shepardson et al. 2014; Simpson 2015a 2016, 2019). Therefore, continued educational outreach is recommended for Rapa Nui.

In turn, this effort will increase the access to archaeology, archaeological training, and archaeological knowledge for the local island population, while helping to create diachronic relationships between archaeologists and the living cultures that archaeologists work with (Simpson 2019).

Concluding Remarks

This thesis has considered economic, ideological, and sociopolitical interaction during Rapa Nui's past by documenting the timing and transfer of basalt from geological mines, quarries, and sources to archaeological sites. This thesis utilised political economy theory, field archaeology and geology, material culture documentation, geochemical analyses, artist reconstructions, radiometric dating, literature review, and educational outreach initiatives. Data provided by these methods and techniques, underpinned by political economy theory, have helped to identify the diversity that existed with regards to the pre–contact acquisition and exchange of basalt on Rapa Nui. Archaeological evidence from 84 sites and a total of 209 geoarchaeological samples suggests that Poike, Ava o'Kiri, Pu Tokitoki, the southwest coast, Rano Kau, and Vai Atare were the major locations for the acquisition of basalt resources on Rapa Nui.

Geochemical evidence from RNGP sites and MAPSE artefacts has identified at least eight unique basalt types and highlights that quarries and sources from Ava o'Kiri and Pu Tokitoki provided most of the material used to manufacture the artefacts analysed in this thesis. The southwest coast also acted as an important source for material, but appeared to be secondary in terms of production. Material from Rano Kau and Vai Atare appears to have been used for purposes other than to manufacture portable artefacts, including possible house manufacture at 'Orongo. ^{14}C dating suggests that the island's basalt quarries were active no later than AD 1455, and they were in use for more than two hundred years.

One significant result of this thesis is that, although successful Rapanui chiefs and elites used power strategies such as control over land, freshwater, seascapes, labour, and staple resource production systems, the bottlenecking of redistribution systems, and the use of ideological domains and landscapes to promote collective and individual agency, it would seem that overall control of the island's stone resources was not used as a power strategy by Rapanui elite to maintain power and to sustain control over the island's ancient political economy.

Finally, at least four pathways for the transfer of basalt were documented in this study: opportunistic, communal, confederation and elite (re)distribution. Taken together, the variety of economic, ideological, and sociopolitical interactions revealed in this study refutes propositions put forward by the collapse narrative and establishes that collaboration and co–operation existed between confederations and *mata* during Rapa Nui's past, especially regarding access to and use of culturally valuable stone such as basalt.

Rapa Nui Geochemical Project (2013–2019)

The Rapa Nui Geochemical Project – which was created to support this thesis – brought together more than 30 professionals from 20 institutions on Rapa Nui and from around the globe to investigate archaeological basalt industries from Rapa Nui (see Acknowledgments and Appendix F for Chilean and Rapa Nui permits and letters of support). The RNGP uses geoarchaeological methods, the documentation of archaeological basalt quarrying sites (measurements, descriptions, and drone and SLR photography and videography), the documentation of museum and archaeological basalt collections (SLR photography, 3D scanning, and a datashare hosted at www.terevaka.net/toki), geochemical analyses (pXRF and ICP–MS), radiometric dating (^{14}C), artists' reconstructions [Appendix H], literature review, and political economy theory to: 1) demonstrate that the Rapanui (like their *Ma'ohi* relatives) were experienced miners and expert stone tool makers who accessed various types of basalt to fabricate a multiplicity of artefacts and construction stones; 2) elucidate temporal and spatial patterns of basalt acquisition, reduction, transfer, and use; 3) delineate economic, ideological, and sociopolitical interaction, including basalt exchange, between members of the ancient Rapanui culture; 4) highlight Rapa Nui's chiefly and elite–controlled ancient political economy; 5) evaluate and challenge cultural interpretations put forward by the 'ecocide' or 'collapse' narrative (Bahn & Flenley 1992; Diamond 1995, 2005); and 6) create public archaeology and educational opportunities for the local Rapa Nui community.

Over four field seasons, the RNGP recorded 84 mines, quarries, and sources (Appendix B) that were used to extract multiple types of fine–grain basalt to make tools such as adzes, axes, knives, and picks. Thirty–one of these sites were selected for geochemical analyses, as they exhibited the most complete evidence for basalt stone procurement, reduction, and artefact manufacture, including extensive *in situ* remains (Appendix C). Between the six RNGP study areas, there was a combined area of 11,842m^2 that was used to acquire and reduce basalt material to manufacture portable artefacts. In turn, basalt artefacts such as *toki* (adze) were used to carve *moai* (statues) and *pukao* (topknots), fabricate *paenga* (house and platform stone), and build *vaka* (canoes). RNGP fieldwork efforts were coordinated with the Sebastián Englert Anthropology Museum (MAPSE), Chilean Heritage Council and Technical Secretary of Heritage (CMN/STP), Terevaka Archaeological Outreach (TAO), Manu Iri Heritage Guardians, and Hotel Explora, to offer archaeological outreach, public archaeology, and educational opportunities for the Rapa Nui community (see Shepardson et al. 2014; Simpson 2015a, 2016, 2019; Torres & Hereveri 2015; Torres et al. 2015; Appendix G).

Geochemical analyses were conducted at a total of three laboratories: two at The University of Queensland's (UQ) School of Earth and Environmental Sciences (Simpson et al. 2017) and one at The Field Museum's (TFM) Integrative Reseach Center (IRC) (Simpson and Dussubieux 2018; Simpson et al. 2018). Trace elements and isotopes were analysed at UQ's Radiogenic Isotope Facility (RIF), School of Earth and Environmental Sciences (SEES), while major elements were analysed in the Environmental Geochemistry Laboratory, SEES (Appendix E). Both major and trace elements were analysed in the IRC's Elemental Analysis Facilities at TFM (Appendix E).

A total of four ICP–MS technologies (and pXRF) were used to obtain elemental readings including Multi–Collector Inductively Coupled Plasma Mass Spectrometry (for Sr–Nd–Pb isotopes), quadrupole ICP–MS (for trace elements), Inductively Coupled Plasma Optical Emission Spectrometry (ICP–OES, for major elements), and LA–ICP–MS (laser ablation inductively coupled plasma–mass spectrometry for major and trace elements). Analyses in Chapter Six reveal that although RNGP geochemical data were obtained from different ICP–MS facilities, the results were comparable. This allowed for the combination of geochemical results for a total of 209 geological and archaeological samples complied by the RNGP. These comprised 117 geological samples from a total of 33 basalt mines, quarries, and sources, seven samples from Rua Tokitoki, three samples from Poike, 61 MAPSE artefacts, and 21 archaeological samples from Rano Raraku (Appendix D). Together, these data allowed assignment of provenance to all but four archaeological samples from Rano Raraku, and all but 11 MAPSE artefacts. Chapter Six provided the possible locations for the quarries of these unsourced RNGP archaeological samples.

The RNGP has produced six peer–reviewed publications, multiple general publications, five reports for the Chilean/Rapa Nui government, two spatial databases, more than 40 academic presentations, and numerous press, media, and Internet showcases (see Appendix I for total thesis and RNGP academic production). Two articles that received in–depth international media coverage include Simpson and Dussubieux (2018) and Simpson et al. (2018). Press releases from these works were showcased in over 200 media, online, and news outlets, for example, by the BBC, Smithsonian, CNN, Newsweek, Archaeology Magazine, New Scientist, and Live Science (see Appendix I). Altogether, the RNGP has proven itself to be a relevant scientific project that has offered ample educational opportunities to the island's community (see Appendix G).

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APPENDIX A

Previous geochemical data for Rapa Nui including stone types, major and minor elements (in both WT% and ppm), and scientific source

LOCATION	ROCK NAME/OTHER ID	SiO_2 WT %	TiO_2 WT %	AL_2O_3WT %	Fe2O3WT %	CaO WT %	MgO WT %	MnO WT %	K_2O WT %	Na_2O WT %	P_2O_5 WT%
ANA KAI TANGATA	BENMOREITE	58.8	1.182	14.65		4.57	1.14	0.26	1.777	5.18	0.383
ANA KAI TANGATA	BENMOREITE	58.79	1.06	14.66	3.53	4.57	1.11	0.37	1.86	5.36	0.48
ANAKENA	BASALT, TRANSITIONAL	50.09	3.283	14.67		8.8	4.25	0.21	0.908	3.74	0.508
ANAKENA	BASALT, TRANSITIONAL	48.24	2.758	18.22		10.59	3.7	0.16	0.491	3.42	0.342
ANAKENA	BASALT	45.68	4.06	14.13	10.2	10.1	5.5	0.1	0.77	3.64	0.45
ANAKENA	DOLERITE	47.8	2.05	20.9		9.04	2.99	0.11	0.7	3.1	0.27
ANAKENA	BASALT	50.5	1.75	16.1		5.59	3.05	0.18	0.88	3.95	0.8
BETWEEN HANGA PIKO AND HANGA ROA	BASALT	51.2	2	14.6		6.18	3.08	0.19	1.25	4.25	0.95
BETWEEN MAUNGA PUI AND VAITEA	THOLEIITE	42.8	4.41	14.91	5.57	8.07	5.04	0.36	0.25	2.7	0.52
BETWEEN RANO RARAKU AND TOA TOA	HAWAIITE	47.66	3.99	14.97	3.92	8.87	4.62	0.28	0.69	3.45	0.58
COAST NORTH OF RANO AROI	BASALT, OLIVINE	48.02	3.34	17.08	2.43	9.4	4.58	0.12	0.78	3.22	0.04
HANGA HO‘ONU	BASALT	42.92	4.68	15.7	7.84	8.22	3.66	0.17	0.67	3.47	1.03
HANGA HO‘ONU	BASALT	46.06	4.8	14.7	4.04	10.82	4.86	0.15	0.79	2.82	0.5
HANGA NUI	BASALT	48.34	3.78	13.06	1.96	10.4	4.74	0.19	0.9	3.61	0.47
HANGA PIKO	BASALT	48.4	2.42	14.6		6.89	3.76	0.16	0.78	4.32	1.01
HANGA PIKO	BASALT	49.4	2.42	5.3		6.95	3.5	0.17	0.9	4.25	1.04
HANGA TETENGA	MUGEARITE	53.06	2.11	14.95	5.46	6.31	2.58	0.33	1.4	4.6	1.06
HIVA HIVA FLOW	BASALT, OLIVINE	48.7	3.23	14.5		7.49	3.85	0.17	1	4	0.92

HOTU ITI	BASALT, TRANSITIONAL	48.36	3.372	15.52		9.59	4.72	0.2	0.6	3.32	0.406
HOTU ITI	BASALT	51.2	2.35	14.6		7.13	2.9	0.14	1.2	4	0.97
MATAVERI	ANDESITE	59.75	0.7	15.42	3.47	4.5	0.93	0.38	1.74	4.75	0.34
MATAVERI	DACITE, ANDESITIC	59.75	0.7	15.42	3.47	4.5	0.93	0.38	1.74	4.75	0.34
MAUNGA ORITO	NOT GIVEN	72.51	0.21	13.35	1.35	0.47	0.16		4.48	4.81	
MAUNGA ORITO	NOT GIVEN	74.24	0.18	13.44	0.08	0.54	0.16		2.79	5.81	
MAUNGA ORITO	NOT GIVEN	72.32	0.21	13.34	1.49	0.46	0.16		4.66	4.7	
MAUNGA ORITO	RHYOLITE	71.92	0.28	13.59	0.51	1.08	0.07	0.11	3.37	5.93	
MAUNGA ORITO	BASALT	49.76	3.4	14.05	0.74	8.45	4.45	0.25	0.505	3.34	0.811
MAUNGA ORITO	BASALT	47.6	4.03	14.45	6.33	8.15	4.35	0.255	0.315	2.9	0.702
MAUNGA ORITO	TRACHYTE	67.56	0.19	14.7	2.92	0.1	0.28	0.025	2.4	3.77	0.031
MAUNGA ORITO	RHYOLITE	72.1	0.16	11.3	0.24	0.61	0.02	0.058	3.9	5.73	0.185
MAUNGA ORITO	BASALT, TRANSITIONAL	71.22	0.195	12.7		0.61	0	0.07	3.789	5.714	0.01
MAUNGA OTU	BASALT, ANDESITIC	53.8	1.46	15.6	7.51	4.88	1.28	0.325	1.66	5.37	0.65
MAUNGA PAREHE	TRACHYTE	67.69	0.342	16.4		0.7	0.08	0.12	3.963	6.01	0.1
MAUNGA PAREHE DOME	TRACHYTE	66.36	0.34	14.7	3.68	1.75	0.05	0.12	4.05	6.34	0.02
MAUNGA PAREHE	TRACHYTE	66.6	0.32	15.4	3.75	0.72	0.05	0.11	4	5.9	0.026
MAUNGA TE PUHA, OVAHE	HAWAIITE	53.5	2.209	14.56		6.45	2.8	0.24	1.275	4.27	1.049
MAUNGA TEA TEA	TRACHYTE	60.62	0.3	17.8	4.22	0.73	0.043	0.113	3.55	5.79	0.03
MAUNGA VEA HEVA	TRACHYTE	64.9	0.31	15.3	4.26	0.55	0.038	0.113	4.05	6.23	0.047
MOTU ITI	COMENDITE	72.3	0.21	13.18	0.82	0.84	0.01	0.08	3.78	5.83	0.01
MOTU NUI	RHYOLITE	72.74	0.28	9.14	2.79	0.94	0.1	0.05	2.82	4.42	1.11
MOTU NUI	RHYOLITE	72.86	0.19	13.48	2.34	0.36	0.06	0.03	3.46	5.44	0
ORITO	NOT GIVEN	71.92	0.28	13.59	0.51	1.08	0.07	0.11	3.37	5.93	0

ORITO	RHYOLITE	68.5	0.22	14.91	3.72	0.54		0.05	3.07	4.63	
ORITO	BASALT	45.4	4.15	13.9		8.32	4.93	0.17	0.59	3.35	0.52
PAPA TEKENA	MUGEARITE	49.57	3.6	13.77	6.3	7.88	3.68	0.32	1.06	4.09	0.56
POIKE	BASALT, TRANSITIONAL	49.88	2.976	14.54		10.09	5.54	0.19	0.569	3.27	0.364
POIKE	BASALT, TRANSITIONAL	48.88	3.285	14.7		10.01	5.33	0.21	0.392	3.35	0.398
POIKE	RHYOLITE	66.58	0.42	14.55	2.35	0.96		0.06	3.92	5.93	
POIKE	BASALT	50.3	2.94	17.87		8.64	3.28	0.18	0.69	3.42	
POIKE	BASALT	49.6	3.06	14.52		9.65	5.25	0.21	0.55	3.2	
POIKE	BASALT	45.84	3.9	15.73		8.44	4.61	0.23	0.37	3.15	
POIKE	BASALT	47.66	3.79	14.3		8.37	4.19	0.21	0.91	3.81	
POIKE	BASALT	48.22	3.29	17.43		9	3.89	0.29	0.82	3.42	
POIKE	BASALT	48.68	2.84	17.54		9.86	4.69	0.27	0.72	3.4	
POIKE	BASALT	49.81	3.25	15.25		9.32	4.46	0.31	0.85	3.5	
POIKE	BASALT, TRANSITIONAL	49.16	2.959	16.75		9.94	4.29	0.21	0.754	3.5	0.387
POIKE	BASALT, TRANSITIONAL	48.52	3.459	14.97		9.65	4.77	0.21	0.672	3.45	0.429
POIKE	BASALT	49.88	1.97	19.54		11.39	4.01	0.15	0.35	2.85	
POIKE	BASALT	49.7	2.8	16.46		10.12	4.81	0.19	0.69	3.12	
POIKE	BASALT	48.64	2.92	15.25		9.66	5.19	0.18	0.19	3.04	
POIKE EAST OF HANGA NUI	HAWAIITE, OLIVINE	48.2	2.51	16.45	5.11	11.18	5.97	0.25	0.32	3	0.31
RANO KAU	BENMOREITE	60.03	1.33	15.08	4.74	3.8	1.64	0.08	2.14	4.38	0.28
RANO KAU	BASALT, ANDESITIC	58.8	1.37	14.88	5.16	3.43	0.69	0.093	2.46	5.49	0.358
RANO KAU	RHYOLITE	72.9	0.16	12.8	0.62	0.52	0.03	0.075	4	5.73	0.016
RANO KAU	BASALT	49.8	2.13	19.37		10.99	4.63	0.14	0.45	2.98	
RANO KAU	BASALT	48.4	3.46	14.86		8.87	5.25	0.22	0.5	3.17	
RANO KAU	BASALT	49.87	3.11	14.1		9.35	5.19	0.19	0.63	3.75	
RANO KAU	BASALT	50	3.62	15.25		8.69	4.52	0.26	0.74	3.4	
RANO KAU	BASALT, TRANSITIONAL	49.29	3.187	15.12		10.17	5.58	0.19	0.546	3.04	0.363

RANO KAU	BASALT, TRANSITIONAL	47.68	3.426	15.01		10.28	5.91	0.21	0.282	3.11	0.379
RANO KAU	BASALT, TRANSITIONAL	47.93	3.373	14.92		10.19	5.79	0.2	0.328	3.11	0.357
RANO KAU	BASALT, TRANSITIONAL	47.74	3.378	14.8		10.29	5.79	0.2	0.297	3.13	0.38
RANO KAU	BASALT, TRANSITIONAL	49.15	1.666	18.72		12.46	5.99	0.13	0.343	2.75	0.178
RANO KAU	BASALT, TRANSITIONAL	48.15	3.02	16.34		9.59	6.17	0.17	1.045	3.38	0.455
RANO KAU	THOLEIITE / BASALT	50.19	1.68	14.99		12.5	5.78	0.16	0.322	2.72	0.179
RANO KAU	THOLEIITE / BASALT						7.45				
RANO KAU	BASALT, ALKALINE / BASALT	48.2	3.078	16.08		9.43	6.13	0.17	0.95	3.38	0.447
RANO KAU	DOLERITE	46.66	4.06	14.28	3.97	7.54	5.35	0.12	1	2.57	0.47
RANO KAU	DACITE	60.92	1.88	13.47	2.99	4.98	1.65	0.14	1.73	4.61	0.35
RANO KAU	NOT GIVEN	74.22	0.09	12.25	0.4	0.98		0.06	3.82	5.21	
RANO KAU	BASALT	47.71	3.24	14.73		9.88	5.27	0.2	0.34	3.28	
RANO KAU WEST SIDE	HAWAIITE	45.55	4.22	14.56	11.8	8.99	4.79	0.29	0.37	3.07	0.35
RANO OROI	BENMOREITE	60.59	1.03	14.17	4.27	3.78	0.92	0.48	2.13	5.15	0.39
RANO RARAKU	HAWAIITE	48.7	3.29	15.46	3.18	9.43	4.74	0.24	0.62	3.29	0.41
RANO RARAKU	BASALT, ANDESITIC	50.02	2.42	15.28	1.82	8.08	3.31	0.2	1.37	4.42	0.4
RANO RARAKU	BASALT	48.14	3.96	15	4.38	8.56	4.63	0.06	1	3.34	0.08
RANO RARAKU	BASALT, ANDESITIC	45.52	2.4	14.32	6.92	5.88	2.98	0.2	1.34	2.89	0.27
RANO RARAKU	BASALT	50	3.15	13.23	2.66	8.7	4.8	0.213	0.84	3.56	0.382
RANO RARAKU	BASALT	68.26	0.21	15.03	3.02	0.32	0.05	0.049	3.4	4.93	0.035
RANO RARAKU	BASALT	50.02	2.42	15.28	1.82	8.08	3.31	0.2	1.37	4.42	0.4
RANO RARAKU	BASALT	54.88	2.28	13.54	2.74	6.48	2.37	0.12	1.27	4.14	0.74

RANO RARAKU	BASALT	45.52	2.4	14.32	6.92	5.88	2.98	0.2	1.34	2.89	0.27
RANO RARAKU	BASALT, PLAGIOCLASE-OLIVINE-CLINOPYROXENE	46.6	3.65	15.3		8.32	4.36	0.16	0.8	3.25	0.71
RANO RARAKU	BASALT	49.8	2.51	13.3		4.99	3.24	0.14	0.8	2	0.81
RANO RARAKU	NOT GIVEN	71.2	0.22	13.6		0.47	0.17	0.06	3.85	5.08	
ROIHO	BASALT, TRANSITIONAL	47.7	2.762	16.34		9.9	7.87	0.18	0.552	3.02	0.365
ROIHO	BASALT, TRANSITIONAL	47.03	3.097	16.44		9.44	7.14	0.18	0.586	3.13	0.501
ROIHO, SOUTH-WEST SIDE	HAWAIITE, OLIVINE	47.79	2.97	15.88	3.14	9.96	7.79	0.08	0.73	2.92	0.19
RUNA AVAE	BASALT	44.2	2.8	19.2	6.26	9.79	4.53	0.21	0.41	3.75	0.319
RUNA AVAE	BASALT	47.4	4.5	14.45	1	8.18	4.73	0.238	0.89	3.53	0.464
RUNA AVAE	BASALT, ANDESITIC	52.6	2	16.05	3.52	6.57	2.95	0.235	1.76	4.5	1.14
SOUTH OF TE MIRO O‘ONE	ANDESITE, BASALTIC	52.2	2.04	15.4		5.47	2.79	0.14	1.6	4.2	0.86
TE MANAVAI	TRACHYTE, QUARTZ	71.1	0.22	13.6		0.36	0.12	0.02	3.85	5.3	0.07
TE MANAVAI	NOT GIVEN	71.4	0.32	13.1		0.59		0.05	3.8	5	
TEREVAKA	BASALT	50.6	2.91	17.53		10.26	3.36	0.18	0.6	3.41	
TEREVAKA	BASALT	48.9	3.13	15.81		8.74	6.75	0.2	0.82	3.09	
TEREVAKA	BASALT/ MUGEARITE	53.1	1.77	16.86		5.47	4.1	0.16	2.82	5.43	
TEREVAKA	BASALT	47.21	3.74	14.26		9.28	4.71	0.23	0.63	3.49	
TEREVAKA	BASALT	48.22	3	15.99		7.26	3.35	0.25	0.59	3.9	
TEREVAKA	BASALT	48.25	2.73	15.97		9.75	7.35	0.19	0.63	3.03	
TEREVAKA	BASALT	48.86	2.99	16.45		9.02	6.42	0.18	0.94	3.39	
TEREVAKA	BASALT	49.86	3.46	14.69		9.15	4.52	0.22	0.75	3.1	
TEREVAKA	BASALT	50.49	2.83	14.78		9.83	6.34	0.2	0.55	3.37	
TEREVAKA	BASALT	51.35	2.96	16.49		9.78	4.03	0.2	0.72	3.47	
TEREVAKA	BASALT	49.17	3.22	15.48		10.3	4.62	0.19	0.63	3.35	

TEREVAKA	BASALT, PLAGIOCLASE-OLIVINE-CLINOPYROXENE	45.6	4.24	15.1		8.2	4.43	0.15	0.64	3.1	0.71
VAI O HAO	BASALT	46.3	4.16	13.6		8.56	4.19	0.16	0.88	3.45	0.48
VAITEA	THOLEIITE	43.32	3.71	15.86	4.53	8.21	5.08	0.32	0.29	2.48	0.44

LOCATION	**ROCK NAME/OTHER ID**	**Li ppm**	**Be ppm**	**B ppm**	**Sc ppm**	**V ppm**	**Cr ppm**	**Co ppm**	**Ni ppm**	**Cu ppm**	**Zn ppm**
ANA KAI TANGATA	BENMOREITE				17.1	11.8	1.24	3.59	0.01	5.21	135
ANA KAI TANGATA	BENMOREITE								1	14	173
ANAKENA	BASALT, TRANSITIONAL				29.3	419	32.7	33.5	18.6	37.8	111
ANAKENA	BASALT, TRANSITIONAL										
ANAKENA	BASALT										
ANAKENA	DOLERITE				35	184	78	28	26		
ANAKENA	BASALT				26	28	20	13	4		
BETWEEN HANGA PIKO AND HANGA ROA	BASALT				30	62	21	17	3		
BETWEEN MAUNGA PUI AND VAITEA	THOLEIITE								23	33	143
BETWEEN RANO RARAKU AND TOA TOA	HAWAIITE								15	35	130
COAST NORTH OF RANO AROI	BASALT, OLIVINE										
HANGA HO‘ONU	BASALT										
HANGA HO‘ONU	BASALT										
HANGA NUI	BASALT										
HANGA PIKO	BASALT				31	63	25	14	3		
HANGA PIKO	BASALT				28	52	22	16	3		
HANGA TETENGA	MUGEARITE								2	23	147
HIVA HIVA FLOW	BASALT, OLIVINE				37	184	32	27	3.5		
HOTU ITI	BASALT, TRANSITIONAL										
HOTU ITI	BASALT				27	67	25	16	3		

MATAVERI	ANDESITE										
MATAVERI	DACITE, ANDESITIC										
MAUNGA ORITO	NOT GIVEN										
MAUNGA ORITO	NOT GIVEN										
MAUNGA ORITO	NOT GIVEN										
MAUNGA ORITO	RHYOLITE										
MAUNGA ORITO	BASALT			13	45	400	45	44	30	85	
MAUNGA ORITO	BASALT			15	40	400	45	43	35	85	
MAUNGA ORITO	TRACHYTE			20			11		85	15	
MAUNGA ORITO	RHYOLITE			27					75	27	
MAUNGA ORITO	BASALT, TRANSITIONAL				4.48	18.7	0	0.02	5.88	3.37	169
MAUNGA OTU	BASALT, ANDESITIC			20	25	6		8	40	35	
MAUNGA PAREHE	TRACHYTE				4			5.1	2.8	7.2	196
MAUNGA PAREHE DOME	TRACHYTE								5	1	177
MAUNGA PAREHE	TRACHYTE			25					100	10	
MAUNGA TE PUHA, OVAHE	HAWAIITE				17.2	86.2	1	16.3	0.69	15.67	121
MAUNGA TEA TEA	TRACHYTE			19					110	11	
MAUNGA VEA HEVA	TRACHYTE			15				6	100	17	
MOTU ITI	COMENDITE								2	1	236
MOTU NUI	RHYOLITE										
MOTU NUI	RHYOLITE										
ORITO	NOT GIVEN										
ORITO	RHYOLITE										
ORITO	BASALT				42	283	28	34	5		
PAPA TEKENA	MUGEARITE								9	35	135
POIKE	BASALT, TRANSITIONAL				33.2	366	22.2	38.9	31.3	54.6	134
POIKE	BASALT, TRANSITIONAL										
POIKE	RHYOLITE										
POIKE	BASALT										
POIKE	BASALT										
POIKE	BASALT										

POIKE	BASALT										
POIKE	BASALT										
POIKE	BASALT										
POIKE	BASALT										
POIKE	BASALT, TRANSITIONAL										
POIKE	BASALT, TRANSITIONAL										
POIKE	BASALT										
POIKE	BASALT										
POIKE	BASALT										
POIKE EAST OF HANGA NUI	HAWAIITE, OLIVINE								84	63	87
RANO KAU	BENMOREITE								6	17	143
RANO KAU	BASALT, ANDESITIC			45	15	95			50	72	
RANO KAU	RHYOLITE			20					50	12	
RANO KAU	BASALT										
RANO KAU	BASALT										
RANO KAU	BASALT										
RANO KAU	BASALT										
RANO KAU	BASALT, TRANSITIONAL										
RANO KAU	BASALT, TRANSITIONAL				36.3	396	107	46.3	42.8	49.7	113
RANO KAU	BASALT, TRANSITIONAL										
RANO KAU	BASALT, TRANSITIONAL				35	299	89.3	33.2	37.1	36.2	115
RANO KAU	BASALT, TRANSITIONAL				27	218	238	33.1	77.4	61.2	71.9
RANO KAU	BASALT, TRANSITIONAL										
RANO KAU	THOLEIITE / BASALT										
RANO KAU	THOLEIITE / BASALT				28	295	330	36.1	76.8	61.2	62.7
RANO KAU	BASALT, ALKALINE / BASALT	6.3			26.2293838	284.0561	111.33782	32.2332368	66.525183	41.251888	95.2376901
RANO KAU	DOLERITE										
RANO KAU	DACITE										
RANO KAU	NOT GIVEN										
RANO KAU	BASALT										

RANO KAU WEST SIDE	HAWAIITE								26	69	151
RANO OROI	BENMOREITE								1	19	168
RANO RARAKU	HAWAIITE								33	57	114
RANO RARAKU	BASALT, ANDESITIC										
RANO RARAKU	BASALT										
RANO RARAKU	BASALT, ANDESITIC										
RANO RARAKU	BASALT			25	40	350	21	41	40	100	
RANO RARAKU	BASALT			37			11		90	12	
RANO RARAKU	BASALT										
RANO RARAKU	BASALT										
RANO RARAKU	BASALT										
RANO RARAKU	BASALT, PLAGIOCLASE-OLIVINE-CLINOPYROXENE				37	300	39	32	7		
RANO RARAKU	BASALT				29	75	25	19	3		
RANO RARAKU	NOT GIVEN				1.5	8	17	2			
ROIHO	BASALT, TRANSITIONAL				27.9	294	209	48.3	139	49.9	99.8
ROIHO	BASALT, TRANSITIONAL				22	306	156	37.4	105	33.2	84.7
ROIHO, SOUTH-WEST SIDE	HAWAIITE, OLIVINE								127	55	91
RUNA AVAE	BASALT			25	30	300	130	30	40	95	
RUNA AVAE	BASALT			17	40	400	85	35	35	30	
RUNA AVAE	BASALT, ANDESITIC			20	25	140		20	30	60	
SOUTH OF TE MIRO O‘ONE	ANDESITE, BASALTIC				28	67	29	13	5		
TE MANAVAI	TRACHYTE, QUARTZ				9.4	10	30	3			
TE MANAVAI	NOT GIVEN				0.3	8	37	4			
TEREVAKA	BASALT										
TEREVAKA	BASALT										
TEREVAKA	BASALT/ MUGEARITE										
TEREVAKA	BASALT										
TEREVAKA	BASALT										
TEREVAKA	BASALT										

TEREVAKA	BASALT										
TEREVAKA	BASALT										
TEREVAKA	BASALT										
TEREVAKA	BASALT										
TEREVAKA	BASALT										
TEREVAKA	BASALT, PLAGIOCLASE-OLIVINE-CLINOPYROXENE				39	315	42	34	4		
VAI O HAO	BASALT				42	241	28	37	4		
VAITEA	THOLEIITE								37	51	126

LOCATION	**ROCK NAME/OTHER ID**	**Rb ppm**	**Sr ppm**	**Y ppm**	**Zr ppm**	**Nb ppm**	**Cs ppm**	**Ba ppm**	**La ppm**	**Ce ppm**	**Pr ppm**
ANA KAI TANGATA	BENMOREITE	28.3	209	85.2	672	64.1	0.325	265	49.6	127	15.4
ANA KAI TANGATA	BENMOREITE	33	250	91	704	64		164			
ANAKENA	BASALT, TRANSITIONAL	10.8	266	51.9	374	39.6	0.11	151	28.2	73.4	8.85
ANAKENA	BASALT, TRANSITIONAL										
ANAKENA	BASALT										
ANAKENA	DOLERITE	7	430	15	154	15		131	13	31	
ANAKENA	BASALT	6	390	80	580	52		290	63	128	
BETWEEN HANGA PIKO AND HANGA ROA	BASALT	13	336					197	56	97	
BETWEEN MAUNGA PUI AND VAITEA	THOLEIITE	1	226	57	361	40		164			
BETWEEN RANO RARAKU AND TOA TOA	HAWAIITE	8	254	52	326	40		187			
COAST NORTH OF RANO AROI	BASALT, OLIVINE										
HANGA HO‘ONU	BASALT										
HANGA HO‘ONU	BASALT										
HANGA NUI	BASALT										
HANGA PIKO	BASALT	5	395	65	550	45		250	48	90	

HANGA PIKO	BASALT	11	369	75	500	60		245	54	105	
HANGA TETENGA	MUGEARITE	30	288	87	522	55		215			
HIVA HIVA FLOW	BASALT, OLIVINE	9	385	53	400	40		190	36	72	
HOTU ITI	BASALT, TRANSITIONAL										
HOTU ITI	BASALT	16	365	70	500	55		250	50	103	
MATAVERI	ANDESITE										
MATAVERI	DACITE, ANDESITIC										
MAUNGA ORITO	NOT GIVEN										
MAUNGA ORITO	NOT GIVEN										
MAUNGA ORITO	NOT GIVEN										
MAUNGA ORITO	RHYOLITE										
MAUNGA ORITO	BASALT			75	300			200	65	70	
MAUNGA ORITO	BASALT			55	300			195	50	70	
MAUNGA ORITO	TRACHYTE			50	875			425	30		
MAUNGA ORITO	RHYOLITE			127	750			500	90		
MAUNGA ORITO	BASALT, TRANSITIONAL	62	22.8	122	638	94.1	0.676	378	82.6	181	21.2
MAUNGA OTU	BASALT, ANDESITIC			90	550			400	75	129	
MAUNGA PAREHE	TRACHYTE	85.4	57	59.4	1355	130	0.165	492	71.3	163	21.4
MAUNGA PAREHE DOME	TRACHYTE	107	51	57	1261	150		368			
MAUNGA PAREHE	TRACHYTE			55	1025			600	35		
MAUNGA TE PUHA, OVAHE	HAWAIITE	22.9	231	76	555	48.5	0.24	198	40.5	113.3	13.3
MAUNGA TEA TEA	TRACHYTE			50	975			550	32		
MAUNGA VEA HEVA	TRACHYTE			95	900			525	132		
MOTU ITI	COMENDITE	76	46	160	861	118		294			
MOTU NUI	RHYOLITE										
MOTU NUI	RHYOLITE										
ORITO	NOT GIVEN										
ORITO	RHYOLITE										
ORITO	BASALT	3	350	36	330	32		150	25	50	
PAPA TEKENA	MUGEARITE	14	270	54	361	39		201			
POIKE	BASALT, TRANSITIONAL	8.31	259	36.1	211	25.7	0.1	108	17.7	41.6	5.43

POIKE	BASALT, TRANSITIONAL										
POIKE	RHYOLITE										
POIKE	BASALT										
POIKE	BASALT										
POIKE	BASALT										
POIKE	BASALT										
POIKE	BASALT										
POIKE	BASALT										
POIKE	BASALT										
POIKE	BASALT, TRANSITIONAL										
POIKE	BASALT, TRANSITIONAL										
POIKE	BASALT										
POIKE	BASALT										
POIKE	BASALT										
POIKE EAST OF HANGA NUI	HAWAIITE, OLIVINE	4	300	32	195	22		140			
RANO KAU	BENMOREITE	54	154	84	831	83		286			
RANO KAU	BASALT, ANDESITIC			110	675			450	82		
RANO KAU	RHYOLITE			135	800			550	80		
RANO KAU	BASALT										
RANO KAU	BASALT										
RANO KAU	BASALT										
RANO KAU	BASALT										
RANO KAU	BASALT, TRANSITIONAL										
RANO KAU	BASALT, TRANSITIONAL	1.91	275	39	219	27.3	0.019	106	17.8	42.9	5.77
RANO KAU	BASALT, TRANSITIONAL										
RANO KAU	BASALT, TRANSITIONAL	0.55	264	35.2	191	22.4		90.1	17.6	41.5	5.37
RANO KAU	BASALT, TRANSITIONAL	3.85	254	20.4	94.3	8	0.05	32.2	6.18	16.3	2.42
RANO KAU	BASALT, TRANSITIONAL										
RANO KAU	THOLEIITE / BASALT										
RANO KAU	THOLEIITE / BASALT	2.58	205	23	119	9.94	0.03	35.1	7.15	20.5	2.83

RANO KAU	BASALT, ALKALINE / BASALT	16.5353817	345.051283	33.68879	240.150522	38.080547	0.18498454	161.855859	26.533013	59.980033	7.45774481
RANO KAU	DOLERITE										
RANO KAU	DACITE										
RANO KAU	NOT GIVEN										
RANO KAU	BASALT										
RANO KAU WEST SIDE	HAWAIITE	3	196	49	322	36		186			
RANO OROI	BENMOREITE	43	198	111	792	77		310			
RANO RARAKU	HAWAIITE	9	298	41	252	30		152			
RANO RARAKU	BASALT, ANDESITIC										
RANO RARAKU	BASALT										
RANO RARAKU	BASALT, ANDESITIC										
RANO RARAKU	BASALT			42	250			162	45	46	
RANO RARAKU	BASALT			40	925			525	65		
RANO RARAKU	BASALT										
RANO RARAKU	BASALT										
RANO RARAKU	BASALT										
RANO RARAKU	BASALT, PLAGIOCLASE-OLIVINE-CLINOPYROXENE	6	400	36	320	47		230	26	55	
RANO RARAKU	BASALT	12	310	68	455	48		257	45	82	
RANO RARAKU	NOT GIVEN	77	31	130	995	115		424	92	200	
ROIHO	BASALT, TRANSITIONAL	5.54	318	37.1	191	26.9	0.03	119	21.6	45.5	6.09
ROIHO	BASALT, TRANSITIONAL	3.66	300	39	272	37.3	0.03	148	29.4	72.6	8.57
ROIHO, SOUTH-WEST SIDE	HAWAIITE, OLIVINE	9	347	32	213	26		179			
RUNA AVAE	BASALT			35	200			155	25	47	
RUNA AVAE	BASALT			55	250			195	35	62	
RUNA AVAE	BASALT, ANDESITIC			90	425			325	67		
SOUTH OF TE MIRO O‘ONE	ANDESITE, BASALTIC	20	350	100	550	60		290	61	122	
TE MANAVAI	TRACHYTE, QUARTZ	83	28	90	1250	155		436	62	125	

TE MANAVAI	NOT GIVEN	85	30	140	985	113		475	74	165	
TEREVAKA	BASALT										
TEREVAKA	BASALT										
TEREVAKA	BASALT/ MUGEARITE										
TEREVAKA	BASALT										
TEREVAKA	BASALT										
TEREVAKA	BASALT										
TEREVAKA	BASALT										
TEREVAKA	BASALT										
TEREVAKA	BASALT										
TEREVAKA	BASALT										
TEREVAKA	BASALT										
TEREVAKA	BASALT, PLAGIOCLASE-OLIVINE-CLINOPYROXENE	4	360	35	330	45		175	24	53	
VAI O HAO	BASALT	10	360	40	330	30		175	23	55	
VAITEA	THOLEIITE	1	221	52	293	38		143			

LOCATION	ROCK NAME/OTHER ID	Nd ppm	Sm ppm	Eu ppm	Gd ppm	Tb ppm	Dy ppm	Ho ppm	Er ppm
ANA KAI TANGATA	BENMOREITE	64.8	15.5	4.81	16.4	2.55	14.9	2.78	8.53
ANA KAI TANGATA	BENMOREITE								
ANAKENA	BASALT, TRANSITIONAL	37.6	9.21	2.85	9.97	1.51	8.82	1.64	4.94
ANAKENA	BASALT, TRANSITIONAL								
ANAKENA	BASALT								
ANAKENA	DOLERITE	17	4.9	1.95	6.1	1	5.7		
ANAKENA	BASALT	84	22	7.3	22	3.5	19		
BETWEEN HANGA PIKO AND HANGA ROA	BASALT	62	18	6.4	17	2.9	18		
BETWEEN MAUNGA PUI AND VAITEA	THOLEIITE								
BETWEEN RANO RARAKU AND TOA TOA	HAWAIITE								

COAST NORTH OF RANO AROI	BASALT, OLIVINE								
HANGA HO‘ONU	BASALT								
HANGA HO‘ONU	BASALT								
HANGA NUI	BASALT								
HANGA PIKO	BASALT	53	13.1	4.05	13	2.16	14		
HANGA PIKO	BASALT	70	18.7	7.2	19	3.2			
HANGA TETENGA	MUGEARITE								
HIVA HIVA FLOW	BASALT, OLIVINE	48	14	4.6	15	2.3	14		
HOTU ITI	BASALT, TRANSITIONAL								
HOTU ITI	BASALT	60	15.4	5.5	16	2.85	17		
MATAVERI	ANDESITE								
MATAVERI	DACITE, ANDESITIC								
MAUNGA ORITO	NOT GIVEN								
MAUNGA ORITO	NOT GIVEN								
MAUNGA ORITO	NOT GIVEN								
MAUNGA ORITO	RHYOLITE								
MAUNGA ORITO	BASALT	46	11.3	3.7		2.1			
MAUNGA ORITO	BASALT	41	10.8	3.4		1.9			
MAUNGA ORITO	TRACHYTE								
MAUNGA ORITO	RHYOLITE								
MAUNGA ORITO	BASALT, TRANSITIONAL	84.8	20.9	3.19	21.1	3.66	22.8	4.57	13.5
MAUNGA OTU	BASALT, ANDESITIC	90	25	7		4			
MAUNGA PAREHE	TRACHYTE	85.5	21.6	5.85	22	3.93	25.5	5.3	16.9
MAUNGA PAREHE DOME	TRACHYTE								
MAUNGA PAREHE	TRACHYTE								
MAUNGA TE PUHA, OVAHE	HAWAIITE	57.8	14.1	4.14	15	2.25	13	2.38	7.05
MAUNGA TEA TEA	TRACHYTE								
MAUNGA VEA HEVA	TRACHYTE								
MOTU ITI	COMENDITE								
MOTU NUI	RHYOLITE								
MOTU NUI	RHYOLITE								

ORITO	NOT GIVEN								
ORITO	RHYOLITE								
ORITO	BASALT	31	9.5	3.1	10	1.8	10.5		
PAPA TEKENA	MUGEARITE								
POIKE	BASALT, TRANSITIONAL	25.4	6.58	2.22	7.28	1.13	6.8	1.29	3.73
POIKE	BASALT, TRANSITIONAL								
POIKE	RHYOLITE								
POIKE	BASALT	29.7	7.1						
POIKE	BASALT	26.7	6.8						
POIKE	BASALT								
POIKE	BASALT								
POIKE	BASALT								
POIKE	BASALT								
POIKE	BASALT								
POIKE	BASALT, TRANSITIONAL								
POIKE	BASALT, TRANSITIONAL								
POIKE	BASALT								
POIKE	BASALT								
POIKE	BASALT								
POIKE EAST OF HANGA NUI	HAWAIITE, OLIVINE								
RANO KAU	BENMOREITE								
RANO KAU	BASALT, ANDESITIC								
RANO KAU	RHYOLITE								
RANO KAU	BASALT	17.5	4.5						
RANO KAU	BASALT	30.1	7.7						
RANO KAU	BASALT								
RANO KAU	BASALT								
RANO KAU	BASALT, TRANSITIONAL								
RANO KAU	BASALT, TRANSITIONAL	25.8	6.72	2.28	7.27	1.14	6.71	1.29	3.55
RANO KAU	BASALT, TRANSITIONAL								
RANO KAU	BASALT, TRANSITIONAL	24.6	6.75	2.25	7.14	1.15	7.12	1.35	3.83

RANO KAU	BASALT, TRANSITIONAL	11.5	3.28	1.22	3.58	0.5	3.57	0.72	2
RANO KAU	BASALT, TRANSITIONAL								
RANO KAU	THOLEIITE / BASALT								
RANO KAU	THOLEIITE / BASALT	13.3	3.77	1.36	4.38	0.7	4.24	0.79	2.36
RANO KAU	BASALT, ALKALINE / BASALT	31.948935	7.28049322	2.37407967	7.36942011	1.13972376	6.71172356	1.285933606	3.38313731
RANO KAU	DOLERITE								
RANO KAU	DACITE								
RANO KAU	NOT GIVEN								
RANO KAU	BASALT								
RANO KAU WEST SIDE	HAWAIITE								
RANO OROI	BENMOREITE								
RANO RARAKU	HAWAIITE								
RANO RARAKU	BASALT, ANDESITIC								
RANO RARAKU	BASALT								
RANO RARAKU	BASALT, ANDESITIC								
RANO RARAKU	BASALT	26	8	2.4		1.3			
RANO RARAKU	BASALT								
RANO RARAKU	BASALT								
RANO RARAKU	BASALT								
RANO RARAKU	BASALT								
RANO RARAKU	BASALT, PLAGIOCLASE-OLIVINE-CLINOPYROXENE	32	7.7	2.6	9	1.45			
RANO RARAKU	BASALT	58	15	4.7	15	2.45	14		
RANO RARAKU	NOT GIVEN	118	25	5.5	18	3			
ROIHO	BASALT, TRANSITIONAL	26.8	6.34	2.13	6.73	1.01	5.92	1.16	3.21
ROIHO	BASALT, TRANSITIONAL	35.5	8.17	2.59	8.55	1.25	7.07	1.29	3.7
ROIHO, SOUTH-WEST SIDE	HAWAIITE, OLIVINE								
RUNA AVAE	BASALT	25	7.1	2.2		1.2			
RUNA AVAE	BASALT	40	11.7	3.2		2			
RUNA AVAE	BASALT, ANDESITIC								
SOUTH OF TE MIRO O‘ONE	ANDESITE, BASALTIC	75	21.6	7.5	22	3.8	21		
TE MANAVAI	TRACHYTE, QUARTZ	66	17	4.1	13	2.3			

TE MANAVAI	NOT GIVEN	71	17.7	4.75	12	1.65			
TEREVAKA	BASALT	29	7.3						
TEREVAKA	BASALT	34.4	8						
TEREVAKA	BASALT/ MUGEARITE	46.2	8.1						
TEREVAKA	BASALT								
TEREVAKA	BASALT								
TEREVAKA	BASALT								
TEREVAKA	BASALT								
TEREVAKA	BASALT								
TEREVAKA	BASALT								
TEREVAKA	BASALT								
TEREVAKA	BASALT								
TEREVAKA	BASALT, PLAGIOCLASE-OLIVINE-CLINOPYROXENE	33	9	3	8	1.4			
VAI O HAO	BASALT	34	9	3	10	1.7			
VAITEA	THOLEIITE								

LOCATION	**ROCK NAME/OTHER ID**	**Tm ppm**	**Yb ppm**	**Lu ppm**	**Hf ppm**	**Ta ppm**	**Pb ppm**	**Th ppm**	**U ppm**	**CITATIONS**
ANA KAI TANGATA	BENMOREITE	1.15	7.73	1.07	14	3.89	2.85	5.6	1.9	Haase et al. (1997)
ANA KAI TANGATA	BENMOREITE									Baker et al. (1974)
ANAKENA	BASALT, TRANSITIONAL	0.65	4.22	0.59	7.05	2.47	1.65	3.16	0.92	Haase et al. (1997)
ANAKENA	BASALT, TRANSITIONAL									Haase et al. (1997)
ANAKENA	BASALT									LaCroix (1936)
ANAKENA	DOLERITE	0.4	2.3	0.33	5	1.4		1.8	0.6	Puzankov and Bobrov (1997)
ANAKENA	BASALT		8.4	1.3	14	3.5		3.6	1.3	Puzankov and Bobrov (1997)

BETWEEN HANGA PIKO AND HANGA ROA	BASALT	1.4	8	1.13	11.2	3.2		4.5	1.7	Puzankov and Bobrov (1997)
BETWEEN MAUNGA PUI AND VAITEA	THOLEIITE									Baker et al. (1974)
BETWEEN RANO RARAKU AND TOA TOA	HAWAIITE									Baker et al. (1974)
COAST NORTH OF RANO AROI	BASALT, OLIVINE									Bandy (1937)
HANGA HO‘ONU	BASALT									LaCroix (1936)
HANGA HO‘ONU	BASALT									LaCroix (1936)
HANGA NUI	BASALT									LaCroix (1936)
HANGA PIKO	BASALT	1.17	7.2	1.08	13.5	4.1		4.2	1.2	Puzankov and Bobrov (1997)
HANGA PIKO	BASALT		9	1.3	12	3.4		3.6	1.6	Puzankov and Bobrov (1997)
HANGA TETENGA	MUGEARITE									Baker et al. (1974)
HIVA HIVA FLOW	BASALT, OLIVINE		6.3	0.95	8.2	2.6		3.2	1.2	Puzankov and Bobrov (1997)
HOTU ITI	BASALT, TRANSITIONAL									Haase et al. (1997)
HOTU ITI	BASALT	1.5	8.5	1.2	12.5	3		3.1	1.4	Puzankov and Bobrov (1997)
MATAVERI	ANDESITE									Bandy (1937)
MATAVERI	DACITE, ANDESITIC									LaCroix (1936)
MAUNGA ORITO	NOT GIVEN									Bandy (1937)
MAUNGA ORITO	NOT GIVEN									Bandy (1937)
MAUNGA ORITO	NOT GIVEN									Bandy (1937)
MAUNGA ORITO	RHYOLITE									Bandy (1937)

MAUNGA ORITO	BASALT		5.3	0.66						Bonatt et al. (1977)
MAUNGA ORITO	BASALT		5.1	0.61						Bonatt et al. (1977)
MAUNGA ORITO	TRACHYTE									Bonatt et al. (1977)
MAUNGA ORITO	RHYOLITE									Bonatt et al. (1977)
MAUNGA ORITO	BASALT, TRANSITIONAL	1.88	12.5	1.74	21.8	6.31	6.56	11.4	3.27	Haase et al. (1997)
MAUNGA OTU	BASALT, ANDESITIC		8.8	1.2						Bonatt et al. (1977)
MAUNGA PAREHE	TRACHYTE	2.8	21.1	3.15	29.3	7.35	5.95	15.4	3.52	Haase et al. (1997)
MAUNGA PAREHE DOME	TRACHYTE									Baker et al. (1974)
MAUNGA PAREHE	TRACHYTE									Bonatt et al. (1977)
MAUNGA TE PUHA, OVAHE	HAWAIITE	0.91	5.9	0.81	9.34	2.92	2.15	3.95	1.27	Haase et al. (1997)
MAUNGA TEA TEA	TRACHYTE									Bonatt et al. (1977)
MAUNGA VEA HEVA	TRACHYTE									Bonatt et al. (1977)
MOTU ITI	COMENDITE									Baker et al. (1974)
MOTU NUI	RHYOLITE									LaCroix (1936)
MOTU NUI	RHYOLITE									LaCroix (1936)
ORITO	NOT GIVEN									LaCroix (1936)
ORITO	RHYOLITE									LaCroix (1936)
ORITO	BASALT		4.6	0.7	7.5	2		2.5	0.9	Puzankov and Bobrov (1997)
PAPA TEKENA	MUGEARITE									Baker et al. (1974)

POIKE	BASALT, TRANSITIONAL	0.5	3.21	0.47	5.33	1.73	1.08	1.69	0.47	Haase et al. (1997)
POIKE	BASALT, TRANSITIONAL									Haase et al. (1997)
POIKE	RHYOLITE									LaCroix (1936)
POIKE	BASALT						1.03			Cheng and MacDougall (1999)
POIKE	BASALT									Cheng and MacDougall (1999)
POIKE	BASALT									Clark and Dymond (1977)
POIKE	BASALT									Clark and Dymond (1977)
POIKE	BASALT									Clark and Dymond (1977)
POIKE	BASALT									Clark and Dymond (1977)
POIKE	BASALT									Clark and Dymond (1977)
POIKE	BASALT, TRANSITIONAL									Haase et al. (1997)
POIKE	BASALT, TRANSITIONAL									Haase et al. (1997)
POIKE	BASALT									White and Hofmann (1982)
POIKE	BASALT									White and Hofmann (1982)
POIKE	BASALT									White and Hofmann (1982)
POIKE EAST OF HANGA NUI	HAWAIITE, OLIVINE									Baker et al. (1974)

RANO KAU	BENMOREITE									Baker et al. (1974)
RANO KAU	BASALT, ANDESITIC									Bonatt et al. (1977)
RANO KAU	RHYOLITE									Bonatt et al. (1977)
RANO KAU	BASALT						0.91			Cheng and MacDougall (1999)
RANO KAU	BASALT									Cheng and MacDougall (1999)
RANO KAU	BASALT									Clark and Dymond (1977)
RANO KAU	BASALT									Clark and Dymond (1977)
RANO KAU	BASALT, TRANSITIONAL									Haase et al. (1997)
RANO KAU	BASALT, TRANSITIONAL	0.49	3.14	0.43	5.19	1.58	1.16	1.46	0.26	Haase et al. (1997)
RANO KAU	BASALT, TRANSITIONAL									Haase et al. (1997)
RANO KAU	BASALT, TRANSITIONAL	0.51	3.13	0.48	5.25	1.57	1.09	1.8	0.24	Haase et al. (1997)
RANO KAU	BASALT, TRANSITIONAL	0.28	1.69	0.25	2.23	0.54	0.44	0.42	0.18	Haase et al. (1997)
RANO KAU	BASALT, TRANSITIONAL									Haase et al. (1997)
RANO KAU	THOLEIITE / BASALT									Haase et al. (1997)
RANO KAU	THOLEIITE / BASALT	0.31	1.96	0.27	2.65	0.69	0.68	0.6	0.23	Haase et al. (1997)
RANO KAU	BASALT, ALKALINE / BASALT	0.47655362	3.053214	0.444976	5.72121513	2.331159	1.39574482	2.87648471	0.83125	Haase et al. (1997)
RANO KAU	DOLERITE									LaCroix (1936)

RANO KAU	DACITE									LaCroix (1936)
RANO KAU	NOT GIVEN									LaCroix (1936)
RANO KAU	BASALT									White and Hofmann (1982)
RANO KAU WEST SIDE	HAWAIITE									Baker et al. (1974)
RANO OROI	BENMOREITE									Baker et al. (1974)
RANO RARAKU	HAWAIITE									Baker et al. (1974)
RANO RARAKU	BASALT, ANDESITIC									Bandy (1937)
RANO RARAKU	BASALT									Bandy (1937)
RANO RARAKU	BASALT, ANDESITIC									Bandy (1937)
RANO RARAKU	BASALT		3.9	0.41						Bonatt et al. (1977)
RANO RARAKU	BASALT									Bonatt et al. (1977)
RANO RARAKU	BASALT									LaCroix (1936)
RANO RARAKU	BASALT									LaCroix (1936)
RANO RARAKU	BASALT									LaCroix (1936)
RANO RARAKU	BASALT, PLAGIOCLASE-OLIVINE-CLINOPYROXENE	0.68	4.3	0.62	12	3		2.6	1	Puzankov and Bobrov (1997)
RANO RARAKU	BASALT		7	1.05	8	2.6		3.2	1.1	Puzankov and Bobrov (1997)
RANO RARAKU	NOT GIVEN	2.3	16	2.4	34	7.6		9.7	3.2	Puzankov and Bobrov (1997)
ROIHO	BASALT, TRANSITIONAL	0.42	2.76	0.38	4.57	1.62	1.16	1.5	0.56	Haase et al. (1997)

ROIHO	BASALT, TRANSITIONAL	0.48	3.13	0.43	5.44	2.34	1.38	2.9	0.85	Haase et al. (1997)
ROIHO, SOUTH-WEST SIDE	HAWAIITE, OLIVINE									Baker et al. (1974)
RUNA AVAE	BASALT		3	0.47						Bonatt et al. (1977)
RUNA AVAE	BASALT		5	0.67						Bonatt et al. (1977)
RUNA AVAE	BASALT, ANDESITIC									Bonatt et al. (1977)
SOUTH OF TE MIRO O‘ONE	ANDESITE, BASALTIC	1.6	10	1.45	12	3.3		4.6	1.6	Puzankov and Bobrov (1997)
TE MANAVAI	TRACHYTE, QUARTZ	1.6	11	1.8	28	6.9		7.9	2.8	Puzankov and Bobrov (1997)
TE MANAVAI	NOT GIVEN	1.1	7.8	1.25	32	6.6		10.2	3.8	Puzankov and Bobrov (1997)
TEREVAKA	BASALT						1.47			Cheng and MacDougall (1999)
TEREVAKA	BASALT									Cheng and MacDougall (1999)
TEREVAKA	BASALT/ MUGEARITE						2.67			Cheng and MacDougall (1999)
TEREVAKA	BASALT									Clark and Dymond (1977)
TEREVAKA	BASALT									Clark and Dymond (1977)
TEREVAKA	BASALT									Clark and Dymond (1977)
TEREVAKA	BASALT									Clark and Dymond (1977)
TEREVAKA	BASALT									Clark and Dymond (1977)

TEREVAKA	BASALT									Clark and Dymond (1977)
TEREVAKA	BASALT									Clark and Dymond (1977)
TEREVAKA	BASALT									White and Hofmann (1982)
TEREVAKA	BASALT, PLAGIOCLASE-OLIVINE-CLINOPYROXENE		4.2	0.6	7	2.2		2.3	0.67	Puzankov and Bobrov (1997)
VAI O HAO	BASALT		5	0.75	6	1.9		3	1.5	Puzankov and Bobrov (1997)
VAITEA	THOLEIITE									Baker et al. (1974)

APPENDIX B

Database of all RNGP archaeological sites under study (n=84)

RNGP #	Name*	Site Type	GPS–S	GPS–W	Open/Cave Site	Alt. (m)	Max length (m)	2nd max length (m)	Cave Height (m)
1	Rua Tokitoki	Source, quarry, and workshops	27'05.273S	109'18.860W	Open	89	24	15	
6	Ava o‘Kiri (south) 1	Workshop and a possible quarry	27'05.729S	109'19.338W	Open	125	2.5	1.5	
7	Pu Tokitoki 1 (S&H 45)	Quarry, workshop	27'05.712S	109'18.526W	Open	75	32	25	
8	Pu Tokitoki 2	Workshop and a possible quarry	27'05.650S	109'18.600W	Open	89	6	5	
9	Pu Tokitoki 3 (S&H 405)	Quarry, workshop	27'05.588S	109'18.632W	Open	80	30	22	
11	Southwest coast 1 a,b	Quarries, workshop	27'09.997S	109'22.885W	Cave	20	11	3	1.3
12	Southwest coast 2	Quarry, workshop	27'10.015S	109'22.838W	Cave	17	8.5	7	2.7
13	Southwest coast 3	Quarry, workshop	27'10.011S	109'22.918W	Cave	14	8.5	8	1.5

14	Southwest coast 4	Quarry, workshop	27'10.021S	109'22.931W	Open, cave	20	21	6	4
15	Southwest coast 5	Quarry	27'10.029S	109'22.972W	Open	35–27	6	3	2.5
16	Southwest coast 6	Quarry, workshop	27'10.034S	109.22.936W	Open, cave	15–13	11.8	3.5	200
17	Southwest coast 7	Quarry, workshop	27'10.037S	109'22.939W	Cave	18	8.5	4.5	1.6
18	Southwest coast 8	Quarry	27'11.354S	109'25.424W	Open	317	5	3	
19	Vai Atare 1	Source	27'11.361S	109'25.422W	Open	319	4	2	
20	Vai Atare 3	Source	27'11.365S	109'25.425W	Open	325	3.1	2.5	
21	Vai Atare 4	Quarry, workshops	27'11.373S	109'25.433W	Open	321	4.5	3.5	
22	Vai Atare 5	Quarry	27'11.404S	109'25.442W	Open	328	12	7	
23	Vai Atare 6	Source	27'11.385S	109'25.459W	Open	324	10	3	
24	Vai Atare 7	Quarry	27'11.399S	109'25.471W	Open	311	14	4	
25	Rano Kau 1	Quarry	27'11.533S	109'25.898W	Open	308–285	4	3	

26	Ava o‘Kiri (north) 1	Quarry	27'05.225S	109'18.973W	Open	69	21	4	
27	Ava o‘Kiri (north) 2	Quarry	27'05.189S	109' 18.957W	Open	72	12	3	
28	Ava o‘Kiri (north) 3	Quarry	27'05.182S	109'18.956W	Open	64	12	3.5	
29	Ava o‘Kiri (north) 4	Quarry, workshop	27'05.160S	109'18.977W	Open	69	35	8	
30	Pu Tokitoki 5	Quarry, workshop	27'05.437S	109'18.398W	Open	59	43	15	
31	Pu Tokitoki 6	Quarry, workshop	27.05.419S	109'18.343W	Open	49	10	10	
32	Pu Tokitoki 7 (S&H 92)	Quarry, workshop	27'05.352S	109'18.271W	Open	36	29	21	
33	Pu Tokitoki 8 (S&H 118)	Quarry, workshop	27'05.337S	109'18.456W	Open	41	25	20	
34	Pu Tokitoki 9 (S&H 99)	Quarry, workshop	27'05.356S	109'18.392W	Open	55	30	8	
35	Pu Tokitoki 10 (S&H 97a)	Quarry, workshop	27'05.360S	109'18.412W	Open	54	14	13	
36	Pu Tokitoki 11 (S&H 120a)	Quarry, workshop	27'05.376S	109'18.460W	Open	63	15	4	

37	Pu Tokitoki 12 (S& H 447d)	Quarry, workshop	27'05.426S	109'18.484W	Open	66	20	6	
38	Pu Tokitoki 13 (S&H 741c)	Quarry, workshop	27'05.113S	109'18.646W	Open	66	22	10	
39	Pu Tokitoki 14 (S&H 720)	Workshop and a possible quarry	27'05.128S	109'18.526W	Open	51	13	6	
40	Pu Tokitoki 15 (S&H 705)	Quarry, workshop	27'05.169S	109.18.548W	Open	58	8	4	
41	Pu Tokitoki 16 (S&H 747a)	Quarry, workshop	27'05.161S	109'18.667W	Open	61	15	11	
42	Pu Tokitoki 17 (S&H 752ab)	Quarry, workshop	27'05.257S	109'18.683W	Open	69	20	14	
43	Pu Tokitoki 18 (S&H 425d)	Quarry, workshop	27'05.280S	109'18.733W	Open	77	15	13	
44	Pu Tokitoki 19 (S&H 453)	Workshop and a possible quarry	27'05.317S	109'18.602W	Open	87	5.5	2.2	
45	Pu Tokitoki 20 (S&H 438)	Quarry, workshop	27'05.353S	109'18.612W	Open	89	18	10	
46	Pu Tokitoki 21 (S&H 437)	Quarry, workshop	27'05.365S	109'18.630W	Open	49	11	10	

47	Pu Tokitoki 22 (S&H 452)	Quarry, workshop	27'05.387S	109'18.610W	Open	88	7	4	
48	Pu Tokitoki 35 (S&H 440ab)	Quarry, workshop	27'05.439S	109'18.587W	Open	71	5	2	
49	Pu Tokitoki 23 (S&H 441)	Quarry, workshop	27'05.475S	109'18.576W	Open	68	24	17.5	
50	Pu Tokitoki 24 (S&H 333)	Quarry, workshop	27'05.522S	109'18.527W	Open	73	24	15	
51	Pu Tokitoki 25 (S&H ?)	Quarry, workshop	27'05.629S	109'18.629W	Open	70	12	5.5	
52	Pu Tokitoki 26 (S&H 381abc)	Quarry, workshop	27'05.458S	109'18.690W	Open	66	33	20	
53	Pu Tokitoki 27 (S&H 371)	Workshop	27'05.416S	109'18.650W	Open	80	5	3	
54	Pu Tokitoki 28 (S&H 379 ab)	Quarry, workshop	27'05.415S	109'18.760W		84	18	11	
55	Ava o'Kiri (south) 2	Quarry, workshop	27'05.856S	109'19.366W	Open	132	4	4	
56	Ava o'Kiri (south) 3	Quarry, workshop	27'05.900S	109'19.311W	Open	127	2.5	2	
57	Ava o'Kiri (south) 4	Quarry, workshop	27'05.799S	109'19.305W	Open	122	35	12	

58	Pu Tokitoki 29 (S&H 335f)	Workshop	27'05.588S	109'18.555W	Open	79	3	2	
59	Pu Tokitoki 30 (S&H 330)	Quarry, workshop	27'05.508S	109'05.470W	Open	71	6	5.5	
60	Pu Tokitoki 31 (S&H 339)	Quarry, workshop	27'05.518S	109'18.452W	Open	74	7.5	3.5	
61	Pu Tokitoki 32 (S&H 321a)	Quarry, workshop	27'05.490S	109'18.436W	Open	78	6	3	
62	Pu Tokitoki 33 (S&H 321b)	Quarry, workshop	27'05.504S	109'18.428W	Open	62	4	2.8	
63	Pu Tokitoki 34 (S&H 318a)	Quarry, workshop	27'05.490S	109'18.370W	Open	54	12	8.5	
64	Pu Tokitoki 35 (S&H? 435c)	Quarry, workshop	27'05.266S	109'18.739W	Open	73	20	10	
65	Pu Tokitoki 36 (S&H 4–450a)	Workshop	27'05.620S	109'18.489W	Open	73	20	12	
66	Pu Tokitoki 37 (S&H 317)	Quarry, workshop	27'05.519S	109'18.329W	Open	61	10	5	
67	Pu Tokitoki 38 (S&H?)	Quarry, workshop	27'05.779S	109'18.370W	Open	56	11	5.5	
68	Pu Tokitoki 39 (S&H 346)	Quarry, workshop	27'05.670S	109'18.431W	Open	71	35	20	

69	Pu Tokitoki 40 (S&H 363ab?)	Quarry, workshop	27'05.653S	109'18.382W	Open	62	13	12	
70	Pu Tokitoki 41 (S&H 349)	Quarry, workshop	27'05.620S	109'18.472W	Open	87	10	6	
71	Pu Tokitoki 42 (S&H353)	Quarry, workshop	27'05.588S	109'18.493W	Open	70	10	8	
73	Poike 1	Source	27'05.652S	109'14.873W	Cliff	150–145	2	1.5	
75	Vai Atare 8	Workshop	27'11.333S	109'25.496W	Open	340	3	1	
76	Vai Atare 9	Quarry, workshop	27'11.320S	109'25.419W	Open	326	4	3.5	
77	Vai Atare 10	Quarry, workshop	27'11.312S	109'25.432W	Open	331	7	3	
78	Vai Atare 11	Quarry, workshop	27'11.416S	109'25.466W	Open	330–342	10	4.5	
79	Southwest coast 9	Quarry, workshop	27'10.154S	109'22.634W	Open	60	3.5	2.5	
80	Southwest coast 10	Quarry, workshop	27'10.050S	109'22.922W	Open, cave	48	15	3	2
81	Southwest coast 11	Quarry, workshop	27'10.052S	109'22.921W	Open, cave	40	8	5	4

82	Southwest coast 12	Quarry, workshop	27'10.065S	109'22.957W	Cave	26	1	1	50cm
83	Southwest coast 13	Quarry, workshop	27'10.053S	109'22.957W	Cliff	15	5	1.5	
84	Southwest coast 14	Quarry, workshop	27'10.048S	109'22.961W	Open	6	15	6	
85	Southwest coast 15	Quarry, workshop	27'10.053S	109'22.970W	Cave	5	20	2.5	.5
86	Southwest coast 16	Quarry, workshop	27'09.996S	109'22.883W	Cliff	7	4.5	1	
87	Southwest coast 17	Quarry, workshop	27'10.051S	109'22.983W	Cliff	5	3.5	1	
88	Southwest coast 18	Quarry, workshop	27'10.047S	109'22.988W	Cave	9	8	2.5	1.5
89	Southwest coast 19	Quarry, workshop	27'10.044S	109'22.989W	Cave	11	11	3	2.5
90	Southwest coast 20	Quarry, workshop	27'10.048S	109'22.996W	Cave	15	15	6	3.5
91	Southwest coast 21	Quarry, workshop	27'10.059S	109'23.016W	Cave/Cliff	13	7	7	1.5

* (S&H = Stevenson and Haoa 2008 site numbers)

RNGP #	Notes
1	Large quarry with evidence of multiple stages of basalt reduction. See Simpson et al. (2017) for a complete site report.
6	Small *puku* with evidence of debitage.
7	A basalt quarry and workshop on both sides of an exposed *puku* (outcrop). In total, there are four depressions (*pu*) filled with source boulders (20cm–>1m), removed and worked cores, flakes, blanks, and debitage. The largest *pu* is 30m by 14m and is 75cm deep. A reduction centre, measuring 10m by 12m, is found to the northwest. This area has thousands of debitage on the surface, indicating large scale fine–grain stone reduction.
8	Small protected workshop underneath a *puku*. Evidence for transported cores and debitage from unknown quarry/source.
9	A major quarry with evidence for high scale lithic production including four large *pu* depressions filled with boulders (10–50cm), hundreds to thousands of pieces of debitage, hammer stones, and a polishing stone (to the north of the site). The main pit (13m by 5m) is 1m deep and is filled with boulders of varying size (20cm–1m). On the east side of the site, there is a notable circular depression filled by stratigraphically thick layers of chipped–stone flakes. Stevenson and Haoa (2008) hypothesize that one million flakes, which present equally several tons of production, came from this site.
10	Spatially large quarry with 5 *pu* depressions with source boulders. Debitage found around site, but not concentration in one area. Chipping stone is intermixed with vesicular *pae* or undressed basalt blocks.
11	The majority of area in this cave was arguably created through the extensive extraction of tabular fine–grain *keho* stone. Every wall exhibits *keho* stone while the entire floor of the cave is covered with debitage and flakes (1–46cm). There is also extensive debitage on the trail to the west and downslope to the ocean shore. This cave and surrounding area were major sources for *keho*.
12	Large irregular shaped cave where debitage is limited to the opening of the cave consisting of small pieces (1–40cm) to the south and larger pieces to the north (5–80cm).
13	Very large mine with two main areas. The entrance to the mine has many *keho* slabs of large size (>1m) which are perfect size for construction stones. To the west of the entrance, there is an exposed shelf with different stratigraphic levels of *keho*. The western area is smaller in total area and has moderate evidence of debitage and *poro* (rounded beach stones). The eastern section is larger in total area and vaunts more evidence of *keho* reduction including flakes and cores (5–20cm). Debitage (<55cm) is found extensively around the edges of cave walls, that was presumably extended through the extraction of *keho*. This site shows intensive evidence for extensive lithic reduction and *keho* manufacture.

14	Complex quarry system with extensive evidence of *keho* extraction. There is significant change in site elevation from the highest (25m.a.s.l) to the lowest points (10m.a.s.l.). Extraction created two main reduction spaces to the east and in the main cave structure to the west. The largest areas of debitage scatter measure 4.5m from the north to south and 6m from the east to west. Flakes, cores, and debitage measure between 5–20cm. A smaller debitage area is found under an excavated hole that has very thin, but high–quality fine–grain basalt. Around this site, there is evidence for *kie'a* (mineral pigment) and *poro* stone deposits that could have functioned as hammer stones for *keho* reduction.
15	Small quarry with exposed *keho* slabs (6.6m) and a small area of debitage. Debitage are mainly small (1–40cm) and larger thin laminates of *keho*, made from a poorer quality basalt, are also present. The site located on a large outcrop above lineal deposits of *kie'a* and small boulder concentrations.
16	Small quarry within a small cave created through extraction of *keho*. There is one main debitage area in the cave and along the side of the *keho* flow with pieces measuring 5–75cm. There are many large boulders in the area made of similar *keho*, but of poorer quality closer to ocean.
17	Extensively quarried *keho* cave site. There are 40–50 large boulders (>1m) around the cave that have fallen naturally and/or have been removed from the source stratigraphy. The entrance of the cave floor and the area directly facing the ocean shore are regularly covered in debitage (1–40cm) and *keho* slabs (10–60cm). Near the opening of cave was a very worked core (<60cm) and associated debitage (<20cm), suggesting a fair amount of stone was extracted and reduced here.
18	Poor quality k*eho* source wall measuring 3m in height. There is little evidence of *keho* extraction and reduction with limited debitage found at the base or around wall.
19	Better quality *keho* with light debitage present around the base (4–10cm). The extraction point is under another flow of unconsolidated lava.
20	Extensive evidence of extraction, but little debitage (5–13cm) present. Larger boulders are found downslope to the south that may be evidence of *keho* reduction sequences.
21	Large excavated deposit of *keho* with notable debitage at wall base. Smaller pieces are 1–20cm with larger boulders measuring 50 –80cm. Site appears to be mined extensively, but there is no evidence (debitage) for portable tool making.
22	Large downhill complex of *keho* and *paenga* (dressed basalt blocks) boulders with four reduction areas. Two of these areas exhibit dense boulders (<50cm). Piled stones have evidence of extraction marks but there is little evidence of smaller debitage (>20cm). This site may be a storage site for both fine–grain and vesicular basalt boulders and cores.

23	Main boulder quarry (~50) with extensive evidence of extraction. *Keho* slabs are also present consisting of large fine–grain basalt laminates (20–100cm). Some of the boulders have extraction marks along with finely finished and polished blocks. The feature could be a repository pit that was created from mining into the side of the wall, then filled in with boulders.
24	Large and long *keho* wall with little evidence of extraction or debitage. This is surprising as this seems stone seems to be a high quality of *keho*.
25	Largest *keho* quarry complex on the island. The site has major workshops with great deal of debitage, large slabs, and worked cliff walls. The topographic highest point of the site is well quarried with evidence of *keho* removal, including *keho* scars and debitage tracing downwards towards the crater. As noted by Simpson et al. (2017) findings about *keho* quarrying in Poike, ropes and baskets were likely used to quarry this material considering the vertical difficulty in accessing the *keho* sources.
26	Large *paenga* quarry with great evidence of extraction on the wall and nearby boulders (50–200cm). There is no debitage on the ground.
27	Two sources of fine–grain basalt and *paenga*. Cores present (50–70cm), but no debitage around base of wall. There is a small cave underneath the *puku*. To the west of this site is a large *papa* with multiple petroglyphs including fishhooks and an octopus.
28	Very large *puku* with indication of stone extraction. Cores present (>45cm) but little evidence of debitage. Next to very large *paenga* which was arguably quarried from the surrounding area. One *Makemake* (creator god) petroglyph present.
29	Largest basalt quarry in Ava o'Kiri. Multiple areas of extraction with cores and flake scars present. There are multiple *Makemake* caved on flake scars. There is evidence for the reduction of stones from boulders (50–90cm) to debitage (5–10cm) with a few preforms present. On the top of the quarry there is further evidence of core extraction and reduction of material. This was a major quarry in the past.
30	Large lava field complete with *paenga* and fine–grade basalt. Quarry is to the east and north and there is a higher ridge with a workshop. In the surrounding field, there are multiple boulders with flake scares (15–50cm) and debitage is located throughout field. The workshop has a lot of debitage (1–20cm) and evidence of hammerstones and preforms (10–20cm).
31	*Puku* with fine–grade basalt associated with vesicular basalt from younger flows. There are ~4 *Makemake* and one bird head petroglyphs in the scars of one boulder. While there seems to be much evidence of stone reduction, there is little debitage (5–10cm) present found to the north of the *puku*. There is also a *taheta* (water collector) present in the *puku*. To the west, is an unfinished *hare moa* (chicken house) structure, while to the south, there is a pile of rubble.

32	A very large workshop and quarry with thousands of flakes (1–20cm), evidence of cores (25–50cm), and hammer stones (10–15cm). There is a southern to northern lowering of terrain (2–3m) with deposits of boulders (20–45cm) and continuous layers of debitage (5–10cm). Two pit repositories (>50cm deep) measuring 4m by 3m and 4m by 2m filled with smaller boulders (10–50cm) are found to the south of the workshop. In some areas, mounds that encircle *pu* are created by piling reduced stone to one side. This was a very large centre of reduction. A *pipi horeko* (boundary marker) is found 30m to the southeast of the site.
33	A basalt quarry and workshop are represented by a *pu* repository excavated at the base of the *puku*. The *puku* is notable because it has many geologic strata including younger vesicular basalt and older fine–grain boulders. The length of the pit is 11m by 6m and is 55cm deep. Like RNGP32, a spoil pile is to the north side of the site made from accumulated chipped stone. There are many large boulders and fragments in the pit repository measuring between 5–60cm.
34	A basalt workshop surrounds a square subterranean structure with walls of stacked stone (370–330cm; 1–3m deep). The margins are surrounded by extensive areas of chipping debris (1–30cm), but not concentrated in one area.
35	A quarry, workshop, and *pu* filled by stone material including ~100 boulders (40–60cm), cores (15–35cm), and debitage (5–15cm). The depth of the *pu* is unknown as it is completely filled with boulders. These features extended onto a *puku* 10m to the south that may be the stone source for this quarry.
36	A workshop with two pits, one 5.2m by 4.6m full of large boulders 40–50cm. The second depository is to the west, much smaller and less defined ~2m in length. There is chipping debris to the north of the eastern (larger) pit.
37	Medium sized basalt workshop. Two pits are found at the margin of the site along with a *hare moa*. There is extensive flaking at margins of the pits to the east. Many cores (15–40cm), debitage (2–15cm), and two preforms are present.
38	A large area of basalt flakes (1–25cm). No formal pit, but a grouping of boulders to the north of a *puku*. A *hare moa* is found 20m to the northeast.
39	Basalt workshop and repository. The workshop is located upslope to the southeast. The workshop is surrounded by boulders. The repository is 11m by 4.8m.
40	Basalt workshop and quarry possibly excavated into a *puku* wall? Many boulders are present to the west, while the workshop it to the west. A minimum number of flakes and evidence of reduction are evident.
41	A basalt workshop defined by a pit repository with ~10 basalt boulders. It is oval in shape 7.20m by 9.30m with 2m of depth. There is a small rock shelter (*karava*) at one end. Upslope, there is also a large reduction workshop which extends to the northwest until a large pile of boulders (*pipi horeko?*).
42	Flaking area and large workshop. Pit repository about 3m by 4m in diameter. Reduction area with many sizes of flakes (5–30cm). The site is next to *pipi horeko*.

43	A quarry, source, and double *pu* repository: 1) 5.8m by 4.1m and 2) 4m by 4m. Sources of raw material (boulders) and flaking debris are located to the east and the south. 10m from the site there are *hare moa* and *manavai* (stone–walled garden). Stone from this site was mined as well as recovered from the surface.
44	Basalt workshop. A single pit repository is filled with boulders 30–60cm. It is slightly oval and extends to the north where there is a smaller pit (1m in length). There is minimum flaking present at the site.
45	Basalt workshop with a pit repository to the east of a *puku* which seems to be the source. There are large boulders of both fine–grain (5–50cm) and vesicular basalt (10–60cm). There is extensive flaking around the pit in all directions, but mostly going downslope towards the north. There appears to be a worn *Makemake* petroglyph on the face of the *puku* to the west of the pit.
46	A repository of boulders (5–40cm) with debitage fill in a depression at the base of a *puku*. The *puku* appears to be the source. There is a 2m by 2m reduction area with hundreds of flakes (<15cm) around the site. To the northeast, there is an alignment of buried stones with one that appears to have a faded *Makemake* petroglyph. Downslope, 30m to the north, there is another *pu* filled with boulders, but it does not show evidence for reduction around its margins.
47	A pit repository located on the side of a hill to the northeast of a *puku*. It is filled with smaller boulders and a medium about of flaking material found in and on the *puku*. There is also a *puku* higher up, to the west, that is make from vesicular basalt. There is also a *hare moa* and stone gardens to the southeast.
48	Arguably the largest and most complex fine–grain basalt quarry on Rapa Nui. Four large basalt workshops (1–4) extend 50m from the south to the north. These four workshops surround a fine–grain *puku* source that was extensively excavated. 1) A small repository (5m by 3m and 35cm deep) is located on an eastern downslope. It is filled in with boulders (10–40cm) and flaking debitage of vast quantity; 2) A smaller pit (5m by 4m and 30cm deep) is filled with boulders and has stratigraphically thick stone–chipping remains; 3) The largest pit, which measured 8.5m by 4m and is 85cm deep, displays many phases in the operational sequence of basalt tool making including numerous boulders (10–50cm), cores, adze blanks, and debitage. Adzes and hammer stones are also present; and 4) The most eastern pit (49cm deep) is 6m by 3m and is filled with boulders (15–59cm) and light flaking debris. A small *pu* (40cm) is located to the east border of the site. At the highest elevation of site, there is a vesicular basalt source/workshop with multiple worked stones present. A rudimentary *ahu* sits 100m to the south of the site.
49	Basalt workshop with a crescent–shape *puku* which is the source. The pit (40cm deep) under the *puku* is 3.7m by 3m and is filled with boulders (5–50cm). Both on top and below the *puku* are huge amounts of flaking debris and smaller boulders (10–30cm). The northern area of debitage extends for 10m from the *puku* and is intermixed with larger vesicular basalt boulders (*pae*). Smaller flakes (<10cm) are found close to the *puku*, while larger flakes (>10cm) are found further away.

50	Basalt workshop to the east of a *puku* with three shallow repositories (<35cm in depth) filled with both fine–grain and vesicular basalt stones (10–40cm). More deposits of vesicular basalt are found to the east. There are numerous deposits of reduced stone and flaking debris at the margins and around the vesicular basalt blocks.
51	Large quarry and source with a fair quantity of flaking debris (1–15cm). There is little evidence of cobbles and no associated pit repository. However, vesicular basalt boulders are present.
52	Close to a *puku* and on a rising hill are a grouping of three repositories: 1) 4m by 1.5m; 2) 4m by 2m; 3) 4m by 2m. The *puku* is completely covered with flaking debris (1–15cm), acting as the main reduction area. To the south of pit number one, there is another area that has large boulders (50–95cm) but minimum flaking debris. To the east of the *puku* are pits numbered two and three. Although overgrown with vegetation, these sites show extensive evidence of flaking and reduction. Pit three exhibits groupings of boulders (20–75cm) including both fine–grain and vesicular basalt. Pit three shows evidence of *Makemake* and a possible *ao* (wood paddle) petroglyphs. This was a major source for extraction and site of lithic reduction. In addition, with its proximity to RNGP49, this quarry acted as a major site for prehistoric basalt lithic production.
53	Very small workshop with a pit repository filled with more vesicular basalt and few fine–grain boulder (5–20cm). There is minimum flaking around the margins.
54	Although overgrown, a very large workshop and repository. The *pu* (1m deep) is located at the base of a *puku* (5m by 7m long) and is composed of very large vesicular basalt boulders (1m of maximum length). Moving from the west of the *puku* is a large reduction area (2m by 2m size) with thousands of fine–grain flakes but with few large boulders. This was a major reduction area and may have also been a *paenga* quarry/workshop.
55	Small cobble workshop northeast of a *puku*. Stone scatter (1–10cm) trends downslope to larger boulders (20–50cm).
56	Boulder outcrop with extensive evidence of extraction. However, little flaking evidence around site. This site continues to the south to a small reduction area.
57	Spatially large workshop found to the south of a gully. The site has one extensively mined *puku* that shows multiple strata of quarried stone including boulders which were targeted for basalt tool manufacture. There is a pit repository (3m by 1m) northwest of the *puku*, which is filled with large boulders (10–45cm) that appear to be from the associated *puku*. To the south of the pit is a *karava*. Continuing for two to eight meters around the *pu* and *puku*, is heavy flake and debitage scatter which terminates around another smaller *puku* to the east.
58	Basalt workshop and reduction area created on top of a low *puku*. The raw material is located below the *puku* in an area of boulders, but there is no major pit repository close to site, but multiple boulder pits are found to the north. There is minimum evidence of flaking.
59	Basalt workshop with a repository that has been dug into the north side of an outcrop that has been filled with basalt. There is a ring of stone and sediment around the repository that is the spoil from excavation. There is chipping debris around the pit and a small reduction area to the north of the main pit (1m by 1m).

60	Basalt workshop with a repository positioned on the east side of a boulder *puku*. The boulders (40–70cm) are associated with smaller fill. Chipping debris is found within and around the edge of the *pu*.
61	Basalt workshop and oval repository located to the north of a *puku*. The depression is filled with rock boulders (30–60cm) with much flaking around the margins.
62	Small basalt workshop 3.5m by 2.5m which includes a *pu* filled with boulders but with little evidence of flaking debris.
63	Basalt quarry, workshop, and repository (6.3m by 5.3m; 65cm deep). It is located to the east of a *puku*. The *pu* is filled with boulders (10–70cm) with heavy flaking debris located around the rim. To the north of the depression is an overgrown grassy patch filled with more boulders (20–50cm) and flakes.
64	A large boulder field with 100s of fine–grain and vesicular stones (4–60cm). There is minimum evidence for flaking on the higher portion of the site. One large boulder exhibits evidence for reduction and hammer stones were found in the area. A *manavai* is located 40m to the southeast.
65	A basalt workshop with no pit, but substantial lithic reduction covers the *puku*, mostly to the north. The *puku* is composed of both vesicular and fine–grain basalt.
66	A small basalt workshop is found within an enclosure which backs into a *puku*. There is limited flaking material around the site. There is a small deposit of fine–grain material to the west that may be the source for this site.
67	Basalt workshop with a small repository to the north and southeast. The excavated depression is empty without evidence of boulders and flaking debitage. There is ample evidence showing how early vesicular basalt flows were peeled to gain access to the fine–grain basalt material.
68	Found on a ridge, four large basalt reduction sites spread out 50m from the south to the north. However, there does not seem to be a source *puku* nearby. 1) A small repository (5m by 3m) located on slope of a hill trending downwards to the east. It is filled in with boulders (10–40cm) and a good amount flaking debitage; 2) A smaller pit 5m by 4m that is filled with boulders and has flaking debitage; 3) The largest pit which measured 8.5m by 4m has numerous boulders (10–50cm) and flaking debitage (5–30); and 4) the most eastern of the pits is 6m by 3m and has evidence for boulders and light flaking debris. The only *ahu* in the area with a single *moai* is found 100m to the south.
69	Three basalt repositories filled with large basalt boulders (10–60cm): 1) 5m by 4m, 2) 6m by 3m, and 3) 5m by 5m. Although there is a great quantity of boulders, there is little chipping stone found around the three *pu*.
70	A large quantity of flaking material to the west and north of a *puku* that looks like the source. The source is excavated under a flow of earlier vesicular basalt flows. A similar pattern found throughout the Pu Tokitoki area.
71	Basalt workshop that has a wide distribution of flaking debris (1–10cm) over an area that is 7.5m by 3m. There are large boulders (20–100cm) to the northwest that seem to be part of a nearby *puku*.

73	The Poike source found ~40m under Ahu Kiri Reva is a single source of high–quality fine–grain basalt. See Simpson et al. (2017) for a complete site report.
75	A possible contemporary workshop with two piles of large *keho* (20–50cm). This site may have been used for material for the reconstruction of ‘Orongo (see Simpson and Dussubieux 2018).
76	Small quarry and workshop of *keho*. There are multiple source rocks and light debitage on and around the exposed flow. There are larger boulders found downhill that may have been part of the reduction process.
77	Large source and quarry with a great amount of debitage next to cliff face. The trail of debris extends downslope 10m to the west. It appears this source was quarried extensively, but there is little evidence of portable tool making including smaller pieces of debitage.
78	Found in a woody area, there is a *puku* with *keho* debitage going north–south on the surface. It is intermixed with an unconsolidated lava flow. As this site is next to an access road, it could be a more contemporary quarry. But, some of the *keho* debitage has older surface patina suggesting it was an older quarry and workshop. To the east of the road (7m) there is the outcropping of *keho* that appears to be another source. This source continues upslope for 15m until reaching another small workshop. It is filled with large boulders (15–75cm) and small pieces of *keho* debitage (<15cm).
79	A *keho* quarry found in a gully where a small extraction area is found to the north. The site provides evidence for a substantial amount of *keho* removal. There is debitage extending downslope to the southeast. There are also numerous large boulders (50–150cm) that may be part of the reduction process.
80	A long *keho* wall (2–10cm width) leads into a cave. There is extensive debitage around the wall of the cave. To the northeast there is a trail that leads to RNGC 79 with *keho* material found throughout the area. There are also many large boulders (<1m) that may be part of the reduction process.
81	A large cave quarry, possibly associated with RNGP 80. The east part of the cave has a *keho* wall with extensive debitage (<15cm) on the surface. The west part of the cave is much larger with two separate walls of *keho*. The southern wall is of a lesser quality material (with less debitage around the wall), while the northern section has much better *keho* quality (with vast quantities of debitage). While there is not much debitage in the wider cave area, *poro* stones and human bone remains are present.
82	A very small quarry located underneath a larger *keho* stone 2m by 1m. The *keho* has been mined from under this larger piece which seems to have good stone quality.
83	A very complex quarry located 10m west of RNGC 82. The western part is composed of a very thick *keho* (5–15cm) that is on top of a layer of thinner *keho* (0–10cm). This thin line of *keho* continues 3m to the east where there is a very large extraction area with thousands of pieces of debitage. There is also a cave above these quarries. Towards the ocean there are large boulders of *keho* that may be part of the reduction process.

84	Located 4m to the south of RNGP82, this site has the most concentrated area of *keho* extraction and reduction. Instead of mining, here the *keho* is parallel to the surface, making the removal of the stone source much easier. There are boulders (20cm–2m) and pieces of debitage (<20cm) located over an area of 13m by 6m. It seems to be a very high quality *keho* albeit thicker in profile than what is found at other mining sites.
85	A very large cave quarry to the northwest of RNGC 84. It is a long cave (W–E) where the roof and descending wall is made of *keho*. It looks like much stone was mined out of this area. While as not much debitage as RNGC 84, there are areas with extensive pockets of quarried material.
86	A small deposit of *keho* under the higher cave line of the southwest coast. There is a minimum amount of debitage found around the base of the cliff.
87	Small outcrop underneath an unconsolidated flow of lava. The *keho* seems to be of good quality (2–10cm). While there are a lot of boulders on the top of the deposit, there is also a fair amount of debitage at the base of the site. There is also 100s of *poro* stones that could have been used to reduce stone at this site.
88	The bottom cave of a dual cave structure associated with RNGC 89. This cave is well developed after mining into the flow of *keho*. There is extensive debitage on the floor of the cave. There is small outcrop to the west that also has debitage. Downslope to the ocean there is also debitage mixed with *poro* stone.
89	Cave on top of RNGP 88. It has debitage on the floor with areas of great deposits. The *keho* is thin (3–10cm), durable, and a perfect size for fishhook manufacture.
90	Large cave 10m to the west of RNGC 88/89 with *keho* of thin proportion. There is little debitage on the floor which is concentrated to two areas of the cave (western and eastern sides). The cave is good example of how mining was required to access the flows of *keho.* There is not much debitage downslope to the ocean, but there is large amount of *poro.*
91	A double cave structure to the east of RNGP90 with a small outcrop and workshop to the west. Both caves have extensive amount of debitage on the surface and around the base of the cave. The *keho* source is a very thin basalt lens (1–8cm) of exceptional quality. The workshop to the west is embedded inside of a hill, which is littered with extensive debitage and reduced stone.

APPENDIX C

EISP and RNGP archaeological artefacts under study (n=78)

Rano Raraku - RNGPRR # 1

Rano Raraku - RNGPRR # 2

Rano Raraku - RNGPRR # 3

Rano Raraku - RNGPRR # 4

Rano Raraku - RNGPRR # 5–6

Rano Raraku - RNGPRR # 7

Rano Raraku - RNGPRR # 8

Rano Raraku - RNGPRR # 9

Rano Raraku - RNGPRR # 10

Rano Raraku - RNGPRR # 11–12

Rano Raraku - RNGPRR # 13

Rano Raraku - RNGPRR # 14–15

Rano Raraku - RNGPRR # 16

Rano Raraku - RNGPRR # 17

Tahai – RNGP # 1

Tahai – RNGP # 2

Tahai – RNGP # 3

Tahai – RNGP # 4

Tahai – RNGP # 5

Tahai – RNGP # 6

Tahai – RNGP # 7

Tongariki – RNGP # 8

Tongariki – RNGP # 9

Tongariki – RNGP # 10

Tongariki – RNGP # 11

Tongariki – RNGP # 12

Tongariki – RNGP # 13

Tongariki – RNGP # 14

'Anakena – RNGP # 15

'Anakena – RNGP # 16

‘Anakena – RNGP # 17

‘Anakena – RNGP # 18

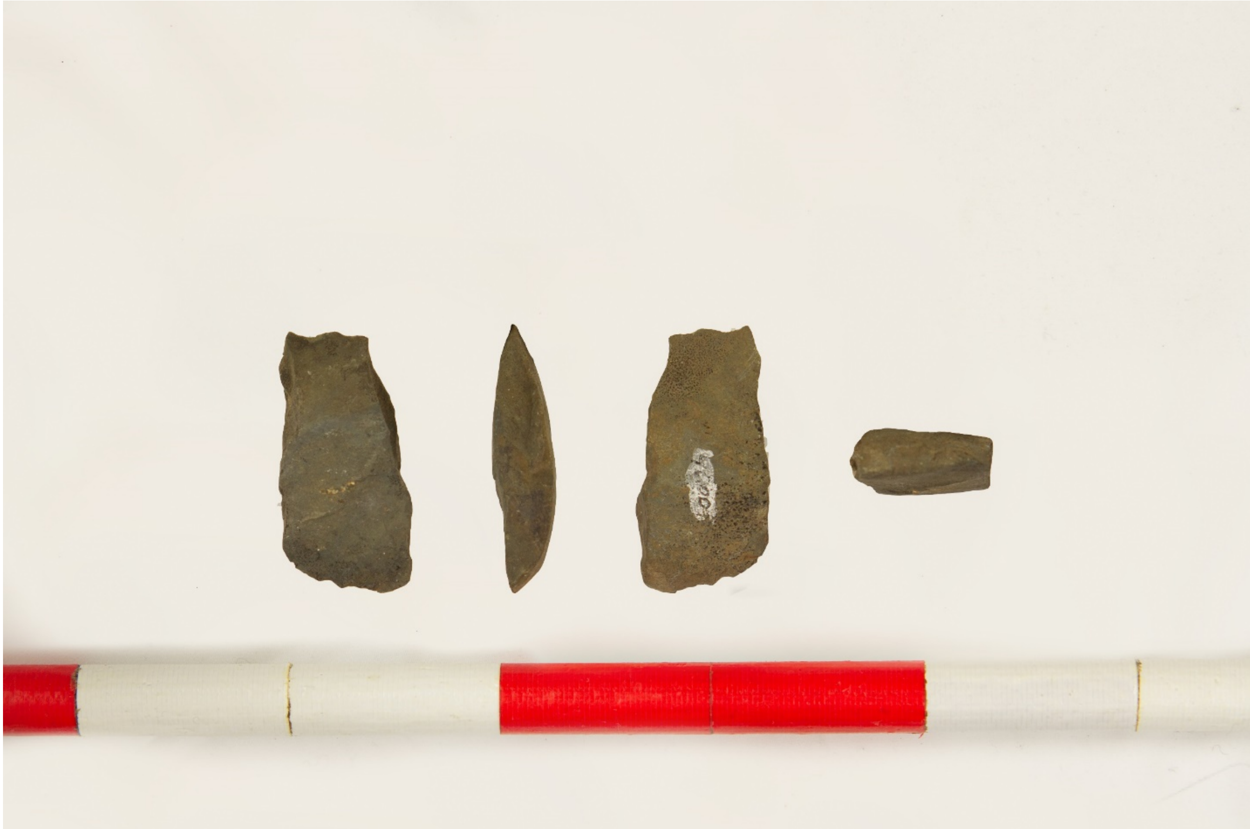
‘Anakena – RNGP # 19

Vai Atare– RNGP # 20

Vai Atare– RNGP # 21

Vai Atare– RNGP # 22

Vai Atare– RNGP # 23



Vai Atare– RNGP # 24

Tautira – RNGP # 25

Tautira – RNGP # 26

Tautira – RNGP # 27

Tautira – RNGP # 28

Tautira – RNGP # 29

Tautira – RNGP # 30

Puku Nga Aha Aha – RNGP # 31

Puku Nga Aha Aha – RNGP # 32

Puku Nga Aha Aha – RNGP # 33

Puku Nga Aha Aha – RNGP # 34

Puku Nga Aha Aha – RNGP # 35

Puku Nga Aha Aha – RNGP # 36

Puku Nga Aha Aha – RNGP # 37

Puku Nga Aha Aha – RNGP # 38

Oroi – RNGP # 39

Oroi – RNGP # 40

Orito – RNGP # 41

Orito – RNGP # 42

Orito – RNGP # 43

Orito – RNGP # 44

Ava Ranga Uka A Toroke Hau – RNGP # 45

Ava Ranga Uka A Toroke Hau – RNGP # 46

Hanga Roa – RNGP # 47

Maitaki te moa – RNGP # 48

Ava o'Kiri – RNGP # 49

Ava o'Kiri – RNGP # 50

O'Rongo – RNGP # 51

Ava Ranga Uka A Toroke Hau – RNGP # 52

Ava Ranga Uka A Toroke Hau – RNGP # 53

Ava Ranga Uka A Toroke Hau – RNGP # 54

Ava Ranga Uka A Toroke Hau – RNGP # 55

Ava Ranga Uka A Toroke Hau – RNGP # 56

Ava Ranga Uka A Toroke Hau – RNGP # 57

Rano Raraku – RNGP # 58

Rano Raraku – RNGP # 59

Rano Raraku – RNGP # 60

Rano Raraku – RNGP # 61

APPENDIX D

Photos of selected RNGP archaeological sites under geochemical study (n=31)

Ava o'Kiri – RNGP # 29

Ava o'Kiri – RNGP # 57

Pu Tokitoki – RNGP # 7

Pu Tokitoki – RNGP # 9

Pu Tokitoki – RNGP # 32

Pu Tokitoki – RNGP #33

Pu Tokitoki – RNGP # 35

Pu Tokitoki – RNGP # 43

Pu Tokitoki – RNGP # 45

Pu Tokitoki – RNGP # 46

Pu Tokitoki – RNGP # 48

Pu Tokitoki – RNGP # 49

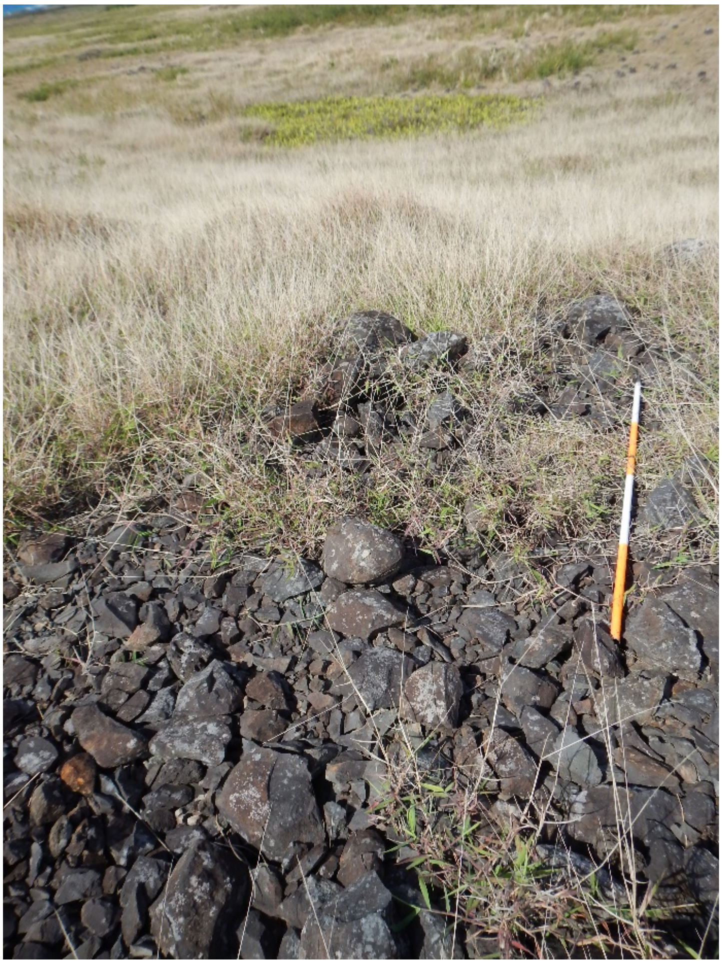
Pu Tokitoki – RNGP # 50

Pu Tokitoki – RNGP # 52

Pu Tokitoki – RNGP # 54

Pu Tokitoki – RNGP # 63

Pu Tokitoki – RNGP # 68



Pu Tokitoki – RNGP # 69

Rano Kau – RNGP # 25

Southwest coast – RNGP # 11

Southwest coast – RNGP # 13

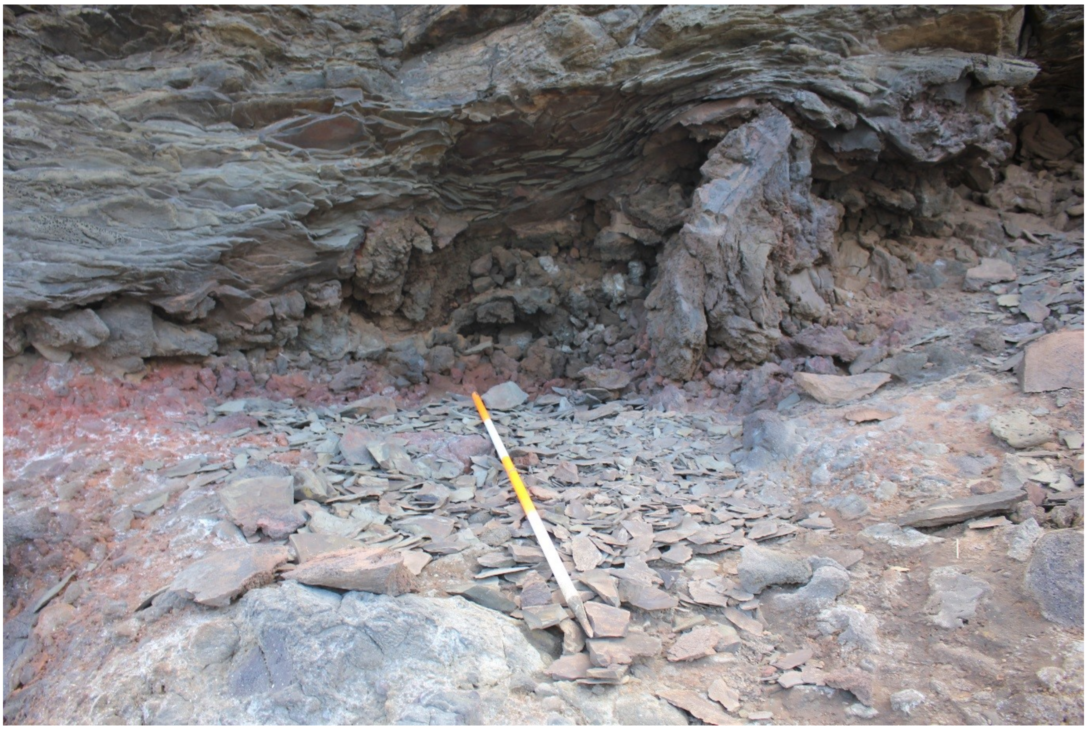
Southwest coast – RNGP # 14

Southwest coast – RNGP # 17

Southwest coast – RNGP # 81

Southwest coast – RNGP # 84

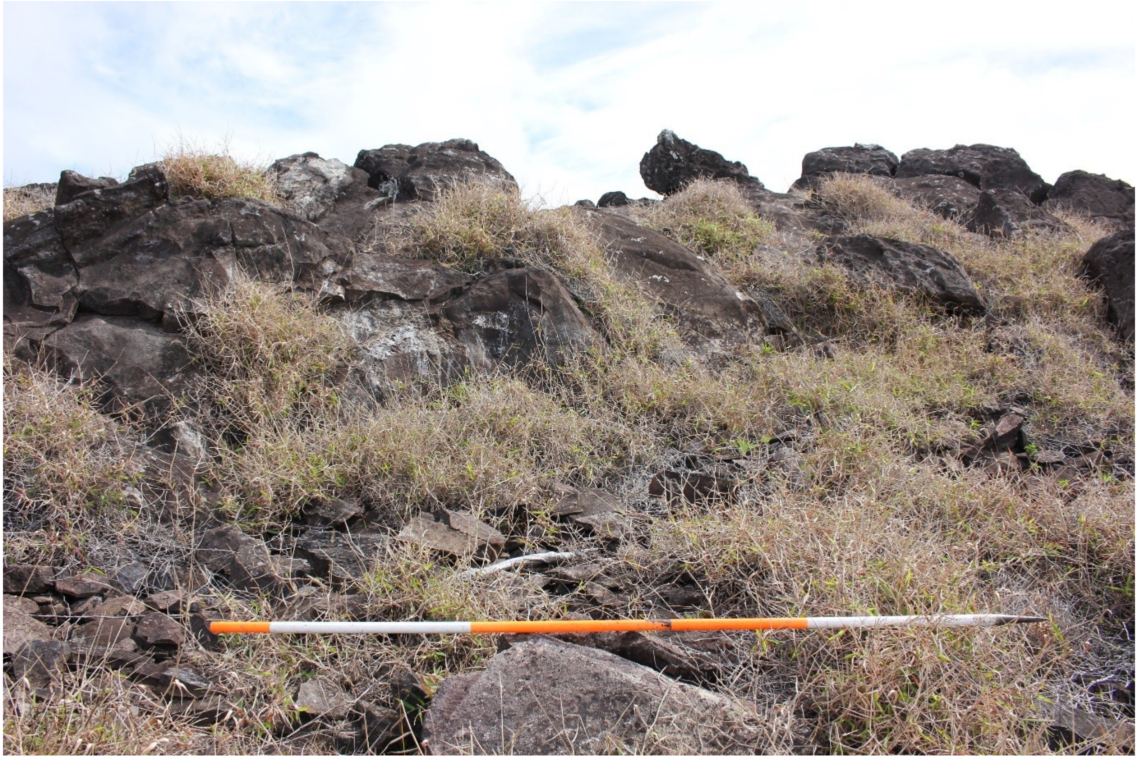
Southwest coast – RNGP # 89



Southwest coast – RNGP # 91

Vai Atare – RNGP # 21

Vai Atare – RNGP # 22



Vai Atare – RNGP # 77

Vai Atare – RNGP # 78

APPENDIX E

EISP & RNGP LA–ICP–MS elemental data

	SiO2	Na2O	MgO	Al2O3	P2O5	K2O	CaO	MnO	Fe2O3	TiO2
RR01	60.5%	5.04%	0.93%	15.1%	0.31%	2.28%	4.50%	0.29%	10.0%	1.04%
RR02	60.2%	4.85%	1.47%	15.2%	0.49%	2.31%	4.48%	0.23%	9.49%	1.18%
RR03	54.9%	4.03%	3.18%	15.4%	0.88%	1.60%	7.10%	0.24%	10.0%	2.60%
RR04	58.0%	4.29%	2.59%	15.9%	0.96%	1.80%	7.27%	0.18%	6.93%	1.97%
RR05	57.5%	3.97%	2.74%	15.3%	1.01%	1.65%	7.11%	0.19%	8.89%	1.47%
RR06	63.3%	5.37%	0.89%	15.2%	0.40%	1.82%	4.48%	0.22%	7.53%	0.69%
RR07	60.1%	3.98%	2.43%	14.3%	0.88%	1.68%	6.85%	0.20%	8.31%	1.15%
RR08	58.4%	3.83%	3.63%	13.7%	0.89%	1.04%	7.50%	0.19%	10.3%	0.42%
RR09	59.7%	4.70%	1.79%	15.5%	0.77%	1.87%	5.03%	0.19%	9.08%	1.17%
RR10	55.4%	3.93%	3.11%	15.3%	0.80%	1.72%	9.48%	0.21%	8.59%	1.31%
RR11	53.3%	3.83%	3.33%	15.7%	0.88%	1.97%	8.08%	0.29%	10.7%	1.82%
RR12	60.4%	5.45%	1.00%	15.6%	0.40%	2.15%	4.63%	0.27%	9.00%	1.05%
RR13	53.4%	4.46%	3.37%	15.4%	1.15%	1.59%	6.96%	0.27%	11.6%	1.76%
RR14	53.1%	3.98%	3.79%	13.9%	1.52%	1.38%	7.41%	0.30%	12.5%	1.98%
RR15	57.7%	3.12%	2.71%	13.5%	0.52%	1.52%	8.35%	0.25%	10.8%	1.43%
RR16	58.0%	4.67%	1.11%	15.7%	0.41%	2.51%	5.50%	0.20%	10.5%	1.31%
RR17	51.0%	3.10%	5.35%	13.8%	0.40%	0.87%	9.58%	0.27%	12.9%	2.71%
PICK 1	60.4%	4.58%	1.94%	14.6%	0.70%	1.93%	4.78%	0.24%	9.51%	1.18%
PICK 2	60.4%	4.59%	1.93%	14.6%	0.70%	1.94%	4.76%	0.24%	9.51%	1.17%
PICK 3	60.5%	4.59%	1.93%	14.6%	0.70%	1.94%	4.73%	0.24%	9.50%	1.17%
PICK 4	60.5%	4.60%	1.92%	14.6%	0.70%	1.95%	4.70%	0.24%	9.50%	1.16%

Major elements for EISP artefacts under study

	RR01	RR02	RR03	RR04	RR05	RR06	RR07	RR08	RR09	RR10	RR11	RR12	RR13	RR14	RR15	RR16	RR17	PICK 1	PICK 2	PICK 3	PICK 4
Li	11	10	9.0	7.6	7.4	11	11	5.7	11	7.8	11	11	11	10	10	9.1	7.4	13	13	13	13
Be	3.5	3.1	2.2	2.8	2.8	3.6	3.0	1.9	2.8	2.6	2.5	3.6	2.8	2.1	1.9	3.3	1.3	3.0	3.0	3.0	3.0
B	4.8	4.8	3.6	5.4	5.6	6.5	6.3	3.9	5.5	4.2	5.6	5.9	3.9	3.9	2.6	4.1	2.2	5.7	5.6	5.6	5.6
Sc	30	25	28	33	29	24	26	28	23	43	33	30	28	32	36	29	43	28	28	28	28
V	3	6	175	151	140	2	83	66	24	193	162	3	145	152	126	7.2	429	52	51	51	50
Cr	1.5	1.6	1.2	1.3	1.6	1.6	1.7	1.5	1.6	1.7	1.8	1.6	1.6	1.5	1.3	1.4	29	0.7	0.7	0.6	0.6
Ni	0.8	0.6	0.8	0.6	1.6	0.5	0.8	0.8	0.2	1.4	2.1	0.5	0.8	0.8	1.1	0.4	25	<dl	<dl	<dl	<dl
Co	4.5	9.5	24	17	18	3	18	25	12	19	27	4	23	22	23	8.8	47	13	13	13	13
Cu	12	14	19	16	33	12	21	13	22	32	31	13	23	15	19	7.4	42	12	12	12	12
Zn	195	224	180	149	201	178	171	123	207	151	183	203	198	227	127	154	127	207	208	208	208
As	1.2	1.4	0.9	1.1	1.6	1.4	1.1	0.5	0.9	1.2	1.1	1.1	0.8	0.8	0.6	0.9	0.3	1.0	1.0	1.0	1.0
Rb	44	34	24	30	23	23	29	13	22	18	21	28	19	22	16	41	12	34	34	34	34
Sr	266	259	347	351	299	263	271	290	280	302	321	270	311	289	293	246	274	245	244	243	242
Zr	732	631	447	491	416	642	493	259	475	522	413	714	453	373	347	691	253	550	552	554	556
Nb	88	74	67	67	58	77	60	14	57	59	59	87	62	55	48	77	36	71	71	71	71
Ag	0.3	0.4	0.2	0.2	0.6	0.3	0.3	0.1	0.2	0.3	0.3	0.3	0.3	0.2	0.1	0.2	0.1	0.3	0.3	0.3	0.3
In	0.4	0.3	0.2	0.2	0.7	0.3	0.2	0.2	0.2	0.4	0.4	0.4	0.3	0.3	0.2	0.2	0.2	0.3	0.2	0.2	0.2
Sn	5.0	6.2	3.4	4.6	4.5	5.1	4.4	1.0	4.3	3.3	3.6	5.3	3.8	3.6	2.0	4.7	1.9	4.3	4.3	4.3	4.3
Sb	1.1	1.4	0.7	0.3	4.6	2.8	1.1	0.8	0.7	2.4	6.8	2.6	2.0	1.5	1.1	1.8	1.5	1.6	1.6	1.6	1.7
Cs	0.4	0.2	0.2	0.3	0.5	0.3	0.4	0.1	0.3	0.5	0.5	0.3	0.3	0.3	0.2	0.2	0.1	0.4	0.4	0.4	0.4
Ba	234	257	183	203	186	274	220	199	250	178	179	271	201	170	109	215	92	230	230	230	231
La	50	57	49	60	47	54	50	26	53	45	41	66	52	45	29	50	20	52	52	52	52
Ce	103	126	112	141	112	129	112	83	123	101	97	129	115	109	64	104	48	121	121	121	122
Pr	15	18	16	20	17	18	16	8.6	18	15	14	21	18	16	9.0	15	7.0	17	17	17	17
Ta	4.4	4.3	4.2	4.5	3.7	5.0	3.9	1.2	3.9	3.4	3.7	5.2	4.0	3.5	1.9	3.5	2.0	4.4	4.4	4.4	4.4
Au	0.03	0.03	0.02	0.02	0.03	0.03	0.03	0.02	0.03	0.03	0.05	0.03	0.03	0.02	0.01	0.02	0.01	0.03	0.03	0.03	0.03
Y	99	99	89	102	71	83	76	60	77	90	71	105	86	77	58	88	44	87	88	88	88
Pb	2.9	4.6	2.6	3.2	5.9	4.6	3.9	2.7	2.9	3.3	5.4	4.5	3.8	3.3	1.2	2.8	1.4	3.0	3.0	3.0	3.0
Bi	0.11	0.09	0.05	0.05	0.16	0.12	0.19	0.09	0.04	0.19	0.43	0.10	0.13	0.06	0.02	0.05	0.03	0.1	0.1	0.1	0.1
U	1.7	2.2	1.3	1.7	1.7	2.4	1.7	1.0	1.8	1.4	1.8	2.1	1.7	1.3	0.5	1.4	0.6	1.8	1.8	1.8	1.9
W	0.8	0.8	0.7	0.7	0.9	0.7	0.9	0.4	0.9	0.6	1.0	0.9	0.7	0.5	0.3	0.7	0.3	0.8	0.8	0.8	0.8
Mo	3.2	4.6	3.0	3.7	3.4	3.3	3.7	0.7	3.4	3.3	3.6	3.5	3.3	3.0	2.1	4.7	1.7	4.0	4.0	4.0	4.0
Nd	49	58	54	67	54	60	55	46	60	50	48	70	63	56	30	51	24	58	58	58	58
Sm	12	14	14	17	13	15	14	7	15	13	12	17	16	14	8	12	6.3	14	14	14	14
Eu	4.0	3.9	4.1	5.0	4.3	4.7	4.1	3.9	4.4	3.8	3.8	4.9	4.8	4.6	2.3	3.2	2.1	4.2	4.2	4.2	4.2
Gd	13	15	14	17	14	15	14	12	15	14	13	17	16	15	8	13	6.9	15	15	15	15
Tb	2.5	2.8	2.6	3.0	2.6	2.9	2.7	2.3	2.8	2.5	2.4	3.3	3.0	2.7	1.4	2.3	1.3	2.8	2.8	2.8	2.8
Dy	12	14	13	15	13	15	14	11	14	12	12	17	15	14	7	12	6.4	14	14	14	14
Ho	3.1	3.5	3.2	3.6	3.1	3.7	3.3	2.7	3.4	3.0	2.9	4.2	3.6	3.2	1.7	2.8	1.5	3.4	3.4	3.4	3.5
Er	6.8	7.6	7.0	8.0	6.6	8.4	7.4	5.9	7.6	6.4	6.1	10	7.8	7.0	3.7	6.1	3.3	7.7	7.7	7.7	7.7
Tm	1.3	1.3	1.2	1.4	1.2	1.5	1.3	1.0	1.2	1.1	1.1	1.6	1.3	1.1	0.6	1.0	0.5	1.3	1.3	1.3	1.3
Yb	6.3	7.2	6.4	7.3	5.9	8.2	6.9	5.3	7.0	5.6	5.4	8.9	6.9	6.2	3.2	5.5	2.9	7.1	7.1	7.1	7.1
Lu	1.3	1.3	1.1	1.3	1.1	1.5	1.2	0.9	1.2	1.1	1.1	1.6	1.2	1.1	0.6	1.0	0.5	1.3	1.3	1.3	1.3
Hf	14	14	11	12	10	17	13	7	12	10	9.3	16	10.7	9.0	5.1	11.9	5.1	13	13	14	14
Th	5.2	6.2	4.4	5.2	4.4	6.7	5.0	2.6	5.4	3.6	4.1	6.6	4.5	3.7	1.8	4.8	1.8	5.8	5.8	5.8	5.8

Minor elements for EISP artefacts under study

	SiO2	Na2O	MgO	Al2O3	P2O5	K2O	CaO	MnO	Fe2O3	TiO2
A01	51.8%	3.68%	1.97%	12.2%	1.28%	1.52%	5.29%	0.48%	19.1%	2.59%
A02	60.0%	4.92%	1.32%	14.3%	0.69%	1.82%	4.53%	0.37%	11.0%	1.00%
A03	56.6%	4.39%	2.74%	15.0%	1.24%	1.58%	6.11%	0.26%	10.5%	1.48%
A04	57.6%	4.41%	2.67%	14.9%	1.09%	1.65%	5.67%	0.26%	10.2%	1.39%
A05	57.3%	4.37%	2.75%	14.9%	1.28%	1.61%	5.89%	0.25%	10.1%	1.39%
A06	59.1%	4.15%	1.22%	15.7%	0.84%	2.14%	4.37%	0.17%	10.8%	1.39%
A07	62.2%	5.22%	1.14%	16.8%	0.54%	2.50%	4.17%	0.11%	6.16%	1.02%
A08	52.1%	3.06%	5.08%	14.1%	0.54%	0.83%	10.78%	0.23%	10.8%	2.35%
A09	56.4%	4.43%	2.67%	15.9%	1.08%	1.71%	7.27%	0.22%	8.57%	1.66%
A10	56.8%	3.88%	2.80%	15.2%	1.00%	1.23%	7.87%	0.19%	9.33%	1.59%
A11	56.9%	4.18%	1.65%	15.9%	0.99%	0.88%	7.32%	0.11%	10.6%	1.35%
A12	57.0%	4.27%	3.76%	15.2%	0.93%	1.19%	6.86%	0.21%	9.0%	1.54%
A13	58.3%	4.06%	2.56%	15.0%	0.87%	1.18%	7.38%	0.27%	8.30%	1.91%
A14	53.6%	3.40%	4.64%	14.1%	0.49%	0.87%	8.66%	0.22%	11.0%	2.89%
A15	61.0%	4.68%	1.72%	15.7%	0.71%	1.67%	5.18%	0.18%	7.84%	1.20%
A16	57.4%	4.41%	2.70%	15.8%	0.98%	1.54%	8.22%	0.19%	7.15%	1.45%
A17	58.7%	4.65%	2.14%	14.7%	0.80%	1.94%	5.34%	0.26%	10.1%	1.31%
A18	56.7%	4.32%	2.54%	14.9%	1.00%	1.74%	7.01%	0.23%	9.43%	1.95%
A19	54.8%	3.90%	3.59%	13.9%	0.93%	1.39%	7.48%	0.26%	11.4%	2.29%
A20	58.9%	4.70%	1.95%	15.4%	0.83%	1.78%	5.39%	0.22%	9.49%	1.22%
A21	67.5%	3.05%	1.82%	10.0%	0.45%	1.43%	4.96%	0.27%	9.39%	1.02%
A22	62.9%	3.50%	1.73%	12.5%	0.80%	1.47%	6.40%	0.19%	8.90%	1.62%
A23	64.8%	3.52%	2.26%	13.2%	0.35%	1.04%	7.97%	0.18%	6.39%	0.25%
A24	62.6%	3.77%	1.94%	13.1%	0.79%	1.54%	6.15%	0.21%	8.40%	1.44%
A25	60.7%	4.28%	1.85%	14.3%	0.82%	1.71%	5.91%	0.20%	8.65%	1.53%
A26	65.6%	5.13%	0.80%	14.1%	0.38%	2.05%	3.58%	0.24%	7.30%	0.71%
A27	62.4%	4.59%	1.54%	14.3%	0.77%	1.73%	4.34%	0.24%	8.97%	0.96%
A28	66.3%	4.94%	0.75%	13.7%	0.39%	1.89%	3.64%	0.25%	7.32%	0.64%
A29	66.7%	4.59%	1.40%	13.7%	0.52%	2.10%	3.11%	0.15%	6.81%	0.76%
A30	61.4%	3.99%	2.93%	13.3%	0.97%	1.24%	5.72%	0.25%	9.06%	1.00%
A31	60.0%	5.23%	0.60%	16.4%	0.33%	2.34%	3.57%	0.25%	10.1%	1.04%
A32	61.6%	5.11%	0.87%	14.6%	0.42%	2.12%	3.35%	0.31%	10.5%	0.91%
A33	67.9%	4.92%	0.63%	14.1%	0.26%	3.56%	2.49%	0.16%	5.25%	0.54%
A34	57.0%	4.45%	2.81%	15.0%	1.31%	1.70%	5.57%	0.26%	10.5%	1.36%
A35	65.1%	5.20%	0.80%	15.1%	0.32%	2.53%	3.39%	0.20%	6.58%	0.64%
A36	55.0%	4.30%	2.91%	15.3%	1.18%	1.70%	6.00%	0.30%	11.7%	1.40%
A37	62.4%	5.36%	0.85%	15.4%	0.43%	2.22%	4.08%	0.29%	8.07%	0.80%
A38	62.3%	5.49%	0.85%	14.9%	0.36%	2.23%	3.81%	0.31%	8.71%	0.83%
A39	63.6%	5.38%	0.84%	15.2%	0.44%	2.26%	3.74%	0.18%	7.28%	0.95%
A40	58.6%	4.64%	2.23%	15.3%	1.07%	1.89%	4.98%	0.25%	9.69%	1.25%
A41	63.0%	5.00%	0.98%	15.1%	0.28%	2.45%	4.08%	0.23%	7.94%	0.84%
A42	56.9%	4.07%	2.64%	13.7%	1.02%	1.60%	6.28%	0.28%	11.7%	1.73%
A43	60.5%	4.64%	1.96%	15.2%	0.76%	1.90%	4.97%	0.19%	8.60%	1.20%
A44	57.4%	4.83%	2.47%	15.0%	1.13%	1.72%	5.50%	0.25%	10.2%	1.34%
A45	59.7%	4.62%	2.48%	14.0%	1.38%	1.48%	5.42%	0.18%	9.30%	1.36%
A46	57.0%	3.78%	2.29%	12.8%	0.68%	1.54%	6.25%	0.21%	13.3%	2.04%
A47	55.9%	4.38%	2.53%	15.3%	0.89%	1.64%	6.58%	0.26%	10.8%	1.58%
A48	53.5%	4.08%	3.37%	13.9%	1.02%	1.75%	6.63%	0.32%	13.4%	1.86%

Major elements for RNGP artefacts under study

	SiO2	Na2O	MgO	Al2O3	P2O5	K2O	CaO	MnO	Fe2O3	TiO2
A49	58.2%	4.12%	2.50%	14.7%	0.98%	1.47%	5.57%	0.24%	10.7%	1.41%
A50	56.1%	4.31%	2.80%	15.0%	1.04%	1.65%	6.79%	0.25%	10.2%	1.68%
A51	62.9%	5.31%	1.07%	14.9%	0.34%	1.95%	4.57%	0.23%	7.85%	0.77%
A52	60.0%	4.60%	2.08%	14.6%	0.76%	1.94%	4.97%	0.25%	9.50%	1.14%
A53	64.3%	4.86%	1.24%	15.5%	0.46%	2.33%	4.11%	0.13%	6.05%	0.89%
A54	55.3%	3.81%	3.38%	13.6%	0.93%	1.43%	6.80%	0.31%	12.7%	1.65%
A55	52.8%	2.72%	3.76%	16.2%	1.03%	0.91%	5.84%	0.32%	14.0%	2.42%
A56	60.3%	4.57%	1.95%	14.6%	0.71%	1.92%	4.84%	0.24%	9.51%	1.19%
A57	60.4%	4.57%	1.95%	14.6%	0.71%	1.92%	4.81%	0.24%	9.51%	1.18%
A58	60.4%	4.58%	1.94%	14.6%	0.70%	1.93%	4.78%	0.24%	9.51%	1.18%
A59	60.4%	4.59%	1.93%	14.6%	0.70%	1.94%	4.76%	0.24%	9.51%	1.17%
A60	60.5%	4.59%	1.93%	14.6%	0.70%	1.94%	4.73%	0.24%	9.50%	1.17%
A61	60.5%	4.60%	1.92%	14.6%	0.70%	1.95%	4.70%	0.24%	9.50%	1.16%

Major elements for RNGP artefacts under study (cont.)

	SiO2	Na2O	MgO	Al2O3	P2O5	K2O	CaO	MnO	Fe2O3	TiO2
G001	63.0%	4.18%	0.33%	17.0%	0.50%	3.48%	1.19%	0.22%	8.85%	1.14%
G002	64.2%	4.53%	0.35%	17.3%	0.22%	2.99%	1.65%	0.10%	7.63%	0.94%
G003	64.6%	4.88%	1.36%	14.0%	0.39%	2.66%	3.66%	0.21%	7.26%	0.86%
G004	57.2%	4.11%	2.72%	15.8%	0.95%	1.33%	7.17%	0.19%	9.01%	1.46%
G005	55.4%	4.11%	3.21%	15.8%	1.04%	1.37%	6.73%	0.26%	10.3%	1.69%
G006	56.0%	2.70%	2.54%	11.1%	0.53%	1.34%	9.38%	0.31%	13.3%	2.69%
G007	58.1%	3.70%	2.24%	14.5%	0.83%	1.55%	7.98%	0.22%	8.96%	1.78%
G008	51.1%	3.37%	4.55%	14.1%	0.70%	1.08%	8.49%	0.34%	14.0%	2.21%
G009	51.2%	3.48%	3.89%	15.0%	0.80%	1.19%	7.41%	0.33%	14.7%	1.88%
G010	54.2%	4.08%	3.79%	14.9%	0.81%	1.47%	8.11%	0.26%	10.5%	1.77%
G011	56.4%	4.08%	2.46%	15.5%	1.01%	1.34%	7.09%	0.22%	10.2%	1.66%
G012	57.1%	4.20%	2.33%	15.6%	0.96%	1.39%	7.84%	0.20%	8.38%	1.92%
G013	55.7%	4.14%	1.87%	15.8%	0.94%	1.58%	7.53%	0.25%	10.2%	1.87%
G014	55.5%	4.07%	3.44%	15.2%	0.94%	1.25%	7.50%	0.30%	10.3%	1.42%
G015	57.2%	3.85%	3.40%	14.0%	1.02%	1.59%	6.17%	0.41%	11.2%	1.09%
G016	57.3%	3.04%	2.69%	13.3%	0.60%	1.51%	9.14%	0.25%	10.2%	1.90%
G017	55.2%	4.14%	3.44%	15.6%	0.91%	1.54%	7.23%	0.22%	9.57%	2.02%
G018	56.2%	4.23%	2.55%	17.6%	0.98%	1.34%	7.66%	0.17%	7.83%	1.29%
G019	55.2%	3.84%	3.03%	16.1%	0.98%	1.18%	7.20%	0.22%	10.8%	1.35%
G020	55.6%	4.16%	3.40%	15.6%	0.87%	1.33%	7.49%	0.23%	9.48%	1.71%
G021	58.0%	3.93%	3.42%	14.0%	0.78%	1.26%	6.46%	0.26%	10.3%	1.44%
G022	55.4%	3.72%	4.62%	14.0%	0.70%	1.18%	6.59%	0.27%	11.9%	1.52%
G023	60.1%	4.39%	1.73%	17.0%	0.83%	1.36%	6.60%	0.16%	6.83%	0.89%
G024	57.5%	4.15%	2.96%	15.2%	0.86%	1.34%	6.69%	0.21%	9.22%	1.78%
G025	57.0%	3.94%	3.68%	14.4%	0.82%	1.26%	7.12%	0.24%	9.66%	1.73%
G026	53.7%	4.57%	2.34%	17.9%	1.09%	1.43%	8.41%	0.19%	8.28%	2.04%
G027	52.6%	4.01%	3.88%	14.9%	0.93%	1.61%	7.93%	0.30%	11.9%	1.78%
G028	54.3%	3.40%	2.87%	12.5%	0.73%	1.64%	8.56%	0.32%	13.1%	2.43%
G029	54.8%	4.05%	2.53%	15.0%	0.80%	1.37%	7.90%	0.28%	11.2%	2.01%
G030	55.0%	4.01%	2.61%	15.0%	0.77%	1.46%	8.11%	0.28%	10.8%	1.85%
G031	54.0%	3.53%	5.52%	12.9%	0.77%	1.22%	7.77%	0.33%	12.0%	1.91%
G032	55.7%	3.78%	3.47%	14.5%	0.90%	1.21%	8.13%	0.23%	9.78%	2.25%
G033	56.2%	2.69%	2.40%	11.5%	0.46%	1.40%	9.92%	0.33%	12.9%	2.13%
G034	55.0%	3.73%	3.04%	14.4%	0.67%	1.65%	8.32%	0.30%	11.5%	1.38%
G035	52.7%	3.24%	5.40%	12.6%	0.74%	1.09%	7.62%	0.25%	14.0%	2.27%
G036	55.5%	4.33%	2.88%	15.8%	0.82%	1.51%	7.51%	0.23%	10.0%	1.26%
G037	54.2%	3.93%	3.39%	16.1%	0.86%	1.52%	7.72%	0.27%	10.6%	1.25%
G038	55.5%	3.31%	1.96%	12.4%	1.10%	1.13%	7.21%	0.26%	14.8%	2.20%
G039	60.0%	4.55%	2.02%	16.1%	0.83%	1.48%	6.55%	0.18%	7.17%	1.03%
G040	58.2%	3.97%	3.17%	14.0%	0.84%	1.39%	6.98%	0.23%	9.59%	1.56%
G041	59.0%	3.88%	2.84%	14.7%	0.82%	1.22%	7.39%	0.19%	8.19%	1.61%
G042	53.7%	3.63%	5.09%	12.5%	0.86%	1.80%	6.18%	0.36%	14.2%	1.63%
G043	53.6%	3.59%	3.75%	14.8%	0.71%	1.08%	8.31%	0.25%	12.1%	1.68%
G044	55.6%	3.77%	3.31%	15.0%	0.79%	1.48%	7.22%	0.24%	10.7%	1.83%
G045	58.4%	4.19%	2.47%	15.9%	0.54%	1.50%	7.60%	0.17%	7.40%	1.80%
G046	59.9%	4.51%	1.53%	17.6%	0.68%	1.54%	6.91%	0.13%	5.91%	1.19%
G047	56.3%	3.88%	3.28%	15.2%	0.83%	1.46%	7.12%	0.23%	9.68%	1.97%
G048	56.7%	3.89%	3.06%	15.1%	0.82%	1.17%	6.85%	0.24%	10.1%	2.05%

Major elements for RNGP sties under study

	SiO2	Na2O	MgO	Al2O3	P2O5	K2O	CaO	MnO	Fe2O3	TiO2
G049	57.3%	4.05%	2.18%	16.0%	0.82%	1.15%	7.40%	0.17%	8.38%	2.49%
G050	58.7%	4.52%	2.30%	16.3%	0.80%	1.39%	7.22%	0.16%	7.34%	1.17%
G051	55.3%	3.85%	2.89%	14.4%	0.95%	1.38%	6.83%	0.26%	11.0%	3.03%
G052	55.9%	3.35%	3.47%	13.3%	0.81%	1.29%	6.99%	0.26%	12.3%	2.30%
G053	57.3%	4.03%	2.38%	16.7%	0.94%	1.10%	7.19%	0.17%	8.49%	1.61%
G054	55.3%	3.71%	3.91%	13.3%	0.87%	1.50%	7.11%	0.29%	11.8%	2.13%
G055	57.1%	4.46%	1.47%	18.0%	0.98%	1.43%	6.68%	0.14%	7.82%	1.86%
G056	58.0%	3.99%	2.48%	15.0%	0.82%	1.09%	6.76%	0.24%	10.1%	1.40%
G057	57.2%	3.92%	2.56%	15.5%	0.95%	1.33%	6.74%	0.22%	9.76%	1.67%
G058	57.8%	2.35%	2.02%	17.7%	0.96%	0.72%	5.73%	0.17%	9.31%	3.16%
G059	53.4%	3.55%	3.87%	13.2%	0.64%	1.18%	7.25%	0.32%	13.7%	2.77%
G060	54.8%	3.55%	3.39%	12.2%	1.08%	1.42%	6.99%	0.26%	13.6%	2.55%
G061	55.6%	3.67%	3.63%	13.0%	1.12%	1.31%	7.04%	0.27%	11.8%	2.53%
G062	60.7%	4.21%	1.92%	14.8%	0.66%	1.53%	6.46%	0.16%	8.04%	1.43%
G063	58.1%	4.51%	1.72%	16.6%	0.90%	1.49%	6.37%	0.14%	8.43%	1.21%
G064	57.3%	4.08%	1.81%	15.8%	0.79%	1.44%	7.10%	0.15%	9.59%	1.52%
G065	55.9%	4.24%	2.80%	15.0%	0.87%	1.19%	6.64%	0.21%	11.1%	1.64%
G066	55.3%	3.97%	2.00%	16.8%	0.80%	0.98%	7.22%	0.13%	11.1%	1.45%
G067	56.4%	4.41%	2.22%	16.0%	0.79%	1.44%	6.12%	0.19%	10.7%	1.50%
G068	53.2%	3.89%	1.87%	15.5%	0.71%	1.08%	6.45%	0.23%	13.9%	3.08%
G069	53.0%	3.76%	3.45%	16.1%	0.65%	1.11%	7.51%	0.21%	11.7%	2.46%
G070	54.4%	3.79%	3.85%	15.7%	0.83%	1.03%	7.42%	0.16%	10.4%	2.24%
G071	57.1%	4.09%	1.91%	14.8%	0.83%	1.66%	7.14%	0.16%	10.4%	1.86%
G072	52.7%	3.80%	2.90%	15.1%	0.80%	1.41%	7.05%	0.25%	13.4%	2.54%
G073	52.2%	3.75%	4.07%	15.2%	0.74%	1.12%	7.28%	0.25%	13.5%	1.89%
G074	54.7%	4.10%	2.62%	14.8%	0.77%	1.36%	7.28%	0.22%	11.2%	2.92%
G075	50.7%	3.63%	2.15%	15.8%	0.89%	0.72%	6.96%	0.27%	16.9%	2.02%
G076	54.4%	3.94%	2.07%	15.3%	1.05%	1.13%	6.96%	0.18%	12.2%	2.72%
G078	55.2%	4.25%	2.69%	16.7%	0.77%	1.28%	7.51%	0.19%	8.4%	2.78%
G079	52.3%	3.80%	4.00%	14.8%	0.72%	1.32%	6.84%	0.26%	12.9%	2.81%
G080	53.0%	3.95%	3.12%	14.7%	0.87%	1.22%	6.55%	0.25%	13.0%	3.22%
G081	50.1%	3.50%	4.17%	13.0%	0.90%	1.20%	6.84%	0.33%	16.1%	3.70%
G082	53.0%	3.42%	4.72%	11.8%	0.77%	1.38%	7.06%	0.35%	14.7%	2.65%
G083	53.8%	4.08%	2.74%	15.9%	0.85%	1.27%	6.92%	0.22%	11.4%	2.66%
G084	60.0%	5.38%	1.04%	14.9%	0.33%	1.90%	4.07%	0.31%	10.7%	1.02%
G085	61.2%	5.34%	0.96%	14.9%	0.33%	1.92%	4.05%	0.21%	10.0%	0.97%
G086	60.7%	5.17%	0.89%	15.4%	0.34%	2.01%	4.46%	0.23%	9.42%	1.19%
G087	57.6%	4.61%	0.94%	13.8%	0.31%	1.76%	3.84%	0.25%	15.9%	0.79%
G088	60.0%	4.91%	1.13%	14.5%	0.30%	1.91%	3.91%	0.28%	12.1%	0.92%
G089	62.2%	5.09%	0.96%	14.6%	0.33%	1.95%	3.85%	0.23%	9.87%	0.81%
G090	63.0%	5.16%	0.71%	14.9%	0.38%	2.08%	3.37%	0.18%	9.31%	0.87%
G091	62.1%	5.29%	0.54%	15.2%	0.30%	1.96%	2.62%	0.20%	10.5%	1.13%
G092	63.8%	4.71%	0.78%	14.0%	0.30%	1.91%	2.81%	0.23%	10.3%	0.89%
G094	63.6%	4.86%	0.90%	14.4%	0.31%	1.80%	3.51%	0.23%	9.29%	0.85%
G095	61.9%	4.84%	0.44%	16.3%	0.35%	1.91%	2.16%	0.14%	10.5%	1.06%
G096	61.8%	5.18%	0.70%	15.9%	0.31%	1.64%	3.51%	0.23%	9.48%	0.97%
G097	62.8%	5.00%	0.83%	14.9%	0.30%	1.87%	3.32%	0.21%	9.59%	0.92%

Major elements for RNGP sties under study (cont.)

	SiO2	Na2O	MgO	Al2O3	P2O5	K2O	CaO	MnO	Fe2O3	TiO2
G098	65.9%	5.73%	0.29%	16.7%	0.37%	2.19%	2.92%	0.06%	4.70%	1.01%
G099	62.1%	5.18%	0.28%	16.1%	0.40%	2.21%	2.26%	0.12%	10.1%	1.06%
G100	60.9%	5.36%	0.22%	18.1%	0.25%	1.92%	1.71%	0.10%	10.0%	1.07%
G101	64.2%	5.72%	0.21%	15.9%	0.38%	2.27%	2.51%	0.09%	7.46%	1.01%
G102	59.6%	5.29%	0.82%	15.3%	0.37%	2.18%	3.99%	0.16%	11.0%	1.14%
G103	59.2%	5.80%	0.42%	16.6%	0.43%	2.29%	2.69%	0.14%	11.0%	1.08%
G104	62.6%	4.81%	0.81%	13.4%	0.36%	1.82%	3.25%	0.27%	9.51%	0.62%
G105	61.9%	4.77%	0.28%	15.4%	0.16%	1.94%	1.60%	0.08%	7.84%	0.80%
G106	60.2%	4.87%	0.37%	15.6%	0.23%	2.00%	1.55%	0.14%	9.54%	0.89%
G107	66.1%	4.30%	0.51%	16.6%	0.18%	2.85%	1.27%	0.09%	7.08%	0.94%
G108	58.7%	4.24%	1.90%	15.8%	0.50%	1.90%	4.92%	0.19%	9.83%	1.43%
G109	69.9%	2.98%	0.44%	12.5%	0.15%	2.68%	2.76%	0.13%	7.26%	1.17%
G110	65.5%	4.56%	0.84%	15.0%	0.18%	3.09%	2.78%	0.14%	7.04%	0.83%
G111	64.8%	4.91%	0.88%	16.3%	0.22%	2.97%	2.58%	0.14%	6.27%	0.84%
G112	65.5%	4.89%	0.23%	15.9%	0.34%	2.99%	1.81%	0.19%	7.18%	0.86%
G113	65.2%	4.59%	0.17%	17.4%	0.29%	2.99%	1.18%	0.04%	7.0%	1.03%
G114	67.4%	3.57%	0.29%	15.5%	0.14%	2.63%	0.97%	0.09%	8.4%	0.96%
G115	65.7%	4.49%	0.73%	16.2%	0.56%	2.77%	1.80%	0.13%	6.7%	0.86%
G116	35.8%	1.67%	2.92%	16.9%	5.38%	0.79%	4.41%	0.31%	26.6%	5.13%
G117	52.4%	2.71%	0.18%	24.5%	0.34%	1.47%	0.78%	0.09%	14.4%	3.07%

Major elements for RNGP sties under study (cont.)

	Li	Be	B	Sc	V	Cr	Ni	Co	Cu	Zn	As	Rb	Sr	Zr	Nb
A01	5.3	2.8	12.2	29	94	1.6	0.9	37	9.3	389	1.4	26	249	409	71
A02	14	3.3	8.4	32	3	1.6	0.4	5.7	12	251	1.6	19	252	588	84
A03	11	2.6	5.5	26	78	0.8	0.3	20	12	191	1.1	32	305	449	62
A04	14	2.7	5.5	24	69	0.8	0.2	19	17	191	1.2	34	288	446	62
A05	13	2.6	5.7	25	80	0.8	0.1	19	20	187	1.0	33	293	445	61
A06	3.9	2.6	13.2	26	22	1.2	0.5	10	17	188	1.3	42	276	549	74
A07	12	3.1	9.0	21	23	1.2	0.5	6	7	150	1.2	73	302	556	79
A08	6.2	1.2	3.6	39	361	18	24.7	43	57	128	0.5	8	305	205	36
A09	9.3	2.7	6.0	29	119	1.0	0.8	20	19	170	1.1	30	336	470	72
A10	8.5	2.6	6.6	28	132	1.0	0.6	19	22	194	0.9	21	329	419	70
A11	4.9	2.4	9.1	26	107	1.9	1.2	11	13	151	1.6	11	299	389	62
A12	8.7	2.2	5.3	24	121	1.7	0.9	24	13	160	0.9	20	307	374	58
A13	7.1	2.3	5.6	30	142	1.7	1.0	18	19	200	1.1	22	310	397	64
A14	6.7	1.5	3.7	38	352	25.0	20.0	40	35	138	0.6	14	289	252	40
A15	6.5	2.6	8.4	22	37	1.6	0.3	10	4	133	0.8	30	299	482	75
A16	8.7	3.2	8.0	33	121	2.1	1.6	18	22	138	1.6	30	320	430	70
A17	11	3.0	6.3	26	27	1.6	0.5	16	17	192	1.5	41	257	523	70
A18	11	2.8	7.5	30	143	1.5	0.8	22	18	171	1.3	33	311	482	69
A19	13	2.2	5.9	37	202	1.6	0.9	27	15	201	1.0	24	291	398	59
A20	11	2.6	5.4	25	30	1.3	0.3	14	18	186	1.0	21	280	473	65
A21	13	2.9	5.5	23	14	0.7	0.8	13	13	192	3.0	26	139	377	46
A22	9.0	2.4	6.0	24	75	0.7	0.5	15	23	191	1.4	29	203	383	48
A23	5.2	2.1	4.2	24	34	0.7	0.8	17	19	78	0.9	12	246	317	8
A24	10	2.4	6.5	23	53	0.7	0.3	16	6	172	1.0	29	208	417	51
A25	10	2.6	6.5	22	54	0.9	0.3	15	15	187	1.0	42	238	469	56
A26	15	3.7	8.1	29	1.2	2.3	0.7	4	9	224	1.6	39	237	541	84
A27	14	2.9	7.3	28	12	2.1	0.5	10	14	229	1.1	35	265	503	68
A28	15	3.4	8.3	26	1.2	1.8	0.4	3	7	211	1.3	36	233	574	80
A29	4.6	3.0	10.1	22	19	1.8	0.3	9	14	214	0.9	31	238	484	71
A30	9.3	2.1	4.0	31	129	1.9	0.4	22	15	196	0.7	22	280	354	43
A31	10	3.8	7.8	35	4.4	2.4	1.0	4	18	202	1.5	38	272	720	98
A32	15	3.3	8.4	30	3.3	2.4	0.8	5	14	244	1.5	34	224	716	95
A33	23	5.2	10.1	15	1.6	2.1	0.5	4	12	219	2.2	70	124	592	106
A34	13	2.6	5.4	26	92	2.3	0.3	22	17	217	1.0	34	282	456	62
A35	17	3.6	7.8	21	1.1	2.4	0.1	4	9	210	1.5	50	208	646	76
A36	14	2.6	4.9	28	98	1.7	0.9	24	13	211	1.2	31	274	471	62
A37	17	3.5	6.5	26	1.4	1.9	0.4	4	10	221	1.4	39	271	680	87
A38	19	3.6	6.8	28	0.8	1.7	0.3	3	7	237	1.4	43	237	721	92
A39	8.4	3.3	4.8	32	1.0	1.6	0.2	3	8	194	0.8	42	237	737	92
A40	16	2.9	5.7	25	60.9	1.5	0.3	17	15	226	1.1	37	265	521	66
A41	17	3.5	7.1	24	0.7	1.0	0.2	6	9	178	1.5	45	228	618	71
A42	11	2.5	7.3	37	82	1.2	0.7	19	11	319	1.4	27	293	440	69
A43	7.2	2.9	5.6	26	22	0.8	0.3	10	19	175	0.9	34	273	530	69
A44	12	2.9	5.0	25	50	0.9	0.6	16	12	239	0.9	36	301	508	63
A45	5.5	2.2	8.0	22	54	1.2	0.9	13	8.1	198	1.2	22	293	408	52
A46	8.1	2.8	4.1	29	96	1.1	1.5	12	18	117	1.1	25	258	422	70
A47	11	2.5	4.6	26	80	0.8	0.3	21	19	179	1.0	29	309	459	57
A48	13	2.7	4.9	31	116	0.5	0.4	26	20	207	1.0	33	264	525	68
A49	11	2.5	6.3	25	68	0.3	0.2	19	15	166	1.2	33	245	397	61
A50	12	2.4	5.1	25	105	0.6	0.4	19	8.4	180	0.7	32	322	458	59
A51	11	3.7	8.8	30	2	1.4	0.5	4.0	8.6	193	1.3	24	271	659	81
A52	15	3.0	6.7	24	25	1.6	0.3	14	16	221	1.1	37	257	496	62
A53	3.9	3.3	8.6	22	21	1.7	0.3	7.3	9.1	176	0.6	42	240	595	77
A54	13	2.0	4.5	35	180	1.7	1.1	31	19	225	0.6	25	271	426	66
A55	14	1.8	3.0	39	276	1.9	2.3	43	28	255	0.2	6	192	419	63
A56	13	3.0	5.7	27	54	0.8	<dl	14	13	207	1.0	34	246	546	70
A57	13	3.0	5.7	27	53	0.8	<dl	14	13	207	1.0	34	245	548	71
A58	13	3.0	5.7	28	52	0.7	<dl	13	12	207	1.0	34	245	550	71
A59	13	3.0	5.6	28	51	0.7	<dl	13	12	208	1.0	34	244	552	71
A60	13	3.0	5.6	28	51	0.6	<dl	13	12	208	1.0	34	243	554	71
A61	13	3.0	5.6	28	50	0.6	<dl	13	12	208	1.0	34	242	556	71

Minor elements for RNGP artefacts under study

	Ag	In	Sn	Sb	Cs	Ba	La	Ce	Pr	Ta	Au	Y	Pb	Bi	U	W
A01	0.4	1.0	3.9	0.8	1.1	256	49	115	17	4.6	0.1	85	3.4	0.5	2.3	1.3
A02	0.5	0.7	4.9	0.7	0.7	262	35	86	13	5.2	0.0	79	3.5	0.2	2.3	1.2
A03	0.2	0.3	4.3	0.3	0.4	217	53	124	17	3.9	0.0	90	3.1	0.1	1.6	0.8
A04	0.3	0.3	4.2	0.4	0.5	219	51	120	17	4.0	0.0	86	3.5	0.1	1.8	0.8
A05	0.2	0.3	3.8	0.3	0.4	218	52	122	17	4.0	0.0	87	3.5	0.1	1.7	0.8
A06	0.5	0.6	5.0	3.1	0.8	227	49	106	15	4.2	0.0	79	4.2	0.3	2.1	1.0
A07	0.3	0.3	5.1	1.4	0.8	291	56	122	16	4.7	0.0	77	4.1	0.1	2.3	1.0
A08	0.2	0.2	2.2	0.8	0.2	100	23	53	7	2.4	0.0	45	2.5	0.1	0.8	0.3
A09	0.2	0.2	4.3	0.9	0.4	210	52	122	17	4.5	0.0	87	3.5	0.1	1.7	0.7
A10	0.2	0.3	3.6	0.6	0.3	174	49	113	16	4.5	0.0	80	3.1	0.1	1.3	0.7
A11	0.4	0.6	4.4	0.6	0.8	195	43	103	15	3.7	0.0	70	3.1	0.3	1.7	0.9
A12	0.2	0.3	3.5	0.3	0.4	191	43	105	14	3.5	0.0	70	2.4	0.1	1.3	0.6
A13	0.2	0.3	3.8	0.3	0.4	195	44	103	14	3.8	0.0	73	2.6	0.1	1.5	0.8
A14	0.2	0.3	2.4	0.2	0.3	117	24	59	8	2.5	0.0	44	1.7	0.1	0.9	0.4
A15	0.2	0.3	4.5	0.2	0.2	236	33	81	11	4.6	0.0	64	2.8	0.1	1.7	0.6
A16	0.3	0.5	4.0	2.5	0.6	195	45	106	15	3.5	0.1	78	4.5	0.3	1.6	1.1
A17	0.3	0.3	4.9	1.4	0.5	246	53	126	17	3.9	0.0	87	4.3	0.1	1.9	0.9
A18	0.3	0.3	4.5	1.0	0.4	215	50	120	17	4.0	0.0	84	3.9	0.1	1.6	0.8
A19	0.2	0.3	3.5	0.6	0.3	178	40	96	13	3.5	0.0	71	2.6	0.1	1.2	0.5
A20	0.2	0.2	4.2	0.5	0.4	244	47	113	16	3.7	0.0	80	4.2	0.1	1.8	0.6
A21	0.2	0.1	2.7	1.0	0.4	135	26	59	8	1.9	0.04	55	1.5	0.0	0.7	0.4
A22	0.2	0.1	2.6	0.9	0.4	151	29	63	9	2.0	0.02	58	1.9	0.0	0.8	0.4
A23	0.2	0.1	1.1	0.8	0.1	117	20	46	6	0.6	0.02	47	1.8	0.0	0.7	0.2
A24	0.2	0.1	3.1	0.9	0.3	169	32	74	10	2.5	0.02	63	2.2	0.0	1.0	0.4
A25	0.2	0.2	3.8	1.0	0.5	208	38	89	12	3.0	0.02	68	2.5	0.0	1.2	0.6
A26	0.5	0.6	5.7	0.7	0.8	270	57	136	19	5.4	0.06	87	3.8	0.4	2.8	1.5
A27	0.4	0.4	4.7	0.5	0.6	249	53	131	19	4.6	0.04	84	3.0	0.1	2.0	1.0
A28	0.4	0.4	5.3	0.4	0.6	267	57	138	20	5.3	0.04	92	3.4	0.1	2.5	1.2
A29	0.3	0.3	4.7	0.4	0.5	264	64	135	19	4.7	0.05	80	3.5	0.2	2.4	1.1
A30	0.2	0.3	3.5	0.3	0.3	162	36	90	13	3.5	0.03	65	2.1	0.1	1.4	0.6
A31	0.3	0.5	4.6	3.0	0.3	241	52	70	16	4.5	0.03	84	3.6	0.3	1.9	1.1
A32	0.4	0.5	4.9	3.1	0.5	256	39	91	14	5.0	0.04	75	4.0	0.2	2.1	1.0
A33	0.3	0.3	7.7	2.1	0.8	304	72	168	22	6.4	0.04	113	4.4	0.1	2.9	1.4
A34	0.2	0.2	3.7	1.5	0.4	209	48	117	17	3.7	0.03	82	2.4	0.1	1.5	0.8
A35	0.3	0.3	5.6	1.5	0.5	293	56	131	17	4.6	0.03	88	3.7	0.0	2.3	1.1
A36	0.3	0.4	3.6	2.7	0.5	185	44	103	15	3.4	0.03	85	2.4	0.2	1.5	0.9
A37	0.3	0.3	5.0	2.5	0.6	265	56	135	19	4.9	0.03	94	3.5	0.1	2.1	1.1
A38	0.3	0.3	5.4	2.1	0.5	278	60	143	20	5.3	0.03	100	3.8	0.1	2.3	1.0
A39	0.3	0.3	5.5	1.4	0.2	281	55	130	18	5.4	0.03	93	2.2	0.1	2.4	0.8
A40	0.2	0.2	4.5	1.3	0.5	233	51	122	17	4.0	0.02	85	3.2	0.1	1.8	0.9
A41	0.4	0.3	5.3	0.3	0.6	261	56	122	16	3.9	0.03	98	3.2	0.1	2.0	0.9
A42	0.3	0.4	4.3	0.5	0.6	205	50	117	17	4.6	0.03	91	3.1	0.2	1.8	0.8
A43	0.4	0.5	4.8	0.4	0.4	243	55	129	18	4.8	0.03	92	4.0	0.1	2.4	0.8
A44	0.2	0.2	3.5	0.3	0.3	234	54	128	18	4.6	0.03	94	2.7	0.0	1.9	0.7
A45	0.2	0.2	3.5	0.5	0.2	220	45	107	16	4.0	0.03	78	3.7	0.1	1.9	0.7
A46	0.3	0.4	2.9	1.9	1.7	159	36	80	11	3.2	0.02	73	2.6	0.1	1.1	1.2
A47	0.2	0.2	3.2	1.1	0.3	194	47	106	15	3.2	0.02	90	2.2	0.0	1.3	0.6
A48	0.2	0.2	3.8	0.6	0.4	190	53	122	17	3.9	0.02	105	2.8	0.1	1.6	0.7
A49	0.2	0.2	4.3	0.1	0.4	208	47	112	16	3.9	0.02	75	3.2	0.1	1.5	0.8
A50	0.2	0.1	2.4	0.6	0.4	192	48	112	16	3.6	0.02	97	1.1	0.0	1.4	0.7
A51	0.5	0.6	4.8	0.2	0.3	241	54	130	18	5.1	0.05	94	3.4	0.3	2.6	1.1
A52	0.3	0.4	4.3	0.8	0.5	232	52	127	18	4.1	0.05	80	3.3	0.1	1.9	1.0
A53	0.3	0.2	5.1	0.0	0.2	273	68	155	21	5.2	0.04	79	4.8	0.1	2.4	1.0
A54	0.2	0.3	3.6	0.5	0.3	172	40	102	15	4.7	0.03	68	2.9	0.1	1.3	0.6
A55	0.2	0.3	3.5	9.1	0.1	221	34	84	13	4.3	0.03	60	2.4	0.0	1.2	0.5
A56	0.3	0.3	4.3	1.6	0.4	229	51	120	17	4.4	0.03	87	3.0	0.1	1.8	0.8
A57	0.3	0.3	4.3	1.6	0.4	229	52	120	17	4.4	0.03	87	3.0	0.1	1.8	0.8
A58	0.3	0.3	4.3	1.6	0.4	230	52	121	17	4.4	0.03	87	3.0	0.1	1.8	0.8
A59	0.3	0.2	4.3	1.6	0.4	230	52	121	17	4.4	0.03	88	3.0	0.1	1.8	0.8
A60	0.3	0.2	4.3	1.6	0.4	230	52	121	17	4.4	0.03	88	3.0	0.1	1.8	0.8
A61	0.3	0.2	4.3	1.7	0.4	231	52	122	17	4.4	0.03	88	3.0	0.1	1.9	0.8

Minor elements for RNGP artefacts under study (cont.)

	Mo	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	Hf	Th
A01	6.0	56	15	4.8	15	3.1	14	3.5	7.3	1.4	6.5	1.4	11	4.8
A02	4.1	45	12	4.6	12	2.6	13	3.2	7.2	1.4	7.5	1.5	16	6.1
A03	3.9	59	15	4.5	15	2.8	14	3.4	7.6	1.3	6.9	1.2	12	5.1
A04	3.6	57	14	4.3	15	2.8	14	3.3	7.4	1.2	6.8	1.2	12	5.3
A05	3.7	59	15	4.6	15	2.9	14	3.4	7.6	1.3	6.9	1.2	12	5.2
A06	3.7	50	12	4.0	12	2.4	11	2.8	6.0	1.1	5.3	1.0	13	5.7
A07	3.3	53	13	4.3	12	2.3	12	2.9	6.4	1.1	6.0	1.1	14	7.0
A08	1.6	26	7	2.4	7	1.4	7	1.7	3.8	0.6	3.5	0.6	6	2.5
A09	3.5	58	14	4.5	15	2.8	14	3.3	7.4	1.2	6.8	1.2	12	5.3
A10	2.7	54	13	4.3	14	2.6	13	3.1	6.9	1.1	6.3	1.1	11	4.3
A11	2.8	52	13	4.7	13	2.4	12	2.7	6.2	1.1	5.5	1.0	10	4.3
A12	2.7	52	13	4.5	13	2.3	12	2.7	6.3	1.0	5.7	1.0	9	3.8
A13	3.1	51	13	4.6	13	2.4	13	2.9	6.9	1.1	6.4	1.1	10	4.2
A14	2.0	30	7.9	2.9	8.1	1.5	8	1.8	4.1	0.7	3.8	0.6	7	2.3
A15	3.1	43	11	5	11	2.0	11	2.5	6.0	1.0	5.8	1.0	13	5.2
A16	4.1	51	13	5	13	2.4	12	2.8	6.5	1.1	5.8	1.1	10	4.2
A17	4.4	60	15	5	15	2.7	14	3.2	7.6	1.2	7.2	1.2	13	5.5
A18	3.6	59	15	5	15	2.6	14	3.2	7.5	1.2	6.9	1.1	12	4.8
A19	2.8	49	12	4	13	2.2	12	2.7	6.4	1.0	5.8	1.0	10	3.7
A20	3.2	56	14	5	14	2.5	14	3.0	7.1	1.1	6.7	1.1	12	5.2
A21	3.3	32	7.7	2.2	8	1.3	8	1.5	4.1	0.6	3.8	0.6	6.8	2.5
A22	2.7	38	9.3	2.8	10	1.5	9	1.8	4.6	0.6	4.0	0.6	7.5	2.6
A23	0.6	27	7.0	2.5	7	1.3	8	1.5	4.1	0.5	3.4	0.5	7.2	2.0
A24	2.8	43	11	3.2	11	1.7	11	2.1	5.7	0.8	5.1	0.7	9.2	3.4
A25	3.1	52	13	3.8	14	2.1	13	2.5	6.6	0.9	5.8	0.9	12	4.3
A26	5.7	64	15	5.3	16	3.1	16	3.9	8.9	1.6	8.7	1.6	17	6.8
A27	4.3	64	16	5.0	16	3.1	16	3.8	8.4	1.4	8.0	1.4	14	5.7
A28	5.2	66	17	5.3	17	3.2	17	4.2	9.5	1.7	9.3	1.7	18	6.7
A29	3.9	63	15	4.3	15	2.8	15	3.5	8.0	1.4	7.5	1.3	14	6.5
A30	2.8	47	12	4.1	13	2.4	12	2.9	6.5	1.1	6.0	1.1	10	3.8
A31	3.8	52	13	4.5	13	2.5	12	2.9	6.5	1.2	5.9	1.2	14	5.3
A32	3.8	46	12	4.3	12	2.3	12	2.8	6.6	1.2	6.4	1.2	17	6.2
A33	6.5	72	17	3.3	17	3.4	18	4.3	10	1.7	9.8	1.7	16	9.2
A34	3.9	58	15	4.4	15	2.7	14	3.2	7.2	1.2	6.5	1.1	11	4.7
A35	5.4	57	14	3.9	14	2.7	15	3.5	8.1	1.4	7.9	1.4	16	7.1
A36	3.8	51	13	4.0	14	2.5	13	3.0	6.6	1.2	6.0	1.1	10	4.1
A37	5.0	61	15	5.0	15	2.9	15	3.6	8.4	1.4	8.1	1.5	16	6.3
A38	5.6	66	16	4.9	16	3.1	16	3.9	9.0	1.5	8.7	1.6	18	6.8
A39	3.7	62	15	5.0	15	2.9	15	3.7	8.4	1.5	7.8	1.4	19	7.2
A40	4.4	60	15	4.4	15	2.8	14	3.4	7.7	1.3	7.1	1.2	13	5.5
A41	4.9	53	13	3.5	13	2.5	13	3.2	7.4	1.3	7.1	1.3	14	6.3
A42	4.1	59	15	4.6	16	3.0	15	3.5	7.6	1.3	6.8	1.3	12	4.7
A43	3.8	62	16	4.4	16	3.0	15	3.7	8.3	1.4	7.8	1.4	15	6.9
A44	3.4	63	16	4.7	17	3.1	16	3.8	8.6	1.4	7.8	1.4	14	6.0
A45	3.2	54	14	4.4	14	2.7	14	3.3	7.2	1.2	6.4	1.1	12	5.6
A46	2.8	37	9	3.0	10	2.0	9	2.3	4.9	0.9	4.5	0.9	8	3.4
A47	3.2	50	13	3.7	13	2.4	12	2.9	6.4	1.1	5.7	1.0	10	4.2
A48	4.0	60	15	4.1	16	2.9	15	3.5	7.9	1.3	7.0	1.3	12	5.0
A49	4.6	55	14	5.0	14	2.7	13	3.3	7.0	1.2	6.4	1.2	11	4.5
A50	3.4	54	14	4.0	14	2.5	13	3.1	6.9	1.1	6.1	1.1	11	4.6
A51	4.7	58	14	4.6	15	3.1	15	3.9	8.4	1.6	8.1	1.6	16	7.0
A52	4.2	58	14	4.2	15	2.8	14	3.5	7.5	1.3	7.0	1.3	12	5.7
A53	3.8	67	16	4.2	15	2.9	14	3.4	7.6	1.3	6.8	1.2	16	7.6
A54	2.9	50	13	3.9	13	2.6	13	3.1	6.6	1.1	6.0	1.1	11	4.3
A55	2.2	43	12	3.6	12	2.3	12	2.8	6.0	1.0	5.7	1.0	11	4.5
A56	4.0	57	14	4.2	15	2.8	14	3.4	7.6	1.3	7.0	1.3	13	5.7
A57	4.0	57	14	4.2	15	2.8	14	3.4	7.6	1.3	7.1	1.3	13	5.7
A58	4.0	58	14	4.2	15	2.8	14	3.4	7.7	1.3	7.1	1.3	13	5.8
A59	4.0	58	14	4.2	15	2.8	14	3.4	7.7	1.3	7.1	1.3	13	5.8
A60	4.0	58	14	4.2	15	2.8	14	3.4	7.7	1.3	7.1	1.3	14	5.8
A61	4.0	58	14	4.2	15	2.8	14	3.5	7.7	1.3	7.1	1.3	14	5.8

Minor elements for RNGP artefacts under study (cont.)

	Li	Be	B	Sc	V	Cr	Ni	Co	Cu	Zn	As	Rb	Sr	Zr	Nb
G001	13	6.3	11.1	32	51	7.0	12.9	7.3	29	183	3.7	58	90	999	147
G002	19	5.0	7.4	21	31	4.8	3.9	7.6	13	189	1.3	62	135	876	127
G003	27	4.0	7.2	23	43	3.8	2.7	7.7	13	178	1.2	29	164	773	113
G004	6.0	2.5	4.2	31	142	2.7	0.8	18	18	188	0.8	24	339	411	59
G005	10	2.2	4.1	29	166	2.9	0.6	20	15	196	0.5	23	329	402	63
G006	7.7	2.3	2.5	46	254	1.6	1.2	29	15	115	0.4	17	234	414	64
G007	8.3	2.3	3.1	31	182	2.2	0.8	18	15	156	0.3	22	308	419	59
G008	10	1.8	2.5	41	231	1.9	1.4	33	22	175	0.3	15	281	405	60
G009	11	2.0	3.5	30	192	1.8	1.3	32	21	192	0.4	18	281	496	72
G010	8.6	2.1	3.4	35	171	2.3	1.7	22	21	140	0.5	19	322	431	62
G011	7.5	3.0	4.4	28	159	2.5	1.6	23	36	205	1.2	22	334	438	65
G012	6.5	2.6	4.3	35	189	2.5	1.1	18	28	174	1.0	21	326	461	73
G013	10	2.6	4.5	27	130	2.0	2.5	16	23	187	0.7	22	330	459	65
G014	10	2.3	3.4	29	151	1.8	0.8	22	16	214	0.3	16	322	412	60
G015	14	2.3	4.7	25	85	1.9	2.4	24	14	209	0.5	27	280	411	60
G016	6.7	2.4	2.8	34	161	1.2	1.1	21	13	110	0.3	21	302	382	56
G017	11	3.0	5.5	27	202	2.5	1.9	24	34	191	1.3	29	335	447	66
G018	5.8	2.6	3.7	28	128	1.9	0.8	15	19	131	0.6	21	369	438	61
G019	7.4	2.1	3.1	32	165	2.0	0.8	21	22	162	0.5	20	342	360	52
G020	9.3	2.1	3.8	29	154	1.8	0.7	20	18	172	0.4	19	330	416	60
G021	10	2.3	6.1	32	127	2.6	1.2	25	20	167	1.2	23	257	351	55
G022	9.1	2.2	5.2	33	149	2.3	0.9	26	15	190	0.8	21	282	364	55
G023	9.1	2.4	5.3	21	63	2.4	0.8	14	26	146	0.8	23	323	401	57
G024	8.9	2.1	4.9	30	155	2.0	0.8	20	21	158	0.5	24	299	392	62
G025	8.0	1.9	4.6	33	157	2.1	0.8	22	18	165	0.4	21	292	374	56
G026	5.3	2.3	3.2	33	164	1.5	0.7	18	21	139	0.7	21	365	477	69
G027	11	2.3	3.9	31	149	1.4	0.9	30	17	175	0.7	25	301	473	68
G028	10	3.0	4.3	40	195	1.5	1.4	29	17	171	1.1	25	242	443	65
G029	8.9	2.4	4.7	36	222	2.0	0.8	19	18	191	0.9	23	296	380	57
G030	11	2.6	4.7	27	228	2.1	1.1	25	17	183	1.0	26	289	436	68
G031	10	2.1	3.6	49	181	2.0	0.8	28	16	223	0.6	20	246	434	72
G032	6.5	2.1	3.5	39	210	1.8	0.7	20	17	159	0.4	16	262	412	69
G033	8.8	2.7	2.6	44	206	1.6	1.1	25	20	120	0.4	18	218	358	49
G034	11	2.3	3.4	38	122	1.5	1.0	27	17	144	0.5	25	261	476	53
G035	13	2.1	2.7	39	208	1.5	0.8	37	26	205	0.4	17	244	380	58
G036	9.4	2.6	3.5	30	109	1.6	0.8	16	20	173	0.5	27	303	441	59
G037	9.1	2.3	3.6	21	100	1.7	0.7	29	12	149	0.6	23	302	404	55
G038	6.9	3.1	6.0	24	131	2.2	1.6	18	33	186	1.1	15	230	344	51
G039	9.3	2.3	5.0	17	72	2.0	0.5	15	19	144	0.5	24	320	387	54
G040	11	2.1	4.6	28	137	1.8	0.4	17	14	166	0.4	23	274	382	54
G041	7.4	1.9	3.8	25	120	1.9	0.4	18	17	185	0.3	20	281	365	54
G042	14	2.5	5.4	26	134	1.5	0.9	41	13	199	0.4	32	227	449	63
G043	7.4	2.0	2.5	36	164	1.2	0.7	25	29	153	0.3	16	287	398	59
G044	9.8	1.9	3.9	28	170	1.2	0.5	23	18	160	0.3	27	275	486	66
G045	7.2	2.5	3.9	34	152	1.2	0.4	16	12	93	0.3	21	297	475	61
G046	5.2	2.2	5.8	24	74	2.2	0.5	11	12	118	0.5	18	312	359	51
G047	9.9	2.2	4.2	35	140	1.7	0.7	22	14	168	0.3	22	255	440	68
G048	9.1	2.0	3.7	30	137	1.6	0.5	17	11	143	0.3	16	258	377	55

Minor elements for RNGP sites under study

	Ag	In	Sn	Sb	Cs	Ba	La	Ce	Pr	Ta	Au	Y	Pb	Bi	U	W
G001	1.0	0.9	9.5	0.8	0.9	316	45	83	15	9.2	0.14	81	6.5	0.8	4.4	2.2
G002	0.7	0.5	8.8	1.6	0.7	334	19	43	6	8.4	0.10	46	5.5	0.3	3.5	1.3
G003	0.4	0.3	6.3	1.3	0.4	334	55	125	19	7.4	0.06	98	4.3	0.1	2.7	1.1
G004	0.3	0.3	3.9	1.7	0.3	193	47	112	16	4.0	0.05	75	2.9	0.1	1.5	0.7
G005	0.2	0.3	4.0	5.4	0.4	193	45	108	16	4.2	0.05	72	3.4	0.1	1.4	0.7
G006	0.2	0.2	2.0	5.5	0.3	99	26	57	8.0	2.2	0.02	66	0.9	0.0	0.5	0.3
G007	0.2	0.2	3.0	0.6	0.3	153	38	88	12	3.1	0.03	75	1.9	0.1	1.0	0.5
G008	0.2	0.3	2.9	1.1	0.3	133	34	81	12	3.5	0.03	70	2.1	0.1	0.8	0.6
G009	0.2	0.2	3.3	0.8	0.3	159	40	95	14	3.9	0.02	71	2.9	0.1	1.0	0.6
G010	0.2	0.4	3.1	1.4	0.3	172	43	103	15	3.8	0.03	81	2.2	0.1	1.2	0.6
G011	0.5	1.0	4.7	8.9	0.6	196	51	119	18	4.4	0.05	80	4.1	0.2	2.0	0.9
G012	0.4	0.4	4.3	1.7	0.4	197	49	117	17	5.1	0.04	85	5.4	0.2	2.0	0.7
G013	0.3	0.3	3.6	1.5	0.4	193	47	114	17	4.5	0.05	79	3.8	0.1	1.6	0.9
G014	0.2	0.3	3.1	0.6	0.3	184	46	110	16	4.2	0.03	77	2.9	0.1	1.5	0.6
G015	0.2	0.3	4.0	0.4	0.4	185	47	114	17	4.3	0.02	73	3.4	0.1	1.6	0.7
G016	0.2	0.1	2.1	0.7	0.2	107	29	65	9.1	2.3	0.02	67	2.1	0.0	0.7	0.4
G017	0.5	0.6	4.9	7.1	0.4	199	49	117	17	5.0	0.06	76	14.8	0.4	2.2	1.0
G018	0.3	0.3	4.2	2.2	0.3	190	54	126	18	4.5	0.03	86	4.9	0.1	1.4	0.8
G019	0.2	0.3	3.4	2.1	0.3	159	40	90	13	3.5	0.02	58	3.3	0.1	1.4	0.7
G020	0.2	0.2	3.5	1.1	0.2	189	43	105	15	4.1	0.03	73	3.3	0.1	1.4	0.8
G021	0.4	0.4	4.0	0.4	0.4	180	42	103	16	4.1	0.08	60	4.2	0.5	2.2	1.6
G022	0.3	0.3	3.5	0.8	0.3	191	37	98	14	4.1	0.06	58	3.1	0.1	1.6	1.0
G023	0.3	0.3	4.7	0.2	0.4	206	47	113	17	4.0	0.03	65	3.1	0.2	1.7	0.8
G024	0.2	0.2	4.1	0.2	0.4	199	44	107	16	4.5	0.03	65	2.6	0.1	1.6	0.7
G025	0.2	0.2	3.4	0.1	0.3	186	42	103	16	4.2	0.03	64	2.5	0.0	1.4	0.6
G026	0.2	0.2	3.3	1.6	0.3	223	50	119	17	3.8	0.02	83	2.6	0.0	1.2	0.6
G027	0.2	0.2	3.4	0.9	0.3	174	42	101	14	3.7	0.02	76	2.7	0.0	1.2	0.6
G028	0.3	0.5	3.0	0.8	0.6	142	33	78	11	3.0	0.05	66	2.8	0.2	1.5	0.7
G029	0.3	0.4	3.3	1.0	0.4	166	35	85	12	3.6	0.05	60	2.6	0.1	1.2	0.6
G030	0.3	0.4	3.7	1.3	0.4	172	38	92	14	4.4	0.04	65	2.6	0.1	1.4	0.8
G031	0.2	0.3	3.4	1.0	0.3	166	38	94	14	4.7	0.03	66	2.5	0.1	1.1	0.6
G032	0.2	0.3	3.5	0.8	0.3	172	38	94	14	4.2	0.03	67	2.5	0.1	1.2	0.7
G033	0.2	0.1	1.9	0.8	0.2	87	22	49	7	1.5	0.01	57	1.0	0.0	0.4	0.3
G034	0.2	0.2	3.1	1.0	0.3	152	33	79	11	2.4	0.02	68	2.1	0.1	1.0	0.5
G035	0.2	0.2	3.0	1.5	0.3	152	38	90	14	3.6	0.03	69	2.8	0.1	1.2	0.6
G036	0.3	0.2	3.8	1.3	0.4	199	41	98	14	3.5	0.02	77	3.4	0.1	1.3	0.7
G037	0.2	0.2	3.3	1.8	0.4	133	29	72	10	2.9	0.04	59	2.6	0.2	1.2	0.7
G038	0.3	0.4	4.4	4.6	0.6	206	41	102	16	4.2	0.1	61	9.3	0.4	2.8	2.0
G039	0.2	0.2	4.2	2.1	0.3	207	39	98	14	3.7	0.0	57	3.6	0.1	1.4	0.7
G040	0.2	0.2	3.6	1.2	0.3	190	40	100	15	3.8	0.0	61	3.2	0.1	1.3	0.6
G041	0.1	0.2	3.0	0.9	0.2	175	36	89	14	4.5	0.0	57	3.1	0.0	1.3	0.5
G042	0.2	0.2	4.1	0.8	0.3	196	44	112	17	4.5	0.0	69	3.5	0.0	1.6	0.7
G043	0.2	0.2	2.9	0.8	0.2	150	37	89	13	3.4	0.0	66	2.6	0.1	1.0	0.5
G044	0.2	0.2	3.8	0.7	0.3	183	43	104	15	4.1	0.0	72	2.7	0.0	1.3	0.6
G045	0.2	0.2	3.6	0.9	0.2	198	47	110	16	3.9	0.0	75	2.8	0.0	1.3	0.6
G046	0.2	0.2	3.4	0.1	0.2	183	35	86	12	3.2	0.0	51	2.3	0.01	1.1	0.5
G047	0.2	0.2	3.7	0.1	0.3	179	42	103	15	4.5	0.0	61	2.3	0.01	1.1	0.6
G048	0.1	0.2	2.8	0.1	0.2	161	35	85	13	3.6	0.0	56	1.8	0.00	0.9	0.4

Minor elements for RNGP sites under study (cont.)

	Mo	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	Hf	Th
G001	5.7	45	12	3.5	12	2.7	13	3.4	8.2	1.8	8.9	1.9	29	11
G002	5.5	20	6	3.1	6	1.4	8	2.2	5.3	1.1	6.1	1.1	26	10
G003	5.2	62	15	4.2	16	3.1	16	4.0	9.2	1.6	8.6	1.6	22	8.7
G004	2.9	55	14	4.4	14	2.6	13	3.1	6.9	1.2	6.2	1.1	11	4.7
G005	3.1	53	13	4.2	14	2.5	13	3.0	6.7	1.1	6.0	1.1	11	4.3
G006	2.4	27	7	2.0	7.1	1.4	6.5	1.6	3.4	0.6	2.9	0.6	5.3	1.7
G007	2.7	42	10	3.2	11	2.0	10	2.5	5.2	0.9	4.6	0.9	7.9	3.0
G008	2.6	41	11	3.2	11	2.1	10	2.5	5.4	0.9	4.7	0.9	8.6	3.1
G009	2.8	47	12	3.5	12	2.2	12	2.7	5.9	1.0	5.3	1.0	10	3.8
G010	3.2	51	13	3.9	14	2.5	12	2.9	6.4	1.1	5.6	1.0	10	3.5
G011	3.4	58	15	4.9	15	3.0	14	3.4	7.2	1.4	6.6	1.3	11	4.9
G012	3.3	58	15	4.7	15	2.9	15	3.5	7.7	1.4	7.1	1.4	12	4.8
G013	3.1	57	14	4.6	15	2.8	14	3.3	7.2	1.2	6.7	1.2	12	4.8
G014	2.3	56	14	4.4	15	2.7	14	3.3	7.2	1.2	6.4	1.1	11	4.5
G015	3.2	56	14	4.2	14	2.6	13	3.1	6.9	1.2	6.4	1.1	11	4.9
G016	2.4	31	8	2.4	8	1.5	7.5	1.8	3.8	0.7	3.4	0.6	6	2.3
G017	3.4	56	14	4.5	14	2.8	13	3.3	7.1	1.3	6.5	1.2	12	5.1
G018	3.0	62	15	4.7	16	2.9	15	3.4	7.6	1.2	6.8	1.2	13	5.1
G019	2.6	44	11	3.6	11	2.1	10	2.5	5.4	0.9	4.8	0.8	9	4.1
G020	2.6	53	13	4.2	14	2.5	13	3.1	6.8	1.1	6.1	1.1	11	4.4
G021	3.3	52	13	4.3	13	2.5	12	3.0	6.4	1.1	6.1	1.1	10	4.3
G022	2.6	46	12	3.9	12	2.3	12	2.8	6.4	1.1	6.1	1.1	10	4.1
G023	3.1	56	14	4.5	14	2.6	13	3.1	6.9	1.2	6.3	1.1	11	4.9
G024	2.9	55	14	4.5	14	2.6	13	3.1	6.9	1.1	6.2	1.1	11	4.5
G025	2.6	53	14	4.3	14	2.6	13	3.0	6.7	1.1	6.1	1.0	10	4.2
G026	3.1	57	14	4.4	15	2.6	13	3.1	6.8	1.1	5.9	1.0	10	4.2
G027	3.1	49	13	3.7	13	2.4	12	2.9	6.4	1.1	5.7	1.0	10	4.1
G028	3.0	38	10	3.0	10	1.9	9.0	2.2	4.9	0.8	4.3	0.8	8	4.3
G029	2.9	43	11	3.6	12	2.1	11	2.5	5.7	0.9	5.1	0.9	9	3.4
G030	3.3	47	12	4.0	13	2.4	12	2.9	6.4	1.1	5.9	1.1	10	3.9
G031	2.6	48	12	3.8	13	2.4	13	2.9	6.6	1.1	6.1	1.1	11	3.8
G032	2.7	50	13	4.0	14	2.4	13	2.9	6.5	1.0	5.7	1.0	11	3.7
G033	2.4	23	6.0	1.8	6.2	1.1	5.5	1.3	2.9	0.5	2.5	0.4	4.0	1.3
G034	2.9	40	10	3	10	1.9	10	2.3	5.1	0.9	4.5	0.8	8.0	3.1
G035	2.3	48	12	3.6	13	2.3	12	2.7	6.2	1.0	5.6	1.0	8.9	3.5
G036	2.9	49	13	4.0	13	2.3	12	2.8	6.5	1.1	5.9	1.1	10	4.3
G037	3.2	36	9.1	3.0	9.3	1.7	8.6	2.1	4.5	0.8	4.2	0.8	7.8	3.1
G038	4.2	55	14	4.4	14	2.7	13	3.3	7.3	1.4	6.7	1.4	11	4.7
G039	2.9	50	12	4.1	12	2.3	12	2.7	6.2	1.0	5.7	1.0	10	4.3
G040	2.8	52	13	4.2	13	2.4	13	3.0	6.7	1.1	6.2	1.1	11	4.1
G041	2.3	48	12	4.0	12	2.3	12	2.8	6.3	1.0	5.7	1.0	10	3.7
G042	3.1	59	15	4.3	15	2.7	14	3.3	7.6	1.2	6.9	1.2	12	5.0
G043	2.1	47	12	3.6	13	2.3	12	2.8	6.2	1.0	5.6	1.0	9.2	3.4
G044	2.9	53	14	3.9	14	2.5	13	3.0	7.0	1.1	6.2	1.1	12	4.6
G045	2.5	54	13	3.9	14	2.6	14	3.2	7.5	1.2	6.8	1.2	12	4.8
G046	2.7	41	10	3.4	10	2.0	10	2.4	5.0	0.9	4.6	0.8	8.6	3.4
G047	3.0	52	13	3.9	13	2.6	12	3.2	6.4	1.1	5.8	1.0	11	4.0
G048	2.4	43	11	3.3	11	2.1	10	2.6	5.4	1.0	4.9	0.9	8.9	3.2

Minor elements for RNGP sites under study (cont.)

G049	4.8	1.9	3.3	28	160	1.9	0.6	18	18	134	0.1	16	286	368	57
G050	6.2	2.3	3.8	25	80	1.9	0.7	16	14	144	0.3	20	292	379	55
G051	8.9	2.1	4.7	28	179	1.8	1.0	23	16	150	0.6	22	251	420	68
G052	7.8	2.3	4.0	34	188	1.4	0.8	31	16	186	0.3	23	230	432	63
G053	6.0	2.1	3.2	25	118	1.3	0.8	17	18	188	0.3	16	294	461	59
G054	10	2.2	4.7	34	117	1.4	0.8	26	14	186	0.2	29	231	432	59
G055	3.5	2.2	4.2	25	106	1.3	0.5	12	12	135	0.2	26	318	486	67
G056	7.5	1.5	2.9	22	153	0.6	0.5	17	15	166	0.6	17	278	307	44
G057	6.4	2.7	4.3	26	82	0.5	0.5	17	17	163	0.5	23	262	466	61
G058	6.4	1.4	1.5	32	119	0.4	0.7	15	9	138	0.0	5	145	558	81
G059	10	1.9	2.7	38	142	0.6	0.9	28	12	241	0.2	17	232	391	61
G060	11	2.1	3.9	38	168	0.8	0.9	30	16	229	0.3	24	208	435	66
G061	12	1.9	3.0	32	129	0.4	0.8	24	10	187	0.4	18	230	384	64
G062	4.0	2.9	3.7	23	78	0.2	0.4	14	12	130	0.3	27	256	462	63
G063	6.0	2.2	4.3	21	54	1.6	0.4	13	16	144	1.2	21	270	382	46
G064	7.7	2.2	4.3	29	84	1.4	0.4	12	11	123	1.0	25	264	382	46
G065	10	1.8	3.7	23	122	1.4	0.6	20	14	154	0.9	19	279	429	60
G066	5.9	1.7	3.0	27	85	1.1	0.6	14	11	150	0.7	13	288	328	43
G067	8.0	2.8	5.6	22	85	1.0	0.6	18	20	158	1.4	22	244	399	53
G068	10.3	2.3	4.2	20	107	0.9	1.1	28	19	155	0.8	18	271	372	58
G069	8.7	1.6	3.1	29	148	0.6	0.7	20	13	153	0.7	21	296	349	56
G070	5.7	2.1	3.1	30	144	0.5	0.6	17	20	156	0.6	17	290	388	56
G071	6.9	2.6	4.4	24	97	0.4	0.3	12	17	172	0.9	29	283	487	69
G072	9.1	2.3	3.9	32	147	0.4	0.6	25	15	167	1.0	23	268	426	63
G073	10	1.8	3.1	34	186	0.2	0.8	28	13	168	0.7	19	293	314	46
G074	10	2.3	3.8	24	134	0.2	0.6	20	15	151	0.7	24	268	451	65
G075	10	1.6	1.4	22	111	0.1	0.6	24	13	219	0.4	7.1	270	433	65
G076	7	1.8	3.0	25	121	0.2	0.6	24	18	249	0.4	18	280	411	59
G078	7	2.1	4.6	26	134	1.8	0.6	16	13	112	1.0	22	279	374	56
G079	13	1.9	4.1	30	169	1.4	0.7	26	10	148	0.8	24	252	332	48
G080	10	2.2	4.0	33	167	0.9	0.6	22	16	151	1.0	20	247	423	67
G081	11	2.2	4.1	36	221	0.8	0.8	27	10	169	0.7	22	219	383	62
G082	15	2.0	4.6	35	151	1.4	1.6	30	11	172	1.1	28	204	361	55
G083	9	2.2	4.2	31	154	0.4	0.6	19	20	138	0.8	22	274	403	60
G084	14	3.2	5.6	28	0.9	0.1	0.1	3.6	7.3	207	0.9	23	212	729	85
G085	10	3.2	8.0	29	0.8	0.2	0.2	3.9	5.7	199	0.8	21	213	744	77
G086	15	3.5	4.1	34	1.5	0.0	0.2	4.6	7.3	233	0.8	53	223	810	91
G087	12	3.5	11.8	26	0.7	0.3	0.2	2.6	13.2	195	4.2	21	204	567	65
G088	18	3.2	5.5	27	0.9	0.1	0.2	4.3	6.8	179	1.1	45	206	740	86
G089	13	3.4	6.7	27	0.6	0.0	0.2	3.0	4.9	182	1.2	37	206	724	81
G090	13	3.4	5.9	28	0.8	0.1	0.1	2.9	2.8	150	0.9	36	208	716	80
G091	9	3.0	6.1	27	0.9	3.0	0.1	2.8	5.0	216	0.7	29	209	747	86
G092	7	3.4	6.9	29	0.8	1.9	0.2	3.1	4.6	180	0.9	44	173	697	80
G094	5.4	3.0	5.4	28	1.1	2.1	0.2	3.3	4.7	186	0.7	42	211	642	72
G095	5.3	3.5	6.6	35	0.9	1.6	0.3	2.1	8.0	215	1.0	18	194	683	84
G096	6.4	3.1	7.2	26	0.8	1.8	0.2	3.6	5.6	196	0.6	26	225	587	68
G097	6.1	3.4	5.8	31	0.7	1.7	0.2	2.9	4.7	175	0.6	38	210	660	77
G098	8.4	2.7	4.7	24	0.9	1.9	0.2	1.7	9.0	126	0.5	63	244	751	92

Minor elements for RNGP sites under study (cont.)

	Ag	In	Sn	Sb	Cs	Ba	La	Ce	Pr	Ta	Au	Y	Pb	Bi	U	W
G049	0.1	0.2	2.6	0.1	0.2	155	35	84	13	3.8	0.0	57	1.8	0.00	0.8	0.4
G050	0.1	0.1	3.2	0.1	0.2	187	39	97	14	3.6	0.0	60	2.1	0.01	1.1	0.5
G051	0.2	0.2	3.9	0.7	0.2	188	43	107	16	4.9	0.0	64	3.0	0.06	1.4	0.6
G052	0.2	0.2	3.5	0.4	0.3	174	46	111	17	4.5	0.03	70	2.4	0.02	1.2	0.5
G053	0.2	0.2	4.3	0.4	0.2	202	45	112	17	4.4	0.02	68	3.2	0.01	1.2	0.6
G054	0.2	0.2	3.6	0.2	0.3	182	43	105	16	4.4	0.02	69	2.4	0.01	1.2	0.6
G055	0.2	0.2	4.5	0.2	0.3	231	46	114	17	4.9	0.02	66	3.1	0.01	1.3	0.7
G056	0.1	0.2	2.3	1.1	0.2	157	29	85	12	3.0	0.02	49	2.0	0.02	0.8	0.4
G057	0.2	0.2	3.9	0.6	0.3	191	46	112	17	4.2	0.02	69	2.5	0.01	1.3	0.6
G058	0.2	0.2	4.6	0.4	0.1	216	27	67	11	5.8	0.02	44	2.5	0.01	0.8	0.5
G059	0.1	0.2	3.0	0.3	0.2	169	34	82	12	4.2	0.02	57	2.1	0.01	0.9	0.4
G060	0.1	0.2	4.1	0.3	0.2	174	41	101	15	4.5	0.02	68	2.4	0.01	1.1	0.5
G061	0.1	0.2	3.5	0.6	0.2	184	43	108	16	4.6	0.02	70	2.2	0.01	1.1	0.5
G062	0.2	0.2	4.0	0.5	0.2	210	39	94	13	4.2	0.02	57	2.5	0.01	1.5	0.7
G063	0.1	0.1	3.6	0.0	0.3	182	33	81	11	2.6	0.2	54	2.4	0.01	0.9	0.5
G064	0.1	0.1	3.4	0.0	0.3	170	33	79	11	2.5	0.2	58	2.3	0.02	0.9	0.5
G065	0.1	0.1	4.0	0.0	0.2	151	38	90	12	3.6	0.1	65	2.6	0.01	1.0	0.5
G066	0.1	0.1	2.7	0.1	0.1	162	29	71	10	2.6	0.1	49	1.6	0.00	0.8	0.4
G067	0.1	0.2	3.8	0.6	0.3	190	41	99	13	3.4	0.08	58	2.7	0.02	1.1	0.7
G068	0.1	0.1	3.8	0.1	0.2	178	36	84	12	3.8	0.06	51	2.5	0.01	1.0	0.6
G069	0.1	0.2	3.1	0.0	0.3	158	29	69	10	2.7	0.03	50	1.7	0.00	0.7	0.4
G070	0.1	0.2	3.5	0.1	0.2	166	41	92	13	3.5	0.02	63	2.2	0.01	0.9	0.6
G071	0.1	0.2	4.6	0.0	0.3	179	37	89	12	3.5	0.02	62	2.8	0.02	1.3	0.7
G072	0.1	0.2	3.6	0.2	0.3	188	39	92	13	4.2	0.02	62	2.7	0.01	1.1	0.6
G073	0.1	0.2	2.8	0.2	0.2	160	30	71	10	3.2	0.01	47	2.1	0.01	0.8	0.6
G074	0.1	0.2	3.8	0.1	0.3	207	39	91	13	4.2	0.004	64	2.7	0.01	1.2	0.6
G075	0.1	0.2	3.9	0.1	0.2	195	33	80	12	4.8	0.01	54	2.1	0.02	0.7	0.5
G076	0.1	0.2	3.3	0.0	0.3	201	37	88	12	4.0	0.20	60	2.5	0.01	1.1	0.6
G078	0.1	0.2	3.1	0.0	0.3	165	36	81	12	3.3	0.05	59	2.1	0.01	1.0	0.5
G079	0.1	0.2	2.7	0.1	0.2	149	29	69	10	2.9	0.04	48	2.2	0.01	0.9	0.5
G080	0.1	0.2	3.3	0.0	0.3	182	39	91	13	4.1	0.04	62	2.6	0.01	1.2	0.6
G081	0.1	0.2	2.9	0.0	0.3	164	34	82	12	3.8	0.04	57	2.3	0.01	1.1	0.5
G082	0.2	0.3	2.7	0.3	0.3	164	29	71	11	3.6	0.03	57	2.8	0.03	0.9	0.5
G083	0.1	0.2	3.3	0.2	0.3	185	38	89	13	3.9	0.03	61	2.4	0.01	1.1	0.6
G084	0.2	0.2	5.3	0.2	0.1	269	56	125	17	5.3	0.03	85	2.6	0.01	1.9	0.6
G085	0.2	0.2	5.0	0.1	0.2	268	53	119	17	5.3	0.03	87	3.9	0.01	1.9	0.8
G086	0.3	0.2	5.6	0.1	0.2	269	57	124	17	5.7	0.04	92	4.1	0.02	2.0	0.7
G087	0.2	0.2	2.4	0.4	0.7	273	49	111	16	4.2	0.03	80	15.0	0.02	1.7	2.2
G088	0.2	0.2	5.0	0.3	0.2	257	55	123	17	5.5	0.03	85	2.8	0.02	2.1	0.9
G089	0.2	0.2	4.9	0.3	0.1	316	54	126	17	5.3	0.04	86	2.7	0.03	2.1	0.9
G090	0.2	0.2	5.2	0.2	0.2	281	48	118	16	5.2	0.03	76	2.3	0.00	2.0	0.9
G091	0.2	0.2	5.5	0.2	0.2	274	38	69	12	5.5	0.03	60	2.8	0.01	2.1	0.9
G092	0.3	0.3	5.3	0.1	0.2	235	32	77	11	5.0	0.06	59	1.6	0.04	1.8	0.8
G094	0.3	0.3	5.0	0.5	0.2	236	36	80	12	4.5	0.05	66	1.6	0.03	1.7	0.6
G095	0.3	0.3	4.3	0.8	0.1	251	27	49	9.1	5.2	0.04	56	2.7	0.04	1.8	0.8
G096	0.2	0.2	4.3	0.8	0.2	247	39	89	12	4.3	0.04	64	2.9	0.03	1.7	0.7
G097	0.3	0.2	4.9	0.1	0.1	249	33	71	11	4.7	0.05	62	1.9	0.03	1.8	0.7
G098	0.3	0.2	5.8	0.5	0.2	293	43	106	14	5.6	0.05	65	3.2	0.02	2.4	0.9

Minor elements for RNGP sites under study (cont.)

	Mo	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	Hf	Th
G049	1.8	44	11	3.5	11	2.2	10	2.6	5.3	0.9	4.5	0.9	8.6	2.9
G050	2.7	47	12	3.7	12	2.3	11	2.8	5.6	1.0	5.0	0.9	9.0	3.6
G051	3.0	55	14	4.1	14	2.7	13	3.3	6.8	1.2	6.3	1.2	11	4.1
G052	2.8	58	15	4.1	15	2.9	14	3.5	7.2	1.2	6.3	1.2	11	4.1
G053	2.6	58	15	4.4	15	2.9	14	3.5	7.0	1.2	6.1	1.1	12	4.7
G054	3.1	54	14	3.9	14	2.8	14	3.4	7.2	1.3	6.5	1.2	11	4.2
G055	3.2	57	14	4.4	14	2.8	13	3.3	6.8	1.2	6.0	1.1	13	5.2
G056	2.0	42	11	3.3	10	2.0	10	2.4	5.0	0.9	4.5	0.8	8	2.7
G057	3.0	57	14	4.1	14	2.8	14	3.4	7.0	1.2	6.4	1.2	12	4.8
G058	2.5	37	10	3.0	10	1.9	9	2.2	4.4	0.7	3.7	0.7	14	5.5
G059	2.6	41	11	3.3	11	2.2	11	2.8	5.7	1.0	5.3	1.0	10	3.4
G060	3.9	51	13	3.7	14	2.7	13	3.2	6.6	1.1	5.8	1.1	11	3.8
G061	2.6	57	15	4.2	15	2.8	14	3.4	6.9	1.2	5.9	1.1	10	4.0
G062	2.8	44	11	3.5	11	2.2	11	2.8	5.9	1.1	5.6	1.0	11	4.7
G063	2.6	45	11	3.7	11	1.8	11	2.2	5.6	0.8	5.0	0.7	9.2	3.2
G064	2.4	45	11	3.7	12	1.9	12	2.3	6.2	0.8	5.4	0.8	9.3	3.0
G065	3.2	53	13	4.0	13	2.2	13	2.6	6.8	0.9	5.9	0.9	11	3.2
G066	1.8	41	10	3.6	10	1.7	10	2.0	5.3	0.7	4.6	0.7	8.2	2.6
G067	3.0	54	13	4.2	13	2.2	13	2.7	7.1	1.0	6.4	0.9	11	3.8
G068	3.0	48	12	3.7	12	1.9	12	2.4	6.3	0.9	5.8	0.9	11	3.5
G069	2.4	42	11	3.6	11	1.8	11	2.2	5.8	0.8	5.2	0.8	10	2.7
G070	2.6	54	13	4.2	14	2.2	14	2.7	7.2	1.0	6.6	1.0	11	3.3
G071	3.9	51	13	4.2	13	2.2	14	2.8	7.3	1.0	6.8	1.0	13	4.1
G072	2.9	54	14	4.3	14	2.3	14	2.8	7.2	1.0	6.6	1.0	12	3.7
G073	2.3	41	10	3.6	10	1.7	10	2.1	5.5	0.7	5.0	0.7	10	2.9
G074	2.8	53	14	4.4	14	2.3	14	2.9	7.5	1.0	7.0	1.0	12	4.0
G075	2.2	49	12	4.2	13	2.0	12	2.5	6.4	0.9	5.6	0.8	12	4.0
G076	2.5	53	13	4.4	14	2.2	13	2.6	6.9	0.9	5.9	0.9	12	3.6
G078	2.5	47	12	4.0	12	2.0	11	2.5	6.2	0.9	5.4	0.9	9.3	3.2
G079	2.4	38	10	3.4	10	1.7	9	2.0	5.2	0.8	4.6	0.7	9.1	3.0
G080	2.5	51	13	4.2	13	2.2	12	2.6	6.7	1.0	5.7	0.9	11	3.6
G081	2.5	46	12	3.8	12	2.0	11	2.5	6.4	0.9	5.5	0.9	10	3.2
G082	3.1	43	11	3.7	11	2.1	12	2.6	6.5	0.9	5.6	0.9	10	2.7
G083	2.7	50	13	4.3	13	2.2	13	2.7	7.0	1.0	6.0	1.0	11	3.7
G084	5.3	66	16	5.1	16	2.9	17	3.8	10	1.5	9.1	1.5	19	6.1
G085	3.5	66	16	5.3	17	3.0	17	3.9	10	1.5	9.3	1.6	19	6.2
G086	3.9	68	17	5.4	17	3.1	18	4.1	11	1.6	9.5	1.6	21	6.8
G087	3.1	63	15	5.1	16	2.8	16	3.8	10	1.5	9.5	1.6	15	4.9
G088	3.5	67	16	5.1	16	2.9	17	3.8	10	1.5	9.1	1.5	20	6.6
G089	3.2	66	16	5.3	16	3.0	17	3.9	10	1.5	9.5	1.6	19	6.6
G090	3.6	63	16	5.2	15	2.8	16	3.6	9.4	1.4	8.9	1.5	20	6.5
G091	4.6	45	11	4.9	11	2.1	12	2.7	7.4	1.1	6.9	1.1	20	6.6
G092	3.4	43	11	4.3	11	2.1	12	2.7	6.6	1.1	6.7	1.2	17	5.9
G094	3.2	45	11	4.5	12	2.2	12	2.8	6.9	1.1	6.7	1.2	16	5.4
G095	3.1	35	9.4	4.2	10	1.9	11	2.6	6.3	1.1	6.4	1.1	17	5.8
G096	2.4	47	12	4.7	12	2.1	12	2.8	6.9	1.1	6.6	1.1	15	5.2
G097	3.1	43	11	4.6	11	2.1	12	2.8	6.8	1.1	6.9	1.2	17	5.8
G098	3.5	51	12	5.3	12	2.2	12	2.8	6.6	1.1	5.9	0.9	18	6.4

Minor elements for RNGP sites under study (cont.)

	Li	Be	B	Sc	V	Cr	Ni	Co	Cu	Zn	As	Rb	Sr	Zr	Nb
G099	6.5	4.4	5.6	27	0.9	1.6	0.2	1.4	6.2	207	0.9	50	210	802	93
G100	10	10.4	7.7	31	0.9	1.4	0.1	1.4	4.8	156	1.1	18	197	738	91
G101	8.3	3.6	6.1	23	0.8	1.4	0.1	1.3	6.7	176	0.9	47	215	829	96
G102	8.1	3.4	5.0	33	1.4	0.9	0.2	5.0	10.3	161	1.2	23	224	762	84
G103	10	4.1	5.5	34	1.4	1.1	0.2	1.7	7.7	172	1.4	27	245	793	88
G104	12	3.6	5.9	27	0.6	2.5	0.3	3.9	7.7	203	1.3	34	186	649	71
G105	8.2	4.5	6.9	27	2.0	2.5	0.1	1.3	7.6	139	1.2	45	184	671	85
G106	10	5.3	10.6	29	1.0	2.2	0.1	1.8	6.4	156	0.8	24	180	700	91
G107	15	4.1	6.9	22	26	2.6	4.2	5.4	14	179	0.7	83	109	876	116
G108	12	3.1	4.4	27	107	2.7	3.9	13.8	15	180	0.6	51	159	566	75
G109	3.0	4.9	2.5	24	56	1.0	3.3	9.9	23	93	0.3	23	93	687	91
G110	11	4.1	4.8	20	23	2.2	3.3	7.0	9.0	136	0.7	45	134	854	101
G111	10	4.0	6.0	22	23	2.1	2.3	6.3	11	127	0.8	74	137	915	106
G112	22	4.4	6.8	19	35	2.1	2.4	8.5	18	136	1.6	64	151	958	126
G113	18	4.9	6.3	22	38	2.4	3.9	5.4	20	163	1.0	65	111	993	130
G114	21	4.7	7.6	20	47	5.5	3.7	5.6	22	179	1.8	72	79	1000	126
G115	13	4.5	9.5	18	37	3.2	4.9	8.1	23	155	2.3	63	107	873	112
G116	21	2.9	4.4	70	609	71	26	41	37	436	10	16	89	457	83
G117	20	3.4	5.1	29	317	11	15	17	29	316	1.3	16	90	575	93
RR01	11	3.5	4.8	30	3	1.5	0.8	4.5	12	195	1.2	44	266	732	88
RR02	10	3.1	4.8	25	6	1.6	0.6	9.5	14	224	1.4	34	259	631	74
RR03	9.0	2.2	3.6	28	175	1.2	0.8	24	19	180	0.9	24	347	447	67
RR04	7.6	2.8	5.4	33	151	1.3	0.6	17	16	149	1.1	30	351	491	67
RR05	7.4	2.8	5.6	29	140	1.6	1.6	18	33	201	1.6	23	299	416	58
RR06	11	3.6	6.5	24	2	1.6	0.5	3	12	178	1.4	23	263	642	77
RR07	11	3.0	6.3	26	83	1.7	0.8	18	21	171	1.1	29	271	493	60
RR08	5.7	1.9	3.9	28	66	1.5	0.8	25	13	123	0.5	13	290	259	14
RR09	11	2.8	5.5	23	24	1.6	0.2	12	22	207	0.9	22	280	475	57
RR10	7.8	2.6	4.2	43	193	1.7	1.4	19	32	151	1.2	18	302	522	59
RR11	11	2.5	5.6	33	162	1.8	2.1	27	31	183	1.1	21	321	413	59
RR12	11	3.6	5.9	30	3	1.6	0.5	4	13	203	1.1	28	270	714	87
RR13	11	2.8	3.9	28	145	1.6	0.8	23	23	198	0.8	19	311	453	62
RR14	10	2.1	3.9	32	152	1.5	0.8	22	15	227	0.8	22	289	373	55
RR15	10	1.9	2.6	36	126	1.3	1.1	23	19	127	0.6	16	293	347	48
RR16	9.1	3.3	4.1	29	7.2	1.4	0.4	8.8	7.4	154	0.9	41	246	691	77
RR17	7.4	1.3	2.2	43	429	29	25	47	42	127	0.3	12	274	253	36

Minor elements for RNGP sites under study (cont.)

	Ag	In	Sn	Sb	Cs	Ba	La	Ce	Pr	Ta	Au	Y	Pb	Bi	U	W
G099	0.3	0.2	5.9	0.3	0.2	284	26	51	9.2	5.6	0.04	62	3.2	0.03	2.1	1.0
G100	0.3	0.2	4.9	0.2	0.1	275	42	31	14	5.8	0.04	96	3.9	0.02	2.7	1.0
G101	0.3	0.3	6.1	0.3	0.4	299	44	100	16	5.9	0.04	72	3.5	0.04	2.2	1.0
G102	0.3	0.2	3.7	1.0	0.3	230	52	115	15	4.1	0.02	94	2.1	0.03	1.4	0.7
G103	0.3	0.3	4.1	0.5	0.2	268	35	70	11	4.6	0.02	70	3.6	0.03	1.8	0.8
G104	0.4	0.5	5.0	0.2	0.2	235	44	91	14	4.4	0.08	76	2.3	0.35	2.0	1.3
G105	0.3	0.2	5.5	0.2	0.2	247	14	20	5.0	5.2	0.03	42	2.5	0.07	2.5	0.8
G106	0.2	0.3	4.8	0.3	0.2	265	13	32	4.7	5.4	0.04	47	3.1	0.04	2.0	0.9
G107	0.3	0.3	7.9	0.1	0.6	307	20	50	7.5	7.3	0.05	57	3.6	0.08	2.5	1.2
G108	0.2	0.3	5.7	0.1	0.3	243	32	69	10	4.8	0.05	54	2.8	0.02	1.7	1.0
G109	0.1	0.1	3.2	0.1	0.2	160	28	59	6.1	2.1	0.01	69	0.8	0.01	0.5	0.3
G110	0.3	0.3	6.2	0.5	0.4	268	51	97	15	4.8	0.03	92	2.8	0.07	1.6	1.0
G111	0.3	0.3	6.8	0.6	0.3	284	63	124	18	5.1	0.04	103	3.4	0.09	2.1	1.4
G112	0.4	0.4	6.4	0.5	0.4	339	33	102	11	7.1	0.06	70	5.6	0.17	2.7	1.5
G113	0.4	0.3	8.9	0.7	0.5	324	28	55	9.3	7.7	0.1	57	5.7	0.17	2.7	1.6
G114	0.7	0.5	10.3	6.1	0.7	265	23	57	8.0	8.1	0.6	60	6.4	0.39	2.8	1.8
G115	0.4	0.4	7.6	2.8	0.4	315	36	76	13	7.2	0.08	71	4	0.12	3	1
G116	0.2	0.8	4.4	1.0	0.3	192	83	96	17	5.3	0.04	63	4.7	0.07	2.0	0.8
G117	0.2	0.5	6.8	0.8	0.3	221	19	41	5.4	6.0	0.05	24	5.1	0.06	1.9	0.9
RR01	0.3	0.4	5.0	1.1	0.4	234	50	103	15	4.4	0.03	99	2.9	0.11	1.7	0.8
RR02	0.4	0.3	6.2	1.4	0.2	257	57	126	18	4.3	0.03	99	4.6	0.09	2.2	0.8
RR03	0.2	0.2	3.4	0.7	0.2	183	49	112	16	4.2	0.02	89	2.6	0.05	1.3	0.7
RR04	0.2	0.2	4.6	0.3	0.3	203	60	141	20	4.5	0.02	102	3.2	0.05	1.7	0.7
RR05	0.6	0.7	4.5	4.6	0.5	186	47	112	17	3.7	0.03	71	5.9	0.16	1.7	0.9
RR06	0.3	0.3	5.1	2.8	0.3	274	54	129	18	5.0	0.03	83	4.6	0.12	2.4	0.7
RR07	0.3	0.2	4.4	1.1	0.4	220	50	112	16	3.9	0.03	76	3.9	0.19	1.7	0.9
RR08	0.1	0.2	1.0	0.8	0.1	199	26	83	8.6	1.2	0.02	60	2.7	0.09	1.0	0.4
RR09	0.2	0.2	4.3	0.7	0.3	250	53	123	18	3.9	0.03	77	2.9	0.04	1.8	0.9
RR10	0.3	0.4	3.3	2.4	0.5	178	45	101	15	3.4	0.03	90	3.3	0.19	1.4	0.6
RR11	0.3	0.4	3.6	6.8	0.5	179	41	97	14	3.7	0.05	71	5.4	0.43	1.8	1.0
RR12	0.3	0.4	5.3	2.6	0.3	271	66	129	21	5.2	0.03	105	4.5	0.10	2.1	0.9
RR13	0.3	0.3	3.8	2.0	0.3	201	52	115	18	4.0	0.03	86	3.8	0.13	1.7	0.7
RR14	0.2	0.3	3.6	1.5	0.3	170	45	109	16	3.5	0.02	77	3.3	0.06	1.3	0.5
RR15	0.1	0.2	2.0	1.1	0.2	109	29	64	9.0	1.9	0.01	58	1.2	0.02	0.5	0.3
RR16	0.2	0.2	4.7	1.8	0.2	215	50	104	15	3.5	0.02	88	2.8	0.05	1.4	0.7
RR17	0.1	0.2	1.9	1.5	0.1	92	20	48	7.0	2.0	0.01	44	1.4	0.03	0.6	0.3

Minor elements for RNGP sites under study (cont.)

	Mo	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	Hf	Th
G099	3.6	36	10	4.7	10	2.0	12	2.9	7.3	1.3	7.8	1.3	20	6.9
G100	4.2	53	13	8.0	15	2.9	18	4.4	11	2.1	13	2.3	18	6.6
G101	4.3	59	14	5.5	14	2.5	14	3.2	7.7	1.3	7.5	1.2	21	7.2
G102	3.6	57	14	4.4	14	2.5	14	3.2	7.7	1.3	7.4	1.3	14	4.6
G103	3.2	43	11	4.6	11	2.0	11	2.6	6.4	1.1	6.1	1.0	16	5.7
G104	2.7	53	13	4.4	13	2.5	14	3.2	7.7	1.3	7.6	1.4	15	5.3
G105	4.1	18	5.2	3.7	6	1.3	8	2.1	5.3	1.0	6.0	1.1	17	5.8
G106	3.7	18	5.2	3.8	6	1.3	8	2.1	5.6	1.0	6.3	1.1	17	5.9
G107	5.5	28	7.7	3.4	8	1.7	10	2.5	6.4	1.1	6.8	1.2	23	8.4
G108	4.0	37	10	4.0	10	1.8	10	2.5	5.9	1.0	5.8	1.0	14	5.4
G109	4.5	21	5.1	1.4	5	0.9	5	1.2	3.0	0.5	2.8	0.5	7	2.1
G110	4.3	53	13	3.5	13	2.4	13	3.2	7.3	1.3	7.0	1.2	16	5.3
G111	4.8	64	16	4.3	16	3.0	16	3.7	8.6	1.5	8.1	1.5	17	6.7
G112	5.7	42	11	4.0	11	2.3	13	3.1	7.5	1.3	7.7	1.4	22	8.4
G113	6.1	33	8.6	3.4	8.4	1.8	11	2.6	6.7	1.2	7.3	1.3	24	9.1
G114	6.3	27	7.4	2.9	8.0	1.8	11	2.8	7.1	1.3	7.6	1.4	26	9.4
G115	6	46	12	4	12	2	13	3	8	1	8	2	22	8.5
G116	5.3	57	14	3.8	13	2.5	14	3.1	7.3	1.2	7.0	1.2	13	3.5
G117	6.9	18	5	2.2	4	0.9	5	1.3	3.1	0.6	3.4	0.6	15	5.4
RR01	3.2	49	12	4.0	13	2.5	12	3.1	6.8	1.3	6.3	1.3	14	5.2
RR02	4.6	58	14	3.9	15	2.8	14	3.5	7.6	1.3	7.2	1.3	14	6.2
RR03	3.0	54	14	4.1	14	2.6	13	3.2	7.0	1.2	6.4	1.1	11	4.4
RR04	3.7	67	17	5.0	17	3.0	15	3.6	8.0	1.4	7.3	1.3	12	5.2
RR05	3.4	54	13	4.3	14	2.6	13	3.1	6.6	1.2	5.9	1.1	10	4.4
RR06	3.3	60	15	4.7	15	2.9	15	3.7	8.4	1.5	8.2	1.5	17	6.7
RR07	3.7	55	14	4.1	14	2.7	14	3.3	7.4	1.3	6.9	1.2	13	5.0
RR08	0.7	46	7	3.9	12	2.3	11	2.7	5.9	1.0	5.3	0.9	7	2.6
RR09	3.4	60	15	4.4	15	2.8	14	3.4	7.6	1.2	7.0	1.2	12	5.4
RR10	3.3	50	13	3.8	14	2.5	12	3.0	6.4	1.1	5.6	1.1	10	3.6
RR11	3.6	48	12	3.8	13	2.4	12	2.9	6.1	1.1	5.4	1.1	9.3	4.1
RR12	3.5	70	17	4.9	17	3.3	17	4.2	10	1.6	8.9	1.6	16	6.6
RR13	3.3	63	16	4.8	16	3.0	15	3.6	7.8	1.3	6.9	1.2	10.7	4.5
RR14	3.0	56	14	4.6	15	2.7	14	3.2	7.0	1.1	6.2	1.1	9.0	3.7
RR15	2.1	30	8	2.3	8	1.4	7	1.7	3.7	0.6	3.2	0.6	5.1	1.8
RR16	4.7	51	12	3.2	13	2.3	12	2.8	6.1	1.0	5.5	1.0	11.9	4.8
RR17	1.7	24	6.3	2.1	6.9	1.3	6.4	1.5	3.3	0.5	2.9	0.5	5.1	1.8

Minor elements for RNGP sites under study (cont.)

APPENDIX F

Letters of support, letters of permission, authorisation permits

UNIVERSIDAD ACADEMIA DE HUMANISMO CRISTIANO
FACULTAD DE CIENCIAS SOCIALES
ESCUELA DE ANTROPOLOGÍA

Núcleo REALIDADES INSULARES

De mi consideración:

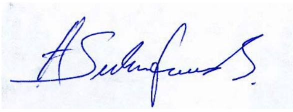
Por la presente declaro conocer y apoyar el proyecto de tesis doctoral del señor Dale F. Simpson Jr. Matriculado en el programa de Doctorado en Arqueología de la School of Social Science en la Universidad de Queensland (Australia), titulado "*Identifying Prehistoric Interaction on Rapa Nui (Easter Island): Modelling the Development of Social Complexity in Extreme Isolation*".

Mediante la presente, comprometo mi apoyo en todos los aspectos técnicos en los que pueda colaborar y expreso que doy los permisos para que pueda acceder a las colecciones de materiales arqueológicas excavadas por mí y que se encuentran en depósito en el Museo Antropológico R. P. S. Englert de Isla de Pascua.

Este proyecto será un gran aporte hacia el conocimiento de la complejidad cultural del pasado en Rapanui. Por lo demás cuenta con importantes elementos de difusión hacia la comunidad, que aportarán hacia el mayor conocimiento y la preservación del patrimonio material del pueblo rapanui.

Se extiende la presente para los fines que estime conveniente y para presentar ante las autoridades competentes en la Isla de Pascua como en el continente.

Muy cordialmente,



Dra. Andrea Seelenfreund
Profesor Titular
Escuela de Antropología
Directora Núcleo de Investigación de las Realidades Insulares
Condell 506, Providencia
Santiago

Santiago22 de marzo, 2014

Condell 343- Providencia - Santiago, Chile. Teléfono: 56 – 2- 7878228 Fax: 7878022

Rapa Nui, 23 de marzo de 2014

CARTA DE APOYO

Por medio de la presente, el infrascrito viene en señalar que conoce al estudiante señor Dale F. Simpson, candidato doctoral (Centennial Scholar, School of Social Sciences University of Queensland), con quién ha mantenido una fructífera relación de intercambio científico en Rapa Nui en los últimos años.

En conocimiento que el señor Simpson ha formalizado su programa de investigación para obtener su doctorado en un relevante tema, de gran interés para nuestra mejor comprensión del pasado de Rapa Nui y respondiendo a su petición, vengo en señalar que apoyo decididamente su proyecto y su investigación y, en lo que me compete, doy mi plena aprobación para que el señor Simpson acceda a colecciones de artefactos líticos derivadas de mis investigaciones, depositadas en el Museo Antropológico de Rapa Nui, ello en el contexto de los procedimientos que son parte de los protocolos del dicho Museo.

Finalmente, cumplo con reiterar que el señor Simpson cuenta con toda mi colaboración para llevar a buen término su estudio.

Profesor
Claudio Cristino

Departamento de Antropología
Centro de Estudios Isla de Pascua y
Oceanía Facultad de Ciencias Sociales
Universidad de Chile

Avenida Ignacio Carrera Pinto 1045, ÑUÑOA, Santiago, Chile www.facso.uchile.cl

April 1st, 2014

VCU

Monroe Park Campus

V I r g i n i a C o m m o n w e a l t h U n i v e r s i t y

Sr. Francisco Torres
Museo Sebastián Englert
Isla de pascua, Chile

Estimado Francisco,

I am writing in support of the research proposed by doctoral student Dale Simpson on archaeological collections present in the Museo Sebastian Englert. I have read the research design for Dale's doctoral thesis. His research on the chemistry of Rapa Nui basalt quarries and the exchange of basalt tools between people in prehistory will contribute significantly to understanding the development of the ancient culture. The proposed work is innovative and methodologically correct.

Please allow Dale to analyze any of the archaeological materials that I have collected over the years (e.g., La Perouse, Maunga Tari, Quadrangle 6, Quadrangle 18, etc.). His work will complement research already conducted on these materials.

Regards,

Christopher M. Stevenson

Christopher M. Stevenson, PhD
Assistant Professor of Anthropology
School of World Studies
Virginia Commonwealth University
Richmond, Virginia 23284 USA
e-mail: cmstevenson@vcu.edu

Anthropology, School of World Studies
312 N. Shafer Street | PO Box 842021
Richmond, Virginia 23284-2021 | 804-827-1111

April 1, 2014

To Whom It May Concern:

Mr. Dale Simpson has shown a genuine commitment to Rapa Nui archaeology for more than a decade. I have had the opportunity to work with Mr. Simpson in fieldwork, publishing, and educational outreach.

In the summers of 2005 and 2011, Mr. Simpson worked as a Visiting Instructor for the Terevaka.net Archaeological Outreach (TAO) program on Rapa Nui. Mr. Simpson contributed to both research design and educational projects with high school students local to the Rapa Nui community.

Mr. Simpson is welcome to investigate and analyze specimens that I collected on Rapa Nui during excavation research in 2005 that are currently stored at the Museo Antropológico Padre Sebastián Englert. I hope that these materials will help to expedite his research.

I believe that Mr. Simpson is an excellent candidate to conduct investigative research on Rapa Nui, as he is not only interested in academic archaeology, but also conservation and community outreach.

Please feel free to contact me (terevaka.net@gmail.com) at any time with additional questions or concerns.

Sincerely,

Britton L. Shepardson, Ph.D.
Director, ***TAO***

Lecturer, Department of Anthropology
Northern Arizona University

THE UNIVERSITY OF QUEENSLAND
AUSTRALIA

School of Social Science
Anthropology, Archaeology, Criminology & Sociology

Professor David Trigger
Head of School

17 April 2014

To whom this may concern,

With regard to Dale F. Simpson Jr., The School of Social Science at The University of Queensland, represented by Head of School Dr Patricia Short and Head of Archaeology Professor Marshall Weisler (Principle advisor), fully recognise that he is one of our Ph.D. candidates and has our full institutional, financial, and professional support to carry out his fieldwork and publish his doctoral thesis entitled:

Identificar Interacción en la Prehistoria en Rapa Nui (Isla de Pascua): Modelización del desarrollo de la complejidad social bajo aislamiento extremo

He has successfully completed his first doctoral milestone with our School, including a school-wide seminar, confirmation document and project panel review. We find his research to be analytically, methodologically and theoretically innovative and relevant, asking important questions about Rapa Nui's prehistoric social interaction, territoriality, and ideas of the island's socio-ecological collapse.

Dale is funded through a University of Queensland Centennial Scholarship, International Postgraduate Research Scholarship, and School of Social Sciences' Research Bursary and Strategic Planning Grant. As such he is fully financed for travel, research expenses, insurance, and geochemical sample analysis.

We believe he has a very feasible Ph.D. project and research design, facilitated by his 13 years of research on the island, with collaborations with multiple institutions and academics to better understand the prehistory of Easter Island. By using UQ's state-of-the-art geochemical facilities, Dale will be able to use this high-precision and accurate technology to better reconstruct patterns of prehistoric interaction. This will be inferred from the spatial distribution of and relation between volcanic sources (quarries) and artefacts and construction stone. His proposed research design also includes components of educational outreach opportunities for the Rapa Nui community, as well as a digital archaeology platform that will provide local access to his research, as well as internationally.

In sum, we fully support Dale's research and believe he has all of the traits necessary to complete his doctoral research on time and on budget. In turn, his results will give us a better understanding and appreciation of Rapa Nui's complex prehistory.

Yours sincerely,

Dr Patricia Short, Head of School

Head of Discipline - Archaeology

School of Social Science
University of Queensland
Brisbane Qld 4072
Cricos Provider Number 0025B

T +61 7 3365 3236
F +61 7 3365 1544

Internet: www.socialscience.uq.edu.au
Email: socialscience@uq.edu.au

UCLA

Cotsen Institute of Archaeology

308 Charl es E Young Drive North
A210 Fowler Building
Box 9 51510
Los Angeles , CA 90095

Dale Simpson, Jr .
30W080 Galbreath Dr.
Warrenville IL 60555

Jo Anne Van Tilburg, Ph.D.
UCLA Rock Art Archive
The Cotsen Institute of Archaeology
A210 Fowler
Los Angeles, CA 90024-1510

21 April 2014

Dear Dale,

Thank you very much for forwarding to me a copy of your very interesting proposed dissertation research this year on Easter Island (Rapa Nui). We are, of course, quite keen to have you include in your collections research the lithics we have.retrieved from our excavations in Rano Raraku Archaeological Zone (Interior Quarry Region), 2009-2014.

Our basalt materials are currently stored largely in Boxes 1, la, 2, and 2a in the Museo Antropol6gico Padre Sebastian Englert (MAPES). The call number is 17-28 (MAPES/Van Tilburg).

As I mentioned in our recent email correspondence, the obsidian materials are being studied by a colleague from the Universidad de Chile. Perhaps the two of you would like to be in communication? It is my understanding that she will be on the island later this year and perhaps at a time that overlaps with your research visit.

With this letter, therefore, I authorize your review and study of the basalt materials within the boxes named above. I do not authorize sampling, whether destructive or norl'-destructive, simply because I do not have the authority to do so. That must be undertaken in accordance with Chilean law, local oversight, and the access parameters established by DBAM and the Consejo de Monumentos Nacionales **(CAMN).**

Finally, we are pursuing our own lithic analyses as part of our own research program. We are pleased to collaborate with you and anticipate;a good exchange of analysis techniques and data. We further anticipate that the pertinent results Oi your dissertation may encourage subsequent or supporting dissemination through publication, some of which may be jointly undertaken.

We wish you success in your research and look forward to reading what we are certain will be new and interesting results.

Sincerely,

Jo Anne Van Tilburg

dibam | DIRECCIÓN DE BIBLIOTECAS, ARCHIVOS Y MUSEOS | SUBDIRECCIÓN NACIONAL DE MUSEOS

MUSEO ANTROPOLOGICO P. SEBASTIAN ENGLERT

Rapa Nui, 04 de Mayo de 2014.

Señor
Dale Simpson
P R E S E N T E

Por medio de la presente confirmo a Ud., el patrocinio del Museo Antropológico P. Sebastián Englert a su proyecto **Interacción en la Prehistoria en Rapa Nui (Isla de Pascua): Modelización del desarrollo de la complejidad social bajo aislamiento extremo.**

El Mapse considera relevante el desarrollar líneas investigativas de bajo impacto en el recurso arqueológico, pero que significan un gran avance en la recolección de información para el estudio del pasado de Rapa Nui y su cultura, como el que usted propone. Confiamos en que nuevos estudios bajo perspectivas diferentes permitirán ampliar el conocimiento sobre temas ya estudiados, así como señalar el camino de futuras investigaciones igualmente importantes, redundando en un mayor conocimiento y protección de nuestro patrimonio.

El Mapse entregará su patrocinio dando las facilidades para que Ud. y su equipo utilicen las instalaciones del Museo para los fines de su investigación. A cambio, Ud., debe dejar en depósito en la biblioteca del museo una copia de toda la información que recolecte durante su estudio. Esta información es de respaldo y no será entregada a otros investigadores por el tiempo que la ley de monumentos garantiza, a menos que usted lo autorice formalmente. Del mismo modo, los objetos y materiales arqueológicos que pudiera recolectar como parte del estudio, deben ser depositados en el Museo para su custodia, tal como lo establece la Ley.

Muy cordialmente,

MUSEO ANTROPOLOGICO R.P.S. ENGLERT — CONSERVADOR — Direc. Bibl. Arch. y Museos

FRANCISCO TORRES HOCHSTETTER
Director
Museo Antropológico P. Sebastián Englert

Ministerio de Educación
Gobierno de Chile

Sector Tahai s/n,
Isla de Pascua
(56-32) 2551020 - 2551021
www.dibam.cl

CONAF
Ministerio de Agricultura
Gobierno de Chile

PARQUE NACIONAL RAPA NUI

AUTORIZACIÓN.

Rapa Nui 02 de Septiembre 2014.

La Corporación Nacional Forestal como organismo que administra y vela por la protección del Parque Nacional Rapa Nui, considera que la solicitud de obtención de imágenes para la investigación denominada "Interacción en la Prehistoria de Rapa Nui " enriquece y es complementaria al permiso preliminar de obtención de material base para el estudio propuesto por el investigador, por lo que se autoriza al Sr. Dale Simpson, pasaporte N° 21.191150-6 de Estados Unidos para sobrevolar mediante dron las siguientes áreas:

1. Sector desde Hanga Poukura hasta Ahu Vinapu.
2. Cantera de keho en Vai a Tare y Maea hono a Hotu Matu'a.
3. Maunga Opipi, Rua Toki-toki hasta Pu Toki-toki.

Cabe indicar que este proceso de prueba se encuentra incorporado dentro de los permisos solicitados por Dale Simpson a la CAMN, debiendo gestionar el permiso correspondiente a la DGAC como lo indica el reglamento asociado a este permiso, el cual debe ser de conocimiento del investigador.

CORPORACIÓN NACIONAL FORESTAL
ADMINISTRADOR
PARQUE NACIONAL
RAPA NUI
ISLA DE PASCUA

HOTU MATU'A PATE
ADMINISTRADOR PNRN.
CONAF – Isla de Pascua.

Rapa Nui, 3 de septiembre de 2014.

Señor
José de Nordenflycht
Secretario Ejecutivo
Consejo de Monumentos Nacionales
P R E S E N T E

Estimado Sr., en consideración a que la ley 17.288 de monumentos nacionales establece que se requiere la presencia de un investigador nacional que actúe de contraparte en investigaciones internacionales, es que por medio de la presente quisiera ratificar por escrito mi participación con ese rol en el proyecto "Interacción en la Prehistoria en Rapa Nui (Isla de Pascua): Modelización del desarrollo de la complejidad social bajo aislamiento extremo", del investigador Sr. Dale F. Simpson.

Lo anterior en atención a que el Museo entregó también el patrocinio al proyecto dada la seriedad y profesionalismo que constantemente ha demostrado el sr. Simpson durante el desarrollo de sus investigaciones en la Isla, cumpliendo con todas las exigencias de la Ley y las que la comunidad le ha planteado, además de dedicar parte de su tiempo al trabajo con el taller patrimonial Manu Iri que el Museo y la Secretaría técnica del Patrimonio Rapanui han llevado adelante durante este año.

Muy cordialmente,

FRANCISCO TORRES HOCHSTETTER
Arqueólogo

C.C.
Sr. José de Nordenflycht, Secretario ejecutivo Consejo de Monumentos Nacionales, Santiago.
Sr. Dale Simpson
Srta. Jimena Ramirez, Jefa Secretaría Técnica del Patrimonio, Isla de Pascua

AUTORIZACIÓN.

Rapa Nui 08 de Septiembre 2014.

La Corporación Nacional Forestal como organismo que administra y vela por la protección del Parque Nacional Rapa Nui, autoriza la ejecución de la investigación en el marco de la tesis doctoral para la Universidad de Auckland del investigador, arqueólogo Sr. Dale Simpson, pasaporte N° 21.191150-6 de Estados Unidos denominada "Interacción en la Prehistoria de Rapa Nui " para lo cual necesita analizar y tomar muestras geológicas de las siguientes áreas:

1. Sector desde Hanga Poukura hasta Ahu Vinapu.
2. Cantera de keho en Vai a Tare y Maea hono a Hotu Matu'a.
3. Maunga Opipi, Rua Toki-toki hasta Pu Toki-toki.

Cabe indicar que este estudio se encuentra aprobado por la CAMN en reunión del Jueves 04 de Septiembre. El arqueólogo reconoce conocer las normas y el reglamento para ejecutar investigación al interior del PNRN y la obligación de realizar la obtención de muestras geológicas con un supervisor institucional.

CORPORACION NACIONAL FORESTAL
JEFE PROV. ISLA DE PASCUA

NINOSKA CUADROS HUCKE.
JEFE PROVINCIAL
CONAF ISLA DE PASCUA.

Mataveri O Tai, 08 de Septiembre2014.

CONVENIO DE AUTORIZACION
PARA REALIZAR ACTIVIDADES DE INVESTIGACION
EN EL PARQUE NACIONAL RAPA NUI

Mediante el presente documento, se autoriza la ejecución de la investigación en el Parque Nacional Rapa Nui denominada "**Identificando la interacción prehistórica en Rapa Nui, Modelo de desarrollo social complejo en extremo aislamiento**", representado por el Sr. DALE SIMPSON de profesión ANTROPOLOGO Nº pasaporte 477492604 de Estados Unidos, con RUT nacional 21.191.150 - 6.

1. Objetivos de la investigación:

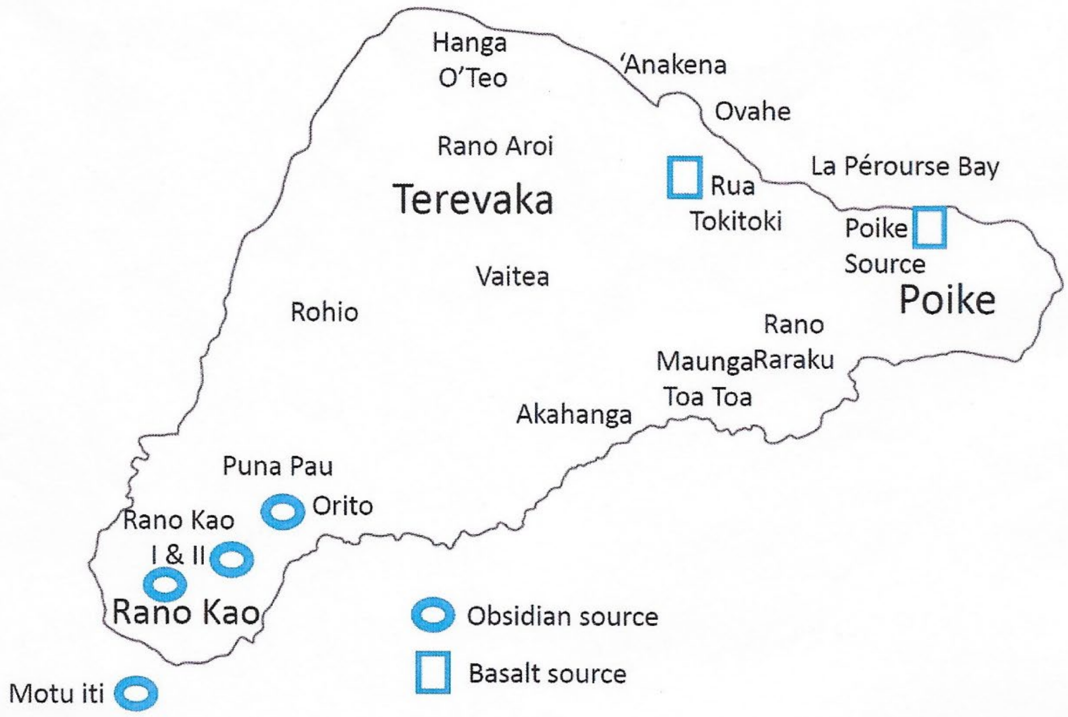
Mediante la caracterización química de las corridas de lava, canteras de piedras, materiales basálticos finos y gruesos de Rapa Nui utilizando la más avanzada Espectrometría de masas de ionización térmica (siglas TIMS en inglés, para los isótopos de Sr), espectrometría de masas con plasma acoplado inductivamente a un colector múltiple (siglas en inglés MC-ICP-MS, para los isótopos de Nd-Pb), ICP-MS cuádruple (para elementos de traza) y espectrometría de emisión óptica con plasma acoplado inductivamente (siglas ICP-OES en inglés, para los elementos más grandes), planeo determinar los patrones espaciales de aprovisionamiento, uso y desecho lítico y refinar los modelos de interacción social (Ayres *et al.* 1998; Beardsley *et al.* 1996; Gioncada *et al.* 2010; Hamilton *et al.* 2011; Harper 2008; Lee 1992; Simpson 2008, 2009, 2012a; Stevenson *et al.* 2013; Van Tilburg 1994; Van Tilburg *et al.* 2008).

Se facilitará con GIS y programas estadísticos que usan la distancia de aprovisionamiento desde las canteras fuente a los sitios ceremoniales y habitacionales, con el fin de evaluar si la adquisición y el uso reflejan la organización social y política ancestral rapanui, de acuerdo con los registros etnográficos, etno-lingüísticos y arqueológicos. (Hotus *et al.* 1988; Routledge 1919; Shepardson 2005; Stevenson 2002).

1. Esta autorización permite las siguientes actividades:

- Realización de fotografía aérea.
- Prospección terrestre y registro fotográfico.
- Extracción de muestras geológicas en canteras indicadas en mapa adjunto.

2. Área de estudio:



3. En caso realizar el hallazgo de restos humanos o bioantropológicos esto debe ser informado inmediatamente a CONAF, debido a que las tumbas y cementerios indígenas en Chile están resguardados bajo una ley especifica.

4. **CONAF deberá proporcionar un Funcionario de la institución para supervisar las actividades que se lleven a cabo dentro del Parque Nacional Rapa Nui**. Es responsabilidad del interesado realizar los traslados del y prestarle la mayor colaboración para el ejercicio de sus tareas. La Arqueóloga o Guardaparque tomará fotografías y presentará informes diarios a CONAF, para verificar el cabal cumplimiento de las disposiciones de esta autorización.

5. Todos los sectores del Parque Nacional Rapa Nui son parte de un Área Silvestre Protegida y además forman parte de un Monumento Histórico, se encuentran protegidos por las leyes nacionales, específicamente por la ley 17.288 de Monumentos Nacionales. Por ello, y debido a la fragilidad de los sitios arqueológicos, el investigador firmante será el responsable de ejecutar e incorporar a su metodología de trabajo lo indicado en los puntos IV y VIII.I del protocolo de investigaciones del PNRN y restringiéndose al área designada para la obtención de muestras geológicas, las cuales deberán cumplir con lo especificado en el formulario de solicitud y propuesta de investigación recepcionada por CONAF.

6. El permiso fuera de las fechas indicadas en el formulario de solicitud no tendrá validez, debiendo los investigadores solicitar su prórroga o renovación a esta Oficina Provincial.

7. La presente autorización sólo se refiere a actividades a desarrollarse dentro del Parque Nacional Rapa Nui, en los sitios ya especificados, y no concierne de ninguna manera a actividades que el solicitante quisiera desarrollar en otros terrenos.

8. En tanto que los sitios donde se realizarán estas actividades corresponden a terrenos del Parque Nacional Rapa Nui, y por lo tanto administrados por esta Oficina Provincial, se extiende esta autorización estando el investigador en conocimiento y cumplimiento del protocolo de regulación de investigaciones científicas del PNRN, por lo que el investigador debe considerar:

- Presentarse personalmente en la Oficina Provincial de CONAF.

- Trasladar diariamente los materiales culturales obtenidos durante la faena de trabajo.

- Respetar el valor cultural de los objetos arqueológicos tratando con actitud de respeto todo tipo de expresión cultural.

- Restringir los trabajos y estudios sólo a los espacios y objetos autorizados.

- Realizar los trabajos de investigación bajo el concepto de mínima intervención.

- En caso de trabajar en espacios con visitación turística se solicita instalar paneles informativos del trabajo en ejecución.

- Las excavaciones deben ser delimitadas a través de estructuras y cintas de seguridad, para el resguardo de las personas y evitar riesgos con los animales asilvestrados presentes en el PNRN.

- Hacer entrega de un informe preliminar inmediatamente terminados los trabajos de campo que incorpore el inventario integral de todos los materiales culturales registrados, mas la fotografía de los elementos más relevantes.

- Los informes deben ser entregados en su versión oficial en el idioma nativo del investigador y una versión con el mismo contenido que el original en idioma español (formato tradicional y digital)

- Entregar a CONAF toda la información en términos de documentos, publicaciones e imágenes compilada a través de los diversos informes emanados por parte del investigador, pudiendo la institución hacer uso de este material para fines de difusión. CONAF, por su parte se compromete al resguardo y manejo adecuado para velar por el derecho de autor sobre la información y otorgar los créditos correspondientes en cada publicación.

- El presente convenio no exime de responsabilidad al solicitante y/o a miembros del equipo de investigación ante eventuales daños que las actividades desarrolladas generen a sitios arqueológicos y/o infraestructura del Parque, o a terceras personas, de acuerdo a las leyes y normas vigentes. Cualquier reparación o indemnización por daños será de su exclusivo cargo. En conformidad a la ley 17.288 de Monumentos Nacionales, cualquier alteración que la ejecución de las actividades desarrolladas generen a sitios, materiales o estructuras arqueológicas, será de responsabilidad del los autores materiales de tales perjuicios. CONAF denunciará los daños y se hará parte en los procesos respectivos para las reparaciones materiales y/o pecuniarias que disponga la justicia. El solicitante ha tomado conocimiento de las leyes chilenas.

CORPORACION NACIONAL FORESTAL
JEFE PROV. ISLA DE PASCUA

NINOSKA CUADROS HUCKE
JEFE PROVINCIAL
CONAF ISLA DE PASCUA

Otorga

Sr. DALE SIMPSON
Nª PASAPORTE: 477492604Estados Unidos

Recibe

CC.

- Administrador del P.N.R.N.
- Unidad Técnica Arqueológica
- Archivo

CONADI
Ministerio de Desarrollo Social
Gobierno de Chile

CODEIPA
RAPA NUI

ACTA REUNIÓN COMISIÓN DE DESARROLLO CODEIPA
09. SEPTIEMBRE. 2014

En Hanga Roa, a 09 días del mes de septiembre de 2014, en dependencias de la Gobernación Provincial de Isla de Pascua, siendo las 10:10 horas, se inicia la reunión con la asistencia de las siguientes personas.

PRESENTES.

Sr. Marta Hotus Tuki. Presidenta de CODEIPA.
Sr. José Rapu Haoa. Comisionado Electo.
Sr. Osvaldo Pakarati Arévalo. Comisionado Electo.
Srta. Anakena Manutomatoma, comisionada Electa.
Sr. Mario Tuki Hey. Comisionado Electo.
Sr. Alberto Hotus Chávez. Presidente Consejo de Ancianos.
Sr. Jorge Pont Chávez. Comisionado Electo
Sra. Elizabeth Velásquez Hotus. Jefa CONADI Isla de Pascua
Sr. Jorge Miranda Pacheco, Abogado Gobernación Provincial Isla de Pascua.
Sra. Ninoska Cuadros Hucke. Jefa Provincial de CONAF.
Sr. Sebastián Molina Bruzzone. Jefe Provincial Bienes Nacionales.
Sr. Tiare Aguilera Hey. Abogado Oficina Provincial Bienes Nacionales.
Sr. Santiago Saavedra. Abogado CODEIPA, Isla de Pascua.

Secretaría Técnica observa que la subcomisión cuenta con el quórum suficiente, tanto para sesionar, como para tomar acuerdos.

Sr. José Rapu abre la sesión en nombre de Dios y de Rapa Nui.

Da a conocer las siguientes informaciones:

- Respecto a Dale Simpson, su permiso por parte de CONAF está en proceso pero está sujeto a lo que la CODEIPA acuerde. Se procede al acuerdo

CON TRES VOTOS AUSENTES DE LOS SEÑORES JOSÉ RAPU HAOA, JORGE PONT CHAVEZ Y MARIO TUKI HEY Y CON TRES VOTOS A FAVOR DE LOS SEÑORES ALBERTO HOTUS CHAVEZ, OSVALDO PAKARATI ARÉVALO Y LA SRTA ANAKENA MANUTOMATOMA SE ACUERDA AUTORIZAR LA UTILIZACION DE UN DRON PARA TOMAR FOTOGRAFIAS AEREAS CON LA FISCALIZACION Y LOS REQUERIMIENTOS QUE SOLICITE CONAF. LAS FOTOGRAFIAS TOMADAS SERAN USADAS, ADEMÁS DEL FIN PARA CUYO OBJETO FUERON SOLICITADAS, DE USO COMUNITARIO DE LA COMUNIDAD RAPA NUI.

Siendo las 12:38 se levanta la sesión.

Secretaría Técnica Comisión de Desarrollo de Isla de Pascua
E-mail: evelasquez@conadi.gov.cl
AV. Atamu Tekena s/n, Isla de Pascua
Fono: 32-2100527 – 32-2100186
www.conadi.cl

Gobierno de Chile

CODEIPA RAPA NUI

MARTA HOTUS TUKI PRESIDENTA CODEIPA	JOSÉ RAPU HAOA COMISIONADO ELECTO
JORGE PONT CHAVEZ COMISIONADO ELECTO	ALBERTO HOTUS CHAVEZ COMISIONADO ELECTO
ANAKENA MANUTOMATOMA COMISIONADO ELECTO	MARIO TUKI HEY COMISIONADO ELECTO
OSVALDO PAKARATI ARÉVALO COMISIONADO ELECTO	SANTIAGO SAAVEDRA IKA ABOGADO ASESOR CODEIPA
NINOSKA CUADROS HUCKE JEFA PROVINCIAL CONAF	SEBASTIÁN MOLINA BRUZONE JEFE PROVINCIAL BIENES NACIONALES

Secretaría Técnica Comisión de Desarrollo de Isla de Pascua
E-mail: evelasquez@conadi.gov.cl
AV. Atamu Tekena s/n, Isla de Pascua
Fono: 32-2100527 – 32-2100186
www.conadi.cl

CONADI
Ministerio de Desarrollo Social
Gobierno de Chile

CODEIPA RAPA NUI

TIARE AGUILERA HEY
ABOGADO BBNN

ELIZABETH VELASQUEZ HOTUS
JEFA PROVINCIAL CONADI IPA

Secretaría Técnica Comisión de Desarrollo de Isla de Pascua
E-mail: evelasquez@conadi.gov.cl
AV. Atamu Tekena s/n, Isla de Pascua
Fono: 32-2100527 – 32-2100186
www.conadi.cl

KOMMISSION FÜR ARCHÄOLOGIE AUSSEREUROPÄISCHER KULTUREN
DES DEUTSCHEN ARCHÄOLOGISCHEN INSTITUTS

KAAK, Dürenstraße 35-37, D-53173 Bonn

Dr. Burkhard Vogt
Direktor
Tel.: ++49 (0)228-99 7712-12
Fax: ++49 (0)228-99 7712-49
burkhard.vogt@dainst.de
www.dainst.de

Bonn, Sept. 14th, 2014

<u>To whom it may concern</u>

This is to certify that we entitle Mr. Dales F. Simpson Jr., Ph. D. candidate from the School of Humanities and Social Science, St. Lucia, Qld., Australia 4072, to use for his dissertation the below artefacts from the German excavations at Ava Ranga Uka A Toroke Hau, Isla de Pascua/Easter Island:

ARUTH 001-08-017 basalt toki, from T1
ARUTH 001-08-024 basalt toki, from T1
ARUTH 001-09-108 basalt toki, from T1
ARUTH 001-09-109 basalt knife fragment, from T1
ARUTH 001-09-145 basalt toki, from T5
ARUTH 001-11-146 basalt toki, from T5

Mr. Simpson will present the necessary documents for exporting, sampling and analyzing the artifacts in accordance with the respective laws and regulations of the Republic of Chile and its competent authorities.

Burkhard Vogt
(director of the German Expedition to Easter Island

CMN CONSEJO DE MONUMENTOS NACIONALES DE CHILE

ORD. Nº: 003523/14

ANT.: Correo electrónico del 08.09.2014 (Ingreso CMN Nº 6124 del 09.09.2014) que adjunta Formulario de Solicitud Arqueológica.

MAT.: Autoriza prospección arqueológica en el marco del proyecto "Identificar interacción en la prehistoria en Rapa Nui (Isla de Pascua): modelización del desarrollo de la complejidad social bajo aislamiento extremo".

Santiago, 26 SEP 2014

A: SR. DALE SIMPSON JR.
ARQUEÓLOGO
UNIVERSIDAD DE QUEENSLAND, BRISBANE, AUSTRALIA
dfsj381@gmail.com

DE: SRA. SUSANA SIMONETTI DE GROOTE
SECRETARIO EJECUTIVO (S)
CONSEJO DE MONUMENTOS NACIONALES

A través del presente y junto con saludarle muy cordialmente, este Consejo acusa recibo de correo electrónico citado en antecedente, mediante el cual remite el Formulario de Solicitud Arqueológica, requiriendo autorización para la realización de una prospección con extracción de muestras geológicas, en el marco de la investigación "Identificar interacción en la prehistoria en Rapa Nui (Isla de Pascua): modelización del desarrollo de la complejidad social bajo aislamiento extremo".

Este Consejo, luego de estudiar los antecedentes y previa presentación y consulta a la Comisión Asesora de Monumentos Nacionales de la Provincia de Isla de Pascua, autoriza la prospección arqueológica, de acuerdo al siguiente detalle:

3.a Para prospección arqueológica				
Región: Valparaíso		Provincia: Isla de Pascua		
Comuna:	Isla de Pascua	Localidad: Rapa Nui		
Superficie aprox.		Polígono coordenadas UTM DATUM: WGS84		
Pu Tokitoki – Ava o´ Kiri			Lat. N.	Long. E.

CMN CONSEJO DE MONUMENTOS NACIONALES DE CHILE

		NW	27°06'38.2"S	109°19'20.6"W
		NE	27°04'42.6"S	109°17'40.8"W
		SW	27°05'50.0"S	109°18'08.6"W
		SE	27°05'51.9"S	109°19'29.4"W
Anexa listado de coordenadas adicionales	SI		NO X	
Superficie aprox.		Polígono coordenadas UTM DATUM: WGS84		
Ana Marama			Lat. N.	Long. E.
		NW	27°06'38.2"S	109°19'20.6"W
		NE	27°06'34.3"S	109°19'04.0"W
		SW	27°07'09.3"S	109°23'55.2"W
		SE	27°07'03.6"S	109°22'39.9"W
Anexa listado de coordenadas adicionales	SI		NO X	
Superficie aprox.		Polígono coordenadas UTM DATUM: WGS84		
Hanga Poukura - Vinapu			Lat. N.	Long. E.
		NW	27°09'58.5"S	109°23'56.9"W
		NE	27°09'58.7"S	109°22'40.8"W
		SW	27°10'18.7"S	109°23'55.2"W
		SE	27°10'16.1"S	109°22'39.9"W
Anexa listado de coordenadas adicionales	SI		NO X	
Superficie aprox.		Polígono coordenadas UTM DATUM: WGS84		
Rano Kau-Vai Atare			Lat. N.	Long. E.
		NW	27°11'16.0"S	109°25'53.0"W
		NE	27°11'17.2"S	109°25'25.6"W
		SW	27°11'35.8"S	109°25'56.4"W
		SE	27°11'36.0"S	109°25'24.3"W
Anexa listado de coordenadas adicionales	SI		NO X	

Se solicita mantener informada de las actividades realizadas a la Secretaría Técnica de Patrimonio Rapa Nui dependiente de éste Consejo, con el fin de mantener la mejor coordinación posible en las actividades a desarrollar en el marco de su trabajo científico.

CMN CONSEJO DE MONUMENTOS NACIONALES DE CHILE

Hacemos presente las disposiciones del Reglamento de excavaciones y prospecciones (Decreto Supremo Mineduc N° 484 de 1990), referidas al informe requerido a los dos años de vigencia del permiso, y a la obligación de aportar la información que eventualmente requiera el Consejo.

Del mismo modo –y en la línea de lo solicitado por la entidad local- se requiere hacer entrega del informe arqueológico final resultante de la citada investigación, incorporando todo el material de registro de la toma de muestras geológicas, junto con el material fotográfico, levantamientos planimétricos y fichas de registro arqueológico con el fin de apoyar la toma de decisiones asociada al sitio en el futuro.

Deseándole éxito en su investigación y sin otro particular, se despide cordialmente de Ud.

CONSEJO DE MONUMENTOS NACIONALES CHILE

SUSANA SIMONETTI DE GROOTE
SECRETARIO EJECUTIVO (S)
CONSEJO DE MONUMENTOS NACIONALES

C.C.: - Archivo Secretaría Técnica de Patrimonio Rapa Nui del CMN.
- Archivo Consejo de Monumentos Nacionales.

MSV/JRG/MAL

CMN CONSEJO DE MONUMENTOS NACIONALES DE CHILE

CON ANEXO

ORD. N°: 003524 /14

ANT.: Correo electrónico del 08.09.2014 que adjunta Formularios de Solicitud Arqueológica y de solicitud para extracción de muestras geológicas desde MH e (Ingreso STP N°173 del 05.09.2014 y CMN Nº 6124 del 09.09.2014).

MAT.: Autoriza envío de muestras de material geológico al extranjero, en el marco del Proyecto "Identificar Interacción en la Prehistoria en Rapa Nui (Isla de Pascua): Modelización del desarrollo de la complejidad social bajo aislamiento extremo".

Santiago, 26 SEP 2014

A: SR. DALE SIMPSON JR.
ARQUEÓLOGO
UNIVERSIDAD DE QUEENSLAND, BRISBANE, AUSTRALIA.
dfsj381@gmail.com

DE: SRA. SUSANA SIMONETTI DE GROOTE
SECRETARIO EJECUTIVO (S)
CONSEJO DE MONUMENTOS NACIONALES

A través del presente y junto con saludarle muy cordialmente, este Consejo acusa recibo de su solicitud de autorizar la extracción del territorio nacional de muestras geológicas desde los sectores de indicados en su permiso de investigación.

La iniciativa se enmarca en el Proyecto "Identificar Interacción en la Prehistoria en Rapa Nui (Isla de Pascua): Modelización del desarrollo de la complejidad social bajo aislamiento extremo".

Este Consejo, luego de estudiar los antecedentes y previa presentación y consulta a la Comisión Asesora de Monumentos Nacionales Provincial, autoriza el envío de dichas muestras geológicas desde Isla de Pascua para ser sometidas bajo

CMN CONSEJO DE MONUMENTOS NACIONALES DE CHILE

DETALLE DE ÁREA DE PROSPECCIÓN PARA EXTRACION DE MUESTRAS GEOLOGICAS SEGÚN FORMULARIO DE INVESTIGACIÓN:

3.a Para prospección arqueológica			
Región: Valparaíso		Provincia: Isla de Pascua	
Comuna:	Isla de Pascua	Localidad: Rapa Nui	

Superficie aprox.		Polígono coordenadas UTM DATUM: WGS84		
Pu Tokitoki – Ava o´ Kiri			Lat. N.	Long. E.
		NW	27°06'38.2"S	109°19'20.6"W
		NE	27°04'42.6"S	109°17'40.8"W
		SW	27°05'50.0"S	109°18'08.6"W
		SE	27°05'51.9"S	109°19'29.4"W
Anexa listado de coordenadas adicionales	SI		NO X	
Superficie aprox.		Polígono coordenadas UTM DATUM: WGS84		
			Lat. N.	Long. E.
Ana Marama		NW	27°06'38.2"S	109°19'20.6"W
		NE	27°06'34.3"S	109°19'04.0"W
		SW	27°07'09.3"S	109°23'55.2"W
		SE	27°07'03.6"S	109°22'39.9"W
Anexa listado de coordenadas adicionales	SI		NO X	
Superficie aprox.		Polígono coordenadas UTM DATUM: WGS84		
			Lat. N.	Long. E.
Hanga Poukura - Vinapu		NW	27°09'58.5"S	109°23'56.9"W
		NE	27°09'58.7"S	109°22'40.8"W
		SW	27°10'18.7"S	109°23'55.2"W
		SE	27°10'16.1"S	109°22'39.9"W
Anexa listado de coordenadas adicionales	SI		NO X	
Superficie aprox.		Polígono coordenadas UTM DATUM: WGS84		
			Lat. N.	Long. E.
Rano Kau-Vai Atare		NW	27°11'16.0"S	109°25'53.0"W
		NE	27°11'17.2"S	109°25'25.6"W
		SW	27°11'35.8"S	109°25'56.4"W
		SE	27°11'36.0"S	109°25'24.3"W
Anexa listado de coordenadas adicionales	SI		NO X	

análisis geoquímico en los laboratorios de la Universidad de Queensland; Brisbane, Australia.

Las muestras geológicas (según detalle adjunto) serán trasladadas para fines científicos, en el marco de la mencionada investigación, que apunta a evaluar la composición geoquímica del basalto en Rapa Nui.

El traslado de dichas muestras deberá efectuarse resguardando sus condiciones de conservación, con un embalaje adecuado. Una vez finalizados los análisis, pedimos remitir a esta entidad un informe ejecutivo que dé cuenta de sus resultados.

Deseándole éxito en su investigación y sin otro particular, saluda atentamente a usted,

CONSEJO DE MONUMENTOS NACIONALES CHILE

SUSANA SIMONETTI DE GROOTE
SECRETARIO EJECUTIVO (S)
CONSEJO DE MONUMENTOS NACIONALES

C.C.: - Destinatario
- Archivo Consejo de Monumentos Nacionales.
- Secretaría Técnica de Patrimonio Rapa Nui

- Listado Detalle de Ubicación de sitios
- Listado Detalle de Muestras Geológicas

MSV/JRG/MAL

CMN CONSEJO DE MONUMENTOS NACIONALES DE CHILE

CON AN

ORD. Nº: 003525 /14

ANT.: Solicitud de investigación y autorización de envío de muestras arqueológicas hacia el extranjero (Ingreso CMN Nº 6124 del 09.09.2014).

MAT.: Autoriza envío de muestras de material arqueológico al extranjero, en el marco del proyecto "Identificar interacción en la prehistoria en Rapa Nui (Isla de Pascua): modelización del desarrollo de la complejidad social bajo aislamiento extremo".

Santiago, 26 SEP 2014

A: SR. DALE SIMPSON JR.
ARQUEÓLOGO
UNIVERSIDAD DE QUEENSLAND, BRISBANE, AUSTRALIA
dfsj381@gmail.com

DE: SRA. SUSANA SIMONETTI DE GROOTE
SECRETARIO EJECUTIVO (S)
CONSEJO DE MONUMENTOS NACIONALES

A través del presente y junto con saludarle muy cordialmente, este Consejo acusa recibo de solicitud de autorización del traslado al extranjero de muestras de colecciones arqueológicas del Museo Antropológico Padre Sebastián Englert.

La iniciativa se enmarca en el proyecto "Identificar interacción en la prehistoria en Rapa Nui (Isla de Pascua): modelización del desarrollo de la complejidad social bajo aislamiento extremo".

Este Consejo, previa presentación y consulta a la Comisión Asesora de Monumentos Nacionales Provincial, autoriza el envío de muestras arqueológicas desde Isla de Pascua hacia el extranjero, para ser sometidas a análisis geoquímico en el laboratorio de la Universidad de Queensland, Brisbane, Australia.

El traslado de dichas muestras deberá efectuarse resguardando sus condiciones de conservación, con un embalaje adecuado. Una vez finalizados los análisis, pedimos remitir a esta entidad un informe ejecutivo que dé cuenta de sus resultados.

Del mismo modo –y en la línea de lo solicitado por la entidad local- las muestras deberán retornar a nuestro país antes de 1 año a partir de la fecha de este oficio.

Deseándole éxito en su investigación y sin otro particular, se despide cordialmente de Ud.,

SUSANA SIMONETTI DE GROOTE
SECRETARIO EJECUTIVO (S)
CONSEJO DE MONUMENTOS NACIONALES

C.C.: - Archivo Secretaría Técnica de Patrimonio Rapa Nui del CMN.
- Archivo Consejo de Monumentos Nacionales.

Adjunta: - Listado Detalle de Ubicación de sitios
- Listado Detalle de Muestras Arqueológicas

MSV/MAL

dibam | DIRECCIÓN DE BIBLIOTECAS, ARCHIVOS Y MUSEOS | SUBDIRECCIÓN DE PLANIFICACIÓN Y PRESUPUESTO

MAPSE
MUSEO RAPANUI

ACTA DE DEVOLUCIÓN N°: 01/2016

Rapa Nui, 07 de marzo 2016 **REF**: Ord. 3525/14 CMN

Los objetos descritos en este documento, han sido devueltos al Museo Antropológico P. Sebastián Englert en las siguientes condiciones.

1.- Datos de la persona que entrega

Nombre : **Dale F. Simpson** RUT : 9.191.150-6

Firma : [signature]

2.- Datos del funcionario que recibe

Nombre : **Francisco Torres Hochstetter** Cargo : **Curador arqueología**

Firma : [signature]

3.- Objetos

NUM. INVENTARIO	NOMBRE DEL OBJETO	ESTADO DE CONSERVACIÓN
	Se adjunta listado aparte.	En general bien. Leer cuadro observaciones para el detalle.

3.- Observaciones

Las piezas volvieron en general en buen estado de conservación. Un par de objetos presentan algunos astillamientos los que se indican en el listado correspondiente. A todas las piezas se les extrajo un poco de material para análisis físico/químico pero no afectan la visión de la pieza ni su integridad.

Se deja constancia, también, que del total de piezas listadas en el original, hay _ que figuran pero que nunca salieron del museo puesto que fueron retenidas en la primera revisión, por considerarse artefactos formatizados. Dichas piezas quedaron en el Mapse en su ubicación original.

Estuvo presente en la revisión de las piezas, el día 4 de marzo de 2016, la funcionaria de la Secretaría Técnica del Patrimonio Rapa Nui, Gabriela Atallah, quien firmó en conformidad el listado luego de revisar las piezas. Sólo faltó revisar junto con ella algunas de las piezas de la colección de Rano Raraku de Jo Anne Van Tilburg. Sin embargo, las pudo ver y se acordó que se revisarían sin su presencia el día lunes 7 de marzo de 2016.

APPENDIX G

RNGP educational outreach efforts

Publications and presentations about RNGP educational outreach efforts

Shepardson, B.L., Shepardson, D., Droppelmann, G., Briggs, K., Larrick, T., Ramirez, R., Atan, B., Pakarati, G., Wilkins, M., Fuentes, J., Ika, H., Moncada, C., Paoa, H., Perez, F., Tuki, I., Tuki, J., Tuki, T., Tuki, T. and Valdebenito, M. (2014). Terevaka Archaeological Outreach 2014 field report: Meeting community objectives. *Rapa Nui Journal* 28(2): 61–5.

Simpson Jr., D.F. (2015c). 2014–15 Ph.D. fieldwork report. Rapa Nui Journal 29(1): 58–66.

Simpson Jr., D.F. (2016a). Minas, canteras y artefactos de basalto: Investigación científica aprobada por la comunidad Rapa Nui (Isla de Pascua). Annales del Museo de Historia Natural de Valparaíso 29: 120–131.

Simpson Jr., D.F. (2019). Conducting Responsible and Ethical Archaeological Research on Easter Island: Building Diachronic and Lasting Relationships with the Local Rapa Nui (Easter Island) Community. *Journal of the Texas Tech University Ethics Center* 3(1): 20–26.

Torres Jeria, P. and Hereveri, S. (2015). *Manu Iri – Guardianes por el patrimonio.* Consejo de Monumentos Nacionales de Chile, Hanga Roa, Rapa Nui. http://www.monumentos.cl/publicaciones/libros/manu-iri-guardianespatrimonio

Torres Jeria, P., Simpson Jr., D.F., and Hereveri, S. (2015). Manu Iri – Guardianes por el Patrimonio. *Correo del Moai* 38: 12–3.

Taller MANU IRI sigue enseñando a niños sobre historia y arqueología: https://www.youtube.com/watch?v=ngU438cdSLk

Manu Iri: https://www.youtube.com/watch?v=O2ffzc0atyc

STEMinar Series: "Behind Easter Island's Moai Statues: https://www.youtube.com/watch?v=M1oI3ABdf1c&t=20s

Conducting responsible and ethical archaeological research on Easter Island: https://www.youtube.com/watch?v=EzTT5fxHLbY

RNGP educational outreach efforts (2014–2019)

2014

Manu Iri Heritage Guardians

Terevaka Archaeological Outreach

2015

Manu Iri Heritage Guardians

Mahinatur Ltda. Anthropology Workshop

2016

Manu Iri Heritage Guardians

Summer archaeological excursions with S. Englert Anthropological Museum

2017

Summer archaeological excursions with S. Englert Anthropological Museum

Archaeological summer camp with S. Englert Anthropological Museum

2018

Hotel Explora Guide School

Summer archaeological excursions with S. Englert Anthropological Museum

2019

Hotel Explora Guide School

Terevaka Archaeological Outreach

Summer archaeological excursions with S. Englert Anthropological Museum

Winter archaeological workshops with S. Englert Anthropological Museum

APPENDIX H

RNGP site reconstructions by Rapanui artist Veri Lobos Haoa

Figure 1. *Keho* mining on the southwest coast (Simpson and Lobos Haoa 2019).

Figure 2. *Toki* manufacture in Pu Tokitoki (Simpson and Lobos Haoa 2019).

Figure 3. *Keho* sourcing in Rano Kau (Simpson and Lobos Haoa 2019).

Figure 4. Basalt sourcing at Poike (Simpson and Lobos Haoa 2019).

Figure 5. *Paenga* manufacture in Roiho (Simpson and Lobos Haoa 2019).

Figure 6. *Paenga* manufacture at Maitaki te Moa (Simpson and Lobos Haoa 2019).

Figure 7. Obsidian sourcing at Motu Iti (Simpson and Lobos Haoa 2019).

Figure 8. Obsidian sourcing at Motu Iti (Simpson and Lobos Haoa 2019).

Figure 9. *Moai* carving at Rano Raraku (Simpson and Lobos Haoa 2019).

Figure 10. *Pukao* manufacture at Puna Pau (Simpson and Lobos Haoa 2019).

APPENDIX I

Total doctoral thesis and RNGP academic production

Theses

Simpson Jr., D.F. (2019). Prehistoric Interaction on Rapa Nui (Easter Island); Modeling the Development of Social Complexity in Extreme Isolation. Unpublished Ph.D. Thesis, School of Social Science, University of Queensland.

Books

Simpson Jr., D.F. and Lobos Haoa, Veri **(in press).** Rapa Nui's stone quarries: An art and colouring book for kids. Rapa Nui Press.
Simpson Jr., D.F. (in prep.). The Prehistoric Miners of Rapa Nui (Easter Island). To be submitted at the end of 2019 to Springer Publications.

Peer–Reviewed Publications

Simpson Jr., D.F., Van Tilburg, J.A., Dussubieux, L. **(2018)**. *Toki* (adze) and pick production during peak *moai* (statue) manufacture: Geochemical and radiometric analyses reveal prehistoric provenance, timing and use of Easter Island's fine–grain basalt resources. Journal of Pacific Archaeology, 9(2): 12–34.
Simpson Jr., D.F., Dussubieux, L. **(2018).** A collapsed narrative? Geochemistry and spatial distribution of basalt quarries and fine–grained artifacts reveal communal use of stone on Rapa Nui (Easter Island). Journal of Archaeological Science: Reports 18, 370–385.
Simpson Jr. D.F., Weisler, M.I., St. Pierre, E., Feng, Y. Bolhar, R. **(2017).** Archaeological documentation and high–precision geochemistry of the Rua Tokitoki adze quarry and Poike's fine–grain basalt source on Rapa Nui (Easter Island). Archaeology in Oceania. 53(1), 15–27.
Simpson Jr. D.F. (2016). Minas, canteras y artefactos de basalto: Investigación científica aprobada por la comunidad Rapa Nui (Isla de Pascua). Annales del Museo de Historia Natural de Valparaíso 29, 120–131.
Larsen, A., **Simpson Jr. D.F**. **(2014).** A Comment to Rull et al. (2013)—Challenging Easter Island's Collapse: the need for interdisciplinary synergies. Frontiers in Evolution and Ecology 2, 56–57.
Simpson Jr., D.F. (2014). A review of Rapa Nui's Geodynamic, Volcanic, and Geologic Evolution. Apuntes de la Biblioteca William Mulloy. Vol. 3, 1–30.

Reports

Simpson Jr., D.F. (2018). Identificar la Interacción en la Prehistoria de Rapa Nui: Modelización del desarrollo de la complejidad social bajo un aislamiento extremo (003523–14; 003523–14; 003523–14). Reportaje Número Cinco por el Consejo de Monumentos Nacionales de Chile, Isla de Pascua.
Simpson Jr., D.F. (2018). Identificar la Interacción en la Prehistoria de Rapa Nui: Modelización del desarrollo de la complejidad social bajo un aislamiento extremo (003523–14; 003523–14; 003523–14). Reportaje Número Cuarto por el Consejo de Monumentos Nacionales de Chile, Isla de Pascua.
Simpson Jr., D.F. (2017). Identificar la Interacción en la Prehistoria de Rapa Nui: Modelización del desarrollo de la complejidad social bajo un aislamiento extremo (003523–14; 003523–14; 003523–14). Reportaje Número Tres por el Consejo de Monumentos Nacionales de Chile, Isla de Pascua.
Simpson Jr., D.F. (2016). Identificar la Interacción en la Prehistoria de Rapa Nui: Modelización del desarrollo de la complejidad social bajo un aislamiento extremo (003523–14; 003523–14; 003523–14). Reportaje Número Dos por el Consejo de Monumentos Nacionales de Chile, Isla de Pascua.

Reports
Simpson Jr., D.F. (2015). Identificar la Interacción en la Prehistoria de Rapa Nui: Modelización del desarrollo de la complejidad social bajo un aislamiento extremo (003523–14; 003523–14; 003523–14). Reportaje Número Uno por el Consejo de Monumentos Nacionales de Chile, Isla de Pascua.
Simpson Jr., D.F. (2015). 2014–15 Ph.D. fieldwork report. Rapa Nui Journal 29(1), 58–66.

General Publications
Simpson Jr., D.F. (2019). Conducting Responsible and Ethical Archaeological Research on Easter Island: Building Diachronic and Lasting Relationships with the Local Rapa Nui (Easter Island) Community. Journal of the Texas Tech University Ethics Center, 3(1), 20–26.
Simpson Jr., D.F. (2015). Un árbol de 50.000 años: La colonización prehistórica del Pacífico. Correo del Moai 40, 12–3.
Simpson Jr., D.F. (2015). 3D scanning of Polynesian Adzes and Rapa Nui material culture. Social of Social Science Newsletter 25, University of Queensland, St. Lucia, Australia.
Simpson Jr., D.F. (2015). Prehistoric Miners of Easter Island. Revista Moe Varua 87, 1–5.
Torres Jeria, P., **Simpson Jr., D.**, S. Hereveri **(2015).** Manu Iri: Guardianes por el Patrimonio. Correo del Moai 38, 12–3
Simpson Jr., D.F. (2014). Masterclass: Entangled – The relationship between humans and things. Social of Social Science Newsletter 21, University of Queensland, St. Lucia, Australia.
Simpson Jr. D.F. (2014). Sourcing Prehistoric Interaction of Rapa Nui (Easter Island): Modeling the Development of Social Complexity in Extreme Isolation. Unpublished Ph.D. Milestone Document University of Queensland, School of Social Sciences.

Spatial Databases
Simpson Jr. D.F. (2017). Basalt quarries and sources as documented and analyzed by the Rapa Nui Geochemical Project. Easter Island Statue Project database.
Simpson Jr. D.F. (2016). Rapa Nui Preliminary Geochemistry (pXRF) Analysis. Terevaka.net Datashare.

Professional Presentations
2018 "Is there a Golden Mean for Rapa Nui's collapse narrative?" Early Pacific Migration Conference – Hanga Roa, Easter Island, Chile.
2018 "Rapa Nui – Polynesian ancestors and genealogies of stone" Warrenville Public Library – Warrenville, IL., U.S.A. Oct. 2018
2018 "Rapa Nui – Polynesian ancestors and genealogies of stone" Speaker Bureau request for Plymouth Place Retirement Community – La Grange, IL., U.S.A.
2018 "¿Colapso o colaboración? Resultados finales de un estudio de cinco años sobre las industrias de basalto arqueológico de Rapa Nui" Museo Sebastián Englert – Hanga Roa, Isla de Pascua, Chile.
2018 "Conducting responsible and ethical archaeological research on Easter Island: Building diachronic and lasting relationships with the local Rapa Nui community" 8th Annual Responsible Conduct of Research and Academic Integrity Conference – Glen Ellyn, IL., U.S.A. (Invited as the featured closing speaker).
2018 "Behind the *moai* statues: Radiometric dating and geochemistry reveal the prehistoric provenance, timing and use of fine–grain basalt resources" College of DuPage STEMCON – Glen Ellyn, IL., U.S.A. (Invited as a featured speaker).

Professional Presentations

2018 "Behind the *moai* statues: Radiometric dating and geochemistry reveal the prehistoric provenance, timing and use of fine–grain basalt resources" The Field Museum Sponsored Archaeometric Workshop – The Social Side of Archaeometry: Scientific Methods for Addressing Anthropological Questions. The Field Museum of Natural History – Chicago, IL., U.S.A.

2018–2017 "Prehistoric miners of Easter Island: Geoarchaeological and geochemical analyses of Rapa Nui's basalt quarries and artifacts reveal more than collapse" Metea Valley High School Advance Placement Science Courses – Aurora, IL., U.S.A.

2017 "Prehistoric miners of Easter Island: Geoarchaeological and geochemical analyses of Rapa Nui's basalt quarries and artifacts reveal more than collapse" Archaeological Institute of America – Rockford, IL., U.S.A. (Invited as a speaker).

2016 "Easter Island (Rapa Nui) research at the Field Museum of Natural History" The Field Museum of Natural History – Chicago, IL., U.S.A.

2016 "Umanga contra colapso: Un estudio geoquímico de los artefactos y las canteras de basalto de Rapa Nui" Museo Sebastián Englert – Hanga Roa, Isla de Pascua, Chile.

2016–2015 "Selected Works" College of DuPage's Celebrating Our Own Presentation – Glen Ellyn, IL., U.S.A.

2015 "Geochemical and technological analyses of Rapa Nui's basalt quarries and artifacts" (with M. Weisler, E. St. Pierre, Y. Feng, F. Torres, and S. Yancovic Pakarati). 9th International Conference on Easter Island and the Pacific – Berlin, Germany.

2015 "Manu Iri: Heritage Guardians for the future" (with P.Torres Jeria, F. Torres, S. Hereveri, V, Haumaru J. Ramirez, M. Atam, L. Edmunds, V. Atam , P. Tepano, Rodrigo Paoa N. Yancovic Pakarati, M. Fortin, F. Ika, G. Pakarati Pate, S. Tepanodie, T. Atan, R. Durán, and H. Huke). 9th International Conference on Easter Island and the Pacific – Berlin, Germany.

2015 "Mineros Prehistoricos de Rapa Nui" Museo Sebastián Englert – Hanga Roa, Isla de Pascua, Chile.

2014 "Prehistoric quarrying, mining, and artifact manufacture on Rapa Nui (Easter Island)" College of DuPage's Global Presentation – Glen Ellyn, IL., U.S.A.

2014 "Prehistoric quarrying, mining, and artifact manufacture on Rapa Nui (Easter Island)" University of Queensland Archaeology Working Paper Series – Brisbane, Australia.

2014 "Identificar la Interacción en la Prehistoria de Rapa Nui: Modelización del desarrollo de la complejidad social bajo un aislamiento extremo" Museo Sebastián Englert – Hanga Roa, Isla de Pascua, Chile.

2014 "Identificar la Interacción en la Prehistoria de Rapa Nui: Modelización del desarrollo de la complejidad social bajo un aislamiento extremo" Mahinatur & Hotel Hanga Roa Anthropological Workshop – Isla de Pascua, Chile.

2014 "Identificar la Interacción en la Prehistoria de Rapa Nui: Modelización del desarrollo de la complejidad social bajo un aislamiento extremo" Terevaka Archaeological Outreach Workshop – Isla de Pascua, Chile.

2014 "Refining Methods in Micronesian and Polynesian Archaeology at the University of Queensland" (with A. Lambries and M. Harris) University of Queensland Archaeology Working Paper Series – Brisbane, Australia.

2014 "Adztangled: The Rapa Nui (Easter Island) *toki* technocomplex" Professor Ian Hodder Masterclass: University of Queensland – Brisbane Australia.

2014 "Prehistoric Interaction on Rapa Nui (Easter Island); Modeling the Development of Social Complexity in Extreme Isolation" University of Queensland, School of Social Science Ph.D. Confirmation Presentation – Brisbane Australia.

2014 "Sourcing Easter Island" Member's speech Chicago Archaeology Society – Evanston IL., U.S.A. (Invited as a speaker).

Professional Presentations

2014 "Do people still live on Easter Island? Collapse versus progress" University of Queensland's Perspectives on Progress Conference – Brisbane, Australia.
2013 "Prehistoric Interaction on Rapa Nui (Easter Island); Modeling the Development of Social Complexity in Extreme Isolation" Australian Network of Student Anthropologists Panel at the 2013 Australian Anthropological Society Conference – Canberra, Australia.
2013 "Prehistoric Interaction on Rapa Nui (Easter Island); Modeling the Development of Social Complexity in Extreme Isolation" University of Queensland School of Social Science Postgraduate Conference – Brisbane, Australia.
2013 "Prehistoric Interaction on Rapa Nui (Easter Island); Modeling the Development of Social Complexity in Extreme Isolation" University of Queensland Archaeology Working Paper Series – Brisbane, Australia.
2013 "Sourcing Easter Island" University of Queensland: School of Behavioral Sciences Three Minute Thesis – Brisbane, Australia.
2013 "Sourcing Easter Island" University of Queensland: School of Social Science Three Minute Thesis (Best presentation award)–Brisbane, Australia.

Selected media coverage regarding RNGP research

Archaeology Magazine – Carving Tools From Easter Island Analyzed https://www.archaeology.org/news/6891-180813-easter-island-tools

CNN – New theory paints more sophisticated picture of ancient Easter Island https://edition.cnn.com/2018/08/13/world/easter-island-statue-study-intl/index.html

New Scientist – Tools reveal Easter Island may not have had a societal collapse https://www.newscientist.com/article/2176464-tools-reveal-easter-island-may-not-have-had-a-societal-collapse/

Smithsonian – Tools Offer More Complex, Cooperative Picture of Easter Island Society https://www.smithsonianmag.com/smart-news/tools-suggest-easter-island-society-didnt-collapse-180970003/

Newsweek – Easter Island's Ancient Society May Not Have Collapsed In Ways Previously Thought https://www.newsweek.com/easter-islands-ancient-society-may-not-have-collapsed-previously-thought-1069950

The Independent – Easter Island natives were sophisticated and peaceful, new study reveals https://www.independent.co.uk/news/science/easter-island-society-collapse-natives-revealed-study-rapa-nui-a8489476.html

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