Searching for the perfectly removable, ultrabasic and dense lower crust

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The two main lines of thinking concerning lower crustal recycling into the mantle are mass balance-related; one is “mechanical”, and comes from shortening estimates in compressional orogens, the other is “chemical”, and is driven by the realization that the continental crust is too silicic to be produced directly by mantle melting. The first line of reasoning can be directly applied to specific mobile belts on Earth, whereas the second remains plagued by our inability to decipher the rate of continental growth through time and thus is difficult to connect to specific orogenic styles. The discourse on tectonic recycling of lower continental crust into the mantle is plagued by the misconception that “foundering of dense, eclogitic material (that is) produced during continental orogenesis …at the base of the crust”, as stated even in the overview for this session. The statement does vaguely imply that solid-state, metamorphic processes in overthickened orogenic crust lead to eclogite facies formation and potentially to subsequent convective removal. However, there is no reason why thickening-related eclogitization (although perfectly plausible) would segregate a felsic upper crust from a mafic-ultramafic lower crust. Instead, subduction-related arc environments are the only realistic settings in which felsic crust can be segregated, because magmatic differentiation operates in corroboration with shortening. Unfortunately, the most cited paper addressing removal of the deepest arc petrologic crust[1] deals primarily with the architecture of ISLAND arcs (mafic rocks, garnet-free pyroxenite residues). Lower crustal delamination in island arcs has neither any significance on continental formation nor any relevance to mechanical mass balance issues mentioned above. Instead, I will argue that transitional or continental arcs are the perfect environments for differentiating felsic crust from a garnet-rich residue that is likely to be recycled in the mantle.

References

[1] Jull, M. and P.B. Kelemen (2001), *J. Geophys. Res.*, **106**, 6423-6446.

Uncertainty of Hf isotope analysis in zircon using LA-MC-ICPMS techniques: Full disclosure

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In-situ Hf isotope measurements of zircon by laser ablation (LA) MC-ICPMS coupled with in-situ U-Pb geochronology by SHRIMP or LA-ICPMS is a potentially powerful technique because both tracer and age information can be determined from small zircon domains. The uncertainties inherent in zircon LA-Hf isotope analysis, however, can be considerable and all must be accounted for in order to assess these data in the context of Hf isotope data determined on chemically purified solutions.

In order to assess precision and accuracy associated with LA-MC-ICPMS zircon Hf analysis we analyzed 7 zircon standards (91500, QGNG, Temora, Peixe, R33, FC-1, and 94-35) during separate analytical sessions. Hf isotope measurements were made using a ThermoFinnigan Neptune MC-ICPMS with a New Wave 213nm Nd-YAG laser. A large source of analytical uncertainty in LA-Hf isotope analysis comes from the interference corrections on mass 176, principally from ^{176}Yb. Mass bias for Yb was exponentially corrected assuming: (1) βYb=βHf and (2) βYb=xβHf, where x is determined by normalizing to a standard and subsequently applied to the “unknowns”.

Internal precision for individual analyses averaged ~1 ε_{Hf} unit (2σ, SE). External precision of each standard during an analytical session ranged from 0.4-1.1 ε_{Hf} units (2σ, SD, n$\geq$6). Between analytical sessions, however, the spread of the session means range over 1.5 ε_{Hf} units, with one Yb rich zircon sample (R33) varying by > 4 ε_{Hf} units. Accuracy of the LA Hf analyses (compared with solution Hf analyses) varied depending on the Yb correction method. For method 1, session averages for 5 samples were accurate within ~1-2 ε_{Hf} units, but Peixe was several ε_{Hf} units low and R33 was ~3 ε_{Hf} units high. Method 2 improved accuracy for R33 (high Yb/Hf) but had little affect on accuracy of Peixe (low Yb/Hf).

Potential sources for variations in precision and accuracy for LA Hf isotope analysis include matrix effects and oxide interferences from Dy or Gd. For initial ^{176}Hf/^{177}Hf ratios a large source of potential error comes from uncertainty in the age, particularly for old zircons. This is not due to the radiogenic correction of the initial ^{176}Hf/^{177}Hf ratio, which is quite small, but in the CHUR reference, which varies by over 2 ε_{Hf} units/100 m.y. Regardless of their sources, all uncertainties associated with LA-MC-ICPMS zircon analyses need to be incorporated into the errors reported on ^{176}Hf/^{177}Hf ratios. These several ε_{Hf} unit uncertainties may not be an issue where large variations in ^{176}Hf/^{177}Hf are expected (e.g., detrital zircons), but they put limitations on applications where small variations in ^{176}Hf/^{177}Hf are significant (e.g., constraining crust-mantle evolution).