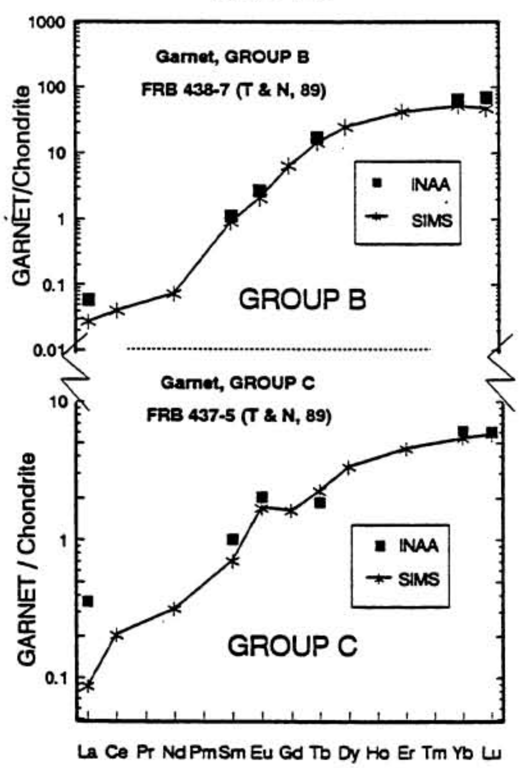
CRUSTAL EVOLUTION ON EARTH: A KEY TO UNDERSTANDING THE TERRESTRIAL PLANETS; Lawrence A. TAYLOR, James O. ECKERT, Jr., Clive R. NEAL*, Dept. of Geological Sciences, University of Tennessee, Knoxville, TN 37996; Ghislaine CROZAZ, McDonnell Center for Space Sciences, Washington University, St. Louis, MO 63130; *Present Address: Dept. of Earth Sciences, Univ. of Notre Dame, Notre Dame, IN 46556.

The origin and evolution of the Earth's crust is intimately tied to the mantle. In fact. the progenitor of the crust is this mantle. However, in any dynamic model of plate tectonics, it is evident that crustal components are returned to the mantle, largely by subduction. In some earlier time, these continental and oceanic crusts were generated from the mantle. These planetary-scale processes can be observed today; but, what about the early processes of crustal recycling? Was the Earth's heat budget such that convective processes in the upper mantle were pervasive? What were the scales of the horizontal and vertical profiles of convection? How fast did the plates move? Was the plate-tectonic scheme, as we know it today, operating during the first 2-3 billion years of Earth's history? Significant insight into the tectonic styles occurring on the early Earth can be effectively obtained by examining interactions of the ancient crust and mantle.

The objectives of our continuing research involve the identification and characterization of the physical and chemical processes which occurred in crust/mantle petrogeneses and subsequent interactions during the early crustal evolution of the Earth. This has been realized through study of xenoliths in kimberlite pipes from the Archean Kaapvaal Craton, southern Africa. Specifically, we have been studying the diamondiferous eclogites from the Bellsbank district, South Africa. We have reported the mineralogy, petrology, and geochemistry on the initial set of eclogites [1] and recently have published our results on the isotope geochemistry [2].

FIGURE 1



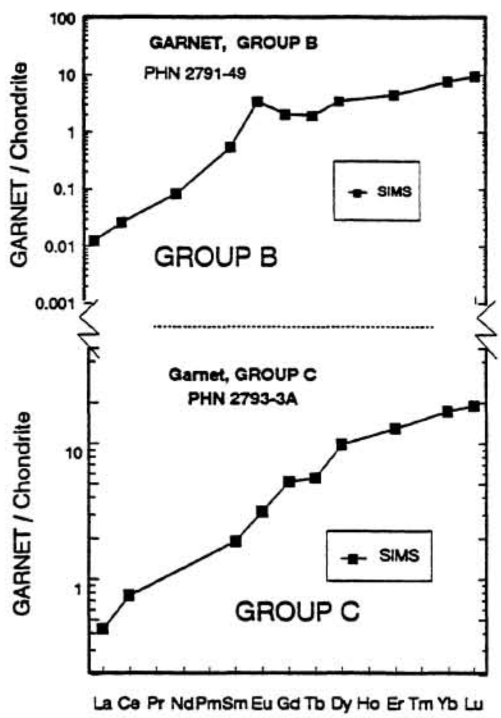
Various lines of evidence point to two different origins for these eclogites [1]. One group of eclogites has all the characteristics of true mantle eclogites. Another group, consisting of cpx with moderate (3-6%) to high (7-9%) Na_2O, has several features which we have interpreted as indicators of a crustal component: 1) garnet and cpx $s^{18}O$ = 2.9-4.7 (versus 5-6 for mantle origin); 2) low Cr contents in the cpx and garnet (<0.1% Cr_2O_3); C_{Nd} = +40 to +219; and 3) positive Eu anomalies (Fig. 1). We have called the eclogite groups A, for mantle derivation, B for moderate Na_2O cpx-high Fe garnet representing a MORB-like protolith, and C for high Na_2O cpx-high Ca garnet, originally from a plagioclase-rich cumulate (hence the positive Eu anomaly). We have concluded that the **Group A** eclogites are high pressure (mantle) igneous cumulates, but that **Group B** and **C** eclogites represent ancient, subducted oceanic crust.

These same eclogites also have been interpreted [3,4] as the products of accumulation of hyper-aluminous cpx -- i.e., mantle origin. Herein lies a controversy. At the center of this dilemma lies the nature of the REE patterns. We claim to observe a positive Eu anomaly, whereas Caporuscio & Smyth [4] claim that the REE pattern is simply a function of MREE enrichment. Such an enrichment implies both a LREE and HREE depletion resulting in a convex upward profile to the garnet and cpx patterns. Which interpretation of the patterns is correct?

SIMS ANALYSES: In an attempt to establish the credibility the INA analyses on ultrapure mineral separates, several cpx and garnet grains were analyzed by SIMS at Washington Univ. Figure 1 shows the excellent agreement between our INAA results and the SIMS analyses. Notice that the pattern for the Group B garnet is normal, whereas the Group C garnet possesses a Eu anomaly. We suggest that this does *not* look like MREE enrichment.

SIMS analyses also were performed on phases from several "new" eclogites, whose major element chemistry was determined by EMP and whose trace-element compositions were not analyzed previsously. Some of these results are shown for illustration (Fig. 2). Notice the lack of any MREE enrichment. Most importantly, however, is the presence of a distinct Eu anomaly. However, the anomaly is in a *Group B* garnet, a phenomenon which was not observed previously. Also, notice the lack of a Eu anomaly in the Group C garnet. These are unexpected results which deserve major consideration.

FIGURE 2



EXSOLUTION OF GARNET FROM CPX: The Group B & C garnets actually occur as exsolution lamellae from a cpx host. Herein may lie the explanation. Even though the Group B eclogite is not high in Al_2O_3, it has a Eu anomaly, while the Group C garnet, with high Al_2O_3, has none. I would seem that the exsolution phenomena may have imparted slight changes in the distributions of the REE. Alternatively, these results can be viewed as supportive of the idea of a compositional and genetic continuum between Groups B & C.

CONCLUSIONS: The presence of a *positive Eu anomaly in minerals of diamondiferous eclogites is a signature of a crustal progenitor.* Importantly, the SIMS analyses *confirm unequivocally the presence of such an anomaly in some of the Bellsbank eclogite garnets.* It follows logically that the Group B & C eclogites, indeed, have crustal parentages.

It appears that plate tectonic processes, similar to those of today, have been active at least since the late Archean. Intimate interaction of the mantle and crust results in a gradual growth of crust throughout time.

References: [1] Taylor and Neal (1989), Jour. Geol., v. 97, p. 551-567. [2] Neal et al., (1990), EPSL, v. 99, p. 362-379. [3] Smyth et al. (1989), EPSL, v. 93, p. 133-141. [4] Caporuscio and Smyth (1990), Contrib. Mineral. Petrol., v. 105, p. 550-561.