Early Archean life-bearing ocean or shear zone? – Akilia re-evaluated

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Evidence for the oldest (>3850 Ma) life on Earth is claimed to be ^{13}C-depleted graphite inclusions in apatite crystals hosted in banded quartz-pyroxene rock from the island of Akilia, SW Greenland (Mojzsis et al., 1996). This rock has previously been interpreted as banded iron formation (BIF), forming part of an inferred supracrustal succession with mafic volcanic rocks. Claims for a >3850 Ma age cannot be verified because no igneous contacts with adjacent tonalitic gneisses can be shown (Nutman et al., 1997 cf. Whitehouse et al., 2001). Field relationships on Akilia (e.g. Myers and Crowley, 2000) document multiple, intense deformation events that have resulted in parallel transposition of Early Archean rocks and significant boudinage, with boudin tails forming the banding in the quartz-pyroxene rock. Geochemical data show distinct REE and other trace-element characteristics that are consistent with an ultramafic igneous, not BIF, protolith for this lithology and the adjacent amphibolites. Later metasomatic silica and iron introduction have merely resulted in a rock that superficially resembles BIF. In this scenario, isotopically light C may be the result of serpentinisation (e.g. Holm and Charlou, 2001) and decarbonation reactions (Rose et al, 1996) providing a CO_2-rich environment for the synthesis of hydrocarbons via Fischer-Tropsch type catalysis (Szatmari, 1989). An ultramafic igneous origin invalidates claims that the graphite inclusions represent evidence for life coeval with the late heavy asteroid bombardment of Earth, and cautions against the application of C-isotopes alone as a unique biomarker for detecting past life.

References

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Where is geochronology going? Dating the processes behind zircon microstructures

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Analytical developments over the past two decades have revolutionised the field of U-Th-Pb zircon geochronology. In particular, the application of secondary ionisation mass spectrometers (SIMS) or laser-ablation microsampling devices attached to ICP mass spectrometers now enables geochronology to be performed with a spatial resolution of a few tens of micrometers or less and a depth penetration substantially less than one micrometer (SIMS) corresponding to sample weights of a few picograms. This spatial resolution capability applied carefully, can be used to address questions of zircon growth mechanism and timing in relation to known or suspected geological events.

An essential complement to the development of high spatial resolution dating is provided by the surface imaging techniques of cathodoluminescence (CL) and back-scattered electron (BSE). In fact, no serious SIMS or laser-ablation study should be conducted without imaging, and even some practitioners of conventional ID-TIMS and/or Pb-evaporation zircon dating now devise ways to image their samples prior to analysis. The information about internal structure and relative growth chronologies yielded by these methods can be used to address key questions such as whether polyphase growth is present and whether a specific growth phase might represent an igneous or metamorphic process. While many case studies have yielded straightforward answers, ambiguities remain and in some cases may be linked to the ambiguous nature of geological processes themselves (e.g. are zircons in a migmatite the result of igneous or metamorphic processes?).

A relatively new development, and one which has great potential in solving the riddle of zircon ages, is the application of zircon microchemistry produced from the same growth phase and/or analysed region as the U-Th-Pb date. Rare-earth elements in particular may be analysed by SIMS and LA-ICP-MS and in metamorphic zircons have the potential to relate zircon growth, and hence ages, to specific mineral reactions such as those producing garnet which results in a heavy REE depleted zircon. Other studies have attempted to link trace elements in zircons to the composition of potential host melts. A simplistic application of zircon/melt distribution coefficients, however, may be in error since zircons can crystallise over a wide range of conditions in a melt. These studies, together with the growing application of oxygen isotopes, and other light element analyses in zircon (e.g. fluorine, phosphorus) represent the new cutting edge in understanding processes of zircon growth and the interpretation of zircon geochronology.