Earliest evidence of life on Earth

ROGER BUICK

Dept. Earth & Space Science and Astrobiology Program,
University of Washington, Seattle WA 98195-1310, USA
(buick@ess.washington.edu)

A key problem for geochemistry, paleobiology and astrobiology is how to recognize the first traces of life on Earth. Because particularly ancient rocks are scarce and poorly preserved, and because traces of primordial life might differ from the remains of modern organisms, the topic has proved especially contentious. Here I present a personal view of the subject, emphasising the diversity of approaches that can be used to address it. Nobody else will agree with my conclusions.

Microfossils represent the preserved bodily remains of primordial life, but in the absence of evidence of behaviour, it is often difficult to prove that an organic sphere or filament was once alive. The most ancient such objects clearly showing signs of behaviour are from the ~2.6 Ga Transvaal Supergroup of South Africa. Stromatolites and other macroscopic trace fossils of microbial activities have a considerable Archean record, with the oldest probably biogenic structures coming from the ~3.45 Ga Warrawoona Group of Australia. Molecular fossils in the form of hydrocarbon biomarkers have been retrieved from shales as old as 3.2 Ga, but there have been concerns about the possibility of contamination. New findings of similar biomarkers from oily fluid inclusions in ~2.45 Ga sandstones of the Matinenda Formation in Canada should allay many of these fears. Finally, stable isotope fractionations can identify the metabolic activities of ancient organisms, with sulfur isotopes indicating that dissimilatory sulfate reduction began as early as ~3.45 Ga. Light carbon isotope values in even older graphites are suggestive of biological autotrophy, but in the absence of sedimentary carbonates to determine the full extent of the fractionation, it is difficult to be certain that it was indeed biogenic. However, in the 3.52 Ga Coonterunah Group of Australia, kerogens in low-grade sedimentary carbonates show fractionations consistent with autotrophy via the Calvin-Benson cycle, indicating that life started modifying geochemical cycling within the first billion years of Earth's history.

History of the Rumuruti chondrite asteroid by ^{40}Ar-^{39}Ar dating

A.I. BUIKIN[1,2], M. TRIELOFF[1], E.V. KOROCHANTSEVA[1,2]
AND J. HOPP[1]

[1]Mineralogisches Institut Universität Heidelberg, Heidelberg, Germany (trieloff@min.uni-heidelberg.de)
[2]Vernadsky Institute of Russian Academy of Sciences, Moscow, Russia

Previous ^{40}Ar-^{39}Ar dating on Rumurutiites yielded complex age spectra, precluding firm conclusions on the early thermal history of Rumuruti and its parent body [1,2]. In an ongoing initiative to constrain the history of meteorite parent bodies [3-6], we applied thermochronological modeling [7,8] to ^{40}Ar-^{39}Ar age spectra of different Rumuruti lithologies (a light type 5/6 clast, a clastic matrix type 3.8 sample, and a type 3 clast). The age spectra show diffusive ^{40}Ar loss (low temperature extractions), partial plateau segments and age drops at high degassing temperatures due to ^{39}Ar recoil. The disturbing features correlate with grain size of the main K carrier phase plagioclase (glass). The coarse grained type 5/6 lithology has the best defined age plateau with 4.53±0.01 Ga. Taking into account that K-Ar ages are about 30 Ma too young due to bias in the K decay constants [3,9], a corrected age of 4.56 Ga implies a very short metamorphic history of the equilibrated rocks from the interior R-chondrite parent body, similar to fast cooled H4 chondrites [3]. This requires impact induced parent body restructuring and very early breccia formation, within a few Ma after R-chondrite parent body formation. Considering the fact that most R-chondrites are light/dark structured regolith breccias consisting of highly recrystallized fragments as well as unequilibrated lithologies and contain solar-wind-implanted rare gases [10], we infer a scenario that the Rumuruti asteroid was collisionally disrupted and reassembled a few Ma after formation, receiving its solar noble gas inventory by solar corpuscular irradiation from the young sun. This is consistent with early irradiation records inferred for some asteroidal planetesimals as well as terrestrial precursor planetesimals [11-17].

References

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