REE, HFSE, LILE, and transition metal exchange between basaltic melt and supercritical Cl-bearing aqueous fluid

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We performed experiments at 1000°C and 200 MPa to quantify the exchange of the REE, HFSE, LILE, and transition metals between a basaltic melt and Cl-bearing supercritical aqueous fluid. Oxygen fugacity was controlled at values from ~approximately Mn-Mn_3O_4 (i.e. NNO+2) to ≤FMQ-1 to constrain the effect of fO_2 on element mass transfer. The melt plus crystals were contained inside an inner 1 mm ID cylindrical capsule that was mechanically open at its top and placed inside in an outer 4.8 mm ID capsule that held the aqueous fluid. The top of the melt column in the inner capsule was the only interface between melt and fluid. The starting solution was restricted to the NaCl ± KCl ± HCl system. The Σ-Cl content of the aqueous fluid was fixed via mass balance by the dissolution of Cl^- from the aqueous fluid into the melt. Recovered silicate glass and crystals were analyzed by using EPMA and LA-ICP-MS. At high fO_2 ≥NNO+2 the charge contained hydrous silicate melt, clinopyroxene, magnetite-spinel solid solution, and a single-phase aqueous fluid. At low fO_2 ≤ FMQ, the charge consisted of hydrous silicate melt, clinopyroxene, olivine (Fo_{78}), and a single-phase aqueous fluid. The modal abundance of crystalline material at run conditions is estimated visually to be 20-25%. Chemical potential gradients in the melt were induced by the exchange of melt constituents with species in the aqueous fluid at the melt-aqueous fluid interface. Qualitative diffusion profiles of melt components were observed in elemental concentration gradients down the length of the recovered glass cylinders to the un-reacted melt volume at the base of the cylinder. Fluid mobile major elements include Fe, Mg, Ca, and Mn. Trace elements that partition strongly into the aqueous fluid are V, Rb, Sr, Zr, Ba, Cs, Pb, Nd, Ce, and U. These data place constraints on the magnitude of mass transfer of silicate melt components into aqueous fluids evolved upon magmatic fluid exsolution.

Early Archean crustal evolution in the Yilgarn: constraints from Lu-Hf in Jack Hills zircons

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The Yilgarn craton of Western Australia contains the oldest materials yet identified in the terrestrial record – Hadean zircons as old as 4.38 Ga – and thus is an ideal candidate for investigating early Archean crustal evolution. Previous studies have focused on Hadean (>4.0 Ga) zircons, but the substantially (>96%) more numerous zircons ranging from 3 to 4 Ga are useful in assessing preservation history for both early Archean and Hadean crustal materials. The Hf isotopic composition of zircons can distinguish between histories involving reworking of older crust and the addition of mantle material. Results of coupled Pb and Hf LA-ICP-MS isotopic measurements for 60 Jack Hills zircons (3.0-4.1 Ga) yield similar age-εHf distribution to that seen for other Jack Hills zircons. However, we find more highly negative εHf values in the interval from 3.7-3.9 Ga than previously seen, underscoring the continental-like signature recognized in previous studies of Jack Hills zircons; our spread in negative εHf values is comparable to that seen from the Hadean zircons. Plots of Pb-Pb age vs. single-stage CHUR and DM Lu-Hf extraction ages reveal a cap on extraction ages at 0.6 and 0.7 Ga, respectively, prior to crystallization. We interpret our results as indicating that Hadean crust as old as 4.4 Ga substantially contributed to granitic magmas in the Yilgarn until at least 3.8 Ga, with some involvement from Hadean crust evident to 3.4 Ga. The cap on extraction age-crystallization age differences suggests a recycling time scale of 0.6-0.7 Ga. The <4.0 Ga record is characterized by a diffuse scatter in extraction ages from ~3.7-4.4 Ga across 0.5 Ga of crystallization ages as well as a dense continuum of extraction ages from ~3.8-4.1 Ga at a crystallization age of 3.4 Ga. A larger sample size for the younger grains may help to discern whether differences in the distribution of extraction ages in the Hadean and Archean reflect real differences or are due to sampling limitations. The crystallization age-extraction age plot is also useful for determining which single-stage extraction ages should be regarded with caution, given the likely crustal melt signature at the 3.4 Ga peak.