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The dynamic Archean to Paleoproterozoic crustal evolution of Brazil: Preface

Brazil is the largest country in South America and contains the majority of the exposed Archean and Paleoproterozoic crust on the continent. As such, Brazil provides a natural laboratory for studies of the ancient Earth. In this Special Issue, contributions reflect the dynamic and protracted growth and reworking of former continents during a time frame of over a billion years, and depict how changes across the evolution of plate tectonics may have influenced the evolution of the interlinked crust-ocean-atmospheric Earth cycles over this period.

Geoscientists extensively debate the mechanisms of continental crust formation, recycling and reworking through Earth history (e.g., Stern, 2007; Cawood et al., 2018; Brown et al., 2020). The rates of production and destruction of the continental crust have changed over time, and have left behind an incomplete geological record (Hawkesworth et al., 2009; Dhuime et al., 2018). Studying the events that shaped the Archean to Paleoproterozoic geological record is hampered by the overprinting of younger tectonic events that superimpose primary features, yet study of these older geological terranes is one of the only ways to interrogate the evolution of the ancient continental crust and plate tectonics. In this Special Issue, authors have focused on Archean relicts and Paleoproterozoic segments in Brazil that witnessed the formation of the first supercontinent, Columbia (also known as Nuna). These ancient lithospheric fragments are now partially overlain by younger sedimentary cover and intertwined by Neoproterozoic orogens that delimit cratonic boundaries but still preserve much of their original conditions of formation.

The first studies of this Special Issue focus on Archean occurrences and reworking events, and how they reflect rates of growth of the continental crust in the Brazilian cratons. The second group of papers of this Special Issue concentrates on the amalgamation of the Archean blocks during the Paleoproterozoic that produced most of the paleo-cratons in Brazil and South America. All contributions of this Special Issue are based on detailed fieldwork, petrology and whole-rock geochemistry associated with high spatial analyses of accessory mineral phases. The contributions provide excellent examples of how to use fundamental tools in geology to better understand the crustal evolution in ancient cratons, and overall attest for an active and dynamic plate tectonics regime and significant ocean-atmospheric changes since the Paleoarchean.

In the opening paper "*Evolution of the 3.65–2.58 Ga Mairi Gneiss Complex, Brazil: Implications for growth of the continental crust in the São Francisco Craton*", de Camargo Moreira et al. (2022) present a zircon U-Pb and Lu-Hf isotopic study of the oldest gneissic occurrences in South America. An evolution from supra-chondritic/chondritic values in the Eoarchean to sub-chondritic in the Neoarchean suggests that the growth of the Eoarchean continental crust in the São Francisco Craton was mostly derived from a primordial mantle composition, and later reworked by the end of the Archean, likely driven by thickening of the crust. Overall, this contribution proposes that the dynamic generation and reworking features observed in cratons worldwide relate to a secular change in the Neoarchean, whereby an isotopic rejuvenation of sources is linked to a transition from stagnant lid to mobile lid tectonics.

The paper "*Unraveling one billion years of geological evolution of the southeastern Amazonia Craton from detrital zircon analyses*", by Rossignol et al. (2022), provides a comprehensive study on detrital zircons from one of the largest cratonic areas in the world, the Amazonia Craton, which depicts episodes of amalgamation and breakup during the Paleo- to Mesoarchean, providing further evidence for the presence of Archean supercontinents. The roots of the Amazonia Craton date back to the Eoarchean, represented by >3.6 Ga old zircon grains dated in the study. The paper also documents a significant shift in depositional style immediately preceded by emplacement of the 2.7 Ga large igneous province. This change to an extensional regime is marked by the presence of iron formation and terrigenous sediments, and potentially resulted from the emergence of the Amazonian Craton above sea level at this time.

In the third paper, "*Paleo- and Mesoarchean TTG-sanukitoid to high-K granite cycles in the southern São Francisco craton, SE Brazil*", Valeriano et al. (2022) focus on the geochemical and isotopic reconstruction of a secular magmatic transition in the Archean, interpreted to represent the evolution of a subduction-like process. A similar magmatic transition is also recognized in the southern São Francisco Craton during the Paleoproterozoic, suggesting a repetition of this process. The Archean crustal evolution recorded in the Campos Gerais complex depicts crustal maturation at the end of the Paleoarchean and can be briefly summarized as follows: The 2.96 Ga TTG and 2.89 Ga sanukitoid magmatic rocks represent continental magmatic arcs with variable crustal contamination resulting from subduction-like processes of oceanic slabs along a Meso- to Paleoarchean continental margin. A collisional event at ca. 2.82–2.81 Ga resulted in the migmatization of the previous rock association, with the emplacement of high-K leucogranites. Renewed 2.77–2.76 Ga intrusive tonalitic TTG magmatism may be indicative of a new phase of subduction-like processes.

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Within-plate 2.67 Ga tholeiitic mafic magmatism completes the Archean evolution preceding the onset of Paleoproterozoic rifting and later processes.

Martins et al. (2022) "*Chemical-Abrasion U-Pb zircon geochronology reveals 150 Myr of partial melting events in the Archean crust of the São Francisco Craton*" present chemical abraded zircon U-Pb analyses from the Belo Horizonte complex, a TTG-granitic complex of the southern São Francisco Craton. The zircon textures and U-Pb data suggest a long-lived period of partial melting events before the stabilization of the São Francisco Craton at ca. 2600 Ma. The partial melting episodes took place between 2.76 Ga and 2.6 Ga and may have occurred at upper crustal levels as a result of tectonic accretion and peeling off of the lithospheric mantle and lower crust. The authors relate this partial melting episode to a fundamental shift in the tectonics of the craton that is also related to production of large syenitic bodies and layered mafic–ultramafic intrusions.

In the paper "*The Paleoarchean Northern Mundo Novo Greenstone Belt, São Francisco Craton: Geochemistry, U-Pb-Hf-O in zircon and pyrite $\delta^{34}S$-$\Delta^{33}S$-$\Delta^{36}S$ signatures*", Teles et al. (2022) investigated pillowed metabasalt and quartzite samples and suggest an anoxic Archean atmosphere during greenstone belt formation in a back-arc basin environment. U-Pb analyses in zircon grains from metabasalt and quartzite units of the greenstone belt point to maximum depositional ages at around 3.3 Ga. New isotope data of zircon and pyrite indicate assimilation of older components (>3.4 Ga) in the presence of anoxic atmospheric conditions and trace elements of pyrite suggest low temperature hydrothermalism.

In the paper "*Neoarchean atmospheric chemistry and the preservation of S-MIF in sediments from the São Francisco Craton*" by Bosco-Santos et al. (2022), a whiff of oxygen is proposed to explain the presence of a mass-dependent fractionation in the São Francisco Craton identified by isotopic analyses in pyrite grains from the Rio das Velhas Greenstone belt sequence. Whole-rock and detrital zircon U-Pb analyses corroborate the Archean age of the sequence. The results of this study suggest that prokaryotic sulfur, iron and methane cycles may have an underestimated role in pre-GOE records.

Moraes et al. (2022) in "*Metamorphic disturbances of magnetite chemistry and the Sm-Nd isotopic system of reworked Archean iron formations from NE Brazil*" demonstrate variable metamorphic and hydrothermal alteration in the Sm-Nd isotope system of iron formations from the São José do Campestre massif in the Borborema Province, and make inferences about the ocean composition during the Archean. The isotopic and trace element data for magnetite-bearing samples are explained with mixing between Archean and Paleoproterozoic sources associated with fluid percolation through shear zones during a regional event at 2.0 Ga. The results of this study indicate that metamorphism can selectively affect chemical proxies used to study iron formations, thus such proxies should be used with care in the interpretation of polydeformed rocks.

In the paper "*A perspective on potassic and ultrapotassic rocks: Constraints on the Paleoproterozoic late to post-collisional event in the São Francisco paleocontinent*" Bersan et al. (2022) propose that potassic and ultrapotassic Paleoproterozoic (2.06–1.98 Ga) magmatism represents the late to post-collisional stages of amalgamation of the proto–São Francisco Craton. The chemistry of the ultrapotassic rocks indicates a metasomatized mantle source, and the strongly negative Hf signature suggests a Paleoarchean contribution. However, these samples also contain a previously unknown juvenile 2.36 Ga zircon source similar to rocks from the southern São Francisco Craton.

Santos et al. (2022) in "*Isotopic and geochemical constraints for a Paleoproterozoic accretionary orogen in the Borborema Province, NE Brazil: Implications for reconstructing Nuna/Columbia*" use zircon U-Pb, whole-rock geochemistry and Sm-Nd isotopes to identify missing portions of the Paleoproterozoic orogens within Neoproterozoic terranes of the Borborema Province. The geological occurrences are ultimately connected to the amalgamation of Columbia. Early stages of subduction are marked by tholeiitic magmas and peraluminous melts are the postulated sources for the younger stages of collision during a cycle that took approximately 50 Ma.

Pinheiro et al. (2022) in "*Archean–Ediacaran evolution of the Campos Gerais Domain — A reworked margin of the São Francisco paleocontinent (SE Brazil): Constraints from metamafic–ultramafic rocks*" explore maximum crystallisation ages from zircon cores to show that mafic and ultra-mafic rocks represent an Archean westward extension of the São Francisco Craton. The marginal region, known as the Campos Gerais Domain represents a fragment of the craton reworked during the Neoproterozoic. A second phase of ultramafic magmatism at 2.1 Ga was identified and interpreted to be related to accretionary events during the Paleoproterozoic.

Teixeira et al. (2022) in "*U-Pb provenance fingerprints of metavolcanic-sedimentary successions of the Mineiro belt: proxies for the continuity of plate tectonics through the Paleoproterozoic*" document the detrital zircon variation across the Mineiro Belt in Brazil and postulate that a continuous growth of the continental crust occurred at least within the Mineiro Belt during the global tectono-magmatic lull through the generation of arcs that ultimately amalgamated against the proto craton at 2.1 Ga. This study suggests that continental growth continued uninterrupted during the Paleoproterozoic.

Klein and Rodrigues (2022) in "*Lu-Hf constraints on pre-, syn, and post-collision associations of the Gurupi Belt, Brazil: Insights on the Rhyacian crustal evolution*" show subduction to collisional stages during the Paleoproterozoic crustal evolution in the Gurupi Belt at the margins of the São Luis Craton. Mostly suprachrondritic Lu–Hf isotope compositions differ from other common occurrences and indicate a juvenile island arc that may have evolved away from the cratonic margins. Comparison with other Rhyacian terranes indicates a similarity to the central-eastern portion of the Baoulé-Mossi Domain of the West African Craton, suggesting a possible close pre-Columbia configuration.

Finally, Almeida et al. (2022) in "*Rhyacian-Orosirian tectonic history of the Juiz de Fora Complex: Evidence for an Archean crustal reservoir within an island-arc system*" propose that slivers of Archean continental fragments may have been involved during the evolution of the Paleoproterozoic juvenile arcs in the São Francisco Craton and the new geochemical and isotopic data suggest a repetition in the secular transition from TTG to sanukitoids in the southern São Francisco Craton (Bruno et al., 2020; Moreira et al., 2020).

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Hugo Moreira *
CNRS-UMR5243, Géosciences Montpellier, Université de Montpellier, France
* Corresponding author.
E-mail address: hugo.moreira@umontpellier.fr

Mathias Schannor
Department of Earth Sciences, University of Cambridge, UK
Department of Earth Sciences, Freie Universität Berlin, Berlin, Germany

Kathryn Cutts
Faculdade de Geologia, Universidade do Estado do Rio de Janeiro, Brazil
Geological Survey of Finland, P.O. Box 96, FI-02151 Espoo, Finland

Nick M.W. Roberts
Geochronology and Tracers Facility, British Geological Survey, Nottingham, UK

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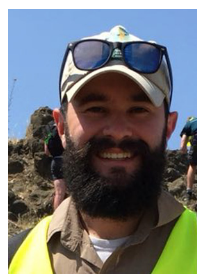

Hugo Moreira is an isotope geochemist expert in Precambrian evolution of the continental crust. He specialised in in-situ analyses of accessory phases, particularly zircon, apatite and titanite and in the petrogenesis of igneous and metamorphic rocks. He has graduated and completed his MSc at the School of Mines, Universidade Federal de Ouro Preto, Brazil in 2015. He was awarded his PhD at the University of Portsmouth, UK, in 2019. He started a postdoc position at the Université de Montpellier, France, in 2020. He works at the CNRS-ERC-MILESTONE laboratory setting up laser ablation and mass-spectrometry methods (U-Pb, Lu-Hf, Rb-Sr and Pb-Pb) with the aim to integrate high spatial resolution analyses in zircon grains and inclusions to the evolution of continents on Earth.

Mathias Schannor is a Humboldt Postdoctoral Fellow at the Freie Universität Berlin (Germany), where he applies radiogenic and non-traditional stable isotopes to better understand the interplay between the Earth's surface and deep interior and its evolution through geological time. He was previously a Humboldt Feodor Lynen Postdoctoral Fellow at the University of Cambridge (UK). He completed his PhD at the Universidade Federal de Ouro Preto (Brazil) in 2018.

Kathryn Cutts is a senior scientist at the Geological Survey of Finland. She gained her PhD from the University of Adelaide (2012) focussing on unravelling the record of polymetamorphic belts using in situ geochronology and P-T modelling. As a post-doctoral researcher (Stellenbosch, South Africa and later Ouro Preto and Rio de Janeiro, Brazil) she applied similar methods to investigate the (poly)metamorphism of Paleoproterozoic and Archean terrains in order to shed light on early earth tectonics. Her current research interests include Archean and Paleoproterozoic tectonics, with a particular focus on the metamorphic and crustal record, and global similarities/differences between Archean-Paleoproterozoic terrains.

Nick M.W. Roberts completed his PhD at the University of Leicester in 2010, where he studied the crustal evolution of southwest Norway. Nick has worked at the British Geological Survey since then, and is based in the Geochronology and Tracers Facility, running a laser ablation ICP-MS laboratory set-up. Nick applies high spatial resolution geochronology and isotope geochemistry to a wide range of themes in Earth science. He has expertise in U-Th-Pb geochronology, analytical methods, igneous and metamorphic petrology, and Precambrian geology. He has a particular interest in the Sveconorwegian and Himalayan orogenies, secular evolution of the continental crust, and methods in dating brittle deformation and fluid-flow. Nick has co-authored over 100 papers, edited several special issues, and currently sits on the editorial board for *Geoscience Frontiers* and *Minerals*.