Precambrian Paleomineralogy: The Known, Unknown, and Unknowable

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The Precambrian was a time of dramatic planetary evolution that is revealed in the changing diversity and distribution of minerals through deep time, yet Earth's early mineralogical record is sparse. What do we know and what can we infer regarding the extent of Precambrian mineralogy? How might that understanding shape our view of Earth's crustal evolution, including crustal growth, impact events, and tectonic processes? Was Earth's Hadean mineral evolution replicated on early Mars, where early stages of mineralization are still preserved? Can we use Earth's evolving mineralogy to elucidate aspects of biological evolution? We exploit large, growing "big data" resources and analytical and visualization methods to investigate Earth's mineral evolution.

Prior estimates that Earth's Hadean near-surface environment may have held ~420 different rock-forming or accessory mineral species that were widely distributed and/or volumetrically significant [*1*] have been challenged as being both too limited and too optimistic. Archean Eon mineralogy may have expanded to as many as 1500 species as a consequence of primarily physical and chemical processes [*2*]. Most of Earth's mineral diversity arose in the Phanerozoic Eon from biologically-mediated mineral-forming processes such as biomineralized carbonate and phosphate deposits, redox-controlled mineral deposition, and subaerial weathering—processes that appear to distinguish Earth from any other known terrestrial planet or moon. While details of Earth's earliest mineralogy are still emerging, any scenario for life's origins that invokes minerals as agents of molecular synthesis, selection, protection, or organization must take into account the limited mineralogical repertoire of the time.

[*1*] R.M.Hazen (2013) Paleomineralogy of the Hadean Eon: A preliminary list. *American Journal of Science*, **313**, 807-843; [*2*] R.M.Hazen et al. (2008) Mineral evolution. *American Mineralogist*, **93**, 1693-1720.