Geophysical Research Abstracts,
Vol. 10, EGU2008-A-02004, 2008
SRef-ID: 1607-7962/gra/EGU2008-A-02004
EGU General Assembly 2008

The Oman ophiolite – some useful analogues for the very early Earth

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Evidence from the other rocky planets indicates that primitive planetary crusts are basaltic. Hence it is probable that the Earth's first crust was also basaltic, formed perhaps, in association with a magma ocean. It is argued here that the extensive outcrop of mafic and ultramafic rocks now preserved in the Oman ophiolite provides useful analogues to some very early Earth processes.

Mantle: Most of what is known about the earliest mantle is inferred from isotopic studies. Actual samples are both rare and disputed. Geochemical criteria applied to 3.8 Ga peridotites from Greenland and Labrador test claims that these samples are unmodified early Archaean mantle. Samples were compared to the mantle array in Mg/Si vs Al/Si (wt %) space, their REE patterns were compared to those of different mantle types and their chromite compositions compared to mantle chromite compositions as expressed by their cr# and fe#. Samples from the south of the Isua Greenstone Belt in west Greenland satisfy these criteria. The character of this early mantle is different from that of the subcontinental lithosphere inasmuch as it experienced a lower degree of melt extraction and was probably more oxidizing. Elemental concentrations of Os are lower than current estimates for the primitive upper mantle.

Felsic Crust: Trondhjemites form 1-2% of the crustal section of the Oman ophiolite. They were formed by the partial melting of the upper (hornblende) gabbros within the ophiolite, facilitated by the ingress of seawater to trigger hydrous melting in the roof-zone of an axial magma chamber. A similar process may have operated during the Hadean, to create small volumes of felsic rocks within a dominantly mafic crust.

Previously it has been argued that >4.0 Ga detrital zircons preserved in sediments of the Jack Hills, western Australia, preserve evidence for a well developed continental crust on the Earth at 4.4-4.5 Ga ago. Here it is shown that there are geochemical similarities between the Jack Hills zircons and the zircons found in trondhjemites in ophiolite sequences, suggesting that the Earth's first felsic crust might have formed through the low-pressure, hydrous partial melting of a mafic parent, in a manner analogous to modern ophiolitic trondhjemites. If this mechanism is valid, it removes the requirement for an extensive felsic continental crust at 4.4-4.5 Ga as the source of the Jack Hills zircons.

Life: Low temperature serpentinisation is an active process in the mantle harzburgites of the Oman ophiolite. Alkaline, calcium hydroxide springs (pH up to 12) in which hydrogen is generated and a calcium carbonate mud is precipitated are well known. A similar environment, in which a mechanism involving highly alkaline solutions in a reducing, marine hydrothermal environment, was postulated by Russell and Hall (J. Geol. Soc. Lond, 154, 377-402; 1997) for the emergence of life. The Oman springs should be more fully investigated.