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Large-scale accumulation and fractionation of anatectic melt during crustal reworking.

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The continental crust is thought to become compositionally differentiated when its lower levels partially melt and the melt ascends to the upper crust. Key questions are how much melt actually reached the upper crust and if a large fraction did not, where is it and what happened to it? These questions are addressed for the Ashuanipi Subprovince, a large (90000 km2) Archean granulite-facies (P 7 kbars, T 850-900oC) greywacke terrain in the Superior Province. Field work and petrology identify three products of anatexis; 1) Pl+Opx+Qz+Bt residual metatexite formed after extraction of ∼31% melt from greywacke, 2) Pl+Qz+Bt+Kfs+Opx diatexite, and 3) Pl+Qz+Kfs±Bt leucogranite. They occupy 14.6%, 42.9% and 18.4% of the terrain respectively, the remainder comprises infertile lithologies and younger plutons.
The composition of some diatexites lie on the metatexite/residuum-anatectic melt tie-line and are simple mixtures of metatexite and anatectic melt. However, most diatexites lie in the three component compositional space defined by the crystallised solids, the fractionated melt from the anatectic melt and the metatexite/residuum. Mass-balance modelling indicates that typical diatexite began as a mixture of 36% metatexite + 64% anatectic melt which, upon reaching ∼25% crystallization, had 73% of the remaining melt segregated from it. Thus average diatexite comprises 56% metatexite + 24% early crystallised solids (mostly Pl and a few % Opx) + 20% fractionated melt; it is 44% “melt product”. Significantly, making the diatexites expelled ∼55% of the initial amount of melt; this fractionated melt crystallised elsewhere. The leucogranites lie between the crystallised solid and its complementary fractionated melt, not at the anatectic melt itself. Most Ashuanipi leucogranites are cumulate rocks produced when anatectic melt reached between 12 and 46% crystallization and ∼45% of the remaining melt was expelled to crystallise elsewhere. Considering the area of each rock type, the present Ashuanipi surface once contained 3.44 times as much melt as made there; it is a crustal level where anatectic melt accumulated, became contaminated and fractionated.
The adjacent Opinaca Subprovince is a slightly shallower (P 6 kbars, T 810oC) greywacke-dominated granulite terrain that produced <5% melt, but contains 63% leucogranite. Most Opinaca leucogranites have highly fractionated compositions that match the melts expelled in making diatexite and leucogranite in the Ashuanipi. Assuming the Opinaca is representative 2 km thick crustal layer immediately above the Ashuanipi, and a geotherm of 30oC km-1, the volume of melt trapped and crystallised between the solidus and the Ashuanipi surface is ∼393959 km3, or 62% of the total melt produced. This does not include “melt products” below the Ashuanipi surface. Thus, <38% of the anatectic melt produced in this collisional orogen reached the upper crust.
The crystallisation of large volumes of anatectic melt deep in the continental crust produces a different geochemical signature to that when melt moves directly to the upper crust. The deeper parts of the melt accumulation zone are enriched in early crystallising phases (mostly plagioclase), whereas the shallower part below the solidus is enriched in components that partitioned into highly fractionated melt.