University of Washington

Abstract

Squeezing Blood from a Stone:
Inferences into the Life and Depositional Environments
of the Early Archaean

Jelte Harnmeijer

Chair of the Supervisory Committee:
Professor Roger Buick
Department of Earth & Space Sciences

A limited, fragmentary and altered sedimentary rock record has allowed few constraints to be placed on a possible Early Archaean biosphere, likewise on attendant environmental conditions. This study reports discoveries from three Early Archaean terrains that, taken together, suggest that a diverse biosphere was already well-established by at least ~3.5 Ga, with autotrophic carbon fixation posing the most likely explanation for slightly older 3.7 - 3.8 Ga graphite.

Chapter 2 aims to give a brief overview of Early Archaean geology, with special reference to the Pilbara's Pilgangoora Belt, and biogeochemical cycling, with special reference to banded-iron formation. Chapter 3 reports on the modelled behaviour of abiotic carbon in geological systems, where it is concluded that fractionations incurred through autotrophic biosynthesis are generally out of the reach of equilibrium processes in the crust. In Chapter 4, geological and geochemical arguments are used to identify a mixed provenance for a recently discovered 3.7 - 3.8 Ga graphite-bearing meta-turbidite succession from the Isua Supracrustal Belt in southwest Greenland. In Chapter 5 and 6, similar tools are used to examine a newly discovered 3.52 Ga kerogenous and variably dolomitized magnetite-calcite meta-

sediment from the Coonterunah Subgroup at the base of the Pilbara Supergroup in northwest Australia. Possible implications for the origin of texturally similar banded-iron formation, which may represent a silicified analogue, are discussed. In Chapter 7, structures from ~3.45 Ga kerogenous meta-chert in the Barberton Greenstone Belt, and similarly aged neptunian fissures in the Strelley Pool Chert, are interpreted as likely oncoidal trace-fossils indicative of complex microbial biofilm formation in Early Archaean shallow marine environments. No abiotic analogues to these structures are known.

Carbon isotope analyses of Early Archaean carbonate, graphite and kerogen from different environments are compared in the concluding synthesis. Systematic isotope trends argue against a significant abiotic Fischer-Tropsch origin for syn-sedimentary carbon. The picture that emerges, rather, is consistent with vigorous Early Archaean pelagic autotrophy, and a benthic biota dominated by fermentation, acetogenesis and methanogenesis. Access to electron acceptors was limited, and seems to have been restricted to sulphate and mineral ferric iron in shallow and deep marine environments, respectively.