Geochemical evolution of marine shore mine tailings in an hyperarid climate

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From 1938 until 1975, floating tailings from the El Salvador mining district were transported in suspension to the sea at Chañaral Bay, Atacama Desert, northern Chile. Since 1975, the tailing have been exposed to oxidation, resulting in a 70-188 cm thick low-pH (2.6-4) oxidation zone at the top resulting in the liberation of Cu, Zn and Ni. These divalent metals that have been liberated in the oxidation zone were mobile under acidic conditions and transported to the tailing surface. Efflorescent salts such as halite and eriochalcite ($CuCl_2.2H_2O$) precipitated on the surface of the tailing, and gypsum and jarosite formed throughout the unsaturated zone. The feasibility of different genetic hypotheses to explain the pore water composition and the precipitated salts was tested with reactive transport modelling. Processes included in the model were heat transfer, evaporation-condensation, vapor and water flow, as well as chemical reactions (secondary salt precipitation and aqueous complexes in equilibrium; silicate and sulphide dissolution and Fe(II) oxidation under kinetic laws). Based on preliminary geochemical modeling, the evaporation of groundwater directly below the salts is not able to reproduce the observed salt association. Three alternative genetic processes that have occurred in the past are being analysed: evaporation of groundwater + surface input of marine aerosol, evaporation of seawater, and evaporation of a Cu-rich deep brine. Pyrite and chalcopyrite oxidation, and silicate dissolution are always assumed to take place in the unsaturated zone. Reactive transport calculations are perfomed with an Object Oriented tool to calculate chemical processes (CHEPROO) coupled with a multiphase flow code (CODEBRIGHT).

Temporal evolution of Archean intermediate to felsic plutonism in the Superior Province

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Archean, intermediate to felsic intrusive rocks in the Superior Province display a characteristic temporal trend in their geochemical characteristics, petrogenesis and field relationships that is interpreted within a modified uniformitarian model. The first stage involves the voluminous, protracted, synvolcanic, pretectonic production of TTG-type magmas characterized by low LILE and compatible trace element abundances, high Na/K, elevated Sr and Sr/Y, fractionated REE with near chondritic HREE with Eu/Eu*>1 and depleted mantle isotopic signature. Most TTGs have geochemical characteristics pointing to eclogitic residues which combined with their volume and the requirement to generate an enriched mantle source (see below) suggests slab melting in a steep subduction model.

The second stage is represented by a widespread but volumetically minor, brief (5-10 Ma) interval of sanukitoid and alkalic magmatism that postdates TTG magmatism by ~5 Ma and is broadly syntectonic (postdates early deformational fabrics defined by peak metamorphic mineral assemblages and is synchronous with regional folding and post-peak metamorphic uplift). These rocks have a dual primitive (elevated Mg# and Ni and Cr abundance) – evolved (elevated LILE and HFSE abundances) character and isotopic signatures suggesting they are sourced from long-term depleted mantle that was metasomatized synchronously with the production of TTG magmas and have interacted with the crust to varying degrees. The abrupt, irreversible transition from slab melting to melting of the metasomatized mantle wedge is attributed to accretion leading to slab break-off and influx of hot asthenospheric mantle at the southward prograding margin of the Superior craton.

A third stage represented by crustally-derived granodiorites and granites with elevated LILE, low compatible trace element abundances, diverse REE characteristics and crustal radiogenic isotope signatures, is initiated synchronously with stage 2 activity but is more protracted and restricted to specific domains within the Superior Province. Both I-type (associated with older TTG-dominated terranes) and S-type (associated with high-grade metasedimentary terranes) varieties are recognized.