Late Archean molecular fossils from scientific drill cores record the antiquity of microbial diversity

JACOB R. WALDBAUER[1], LAURA S. SHERMAN[2], DAWN Y. SUMNER[3] AND ROGER E. SUMMONS[2]

[1]Joint Program in Chemical Oceanography, Massachusetts Institute of Technology and Woods Hole Oceanographic Institution, Cambridge MA USA (jwal@mit.edu)
[2]Department of Earth, Atmospheric, and Planetary Sciences, Massachusetts Institute of Technology, Cambridge MA USA (sherman3@mit.edu; rsummons@mit.edu)
[3]Department of Geology, University of California, Davis CA USA (sumner@geology.ucdavis.edu)

The Agouron Griqualand Drilling Project has recovered a series of cores from the Neoarchean-Paleoproterozoic sedimentary cover of the Kaapvaal Craton, South Africa. With molecular fossil (biomarker) analysis in mind, this scientific drilling effort took measures from the outset to minimize the potential for organic contamination of the core material. We present the results of organic molecular biomarker analyses of sedimentary rocks from the Transvaal Supergroup, ca. 2.67 to 2.46Ga.

Bitumens from the Agouron cores consistently show syngenetic characteristics over more than 2500m of stratigraphy, despite the very low quantities of hydrocarbon extractable from the Transvaal rocks. These characteristics include high thermal maturity, absence of biomarkers from later-evolving organisms, correspondence between more- and less-matrix-associated bitumen pools, and sharply contrasting composition of overlying strata in the same core. Furthermore, comparisons of biomarker contents in stratigraphically correlated intervals from diverse lithofacies in two boreholes separated by 24km provide strong support their syngenetic nature.

The suite of molecular fossils identified in the late Archean bitumens includes hopanes attributable to bacteria, potentially including cyanobacteria and methanotrophs, and steranes of eukaryotic origin. The presence of fossils of steroids, whose synthesis requires molecular oxygen, suggests that aerobiotic processes (involving the production and consumption of O_2) were underway by the late Archean. This molecular fossil record provides evidence for an origin of the three principal Domains of cellular life in the Archean Eon.

The $^{187}Os/^{188}Os$ of the convecting upper mantle: An update

RICHARD J. WALKER

Department of Geology, University of Maryland, College Park, MD, 20742 USA (rjwalker@geol.umd.edu)

What is the proportion of recycled oceanic crust that remains isolated within the mantle? Osmium isotopic data relevant to question have been accumulating for more than 40 years. Seminal papers that attempted to estimate the $^{187}Os/^{188}Os$ of the convecting upper mantle utilized data from Os alloys derived dominantly from upper mantle assemblages to conclude that the upper mantle evolved with a generally “chondritic” Re/Os. This conclusion is too vague to be used to good advantage with respect to oceanic crustal recycling and isolation, yet we have not advanced much beyond it.

Studies of abyssal peridotites, MORB and ophiolites have revealed considerable complexity in the Os isotopic evolution of the convecting upper mantle. For example, although the Os isotopic compositions of MORB and abyssal peridotites overlap, almost all MORB is more radiogenic than abyssal peridotites. Although some of the disparity may be tied to seawater-rock interactions, it is now clear that at least some MORB sources evolved with higher Re/Os ratios than are represented in most abyssal peridotites. Further, the $^{187}Os/^{188}Os$ of abyssal peridotites are quite variable. Some of these heterogeneities relate to long-term Re/Os variations in the mantle, not seawater alteration. Studies of ultramfic sections of ophiolites have provided complementary data to those from abyssal peridotites and MORB, but individual ophiolites are isotopically heterogeneous and ophiolite materials may not always record primary mantle compositions.

One of the most important recent observations regarding this topic is the documentation that even small domains within the convecting upper mantle develop and retain considerable Os isotopic heterogeneity. This is most clearly revealed in datasets for large numbers of Os-Ir-Ru alloy grains weathered from individual ophiolites, and also in suites of abyssal peridotites from discrete locations. Peridotites from the 6 Ma Taitao ophiolite (Chile) show correlations between melt depletion indicators, such as Mg# of olivines, and $^{187}Os/^{188}Os$. This type of correlation has long been observed in samples from the subcontinental lithospheric mantle, but not directly for the convecting upper mantle. Collectively, these results suggest that some chemical heterogeneities related to melt extraction, present at the cm^3 to km^3 scale, were created and preserved in the upper mantle >1.5 Ga ago. This means that analysis of a limited number of samples from a given location (e.g. an ophiolite) may not yield a meaningful average composition. Based on consideration of the worldwide database for abyssal peridotites and ophiolites, the $^{187}Os/^{188}Os$ of the convecting upper mantle is ~0.125 to 0.126. This ratio, in comparison to current estimates for primitive upper mantle (>0.129) suggests that mafic slabs that are isolated from the convecting mantle may comprise 5 to 8% of its mass.