g13 Continental roots < tectosphere, diamonds >

> The Lehmann discontinuity was discovered through exacting scrutiny of seismic records by a master of a black art for which no amount of computerization is likely to be a complete substitute. —Francis Birch.[1]

Radioactive elements, which release heat, are concentrated in granitic crustal rocks of cratons. However, heat fluxes exiting continental and oceanic crusts are nearly the same. Also, seismic velocities at 150-400 km depths are faster beneath shields and platforms (i.e. the continental cratons) than beneath ocean basins (***Figure g13.1***). From observations as these, calculations find the mantle temperature to be 400 ºC cooler below the continental crust of cratons than mantle at the same level below oceanic crust.[2] The implied thicker lithosphere of cratonic areas could be upper mantle depleted of basaltic components. If so, it has a different origin than does the 100 km thick lithosphere that forms at oceanic ridges and which is synonymous with "oceanic plate" in plate tectonics. The additional cratonic lithosphere thickness was named the *tectosphere* by **Thomas (Tom) H. Jordan** in 1975.[3]

The tectosphere is a thermal boundary-layer stabilized against internal convection by dryness which greatly increases the resistance of olivine to deformation.[4] The *isopycnic hypothesis* is that continents, at every level within this viscous thermal boundary-layer (below the elastic mechanical lithosphere), have a +ve buoyancy due to lower compositional density of mantle peridotite (depleted in iron by partial melting that produces eruptive basalts) exactly compensated by the –ve buoyancy due to a lessened temperature gradient (by heat removed by the eruptives). The tectosphere moves with the continent when a plate containing the continent moves. But the tectosphere becomes sheared where it extends deep into the mantle by the absolute plate movement. This produces seismic anisotropy in the mantle there below 150 km where temperatures are higher than ~1,000 ºC (as shown by mineral equilibrium studies of kimberlite inclusions) but not deeper than 400 km. Below that depth, the even higher temperature and confining pressure, mobilize the olivine is to the extent that anisotropy becomes insignificant.

In the anisotropic mantle, horizontally-polarized shear waves SH travel faster than vertically-polarized shear waves SV. This shear-wave splitting is related to the lattice preferred orientation of olivine, which depends on finite strain. Crystal axes {100}, {010}, and {001} in olivine tend to become aligned with the longest, shortest, and intermediate strain-axes respectively. Simple shear should orient the {100} axis of the olivine in the direction of plate motion. For example, the absolute plate-motion direction of Southern Africa is N30ºE (this was determined by Robert S. Dietz in 1970 using hotspots as a stationary frame of reference).[5] Since the end of the Jurassic, the African plate has traveled about 3000 km. Beginning in 1992. ❑

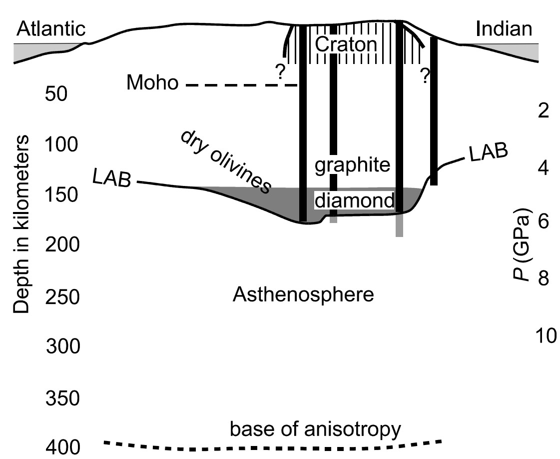

Figure g13.1 [6] Coss section of the Kaapvaal craton in southern Africa based on petrologic studies of kimberlite diatremes—vertical volcanic pipes (black) down-excavated by fluid to gas outward streaming of CO_2 and left filled with a breccia of crust and mantle rocks in an ultramafic volcanic matrix (that has usually been altered to clays and secondary calcite). Diamonds form at depths >150 km. Significantly, only in the craton do kimberlites contain diamonds.[7] The line LAB marks the transition between the lithosphere and anisotropic SH>SV asthenosphere. This boundary at depths of ~200-240 km under continents is the (Inge) Lehmann discontinuity, and, at depths of 60–80 km, under oceans is the (Beno) Gutenberg discontinuity.