The Cloud Paradigm: Geostable Molecules as Proxies for Surface Oxygenation

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Over the past fifty years, geoscientists have struggled to understand how and when earth's surface became habitable to complex, intelligent life. One of the prevailing scenarios, comprehensively articulated by Cloud, Holland and others, proposes an initially anoxic or very low O₂ atmosphere. Although photosystem II appeared relatively early, there was an extended period of imbalance between sources and sinks of O₂ through pervasive feedback between biosphere, atmosphere, hydrosphere and lithosphere.

Ultimately, O₂ accumulated in the atmosphere to near its present level at about 540 Ma. Life evolved concurrently. This talk examines new evidence for and against this idea based on the distributions and stable carbon isotopic values of molecular fossils that were extracted from well-preserved Late Archaean sediments. Samples were recovered as drill core from the Mount McRae Formation in the Mt. Bruce Supergroup, Pilbara craton and the Transvaal Supergroup of the Kaapvaal craton. The molecular fossils we identified comprise a diverse hydrocarbon assemblage including steroids that indicate that oxygen-dependent biosynthetic pathways were extant and carotenoid residues diagnostic for phototrophic sulfur bacteria. Both classes of compounds suggest that small amounts of O₂ were available in the marine environment well before the Great Oxidation event.

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