Eoarchean mafic crust in the Nuvvuagittuq greenstone belt

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Our understanding of the early differentiation of the Earth's crust and mantle is limited by the dearth of preserved rocks with ages older than 3.8 Ga. Recent geochronology work on a felsic unit within gabbroic rocks of the Nuvvuagittuq greenstone belt gives a minimum age of ~3.8 Ga for the supracrustal assemblage. The Nuvvuagittuq greenstone belt is a volcano-sedimentary sequence composed mainly of a peculiar cummingtonite-amphibolite ("faux-amphibolite") intruded by numerous ultramafic and gabbroic sills. The faux-amphibolite consists of mafic gneisses (5 to 15 wt% MgO) composed of cummingtonite + plagioclase + biotite + quartz ± garnet, with a compositional layering defined by variations in the proportions of biotite and cummingtonite. The faux-amphibolites have a similar major element composition to the gabbro sills that intrude them, but are relatively depleted in Ca and exhibit LREE-enriched profiles in contrast to the flat to slightly LREE-depleted profiles of the gabbro and ultramafic sills. The dominance of cummingtonite in the faux-amphibolites appears to reflect their anomalously low Ca content, whose origin remains unclear. All samples of the faux-amphibolite yield negative $\varepsilon Nd_{(3.8\ Ga)}$ values ranging from -5.3 to -0.3, whereas samples of the gabbro and ultramafic sills have mostly positive $\varepsilon Nd_{(3.8\ Ga)}$ values ranging from -2 to +4, indicating derivation from a mantle already depleted at 3.8 Ga. Sm-Nd isochrons for the sills are consistent with an age of 3.8 Ga and, like most terrestrial rocks, their $^{142/144}Nd$ ratios are indistinguishable from the terrestrial standard. Preliminary analyses of the faux-amphibolite and the dated felsic unit, however, suggest that they may have slight ^{142}Nd deficits relative to the terrestrial standard. The fact the faux-amphibolites are intruded by the gabbro sills suggests that they may represent an older gabbroic crust, possibly derived from an enriched reservoir complementary to the depleted reservoirs created during the early differentiation of the Earth.

Insights on Hadean Geodynamics from diamond stability constraints

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Hadean Diamonds

The recent discovery of diamond inclusions in zircons of Hadean age (4.4-4.0Ga) poses a paradox. The zircons are preserved in younger (Archaean) assemblages in the Jack Hills, Western Australia. Their oxygen isotopes suggest they formed in shallow, probably hydrated, felsic magma chambers, at temperatures of ~680°C [1, 2]. These shallow, hot conditions are not consistent with the stability of diamond. Recent examples of diamond inclusions in zircon come from ultra-high pressure massifs in Kazakhstan, where diamond replaced the original graphite [3].

A number of scenarios for exist for explaining their coexistence under Hadean conditions. We examine a number of tectonic scenarios, the most plausible involve some form of subduction, sagduction (vertical tectonism), or a whole-scale mantle overturn event.

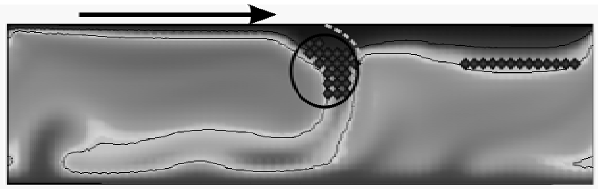

Figure 1: Finite element model of subduction under early conditions, showing the stability of diamonds in the downthrust lithosphere (circle) despite high surface heat flux.

Geodynamic Simulations

We use a Lagrangian intergration point finite element method to recreate candidate scenarios for graphite->diamond conversion for thermal conditions appropriate for the Hadean. The PT path of near-surface zircons into the diamond stability field, and their exhumation to the surface, provides an important constraint on Hadean lithospheric dynamics. These scenarios have contemporary analogues in exhumed continental subduction zones such as western Norway. We discuss the key features and similarities of each geodynamic model, and summarize physically plausible models for the global Hadean tectonic regime.

[1] Menneken M. *et al*. (2007) *Nature* **448**, 917-920. [2] Mojzsis *et al.* (2001) *Nature* **409**, 178-181. [3] De Corte (2000) *Island Arc* **9**, 428-438.