Geoscience Frontiers 10 (2019) 1219–1221

HOSTED BY

ELSEVIER

Contents lists available at ScienceDirect

China University of Geosciences (Beijing)

Geoscience Frontiers

journal homepage: www.elsevier.com/locate/gsf

Editorial

"Miles wide and miles deep" – Exploring the depth and breadth of geoscience during the first ten years of *Geoscience Frontiers*

When early explorers first crossed the Platte River in what is now Nebraska (USA), it was said the river was "a mile wide and an inch deep" (Mokler, 1923; Smith, 1971). This phrase was used to describe not only the difficulty in crossing the river but also in navigating its length. The trouble with a river being too wide is the risk that it won't provide the depth necessary to be useful. The same thing can be said of multidisciplinary scientific journals. While a journal can claim to be multidisciplinary, there is a risk of it being so broad that its articles can only engage the reader at a superficial level. Nothing could be further from the truth with *Geoscience Frontiers.* Over the past ten years, this journal has successfully navigated the wide breadth of geoscience while providing a level of depth and detail that rivals discipline-specific journals.

From humble beginnings, *Geoscience Frontiers* quickly rose to prominence and has maintained an impact factor above 4 for the past three years. Under the direction of Prof. Xuanxue Mo and Prof. M. Santosh, and a multinational editorial board, the journal has attracted articles from a wide array of prominent scientists. Currently, *Geoscience Frontiers* is ranked in the top 10% of multidisciplinary geoscience journals worldwide by the Thomson Reuters InCites Journal Citation Reports. This Virtual Special Issue has been put together to celebrate the 10th Anniversary of *Geoscience Frontiers* and highlights the breadth and depth of the scope of the journal.

As our understanding of the Earth grows, the fields of geoscience reveal a profound level of interconnection. The future of geoscience is consequently integrative and as geoscientists, we have an opportunity to reap the benefits of the synergy a multidisciplinary geoscience journal provides. The future of our planet also requires a responsible use of the Earth's resources and the protection of its environments that make up the biosphere, atmosphere, hydrosphere and geosphere. Geoscientists are key custodians in this role, not just in scientific research, but in dissemination of this science to the public and to the policy-makers. Peer-reviewed journals provide the major route for the publication of scientific results, and have a major role to play in scientific communication, dissemination and discussion. *Geoscience Frontiers* is a forward-thinking, free-to-all, open-access journal that promotes the publication of research from all nations and is accessible around the world. With *Geoscience Frontiers* we can be confident that we are 'doing our part' for the progression of science.

Articles in this issue have been selected from sub-disciplines spanning the spectrum from modern methodologies of machine learning and geochronology to climate change and early Earth geodynamics. The articles are organized into categories with timescales spanning from the Anthropocene to the Hadean. In the area of Anthroprogenic geoscience, Geographic Information System (GIS) techniques are widely adopted across all fields. In Prasannakumar et al. (2012), they were used to determine the vulnerability of forested mountain regions to soil erosion in India. Machine learning is another fundamental scientific technique that is rapidly becoming a major tool across all fields of geoscience. The concept of machine learning is explored in the realm of geoscience and remote sensing by Lary et al. (2016). Climate change is one of the biggest scientific topics of our time, and its effect on the seasonal Asian monsoon is evaluated using decadal variation of precipitation and temperature in Loo et al. (2015).

Two tools common to many articles in *Geoscience Frontiers* are thermochronology and geochronology, which allow us to place absolute constraints on the rates and timing of geological processes deep into Earth history. Glorie and De Grave (2016) use low-temperature thermochronology to explore the exhumation of the Tianshan and Altai-Sayan mountain systems, and Vermeesch (2018) provides a free, flexible, user-friendly, and future-proof platform (IsoplotR) to analyze and visualize geochronological data.

Plate tectonics is, without question, the most important geological paradigm of the twentieth century. Following its widespread acceptance in the late 1960s and 1970s and the continued development of models and intricacies throughout the 1980s to 2000s, the past decade has witnessed significant debate over major questions regarding this paradigm. Questions such as when did plate tectonics begin, what did Earth's geodynamic regime look like before plate tectonics, and how has the volume of continental crust changed over time? *Geoscience Frontiers* has provided a platform for key articles contributing to these debates. How tectonics may have evolved in the Hadean is discussed by Maruyama et al. (2018), who propose that the bombardment of chondrites and the addition of volatiles from these extraterrestrial bodies played a key role. The tectonics of the late Paleozoic is compiled into a full plate model by Domeier and Torsvik (2014), in a major compilation of paleomagnetically constrained paleogeographical data. The tectonic 'dynasty' of the Central Asian Orogenic Belt (CAOB) has been a major player in our understanding of accretionary tectonics; Xiao et al. (2014) provide a review of suture zones in the southern part of the CAOB.

Lid tectonics is the current major paradigm for early Earth history. Lid tectonics or 'stagnant lids' are now much debated and modelled. Bédard (2018) provides a comprehensive review of their

Peer-review under responsibility of China University of Geosciences (Beijing).

https://doi.org/10.1016/j.gsf.2019.01.004

origin and geochemistry, and proposes models for their existence in the Archean Earth. Stern et al. (2018) discuss the role of plate versus lid tectonics in planetary geology and provide a new classification termed the Tectonic Activity Index. Condie et al. (2016) discuss the geochemistry of mantle-derived rocks formed in the time period of the Archean–Proterozoic boundary, an interval commonly invoked as marking the transition from a lid tectonic to a plate tectonic regime.

The continental crust forms the archive of Earth history, provides the substrate on which we live and thrive, and hosts most of our natural resources. Yet the timing and mechanisms for formation of the continental crust host lively debate. One of the major paradigms of the last decade is the recognition that the geological record of continental crust is likely to be significantly biased. Spencer et al. (2015) test the hypothesis that major continental collisions bias the preservation of continental crust created during phases of supercontinent amalgamation. Zhai (2014) reviews the formation of the North China Craton, demonstrating major crustal growth at 2.7 Ga through the amalgamation of continental microblocks, and major reworking at 2.5 Ga. In addition to its formation, the destruction of continental crust has also become an important facet of our understanding of Earth history. Kawai et al. (2013) discuss how continental crust is subducted at plate margins and forms a 'second continent' at the mantle transition zone.

Our understanding of plate tectonics and the formation of continental crust is now intimately linked to the supercontinent cycle. This largely accepted phenomenon of Earth evolution is one of the most important paradigms of the last decade and plays a critical role in the evolution of not only the geosphere, but also the hydrosphere, atmosphere and biosphere. Nance and Murphy (2013) provide a thorough review of the supercontinent cycle model, and its origin through the literature. Meert (2014) examines a particular aspect of the supercontinent cycle, namely that certain continents seem to repeatedly amalgamate in certain arrangements, while others lack any consistency in supercontinent reconstructions. Young (2013) documents the correlation between major environmental changes during Earth history and their links to the supercontinent cycle, highlighting the importance of impact tectonics on Earth's climate, and how the interplay of these processes provided the backdrop for the evolution of life. Roberts (2013) provides a review of global tectonics during the 'boring billion' (ca. 1.6 Ga to 0.6 Ga), a time traditionally perceived as a period of atmospheric and biotic stability, but which witnessed the transition from the Columbia (Nuna) supercontinent to the Rodinia supercontinent.

Mafic rocks are important to our understanding of the formation of oceanic crust and its involvement in plate collision. They also provide windows into geochemical processes of the mantle. Saccani (2015) provides a thorough review of basaltic chemistry and a new discrimination diagram for differentiating post-Archean ophiolitic basalts. The formation of Large Igneous Provinces (LIPS) is an important aspect of Earth history, providing resources such as critical metals, and impacting the climate in a profound way. Shellnutt (2014) provides a synthesis of the late Permian Emeishan LIP and discusses its role in affecting Earth's biota.

Metamorphic rocks are critical to our understanding of the behavior of continental crust during plate collision, and allow us to track how mountain belts have evolved through time. Brown (2014) provides a comprehensive review of the contribution that metamorphic petrology has made to our understanding of the Earth's lithosphere, and how the continental crust has formed and behaved through geologic time. Kelsey and Hand (2015) provide a review of ultra-high temperature metamorphism, describing the tools used to understand the pressure-temperature history of such rocks, and explaining the formation of these rocks in terms of plate tectonics. Metamorphic petrology now relies heavily on pseudosection analysis based on thermodynamics. Palin et al. (2016) present a model whereby the geological uncertainty of such pseudosections can be quantified, thereby providing an estimate of precision that can be translated to geological models.

Understanding mineral systems is critical to the exploration and extraction of Earth's limited mineral resources. Models for the formation of mineral deposits continue to be refined and debated. Two articles in this issue discuss the gold and rare earth mineralization. Smith et al. (2016) demonstrate metasomatically enriched lithosphere are the most plausible source of rare earth mineralization and that it is through hydrothermal and weathering processes that the highest grade ore is formed. Groves and Santosh (2016) provide a unified model for orogenic gold deposits formed from such fluid sources, and argue that the model can be applied to all orogenic gold systems.

We hope that the articles in this Virtual Special Issue of *Geoscience Frontiers* demonstrate both the depth and breadth of geoscience disseminated through this open-access journal, and inspire both established and early career authors to contribute to this rapidly growing journal.

Acknowledgements

We would like to acknowledge all of the authors who have contributed to *Geoscience Frontiers* over the last ten years, and also all of the reviewers, without whom the journal could not exist. We would also like to warmly thank the editorial team in Beijing, China, who keep this journal alive and do all the 'heavy-lifting'.

References

Bédard, J.H., 2018. Stagnant lids and mantle overturns: implications for Archaean tectonics, magmagenesis, crustal growth, mantle evolution, and the start of plate tectonics. Geoscience Frontiers 9, 19–49. https://doi.org/10.1016/j.gsf.2017.01.005.

Brown, M., 2014. The contribution of metamorphic petrology to understanding lithosphere evolution and geodynamics. Geoscience Frontiers 5, 553–569. https://doi.org/10.1016/j.gsf.2014.02.005.

Condie, K.C., Aster, R.C., Van Hunen, J., 2016. A great thermal divergence in the mantle beginning 2.5 Ga: geochemical constraints from greenstone basalts and komatiites. Geoscience Frontiers 7, 543–553. https://doi.org/10.1016/j.gsf.2016.01.006.

Domeier, M., Torsvik, T.H., 2014. Plate tectonics in the late Paleozoic. Geoscience Frontiers 5, 303–350.

Glorie, S., De Grave, J., 2016. Exhuming the Meso–Cenozoic Kyrgyz Tianshan and Siberian Altai-Sayan: a review based on low-temperature thermochronology. Geoscience Frontiers 7, 155–170.

Groves, D.I., Santosh, M., 2016. The giant Jiaodong gold province: the key to a unified model for orogenic gold deposits? Geoscience Frontiers 7, 409–417.

Kawai, K., Yamamoto, S., Tsuchiya, T., Maruyama, S., 2013. The second continent: existence of granitic continental materials around the bottom of the mantle transition zone. Geoscience Frontiers 4, 1–6.

Kelsey, D.E., Hand, M., 2015. On ultrahigh temperature crustal metamorphism: phase equilibria, trace element thermometry, bulk composition, heat sources, timescales and tectonic settings. Geoscience Frontiers 6, 311–356.

Lary, D.J., Alavi, A.H., Gandomi, A.H., Walker, A.L., 2016. Machine learning in geosciences and remote sensing. Geoscience Frontiers 7, 3–10.

Loo, Y.Y., Billa, L., Singh, A., 2015. Effect of climate change on seasonal monsoon in Asia and its impact on the variability of monsoon rainfall in Southeast Asia. Geoscience Frontiers 6, 817–823.

Maruyama, S., Santosh, M., Azuma, S., 2018. Initiation of plate tectonics in the hadean: eclogitization triggered by the ABEL bombardment. Geoscience Frontiers 9, 1033–1048.

Meert, J.G., 2014. Strange attractors, spiritual interlopers and lonely wanderers: the search for pre-Pangean supercontinents. Geoscience Frontiers 5, 155–166.

Mokler, A.J., 1923. History of Natrona County, Wyoming, 1888-1922. RR Donnelley & Sons Company.

Nance, R.D., Murphy, J.B., 2013. Origins of the supercontinent cycle. Geoscience Frontiers 4, 439–448.

Palin, R.M., Weller, O.M., Waters, D.J., Dyck, B., 2016. Quantifying geological uncertainty in metamorphic phase equilibria modelling; a Monte Carlo assessment and implications for tectonic interpretations. Geoscience Frontiers 7, 591–607.

Prasannakumar, V., Vijith, H., Abinod, S., Geetha, N., 2012. Estimation of soil erosion risk within a small mountainous sub-watershed in Kerala, India, using Revised

Universal Soil Loss Equation (RUSLE) and geo-information technology. Geoscience Frontiers 3, 209–215.
Roberts, N.M.W., 2013. The boring billion?–Lid tectonics, continental growth and environmental change associated with the Columbia supercontinent. Geoscience Frontiers 4, 681–691.
Saccani, E., 2015. A new method of discriminating different types of post-Archean ophiolitic basalts and their tectonic significance using Th-Nb and Ce-Dy-Yb systematics. Geoscience Frontiers 6, 481–501.
Shellnutt, J.G., 2014. The Emeishan large igneous province: a synthesis. Geoscience Frontiers 5, 369–394.
Smith, M.P., Moore, K., Kavecsánszki, D., Finch, A.A., Kynicky, J., Wall, F., 2016. From mantle to critical zone: a review of large and giant sized deposits of the rare earth elements. Geoscience Frontiers 7, 315–334.
Smith, N.D., 1971. Transverse bars and braiding in the lower Platte River, Nebraska. The Geological Society of America Bulletin 82, 3407–3420.
Spencer, C.J., Cawood, P.A., Hawkesworth, C.J., Prave, A.R., Roberts, N.M.W., Horstwood, M.S.A., Whitehouse, M.J., 2015. Generation and preservation of continental crust in the Grenville Orogeny. Geoscience Frontiers 6, 357–372. https://doi.org/10.1016/j.gsf.2014.12.001.
Stern, R.J., Gerya, T., Tackley, P.J., 2018. Stagnant lid tectonics: perspectives from silicate planets, dwarf planets, large moons, and large asteroids. Geoscience Frontiers 9, 103–119.
Vermeesch, P., 2018. IsoplotR: a free and open toolbox for geochronology. Geoscience Frontiers 9, 1479–1493. https://doi.org/10.1016/j.gsf.2018.04.001.
Xiao, W., Han, C., Liu, W., Wan, B., Zhang, J., Ao, S., Zhang, Z., Song, D., Tian, Z., Luo, J., 2014. How many sutures in the southern Central Asian orogenic belt: insights from east Xinjiang–west Gansu (NW China)? Geoscience Frontiers 5, 525–536.
Young, G.M., 2013. Precambrian supercontinents, glaciations, atmospheric oxygenation, metazoan evolution and an impact that may have changed the second half of Earth history. Geoscience Frontiers 4, 247–261.
Zhai, M., 2014. Multi-stage crustal growth and cratonization of the North China Craton. Geoscience Frontiers 5, 457–469.

Christopher J. Spencer*
The Institute of Geoscience Research (TIGeR), School of Earth and Planetary Sciences, Curtin University, Perth, Australia

Nick M.W. Roberts
NERC Isotope Geosciences Laboratory, British Geological Survey, Keyworth, UK

R. Damian Nance
Department of Geological Sciences, Ohio University, Athens, OH, 45701, USA

Department of Geology and Geophysics, Yale University, New Haven, CT, 06511, USA

* Corresponding author.
E-mail address: cspencer@curtin.edu.au (C.J. Spencer)

Available online 9 March 2019