Vertical tectonics in the Neoarchean: Evidence from U-Pb detrital zircon age distribution in "Timiskaming type" sedimentary rocks in the Island Lake greenstone belt, Superior Province, Canada

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Two distinct tectonic regimes have been proposed to have been operating in the Archean, vertical and horizontal ('modern style") tectonics. Most authors see these as separate processes that would have operated exclusively from each other, although recent work has suggested that they could be contemporaneous and that the Neoarchean represents a transition from a time dominated by vertical tectonics to one dominated by horizontal tectonic processes (Lin, 2007, and references therein).

Studies on Archean greenstone belts can help to test these ideas, and this study investigates a clastic sedimentary package that is characteristic of Neoarchean greenstone belts, the "Timiskaming-Type" sediments. Traditionally these sequences are interpreted to have been deposited in strike-slip basins opened by horizontal tectonic processes. More recent studies have suggested that these sediments were deposited in inter-diapiric basins formed by vertical tectonic processes.

This study investigates the distribution of U-Pb detrital zircon ages within the Island Lake Group, a "Timiskaming type" sedimentary succession located in the Island Lake greenstone belt. The distribution of observed ages is distinct from unit to unit throughout the succession, and correspond to the ages of supracrustal and plutonic rocks in the belt. The data are consistent with a model that involves erosion down through a supracrustal pile in the early stage of basin formation and sedimentation followed by unroofing of plutons in the latter stages. The model presented here involves sagduction and diapirism processes that produce an inter-diapiric basin as a result of vertical tectonics.

Reference

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A petrologic view of mantle geochemistry: Os and He evidence for ancient depleted mantle heterogeneities

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Osmium isotopes in MORB and OIB appear to give a very different picture of the chemical history of the mantle than traditional isotope systems such as Sr, Nd and Pb. In particular, Os isotopes suggest that depleted, harzburgitic heterogeneities persist in the both the OIB and MORB source for at least 2 Ga, much longer than generally suggested by Sr, Nd or Pb isotopes. Recent partitioning experiments imply that He isotopes also record ancient depleted heterogeneities in the mantle [1]. In this talk I will show that the He and Os records of mantle depletion agree very well, with both indicating large melting events at 1.2, 1.9 and 2.7 Ga, corresponding well with peaks in the age distribution of continental crust. The agreement of these two independent mantle isotopic systems with the crustal record of melting is strong evidence for large melting events in the Earth's past.

Why don't we see this history in Sr, Nd and Pb? One possible explanation is that the mantle is largely heterogeneous, consisting of 15-20% subducted basaltic crust (eclogite) set within a matrix of depleted olivine-orthopyroxene rich matrix (harzburgite). This is essentially the marble-cake model of Allegre and Turcotte [2], and is supported by seismic scattering results [3] showing about 17% of the mantle consists of 10 km sized heterogeneities (presumably the eclogitic components).

If so, the eclogitic components would contain nearly all of the Sr, Nd and Pb in the mantle, while the harzburgite matrix would contain most of the Os and He (and probably the other noble gases). The eclogitic components have low melting temperatures and would melt readily if brought into a mid-ocean ridge system. Those melts would form the oceanic crust, which would eventually be subducted, turn back into eclogitic heterogeneities, which would then melt in a ridge again... This is the cyclic, young history recorded by Sr-Nd-Pb, the history of enrichment. In contrast, the refractory harzburgite would not easily melt again, even if brought into a ridge system, and so should be quite persistent in the mantle. As these refractory heterogeneities are relatively inert, they should record the timing of ancient melting events more readily than isotopes in low melting temperature phases. Thus from a petrologic viewpoint, the difference in histories recorded by Sr-Nd-Pb versus Os-He may be a natural consequence of the different minerals in which they reside.

References

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[2] Allegre and Turcotte (1986, Nature 323: 123-127
[3] Helffrich and Wood, 2001, Nature 412: 501-507