AOGS 2006

Geochemical and Geophysical Evidence for Lithospheric Processes

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Samples of the deep lithosphere are delivered to the surface as small xenoliths with restricted petrological context, and as tectonic slivers on the scale of km2 but commonly with metamorphic petrological overprints. Geophysical information (especially tomography) allows us to extrapolate mantle rock-type domains between the magmatic virtual drill holes (kimberlites and basalts) that carry xenoliths, and to build up 3-D images of lithosphere composition, sometimes in time-slices (4-D) reflecting episodes of magmatic activity (O'Reilly and Griffin, 2006). Xenolith data reveal significant differences in composition and physical properties between Archean and Phanerozoic mantle (Griffin et al., 1999); much intermediate "Proterozoic" mantle may represent reworked Archean material. Although depleted ancient SCLM cannot be recycled through convection due to its low density (eg O'Reilly et al., 2001), truly pristine Archean mantle may be very rare as these buoyant blobs undergo repetitive geochemical transformation to varying degrees. Extensional regimes, including the formation of oceanic lithosphere, will mechanically disrupt ancient low-density lithosphere, forming discrete domains embedded within newly-formed lithospheric mantle. High-resolution seismic tomography images show low-density regions both in oceanic upper mantle and below the conventional lithosphere-asthenosphere boundary (LAB) beneath continental and especially cratonic regions. These coherent low-density domains appear to persist, in some cases, down to the transition zone beneath some cratons and may represent lithosphere regions originally formed in the Archean

that have resisted being entrained in the convecting mantle since that time. The tomographic images also show that craton margins commonly have linear boundaries which align with tectonic lineaments and linear zones of magmatism that may be episodic through long time spans. Central cores of these cratonic regions have seismic properties indicating low density and low thermal state and appear to be strong and coherent as the location of volcanoes and kimberlite pipes avoid these central areas and cluster at the margins. Low-density, "hot" regions between some cratonic domains appear to connect with deep regions of upwelling generated below the lithosphere-asthenosphere boundary (Deen et al, 2006). This deep upwelling may mechanically disrupt older thicker lithopshere and is one of the mechanisms that can cause lithosphere thinning. References: Deen, T., Griffin, W. L., Begg, G., O'Reilly, S. Y. & L. M. Natapov, L., 2006. G3 in press. Griffin, W. L., O'Reilly, S. Y. & Ryan, C. G., 1999. The Geochemical Society, Special Publication No.6, pp 13-43. O'Reilly, S. Y., Griffin, W. L., Poudjom Djomani, Y. H. & Morgan, P., 2001. GSA Today, 11 (4) 4-10. O'Reilly, S. Y. & Griffin, W. L., 2006. Tectonophysics DOI 10.1016/j. tecto.2005.11.014.