

Genesis of igneous rocks associated with El Teniente Cu-deposit, Chile

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El Teniente, the world's largest Cu-deposit, is hosted in Late Miocene and Pliocene plutonic rocks that intrude older Abanico (>15 Ma) and Farellones Formation volcanics (15.2 to 7.5 Ma). The plutonic rocks include a large (>50 km³) mafic sill complex (8.9 Ma), the smaller (~20 km³) Sewell equigranular tonalite (7.1 Ma), small (<1 km³) qtz-diorite porphyry bodies (6.1 Ma), the Cu- and S-rich "Porphyry A" anhydrite-bearing granitoid stock (5.7 Ma), the Teniente Dacite Porphyry dike (<1 km³; 5.3 Ma), and finally minor latite dikes (4.8 Ma). Multiple Cu-mineralized magmatic-hydrothermal breccia pipes have been dated at >7.1 Ma, 6.3 Ma, 5.7 Ma, and between 4.9 to 4.4 Ma, the age of formation of the Braden Breccia pipe, the central litho-structural unit in the deposit. These breccias have their roots below the deepest level of mining and exploration drilling and were derived from the same magma chambers as the intrusives, >4 km below the paleo-surface. To produce the ~100x10⁶ tonnes of Cu in the deposit requires a batholith size (>600 km³) amount of Andean magma with ~100 ppm Cu. We suggest that the mineralized breccias and the progressively smaller volumes of more fractionated Miocene and Pliocene plutonic rocks were derived from the roof of a large, long-lived, thermally and chemically stratified, open-system magma chamber recharged from below by mantle-derived mafic magmas. Only when this system fully solidified did post-mineralization mantle-derived ol-hbl-lamprophyre dikes (3.9 to 2.8 Ma) and ol-basaltic andesite lavas (2.1 to 1.8 Ma) again pass through the system to the surface. These were the final igneous events prior to the >40 km eastward migration of magmatism due to decreasing subduction angle below this part of the Andes. A significant progressive temporal isotopic evolution to higher ⁸⁷Sr/⁸⁶Sr (0.7033 to 0.7050) and ²⁰⁶Pb/²⁰⁴Pb and lower ϵ_{Nd} (+6.2 to -1.1) occurred for mantle-derived mafic magmas, and by implication their mantle source region, between the Late Oligocene and Pliocene. This was due to increased mantle-source region contamination by subducted crust tectonically eroded off the continental margin. The ol-hbl-lamprophyres also imply extensive hydration of the mantle below this portion of the Andean arc by the Pliocene, which may have played an important role in producing oxidized volatile-rich magmas and mineralization at El Teniente.

Adsorption of fluoride on synthetic hydroxyapatite

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Hydroxyapatite (Ca₅(PO₄)₃OH, HAP) is used in different forms for the removal of fluoride from drinking water. It is the main constituent of bone char, a filter material used in several developing countries [1]. Synthesized HAP granules have also been used for defluoridation purposes. One of the critical features of filter materials used for fluoride removal is their capacity, since groundwater used for drinking can contain up to 20 mg/L fluoride, necessitating frequent regeneration. This can be a limiting factor for the deployment of filters in remote regions. Factors that influence fluoride uptake, which is primarily the exchange of the hydroxide ion for fluoride to form fluorapatite, still need to be clarified for the most effective use of HAP. The most important factors are thought to be related to solution chemistry and the influence of the preparation of granules for filter use.

In batch experiments fluoride uptake kinetics and capacities on HAP were determined at 25°C, with deionized water and a solid:liquid ratio of 1:500. Initial fluoride concentrations ranged from 0.4 to 4.9 mmol/L at a solution pH of 7.3. The pH dependence was also investigated.

It was found that fluoride uptake was a function of initial fluoride concentration, pH and time. Within the first hours the fluoride uptake reached a maximum of approximately 75% for an initial concentration of 0.4 mM at pH 7.3. Equilibrium was achieved only after approximately 28 days. For a fluoride content at equilibrium (equivalent to the inlet concentration in a column experiment) of 1 mM, approximately 0.6 mmol/g fluoride was adsorbed on HAP. Under the same conditions bone char uptake capacity is around 0.05 mmol/g [2]. The maximum fluoride uptake on HAP was approximately 0.8 mmol/g.

[1] Fawell, Bailey, Chilton, Dahi, Fewtrell & Magra (2006), Published on behalf of the WHO, IWA Publishing, London, 129 pp. [2] Bregnhøj (1995), PhD Thesis; Institute of Environmental Science and Engineering, Lyngby, Technical University of Denmark, 112 pp.