EARLY CRUSTAL EVOLUTION: CONSTRAINTS FROM VARIABLE REE PATTERNS IN METASEDIMENTARY ROCKS FROM THE 3800 MA ISUA SUPRACRUSTAL BELT, WEST GREENLAND.


INTRODUCTION: REE in sediments are thought to express an average of rocks exposed to weathering and erosion during their time of formation, as REE have been shown to remain largely unfractonated by processes of sedimentation and metamorphism [1-3]. Recent work on Archaean sediments has noted broadly coherent REE patterns (fractionated LREE, positive Eu-anomaly, flat HREE), suggesting derivation from a crust dominated by volcanic rocks of island-arc calc-alkaline affinity, or a mixed bimodal dacite-tholeiite suite [4-6]. Other Archaean sediments with HREE-depleted patterns may be derived locally, or from a widespread single source [5-7]. It remains to be demonstrated that these characteristics are typical of all Archaean cratons, and whether average crustal compositions do in fact represent a meaningful inference from REE data.

The ca. 3800 Ma Isua supracrystals constitute the oldest comprehensively dated rocks in Earth [8-10], with the most precise determination being 3769±1 Ma by U-Pb analysis of single zircons [11]. As such, they provide an important constraint on the physical and chemical state of the crust at that time, and a possible window to still older material. In order to address the questions raised above, we have carried out a REE study of Isua clastic metasedimentary rocks, and report results here from three different stratigraphic units.

GEOLOGICAL OVERVIEW: Initial descriptions of the Isua belt outlined a diverse range of lithologies [12,13], whereas recent detailed mapping has revealed a stratigraphic sequence [14]. The main group - SEQUENCE A - contains various amphibolites, quartz-rich chemical metasediment (including ironstone and calc-silicate types), and felsic musc-bio (+qtz+plag+kf) gneiss. A tectonically separate group - SEQUENCE B - contains a lower unit of felsic musc-bio (+qtz+plag+garn+kf) gneiss, and an upper unit of garn-bio (+qtz+plag+mus+kf) schist with some felsic interlayers. SEQUENCE B may be older than SEQUENCE A, or correlate with the lower part of it. The musc-bio gneisses of both sequences are interpreted as felsic volcanoclastic graywackes; graded-bedding is preserved locally, and distinctive "conglomeratic" horizons occur in which clasts appear to be fine-grained volcanic rock. The garn-bio schists of Sequence B appear to have been derived from a heterogeneous pelitic to semi-pelitic protolith.

RESULTS: REE were determined by isotope-dilution mass spectrometry; chondrite-normalized data for 18 samples are illustrated on the accompanying figure.

Musc-bio gneisses of Sequence A have strongly fractionated REE, with small negative Eu-anomalies (Eu/Eu*=0.72-0.96). Musc-bio gneisses of Sequence B, however, have only moderately fractionated REE, and highly variable negative Eu-anomalies (Eu/Eu*=0.45-0.96). Garn-bio schists of Sequence B have low REE concentrations; LREE are moderately fractionated, Eu-anomalies are variable (Eu/Eu*=0.88-1.21), and HREE show a modest to strong slope reversal (Gd<Yb).

DISCUSSION: In Sequence A musc-bio gneisses, the consistency among all REE patterns, and the similarity between the clast-matrix pair and other samples, suggest that a single component dominates the REE characteristics of this unit. The relatively consistent patterns for Sequence B musc-bio gneisses also suggest that their REE are dominated by a single component, whereas the variable Eu-anomaly may indicate feldspar fractionation in the source rocks, or selective removal of feldspar components during weathering and sedimentation. The fact that musc-bio gneisses from both the upper and lower units of Sequence B have similar patterns suggests that the same source contributed REE to this sequence during its entire accumulation history. It is our opinion that REE in the musc-bio gneiss units reflect derivation from two distinct felsic volcanic sources, preserved locally as clasts in conglomerates.
REE IN EARLY ARCHAEOAN METASEDIMENTS
BOAK, J.L. et al.

The moderately fractionated LREE in garn-bio schists are most plausibly interpreted in terms of a component similar to that of musc-bio gneisses with which they are locally interlayered. Bulk compositions of garn-bio schists suggest a contribution from mafic rocks; our data for an Isua amphibolite shows that incorporation of REE from this type of material could reduce LREE concentrations, but cannot account for the upturn in HREE. High Cr and Ni in garn-bio schist suggest an ultramafic component as well; data for an Isua peridotite do indicate an upturn for HREE, but concentrations are so low that an unusual enrichment process is necessary for this sample to be representative of a component in garn-bio schists. Thus, we are unable to model REE patterns in garn-bio schists in a completely satisfactory way at the present time, although it is apparent that several distinct sources/rock types contributed material to the protoliths of the Isua sediments. We prefer to associate those sources with a penecontemporaneous, evolving volcanic complex.

Given the uncertainties in mixing proportions for source rocks and their REE it is unclear how estimates of volume proportions of source rocks can be made. Consequently, estimates of early Archaean crustal composition based on REE in Isua sediments are premature.