Application of Advanced Analytics and Visualization in Mineral Systems

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Citation: Morrison et al., 2019. Application of Advanced Analytics and Visualization in Mineral Systems. *Acta Geologica Sinica* (English Edition), 93(supp. 1): 55

The key to answering many compelling and complex questions in Earth, planetary, and life science lies in breaking down the barriers between scientific fields and harnessing the integrated, multi-disciplinary power of Earth, planetary, and bioscience data resources. We have a unique opportunity to integrate large and rapidly expanding "big data" resources, to enlist powerful analytical and visualization methods, and to answer multi-disciplinary questions that cannot be addressed by one field alone.

Recent years have seen a dramatic increase in the volume of mineralogical and geochemical data available for study. These large and expanding data resources have created an opportunity to characterize changes in near-surface mineralogy through deep time and to relate these findings to the geologic and biologic evolution of our planet over the past 4.5 billion years (Hazen et al., 2008; Liu et al., 2017). Using databases such as the RRUFF Project, the Mineral Evolution Database (MED), mindat, and EarthChem, we explore the spatial and temporal distribution of minerals on Earth's surface while considering the multidimensional relationships between composition, oxidation state, structural complexity (Krivovichev, 2013), and paragenetic mode.

These studies, driven by advanced analytical and visualization techniques such as mineral ecology (Hazen et al., 2015), network analysis (Morrison et al., 2017), and affinity analysis, allow us to begin tackling big questions in Earth, planetary, and biosciences. These questions relate to understanding the relationships of mineral formation and preservation with large-scale geologic processes, such as Wilson cycles, the oxidation of Earth's atmosphere, and changes in ocean chemistry. We can also investigate the abundance and likely species of as-yet undiscovered mineral, as well as estimate the probability of finding a mineral or mineral assemblage at any locality on Earth or another planetary body. Given the spatial and temporal distribution of minerals on Earth, which was heavily influenced by life, we can explore the possibility that Earth's mineral diversity and distribution is a biosignature that can be used for future planetary evaluation and exploration. These geologic resources also facilitate integration across disciplines and allow us to explore ideas that one field alone cannot fully characterize, such as how the geochemical makeup of our planet affected the emergence and evolution of life, and, likewise, how life influenced chemical composition and geological processes throughout Earth history.

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Key words: minerals, network analysis, data-driven discovery, mineral evolution, mineral ecology

Acknowledgments: This work was supported by the W.M. Keck Foundation's Deep-Time Data Infrastructure project, with additional support by the Deep Carbon Observatory, the Alfred P. Sloan Foundation, a private foundation, and the Carnegie Institution for Science.

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