Bronze chisel at horvat haluqim (central negev highlands) in a sequence of radiocarbon dated late bronze to iron I layers

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MINING FOR ANCIENT COPPER

Essays in Memory of Beno Rothenberg

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Essays in Memory of Beno Rothenberg

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PREFACE

There is no better way to honor the memory of Beno Rothenberg (1914–2012) than by publishing a volume dedicated to new studies on copper in antiquity. Rothenberg's pioneering work in the Timna Valley, which was the center of his academic career, focused on ancient copper mining and smelting technologies, and paved the way to other studies of this metal and its role in ancient societies around the world.[1] Rothenberg's work is considered by many to be a cornerstone in the development of archaeometallurgy as an integrative research discipline; as such, the study of ancient metal and metal production technologies is based on a synthesis of various avenues of investigation from the natural and social sciences and the humanities, the main objective of which is the study of the people and societies behind the artifacts and technologies.[2] This book celebrates just such an approach with a collection of studies that includes, in addition to contributions on technologies, results of research on various aspects of the production and use of copper in ancient societies: from the geological settings of copper mines to the diet of metalworkers and the characteristics of metal trade systems. The studies range from Oman to the British Isles, with a special emphasis on the southern Levant and the Arabah Valley. They testify not only to the current prosperity of research in the geographical region whose systematic study was pioneered by Rothenberg, but also to the growth and vitality of the research discipline that Rothenberg fundamentally helped to advance (cf., Thornton 2012, Roberts and Thornton 2014).

The book's publication follows the international conference on "Copper in Antiquity" held at the Timna Park (southern Arabah, the Eilot Regional Council) in 2013. The conference, also in memory of Rothenberg, was organized by Tel Aviv University and the Timna Park with the help and support of other organizations,[3] and steered by E. Ben-Yosef with the help of Y. Goren, H. Ginat and A. Holzer. Some of the contributions are based on presentations given at the conference, while others were written especially for the book.

The 37 chapters of the book, contributed by 66 scholars, present a wide array of topics. They are organized in five sections—the first four are divided by geography, while the final section includes studies related specifically to metalworking. The geographic sections are organized according to their proximity to Timna, which, as mentioned above, was at the core of Rothenberg's academic work. The book commences with Timna itself (Section I), goes on to nearby Nahal ʿAmram (Section II), a smaller copper ore district located ca. 5 km to the south of Timna, also within the general region of the southern Arabah Valley. The next section (III) deals with the Faynan copper ore district in the northern Arabah Valley, together with contributions on the Negev and southern Canaan. The last geographic section (IV) contains contributions related to various locations, from Oman to the British Isles, through Cyprus and Greece. This wide geographic spectrum helps to contextualize the intense research in the southern

1 On Rothenberg's work and its contribution to archaeometallurgical research, see Pigott (1996), Ben-Yosef (2012).

2 Rothenberg's research into the metallurgical aspects of the ancient copper ore district of Timna was part of his broader quest for a better understanding of the archaeology and history of the Negev and the Arabah, which started even before his independent projects, while he participated in the expeditions of N. Glueck and Y. Aharoni. This background helps to explain Rothenberg's integrative approach to archaeometallurgical research, and his keen interest in questions related to the society behind the technology— or as he himself put it, archaeometallurgy helps us understand "not only how men made metal, but also how metal made men" (via Bachmann 1990).

3 These organizations include the Dead Sea and Arava Science Center, the Institute of Archaeo-Metallurgical Studies (IAMS) at University College London, the Jewish National Fund, the Eilot Regional Council, the Israel Government Tourist Corporation and the Economic Corporation for the Tourism Development in Hevel Eilot.

Levant presented in the previous sections, and in general emphasizes common denominators in the study of copper across diverse cultures and space.

Section I, "Timna Valley," consists of nine chapters.

- Chapter 1 presents the geological settings of the copper ore, which is a necessary background to the archaeometallurgical research of the region (mining and smelting technologies, distribution of sites, etc.). It also provides a basic background to the ore bodies of Faynan, the Jordanian counterpart of Timna, and Umm Bogma in southern Sinai, both heavily exploited in antiquity.
- Chapter 2 presents an overview of the rather tumultuous debates over the date of the earliest evidence of smelting in the valley, and over the chronology of the main phase of copper exploitation there. The latter is related to the question of "King Solomon's Mines," a subject that is again part of the scholarly discourse as a result of recent discoveries.[4]
- Chapter 3 introduces the Central Timna Valley Project, which commenced in 2012 and has focused since that time on investigating the Late Bronze and Iron Age s (13th– 9th centuries BCE) mining and smelting sites of the region, with emphasis on technological developments and social processes of the people responsible for the copper industry (the early phase of the Edomite Kingdom).
- Chapter 4 presents new data on the diet of the Late Bronze and Iron Age metalworkers, based on remains of mammalian and fish bones from the main smelting sites in Timna. These data are presented together with a summary of previously published materials from Timna and Faynan in order to assess the social status, ethnicity, and other aspects of the people directly engaged in the smelting activities in these periods.
- Chapter 5 is a detailed report of Rothenberg's last excavations at Timna (2001–2002), in the complex shafts and gallery system of Mine T (dated to the Chalcolithic period). The report integrates all the data from the earlier excavations at the mine (1974-1976) into a comprehensive presentation of the research and its results.
- Chapter 6 provides a fresh look at the Egyptian inscription that was found in 1972 on the cliffs above the "Hathor Temple," and in particular at Ramessesempere, the head of the Egyptian expedition to the mines in the days of Ramesses III.
- Chapter 7 presents preliminary results of an archaeomagnetic study of pottery sherds from the Yotvata Fortress. Located just above the nearest permanent water source to Timna, the fortress has been associated with the Egyptian phase of copper production and interpreted as part of the efforts to maintain water supply at this time. The results suggest Late Bronze Age activities, thus corroborating the excavator's dating and supporting his interpretation of the site.
- Chapter 8 presents a fresh interpretation of the later (Iron Age) phase of the "Hathor Temple," with an intriguing suggestion that the place served for the worship of YHWH, the deity of the Israelites, whose source may have been in the south and in connection to ancient metallurgy.
- Chapter 9 presents an analysis of the genealogy of Esau (Edom), in light of our current understanding of the region and the rather fluid role of tribes and clans in forming political alliances. Such alliance is probably behind the Iron Age copper exploitation in Timna and the northern Arabah.

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4 Forty years after the excavations of the "Hathor Temple" in the center of the Timna Valley and the consequent revision in the dates of all major smelting and mining sites, new radiocarbon dates indicated that one of the smelting camps was most active during the 10th – 9th centuries BCE, and not earlier than the second half of the 12th century BCE (Ben-Yosef, Shaar, Tauxe and Ron 2012). This in turn triggered new research in the valley, which has demonstrated that the peak in production was indeed in the early Iron Age and after the Egyptians left the region (Ben-Yosef, this volume); while possible connections to Jerusalem are still debated, the new chronological framework and evidence of long-distance copper trade necessitate reconsideration of the region's role in this formative period in the history of the southern Levant.

Section II, "Nahal ʿAmram," consists of six chapters, all of which present results of a recent interdisciplinary project led by Uzi Avner and focused on the history of mining and smelting in this region.

- Chapter 10 is an overview of the Nahal ʿAmram Project, and provides the dating skeleton of the different sites based on artifact typologies and a large suite of new radiocarbon dates. The main periods of activity were found to be Late Bronze–Iron Ages, Nabataean–Byzantine and Early Islamic.
- Chapter 11 presents volume and mass estimates of mining dumps and slag piles. In addition to enhancing our understanding of the scale of mining and smelting in the Nahal ʿAmram area and nearby sites, the chapter contributes to the development of research methods by the introduction of high-resolution terrestrial laser scans as an efficient technique to tackle such problems.
- Chapter 12 presents a study of paleo-floods based on their record within Nahal ʿAmram's mines. The galleries preserve unique evidence of mega-floods, whose contexts provide important information on their frequencies in the past.[5]
- Chapter 13 presents the diet of the miners based on faunal remains found within the galleries, and concludes that their food was surprisingly rich.
- Chapter 14 presents a detailed report of the comprehensive underground survey of the mines in Nahal ʿAmram, including new mapping of the entire system.
- Chapter 15 presents a preliminary chemical analysis of slag in an attempt to assess developments in smelting technologies through time.

Section III, "Faynan, the Negev and Beyond," consists of eight chapters.

- Chapter 16 presents an overview of the intensive, large-scale anthropological archaeology project in Faynan, Jordan, directed by Thomas Levy and Mohammad Najjar. Commenced in 1997, the project has shed new light on the history of copper ore exploitation in the northern Arabah from the Neolithic to the Late Islamic period, with a substantial contribution to the early Iron Age archaeology of the region. The latter is the focus of the chapter, which discusses the most recent finds and their interpretation by the excavation team (and addresses some criticism).
- Chapter 17 also focuses on Faynan. It presents a new study on the technological developments and organizational structure in the Bronze Age, based primarily on the finds of the comprehensive archaeometallurgical project of the Deutsches Bergbau-Museum (under the direction of Andreas Haputmann, 1983–1993).
- Chapter 18 presents an overview of the Early Bronze Age IV settlement wave in the Negev, with emphasis on its connection to the copper trade between the northern Arabah (Faynan) and Egypt.
- Chapter 19 presents a new study on copper ore fragments found in the Chalcolithic (Ghassulian) site of Abu Matar in the Beer-sheba Valley. While the majority of the ore fragments correspond with the mining site of Faynan, one type offers closer association with ore formations in Anatolia and the Caucasus.
- Chapter 20 presents a lead isotope study of a 12th century BCE bronze chisel from Horvat Haluqim in the Negev. The results suggest that the copper originated in Faynan and that an active metal trade network existed in the south in that period.
- Chapter 21 presents a brief summary of the discovery of Kuntillet ʿAjrud in northeastern Sinai, a unique, possibly cultic site, near the road between the Mediterranean Sea and Elath (Darb al-Ghaza).

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5 The ancient mining landscape of the southern Arabah holds important evidence of the paleo-environment and young geomorphological processes; see, for example, the previous studies of Hauptmann and Horowitz (1980) and Shlomi *et al*. (2015).

Rothenberg's visit to the site in 1967 was an important milestone in its research. The site probably served as an important road station; however, it is not clear if it was related to the copper trade.[6]

- Chapter 22 presents a new study on the provenance of copper in Canaan during the second half of the second millennium BCE. Based on chemical and lead isotope analyses of final copper-based objects, it is demonstrated that Timna played an important role in the copper trade after the Egyptians left the region, and in particular during the 11th century BCE.
- Chapter 23 is a comprehensive overview of our current knowledge of Islamic copper production in the Arabah Valley. While in the Early Islamic period the copper mines of the southern Arabah (Timna and Nahal ʿAmram) were most active, in the Late Islamic period mining activities are documented only in Faynan.

Section IV, "Beyond the southern Levant: Cyprus, Oman, Greece and Britain," contains six chapters, all related to primary copper production (i.e., ore mining and smelting), as evidenced in the archaeological record and historical documentation.

- Chapter 24 presents evidence from a Late Bronze Age (13th century BCE) miners' settlement in the Apliki ore district of Cyprus, which was exposed by modern exploitation of the region.
- Chapter 25 is also focused on Cyprus, albeit in a much later period. It presents the case of King Herod's exploitation of the Cypriot mines (1st century BCE), as relayed by Flavius Josephus, and suggests that this was the major source for Herod's wealth, which enabled his grandiose construction enterprises in Judea and many cities around the Mediterranean.
- Chapter 26 presents preliminary results of an ongoing archaeometallurgical research on Iron Age copper production in the northern al-Hajjar Mountains in Oman. This research is part of a multi-faceted project, which includes surveys, excavations and complementary laboratory work.
- Chapter 27 presents a new study of one of the mines in Mount Pangaeon in northeastern Greece, and at a nearby smelting site (Valtouda). The study includes documentation of mining technologies from the Roman period to the days of the Ottoman Empire, and an assessment of the complex history of exploitation of the multi-metallic (gold-silver-copper) ore body.
- Chapter 28 presents preliminary results of a study on the Bronze Age Great Orme copper mine in north Wales. The study attempts to establish a robust geochemical signature for the ore body, in order to enhance the quality of provenance studies and in turn to reassess the scale of the mining activities (and its geographical impact) and the importance of the site in Bronze Age Britain.
- Chapter 29 is also concerned with Britain in the Bronze Age. It presents new copper mining sites and discusses the main phase of Bronze Age copper exploitation in Britain based on reexamination of radiocarbon dates. The study demonstrates that widespread small-scale mining activities took place in western Britain between ca. 2000–1500 BCE (the termination possibly related to the beginning of copper importation from Europe).

Section V, "Metalworking," consists of eight chapters, all related to secondary copper production (e.g., alloying, recycling, mending and casting) and final copper objects.

- Chapter 30 discusses the transition from copper to iron in the southern Levant. Based on the archaeological evidence, it seems that Judah adopted iron-working earlier than its northern counterpart,

6 Although Kuntillet ʿAjrud is located near one of the main roads between Gaza and Timna, its accepted dating to the 8th century BCE precludes the possibility that it was connected to the copper trade, as the Arabah copper industry ceased at the end of the 9th century BCE (e.g., Ben-Yosef, Shaar, Tauxe and Ron 2012). However, if the beginning of the occupation at Kuntillet ʿAjrud were to be dated earlier, such a connection should be considered (cf., Schniedewind 2017, contra the opinion of the excavator).

the Kingdom of Israel. Various possible reasons for this discrepancy are discussed, among them the stronger affiliation of Judah to metalworking and trends in metallurgical developments based on its connection to the flourishing early Iron Age copper industry of the Arabah.

- Chapter 31 presents a detailed report on the early Iron Age metallurgical workshops at Tel Dan, with evidence for bronze-working and recycling.
- Chapter 32 presents the results of a study on metal recycling procedures based on archaeological finds and Jewish literary sources of late antiquity. The study demonstrates that contrary to the notion that recycling resulted in poor control over composition and quality, the management of scrap metal was actually a developed and sophisticated industry that provided reliable products.
- Chapter 33 presents a study of Early Bronze Age copper refining. Based on evaluation of the technology, the author suggests identifying crucibles depicted in Egyptian Old Kingdom tombs and the Old Babylonian site of Tell edh-Dhibaʿi as refining vessels.
- Chapter 34 presents new evidence of Late Bronze Age bronze production in Qantir–Pi-Ramesse. The evidence indicates a rather high technological variability, as alloying was achieved by different methods, including mixing fresh metals (copper and tin ingots?), recycling and cassiterite cementation.
- Chapter 35 presents copper harpoons of Pre-Dynastic Egypt and discusses their significance in the Naqada culture. An overview of the finds and relevant artistic depictions suggest that they were not only weapons, but also an important symbol that played several roles in ancient Egyptian society.
- Chapter 36 presents new data on bronze working at Sumhuram (Oman). The alloying process was evaluated based on the analysis of metal items dated from the 3rd century BCE to the 4th century CE and other evidence from the site. No diachronic trends or correlation between shape/function and chemical composition were found, suggesting low standardization.
- Chapter 37 discusses the use of copper for the production of weapons at times when iron was the dominant metal of choice. The case study of socketed copper alloy arrowheads of the 7th century BCE demonstrates that copper still had an advantage when certain forms were desired, and even more so given the ability to mass produce by casting.

The wide-ranging contents of this volume demonstrates the importance of copper in the shaping of human history. Since the dawn of metallurgy more than 7,000 years ago, copper has been used to produce a wide assortment of objects with different functions in ancient societies, from ornaments, cult and art to agricultural and domestic tools, weapons and coinage.[7] This in part is what makes copper, and the evidence related to the efforts invested in its production, so well suited for deciphering social meaning and extracting knowledge about the past.

This book, in memory of Beno Rothenberg, also commemorates his friend and colleague, Professor Tim Shaw (1934-2017), who contributed, together with Alexandra Drenka, a comprehensive chapter on Mine T in Timna (Chapter 5). Shaw was Professor of Mining Engineering at Imperial College London, who became fascinated with the archaeology of ancient mines (*mining archaeology/Montanarchäologie*)[8] through his work with Rothenberg in Timna. He was engaged in archaeological research and in teaching archeaologists for many years, including at the archeaometallurgy summer school of the Institute of Archaeo-metallurgical Studies (IAMS) at University College London. Shaw's research achievments will undoubtedly continue to be part of the investigation of the Timna mines and other ancient mining districts around the world.

7 On this, in relation to the modern exploitation of copper, see the recent publication of Golding and Golding (2017).

8 This research field, sometimes included under the broader discipline of "archaeometallurgy," has been attracting a growing interest in recent years (cf., Stöllner 2014).

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Erez Ben-Yosef, Editor
2018

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CHAPTER 20

BRONZE CHISEL AT HORVAT HALUQIM (CENTRAL NEGEV HIGHLANDS) IN A SEQUENCE OF RADIOCARBON DATED LATE BRONZE TO IRON I LAYERS

Hendrik J. Bruins, Irina Segal and Johannes Van der Plicht

The rural settlements in the central Negev highlands and adjacent Sinai area, usually assigned to the Iron IIA, are enigmatic in terms of origin, duration and ethnicity. Very few metal objects have thus far been found at these sites. Excavations at Horvat Haluqim at the edge of an ancient terraced field in the Eastern wadi revealed a continuous series of finely stratified layers in which a bronze chisel was found. Radiocarbon dates for these layers range from the 14th century BCE in the deeper layers to the 12th century BCE in the upper layers. The composition of the bronze chisel, dated to the 12th century BCE, is 89.7% copper, 2.5% tin and 1% lead. The lead isotope ratios show that the origin of the copper ore is from the Faynan Dolomite-Limestone-Shale (DLS) unit. Therefore, trade relations probably existed in the 12th century BCE between Horvat Haluqim and the Faynan area. The Zin Canyon with its springs is a convenient natural east–west route that connects the Faynan area with Horvat Haluqim. Various metallurgic sites in the Faynan area, as well as in the Timna area, have radiometric absolute dates within the Late Bronze and early Iron Ages. The so-called empty second millennium BCE in the region is gradually becoming more visible with the use of geoarchaeology and radiocarbon dating. It seems that local desert inhabitants are related to these settlements, possibly the biblical Amalekites, as proposed by Beno Rothenberg more than 40 years ago.

INTRODUCTION

The rural archaeological site of Horvat Haluqim is situated in the central Negev highlands a few km northeast of Kibbutz Sede Boker. The site is spread along three terraced wadis of the first stream order,[1] sloping southward from the Haluqim Anticline (Fig. 20.1). The average annual rainfall at the nearby Sede Boker meteorological station during the decade of 1990–2000 was 93.3 mm (Bruins 2012: 39). According to Cohen (1976), who excavated a number of structures at the site in 1971–1972, Horvat Haluqim consists of 25 buildings and four cisterns. Besides a Roman watchtower, most of the remains at the site were dated by him to the Iron II (10th century BCE) (*ibid*.; Cohen and Cohen-Amin 2004).

Cohen classified the largest building as an oval fortress, 23 × 21 m in diameter, characterized by casemate rooms surrounding an inner courtyard. The building is situated along the Eastern Wadi, about 100 m downstream (south) from the nearest ancient agricultural terraced fields. Such comparatively

1 The initial part of a wadi in a natural valley system, draining the runoff waters of the related hilly catchment at the Haluqim Anticline.

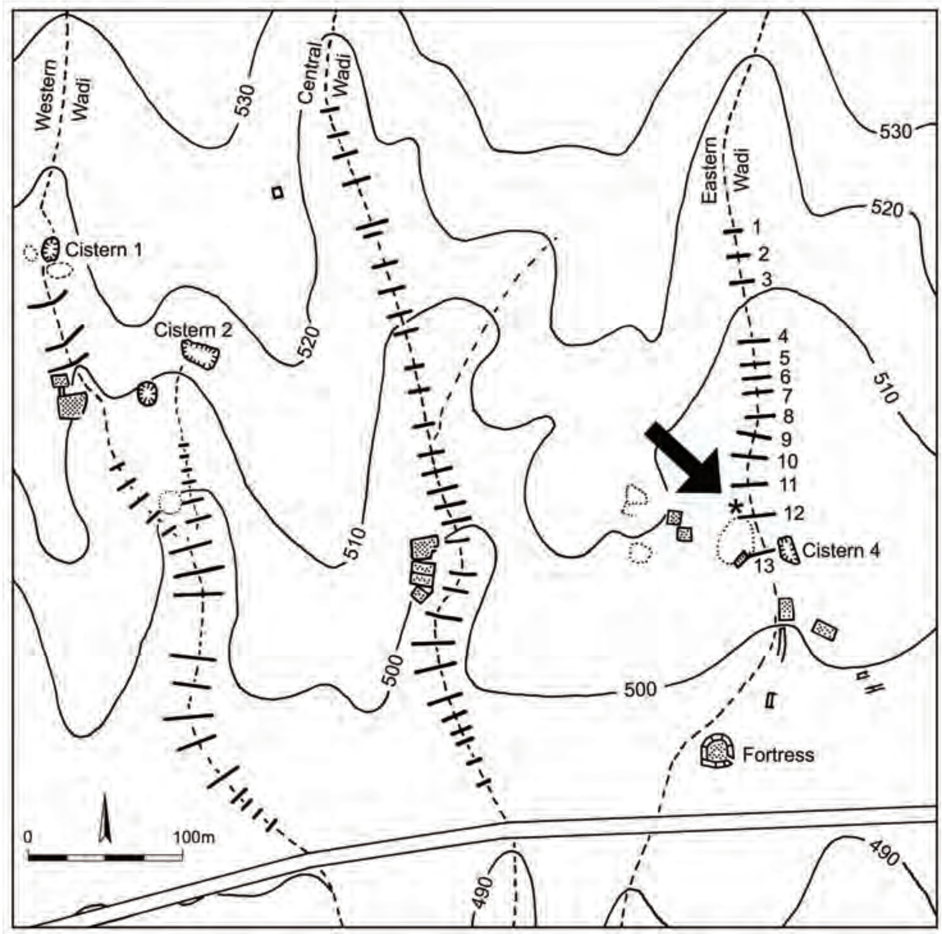

Fig. 20.1: Map of the rural desert site of Horvat Haluqim, showing the three terraced wadis and the adjacent buildings and cisterns. The bronze chisel was uncovered at the westernmost edge of Terraced Field 12, as indicated by an arrow and star *, about 4 m upstream (north) of Terrace Wall 12.

large buildings with oval, irregular or rectangular architectural outlines have been found at dozens of sites in the central Negev highlands and the adjacent northeastern Sinai (*ibid*.). The various scholarly opinions regarding these types of structures is beyond the scope of this article. We only mention these structures here as one of the important features at the site of Horvat Haluqim.

It was Cohen's assessment (1976: 34, 40) that the ancient terraced agricultural fields in the three wadis at Horvat Haluqim probably dated to the Iron Age, in view of the position of some building remains next to such terraced fields. At the time (1970s, 1980s), Cohen's proposition was innovative, since even today many archaeologists maintain that the terraced agricultural fields in the Negev highlands do not predate the Byzantine or late Nabatean period. However, all these opinions were based on circumstantial evidence, as ancient agricultural fields in the Negev highlands had not been excavated at the time.

Bruins renewed excavations at Horvat Haluqim since 1982 (1986, 2007; Bruins, Van der Plicht and Haiman 2012), in the context of the Negev Emergency Survey and following consultations with Rudolf Cohen. His initial investigations dealt with the terraced agricultural fields in the realm of landscape archaeology and geoarchaeology, with special focus on soil science, geomorphology and agriculture based on runoff/floodwater (Bruins, Evenari and Nessler 1986; Bruins 1990, 2007, 2012; Bruins and

Ore 2009; Bruins and Van der Plicht 2017). Often there is no organic material for radiocarbon dating in ancient terraced fields and OSL dating is required to obtain data concerning the age of the terrace soils and underlying sediments (Avni, Avni and Porat 2009; Avni, Avni and Porat 2012; Avni *et al*. 2006).

In this article we present the discovery of a bronze chisel, unearthed *in situ* at the edge of Terraced Field 12 (Area 5), situated in the Eastern Wadi of Horvat Haluqim (Figs. 20.1–2). The bronze chisel was found in a sequence of alternating dark and light-colored layers. Total station measurements of the chisel and five organic samples excavated in its vicinity resulted in a detailed stratigraphic resolution and radiocarbon chronology.

BRONZE OBJECTS IN IRON AGE SITES OF THE NEGEV HIGHLANDS

Following extensive surveys and excavations of many Iron Age rural settlements in the Negev highlands, Cohen (1986: 395) emphasized that only very few metal objects were uncovered, as observed also by Meshel (2000: 68). These objects include a bronze axe found in the Nahal Zena Fortress (Cohen and Cohen-Amin 2004: 65–67), an arrowhead in Atar Ha-Ro^{c}a (Cohen 1986: 395), an arrowhead in casemate Room 14 of the Har Boqer Fortress (Cohen and Cohen-Amin 2004: 45–47), three copper awls in Building 4 at the Ramat Matred site, and a needle in the Nahal Sirpad Fortress (Cohen 1986: 395).

Therefore, the excavation of a bronze chisel at Horvat Haluqim adds new information to the very limited corpus of metal objects found thus far in these rural central Negev settlements. Our investigation of its stratigraphic position, radiocarbon chronology and chemical composition yielded new data concerning the age of certain rural elements in these settlements, as well as regional copper trade relations.

METHODOLOGY

Excavations were conducted during 2007 at the edge of Terraced Field 12, in the northwestern part of Area 5. An electronic Pentax Total Station PCS/2s theodolite was used to measure various excavation positions and establish absolute elevation levels for the bronze chisel and stratigraphically related organic samples used for radiocarbon dating.

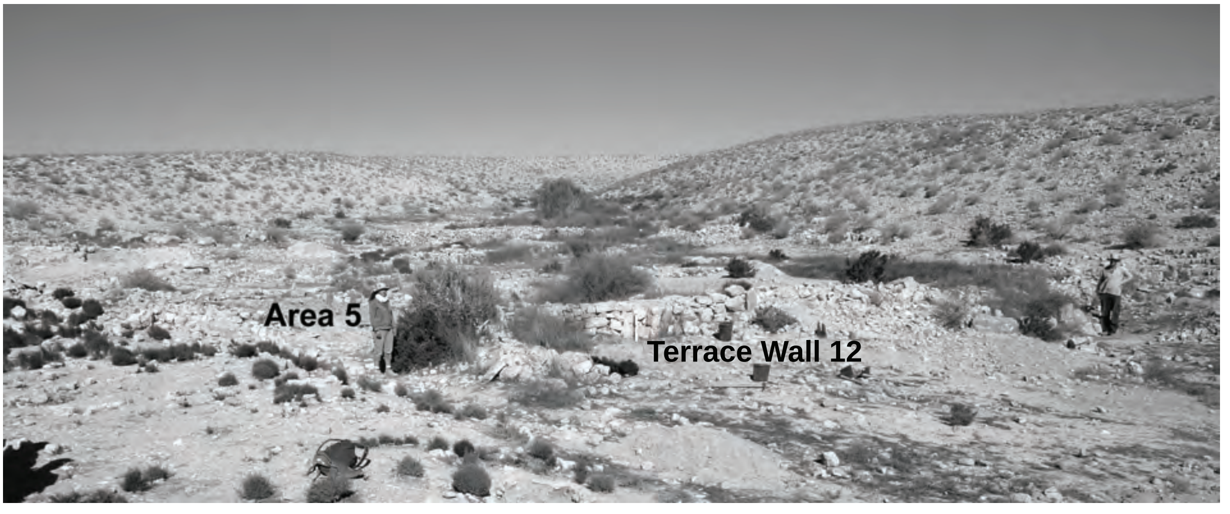

Fig. 20.2: The terraced Eastern Wadi at Horvat Haluqim, looking northward. Terrace Wall 12, oriented east–west, is shown in the foreground. The Terrace Wall once continued where the person on the left is standing. The bronze chisel was excavated in Area 5.

The organic samples were measured at the Radiocarbon Laboratory of the University of Groningen (the Netherlands) with standard procedures for the materials involved. The samples, composed of charred organic material, small black particles or flecks in the terrace soil layers, were pretreated using conventional chemical approaches to remove modern organic material and soil carbonates. The pretreatment of animal bones is somewhat different, as the collagen fraction was separated from the bone sample and subsequently purified. In each case, the purified organic matter was converted into CO_2 and subsequently into solid carbon to prepare the graphite targets for the ion source of the Accelerator Mass Spectrometer (AMS) at Groningen University, according to the methodology described by Van der Plicht *et al.* (2000) and Aerts-Bijma, Van der Plicht and Meijer (2001).

The bronze chisel was put through chemical and isotopic analyses, conducted by Irina Segal in the Geochemistry Department of the Israel Geological Survey in Jerusalem. Drillings were made in the chisel to obtain samples of the internal non-weathered part of the metal. A sample (25 mg) of the metal was dissolved in aqua regia (HNO_3: HCl = 1:3). This solution was analyzed for chemical composition using an Inductively Coupled Plasma Atomic Emission Spectrometer (ICP-AES, Optima 3300, Perkin Elmer). The same solution was used for lead isotope measurements by a Multiple Collector ICP Mass Spectrometer (MC-ICP-MS, NU Plasma). A provenance study was made, based on the lead isotope ratios measurements, in order to investigate the source of the copper in the chisel.

RESULTS

THE BRONZE CHISEL

The chisel was found in a section of Area 5A termed the “copper spot,” following its discovery (Fig. 20.3). The precise location of the chisel is indicated by an arrow in Fig. 20.4. The bronze chisel is weathered on the surface, showing various green spots of copper oxidation (Fig. 20.5). It is 4.6 cm long, is (maximum) 0.8 cm wide at its broad end and (maximum) 0.6 cm thick. The narrow end of the chisel is 0.4 cm wide and 0.25 cm thick. Bronze chisels of this period are usually longer and it is quite possible that the chisel broke at its thicker end during use.

Radiocarbon Dating of Layers above and below the Bronze Chisel

The excavated layers in Area 5 of Terraced Field 12 are characterized by thin layers running more or less parallel to each other (Figs. 20.3–4). The colors vary, as some are dark and others lighter. The layers are not inside a building, but are located on the western edge of Terraced Field 12. However, a badly preserved building structure is present to the south of Area 5. This structure, to be excavated at a later date, forms a kind of extension of Terrace Wall 12, subsequently continuing as a low wall surrounding an oval courtyard, situated to the west of Terraced Field 13 (Fig. 20.1). Micromorphology samples were taken of the excavated layers, but these detailed stratigraphic results on the microscopic level will be published elsewhere.

The total station measurements determined the elevation of the bronze chisel to be in the range of 502.64 m to 502.63 m (Table 20.1). A sample of charred organic material (a dark fleck in the finely stratified layers) and a bone fragment were found at a similar level of 502.64 m (0 to 1 cm above the level of the bronze chisel. Both radiocarbon dates (GrA-37496 and GrA-37497) are quite similar, within 1σ of each other (Table 20.1). Their full 1σ and 2σ calibrated age ranges are shown in Table 20.1. The median calibrated values are 1108 BCE and 1146 BCE, respectively. Both dates can be classified in cultural archaeological terminology as belonging, on the basis of time, to the Iron I.

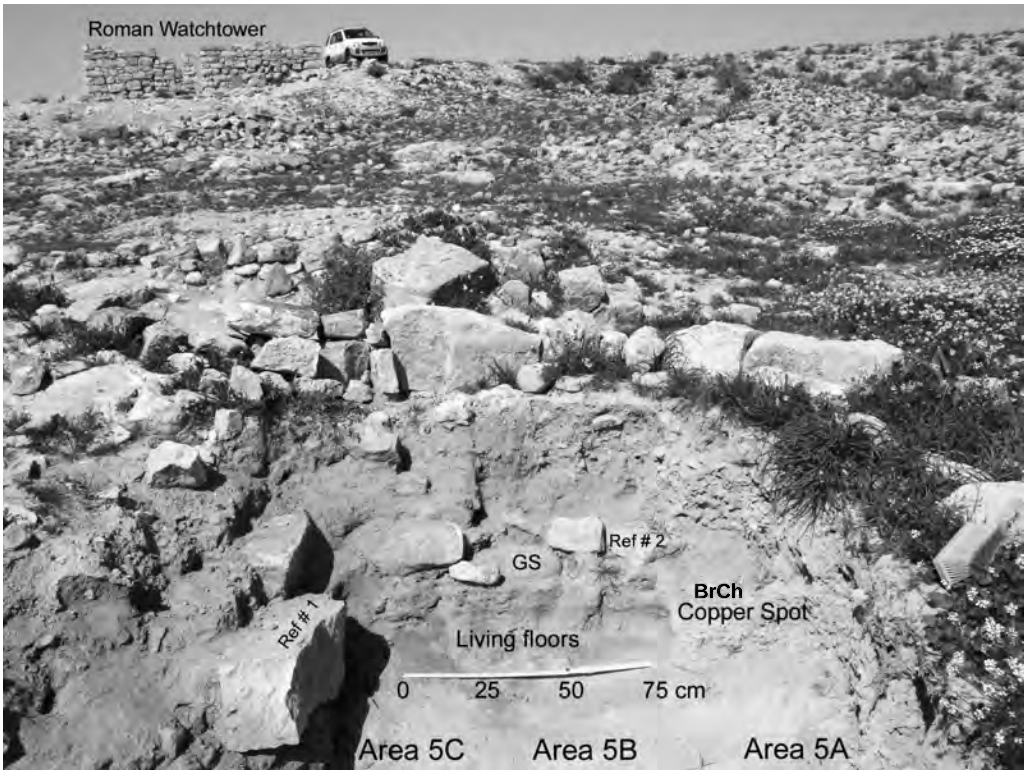

Fig. 20.3: Area 5A, 5B and 5C in the westernmost part of Terraced Field 12. The bronze chisel (BrCh) was uncovered in the "Copper Spot" area, located in Area 5A. The parallel oriented layers (possibly living floors) are visible above the measuring staff. Two stones (Ref#1 and Ref#2) served as measurement points in relation to relative depth and absolute height. An *in situ* grinding stone (GS), typical for crushing cereal grains, was found in the upper part of the finely stratified layers. The Roman watchtower can be seen on the hill spur in the west.

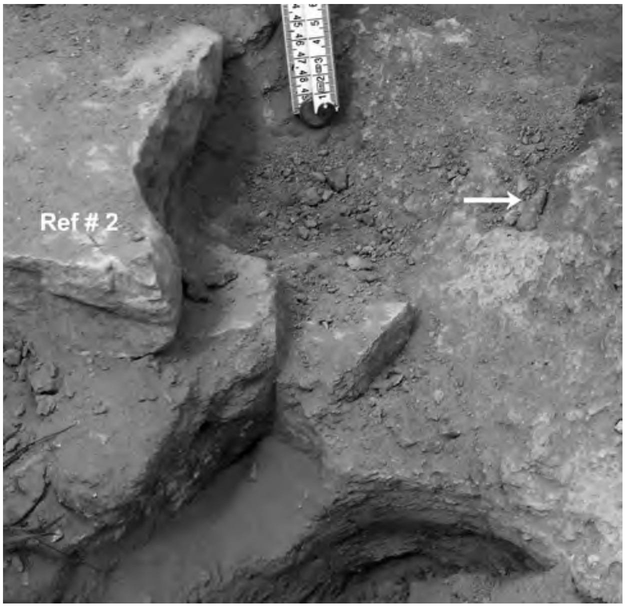

Fig. 20.4: The location of the bronze chisel in Area 5A, upon discovery, is indicated by a white arrow. It was found in a sequence of fine layers, visible as thin parallel layers in the vertical section below the white arrow.

TABLE 20.1: STRATIGRAPHIC POSITION OF THE BRONZE CHISEL IN RELATION TO RADIOCARBON DATED ORGANIC MATERIALS IN ADJACENT LEVELS WITHIN THE FINELY STRATIFIED LAYERS OF AREA 5 (FIGS. 20.1–3), TERRACED FIELD 12, EASTERN WADI, HORVAT HALUQIM

Sample # and Date	*Area and Depth**	*Organic Material Dated*	*Groningen Sample #*	*^{14}C Date (BP)***	*$\delta^{13}C$ (‰) ****	*Calibrated Date Year BCE (1σ) *******	*Calibrated Date Year BCE (2σ)*	*Calibrated Date Year BCE (Median)*
HH-2007-03 11/03/2007	Area 5A, 502.64 m	Charred organic material	GrA-37496	2915 ± 40	-22.95	1192–1143 (21.8%) 1132–1046 (46.4%)	1256–1252 (0.3%) 1231– 997 (95.1%)	1108
HH-2007-05 11/03/2007	Area 5B, 502.64 m	Bone, indeterminable	GrA-37497	2940 ± 40	-18.23	1215–1083 (66.3%) 1064–1059 (1.9%)	1261–1018 (95.4%)	1146
Bronze chisel 11/03/2007	Area 5A, 502.64 m 502.63 m							
HH-2007-01 11/03/2007	Area 5A, 502.61 m	Bone, sheep/goat, upper jaw M3 right, ca 2 years old	GrA-37493	2960 ± 40	-17.12	1257–1251 (2.1%) 1231–1116 (66.1%)	1286–1031 (95.4%)	1171
HH-2007-16 25/01/2007	Area 5B, 502.58 m	Bone, rib, medium-sized mammal	GrA-37515	3020 ± 40	-18.27	1378–1345 (14.2%) 1305–1211 (54.0%)	1397–1156 (91.5%) 1147–1128 (3.9%)	1267
HH-2007-24 13/03/2007	Area 5A, 502.50 m	Charred organic material	GrA-48874	3115 ± 40	-23.14	1433–1376 (40.4%) 1346–1304 (27.8%)	1494–1479 (2.1%) 1456–1269 (93.3%)	1379

* The depth values are absolute elevation levels based on measurements with a Total Station. The soil surface levels of Terraced Field 12 in 2007 next to excavation Area 5 ranged from 503.17 m in the west to 502.94 m in the northeast (Fig. 20.2).

** The radiocarbon dates are reported by convention in BP, i.e., based on the Oxalic Acid standard, using correction for isotopic fractionation with $\delta^{13}C$, and using the so-called Libby half-life value (Mook and Streurman 1983).

*** The $\delta^{13}C$ is the $^{13}C/^{12}C$ ratio of the sample material, expressed in per mille difference from the standard (Mook and Streurman 1983).

**** The radiocarbon dates, measured by AMS at Groningen University, were calibrated with OxCal v. 4.2.2 (Bronk Ramsey 2001, 2013) using the ratified IntCal13 calibration curve (Reimer *et al*. 2013). The calibrated ages are given in three columns: 1σ (68.2% p) represents the age range(s) with highest relative probability; 2σ (95.4% p) gives most of the possible age ranges including those of relatively low probability; the median is a "central" numerical value in the sense that half of the total calibrated age is older than the Median and the other half is younger.

Two other bone fragments and a sample of charred organic material (dark fleck in the finely stratified layers) were found at different elevations below the stratigraphic position of the bronze chisel (Table 20.1). The 1σ and 2σ calibrated age ranges of GrA-37493, GrA-37515 and GrA-48874 are shown in Table 20.1. The radiocarbon results are very consistent with increasing stratigraphic depth. The respective median calibrated values are 1171 BCE, 1267 BCE and 1379 BCE. We have here evidence of a stratified sequence from the Late Bronze Age to the Iron I, suggesting continuous occupation on the western edge of Terraced Field 12 in the Eastern Wadi of Horvat Haluqim during this time period. The bronze chisel, situated stratigraphically between GrA-37497 and GrA-37493, dates most likely to the 12th century BCE.

Chemical Composition of the Bronze Chisel

The geochemistry of the chisel shows a composition of tin bronze, containing 89.7% copper, 2.5% tin and 1% lead. All other elements are present in trace concentrations (Table 20.2).

The lead isotope ratio measurements ($^{204/206}$Pb, $^{208/206}$Pb, $^{207/206}$Pb) of the bronze chisel are shown in Table 20.3. Comparison of these results with lead isotope ratios of relevant copper ores in the region, Faynan (Hauptmann *et al.* 1992), Timna (Gale *et al.* 1990) and Sinai (Hauptmann, Begemann and Schmitt-Strecker 1999), are shown in Figs. 20.6–7. It is clear that the bronze chisel from Horvat Haluqim has lead isotope ratios that are most similar to Faynan DLS, i.e. the copper ore found at Faynan in the Dolomite-Limestone-Shale unit of Cambrian Age (Hauptmann *et al.* 1992). The distance from Horvat Haluqim to Faynan, as the crow flies, is about 73 km, while the distance to Timna is considerably longer, about 125 km.

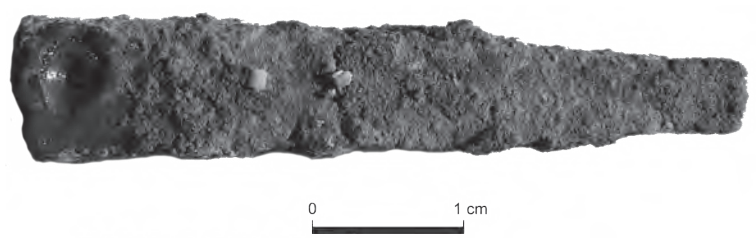

Fig. 20.5: Close-up of the Horvat Haluqim copper chisel, 4.7 cm long and 0.9 to 0.5 cm wide. Its tapered end to the right was probably hardened and flattened by repeated heating and hammering. The chisel may have been broken during usage in the past at its wider and thicker left end. Here a sample was drilled for our chemical investigation, exposing the bronze metal.

Table 20.2: Chemical Composition, in Weight Percentages, of the Bronze Chisel from Horvat Haluqim

S	*Pb*	*Co*	*Ni*	*Mn*	*Fe*	*Cu*	*Ag*	*Sb*	*As*	*Sn*	*Zn*	*Au*
0.3	1.04	0.026	0.031	<0.001	0.05	89.7	<0.005	<0.01	<0.01	2.51	0.03	<0.01

Table 20.3: Lead Isotope Ratios of the Bronze Chisel from Horvat Haluqim

	$^{204/206}Pb$	σ	$^{208/206}Pb$	σ	$^{207/206}Pb$	σ
Measurement 1	0.05563	0.00002	2.1203	0.0012	0.8691	0.0002
Measurement 2	0.05565	0.00003	2.1200	0.0014	0.8692	0.0003
Measurement 3	0.05563	0.00002	2.1215	0.0010	0.8696	0.0002
Average	0.05563	0.00001	2.1204	0.0005	0.8693	0.0002

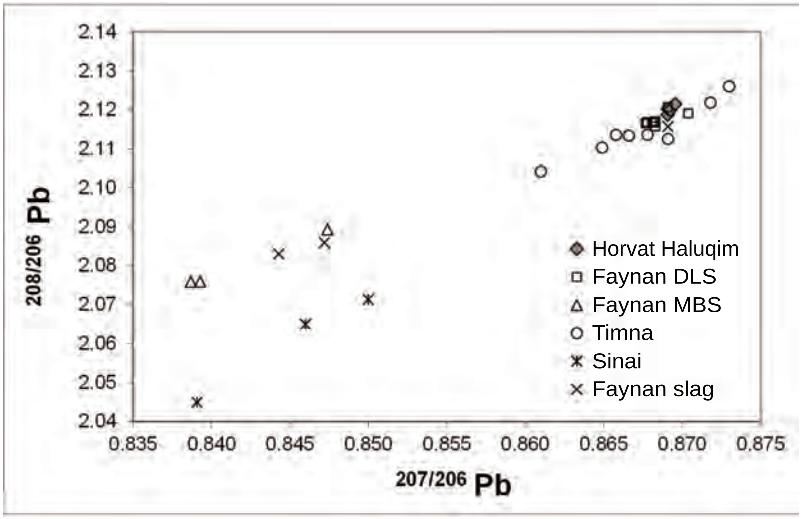

Fig. 20.6: Lead isotope ratios of $^{208/206}$ Pb and $^{207/206}$ Pb of the bronze chisel from Horvat Haluqim, in comparison to Faynan ores and slag (Hauptmann *et al.* 1992), Timna ores (Gale *et al.* 1990) and Sinai ores (Hauptmann, Begemann and Schmitt-Strecker 1999).

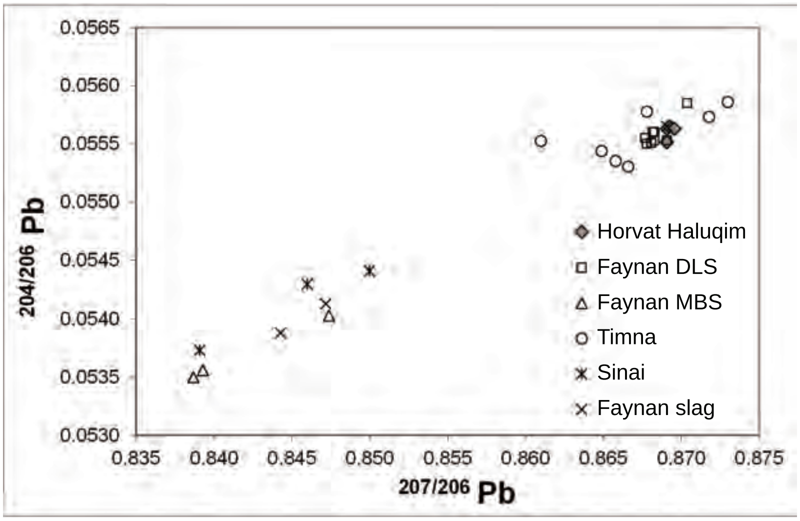

Fig. 20.7: Lead isotope ratios of $^{204/206}$ Pb and $^{207/206}$ Pb of the bronze chisel from Horvat Haluqim, in comparison to Faynan ores and slag (Hauptmann *et al.* 1992), Timna ores (Gale *et al.* 1990) and Sinai ores (Hauptmann, Begemann and Schmitt-Strecker 1999).

DISCUSSION

The bronze chisel from Horvat Haluqim, situated in a sequence of finely stratified layers in an open rural context at the western edge of Terraced Field 12, is dated by radiocarbon to the 12th century BCE. Layers below the bronze chisel become gradually older, reaching the 14th century BCE. A weathered bronze chisel in the Petrie Museum of Egyptian Archaeology UCL (London), dated on archaeological criteria (*not* by radiocarbon) to the 19th Dynasty (Fig. 20.8), looks rather similar to the Horvat Haluqim chisel. They have analogous shapes and dimensions in terms of width and thickness. The Horvat Haluqim chisel appears too short, 4.6 cm, for convenient handling with a hammer. It was probably longer, like the Egyptian 19th Dynasty example (Fig. 20.8), and seems to have broken in the past at its broad end (Fig. 20.5).

Fig. 20.8: A weathered bronze chisel, similar to the one found at Horvat Haluqim. The Egyptian flat chisel, 8.5 cm long and 0.8 cm wide, flattened and flared at the left end, is dated to the 19th Dynasty. Copyright University College London, the Petrie Museum of Egyptian Archaeology UCL, in London, catalogue number UC29303, published here by permission.

The five radiocarbon dates of the sequenced layers are consistent in stratigraphic order. They constitute a problem for the conventional archaeological framework in the area. Extensive surveys and excavations in the central Negev and northeastern Sinai during the 1970s and 1980s convinced Cohen and others that the entire 2nd millennium BCE (Middle Bronze II and III, Late Bronze and Iron I) is absent in this region. However, ^{14}C results of Tell el-Qudeirat, the Qudeirat Valley and Horvat Haluqim yielded dates in the second millennium BCE (Bruins 1986; Bruins and Van der Plicht 2005, 2007, 2017; Carmi and Segal 2007; Van der Plicht, Bruins and Nijboer 2009; Bruins, Nijboer and Van der Plicht 2011).

Concerning the vexing question of origin and ethnicity of these settlements, Cohen (1976: 49) interpreted the site of Horvat Haluqim and similar rural settlements as "the expansion of the Solomonic kingdom into the central Negev highlands." Hence these sites were considered by Cohen as Israelite. The end of these settlements was attributed by him to the campaign by Pharaoh Shishak (Cohen 1976: 50; Cohen and Cohen-Amin 2004). Therefore, the time of human activity in these settlements, from establishment to abandonment, was rather short in the above interpretation, only a few decades from about the middle of the 10th century BCE to roughly around 925 BCE. Although ceramic finds at Horvat Haluqim are comparatively rare, hand-made Negbite pottery dominates, which cannot be used for dating, due to its long time range (Cohen 1976: 44). Only a small fraction of the ceramic finds at Horvat Haluqim, i.e., wheel-made pottery, was included in the above archaeological age assessment.

A comprehensive discussion of the Iron Age sites in the Negev is beyond the scope of this article. Nevertheless, it is appropriate to include here the viewpoints expressed by Beno Rothenberg. His excavations at Timna (Rothenberg 1972: 153–170) showed the presence of hand-made Negbite pottery in contexts with Egyptian material remains of the 19th and 20th Dynasties, ranging from Sethos I (1318–1304 BCE) to Ramesses V (1160–1156 BCE). Therefore, he suggested that the rural settlements in the central Negev, dominated by Negbite pottery, may have a longer history that preceded the Iron IIA, and include the Late Bronze Age and Iron I. These propositions by Rothenberg are indeed supported by the above series of radiocarbon dates from Horvat Haluqim.

Rothenberg (1967: 86–100; 1972: 153–154; 1979: 122–123; 1996–1997: 36) proposed that the biblical Amalekites established the central Negev settlements in the Late Bronze Age. The word Amalek or Amalekites occurs about 50 times in the Hebrew Bible, for example Num 13:29–עֲמָלֵק יוֹשֵׁב בְּאֶרֶץ הַנֶּגֶב– which can be translated as "Amalek resides (dwells) in the land of the Negev." Rothenberg (1972: 181–182) also suggested that the population of the Negev highlands may have been involved in the copper industry at Timna.

The chemical composition of the bronze chisel from Horvat Haluqim (Figs. 20.6–7) points to Faynan, rather than Timna, as the source of the copper ore. Radiocarbon dates from a variety of metallurgic sites in the southern Levant were compiled by Ben-Yosef *et al.* (2010). These dates show quite a number of sites in both the Faynan–Timna areas having radiocarbon ages in the Late Bronze and Iron I. Also archaeomagnetic dating of Site F2 at Timna, as well as ^{14}C and TL dates, show that copper production took place in the region during the Late Bronze and early Iron Ages, 13th to 11th century BCE (Ben-Yosef, Tauxe and Levy 2010). Later in the Iron Age, copper production was prominent at Khirbat en-Nahas, covering the 10th and 9th centuries BCE (Levy *et al*. 2008) and also at Timna Site 30 during the 11th to 9th centuries BCE (Ben-Yosef *et al*. 2012).

CONCLUSIONS

Detailed radiocarbon dating of a sequence of layers on the edge of Terraced Field 12 in the Eastern Wadi of Horvat Haluqim gives evidence of continuous occupation from the Late Bronze Age to the Iron I (14th to 12th centuries BCE). A bronze chisel excavated in these layers was dated by radiocarbon to the 12th century BCE. Lead isotope ratios of the bronze chisel show that the origin of the copper ore is from the Dolomite-Limestone-Shale unit of the Cambrian Age in the Faynan area. Apparently trade relations existed between Horvat Haluqim and the Faynan area in the 12th century BCE. The most convenient east–west route from the Faynan area through the Negev to Horvat Haluqim is via the Zin Canyon, which contains a number of springs. Various metallurgic sites are known in the Faynan area, as well as in the Timna area, having absolute dates within the Late Bronze and early Iron Age. The so-called empty second millennium BCE in the central Negev highlands and northeastern Sinai is gradually showing more evidence of archaeological features that had remained "invisible" with traditional archaeological methodologies, lacking or ignoring both geoarchaeology and radiocarbon dating. Local desert inhabitants probably established these settlements, possibly the biblical Amalekites, as proposed by Beno Rothenberg more than 40 years ago.

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