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Tracing lithosphere amalgamation through time: chemical geodynamics of sub-continental lithospheric mantle

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The theory of plate tectonics is a relatively young concept in the Earth Sciences and describes the surface expression of planetary cooling via magmatism and reconciles mantle convection and plate movement with orogenesis, earthquakes and volcanism.

Detailed observation of current tectonic plate movement has purported a relatively clear picture of the planet's geodynamics. Modern oceanic basins are the predominant sites of thermal equilibration of Earth interior resulting from decompressional, convective melting of peridotites. This magmatism generates mid-ocean ridge mafic crust and depleted upper mantle and in this model, oceanic crust becomes associated with buoyant mantle to form oceanic lithosphere. Subduction zones return this material together with sediments into the deeper mantle and presumably aid the formation of continental crust via arc magmatism.

The mechanisms of continental crust amalgamation with buoyant mantle are less clear, and distinctly more difficult to trace back in time because metamorphism and metasomatism render the processes associating convecting mantle with continental crust elusive. Paramount in assessing these mechanisms is understanding the timing of crust and mantle formation so that the onset of plate tectonics and potential changes in modi operandi with respect to convection, mantle composition and melting pressure and temperature may be traced from the early Hadean to the present day. Typically the formation age of continental crust is more easily determined from felsic samples that contain accessory and relatively robust phases such as zircon and monazite that render a geochronological approach feasible. The lack of equally robust minerals and pervasive and ubiquitous metasomatism afflicting obducted orogenic peridotites and mantle xenoliths obliterates primary mineralogical and geochemical information. Hence it has proven difficult to acquire mantle depletion ages from continental lithospheric mantle, perhaps with the exception of Re-Os isotope dating of cratonic peridotites.

Empiric mineralogical and geochemical data of continental and oceanic lithospheric mantle has been examined extensively and metasomatism has been studied in great detail. I will present a numerical modelling approach generating a comprehensive catalogue of variously depleted plagioclase-, spinel- and garnet-peridotite major and trace element compositions. In addition primary Pb, Sr, Nd, Hf and Os isotope data will approximate refractory mantle generated during Earth's major episodes of depletion and continental crust formation (1.2, 1.8, 2.9, 3.8 Ga). These hypothetical compositions will be compared to natural peridotites from on- and off-cratonic xenoliths, abyssal and orogenic peridotites to identify those rare samples least altered by interaction with silicate, hydrous and carbonatitic melts. Extremely depleted mantle has the potential to harbour Pb, Sr, Nd, Hf and Os isotope compositions that would be easily recognized if silicate melts were generated from this type of pristine mantle and the record of volcanic rocks will be examined to identify potential lithospheric melts.