Geophysical Research Abstracts
Vol. 20, EGU2018-3749-1, 2018
EGU General Assembly 2018

Primitive continents suppressed oxygenation during the Archean

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The development of Earth's oxygen cycle 3.0-2.4 Gyr ago is one of the most important geochemical occurrences in the history of system Earth. In spite of its fundamental importance, this process is not well understood and its causes and governing mechanisms are yet to be fully characterized. For decades, suggestions have been made of a link between the global oxygen cycle – most notably oceanic atmospheric oxygenation – and the changing composition of the continental crust. Crustal evolution during the Archean is nevertheless subject to large uncertainty and any such link is obscured. Preservation of Archean crust is a prime issue in this regard; preserved fragments are typically strongly altered and overprinted, and may otherwise be subject to preservation bias. To circumvent this issue, we use the composition of terrigenous sediments deposited during the past 3.7 Gyr to estimate average continental composition and changes therein. We use Cr/U as a new tracer in these sediments. This ratio has demonstrably strong resolving power for (source-)lithology, and both elements show similar behaviour during detrital transport and weathering. The Cr/U data reveal a striking secular change in the composition of the exposed continental crust during the Archean. Before 3.0 Gyr ago, the crust was mafic and contained significant modal proportions of olivine. Such crust supported serpentinization, which—in present-day analogues—is known to cause strong oxygen scavenging in the immediate environment. The decline in olivine-bearing continental crust was coeval with the first accumulation of molecular oxygen in the oceans and the disappearance of such crust was followed almost instantly by atmospheric oxygenation. This systematic leads us to conclude that the early oxygen cycle was ultimately limited by the composition of the exposed upper crust and remained underdeveloped until modern andesitic continents emerged.