Reactive fluid flow and time-integrated fluxes in an upper crustal magmatic-hydrothermal system, Krušné hory Mts., Central Europe

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Advances in thermodynamic modeling of fluid-mineral interactions at elevated temperatures and pressures permit calculation of time-integrated fluid fluxes in metamorphic complexes and shear zones using inversion of mineral reaction progress and application of local equilibrium. Such estimates may, however, only provide an upper bracket on the integrated fluid flux when the incoming fluid is out of equilibrium with the host lithology. We extended the transport theory to account for effects of thermal and pressure gradients and chemical disequilibrium simultaneously, and apply it to greisen alteration in the Western Krušné hory granite pluton (central Europe). Veins and swarms of fracture-controlled greisens up to 400 m long and 800 m deep show the following spatial alteration zoning (from margin to interior): greisenized granite, muscovite-quartz greisen, topaz-quartz greisen, pure quartz greisen, and hydrothermal quartz vein. Greisen textures and distribution of relics of magmatic quartz phenocrysts suggest that greisenization was a constant-volume replacement process. We modeled set of infiltrating fluids, from 650 °C and 1 kbar (magmatic fluid phase exsolving at the solidus) to 400 °C and 500 bar (greisen formation). The corresponding time-integrated fluid fluxes vary from 10^2 to 10^6 m^3 fluid m^{-2} rock, dictated by chemical disequilibrium whereas pressure and temperature gradients have subordinate effects. Successive replacement of feldspar by muscovite and topaz under conserved volume constrains the time-integrated fluid flux to $0.2\text{-}1.0 \cdot 10^3$ m^3 fluid per m^2 rock. The formation of a single greisen vein with a typical volume of $0.1\text{-}5 \cdot 10^4$ m^3 would require $0.01\text{-}3.10^7$ m^3 aqueous fluid. For a characteristic vein length (transport distance) of 400-800 m, the plausible fluid flow rate is 10^{-10} to 10^{-9} $m.s^{-1}$. By using mass balance and an assumed 5 wt. % H_2O dissolved in a granitic magma, such amount of fluid phase would have exsolved from 5.10^5 to 3.10^8 m^3 magma or an intrusion measuring $0.8\text{-}7 \cdot 10^2$ m in each dimension, which is comparable with dimensions of the host granitic pluton. Our results indicate that strong alterations may be produced by integrated fluid fluxes that are by 2-3 orders of magnitude lower than those in metamorphic shear zones.

Fluid and trace element migration in subducted oceanic rocks from Ecuador

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The ophiolite association of the Raspas complex in Ecuador, representing subducted oceanic lithosphere, stands out by high-pressure zoisite veins and associated metasomatized zoisite eclogites, indicating fluid flow and element mobility at depth of about 60 km. Fluid inclusion investigations in vein zoisite and metasomatized zoisite eclogites reveal a homogeneous low-salinity fluid composition in the system H_2O-NaCl-CH_4-CO_2 which is conform with an open-system fluid infiltration derived from an external source. Deserpentinized, pseudo-spinifex textured chlorite harzburgites found within the ultramafitites of the Raspas Complex are a potential source for the external CH_4-bearing low-salinity aqueous fluid. However, the enrichment in LREE, MREE, Pb, Sr, Th, U, found in the metasomatically overprinted seafloor-altered MORB-type eclogites and in zoisite veins can be explained best by leaching of these elements from metabasites and metapelites in zones of intense fluid-rock interaction. A garnet-amphibole rock, deficient in LREE and Sr, could represent such a leached metabasite. Other LIL elements, as well as B, Th and U could be derived from metapelites. All the elements enriched in the metasomatized eclogites and zoisite veins must have been fluid mobile at eclogite-facies conditions and transported by channelized fluid flow and high fluid flux.