Depth-temperature-time evolution in Central Andean magmatic systems

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Taapaca, Parinacota, El Misti and Lascar represent distinct volcanic differentiation regimes in the Central Andes. Their variable evolution histories with respect to compositional range and eruption rates result from differences in the magma plumbing and storage systems. We present the reconstruction of P-T-t evolution of the end-member Andean volcanic systems using amphibole barometry, hornblende-plagioclase thermometry and magnetite-ilmenite thermo-oxy-barometry.

El Misti (<112 ka) and Lascar (<43 ka), both characterized by narrow compositional range of erupted lavas and high eruptive rates (~0.8 km^3/ka), reveal similar magma stagnation levels of 5 to 10 kb, a continuous range of crystallization temperatures from 840°C to 980°C and limited range of oxygen fugacity of 0.7 to 1.9 log units above NNO.

Taapaca dome complex (1270 ka) generated uniform dacitic composition with low eruptive rates (0.024 km^3/ka). Uniform magma storage depth at about 6 to 8 km in oxidizing conditions from 1.0 to 2.0 log units above NNO and variable temperatures at 730°C, 830°C and 950°C were obtained from samples throughout the history of the volcano.

Parinacota (163 ka) shows distinct batches from amphibole-bearing andesite to rhyolite with change to basaltic andesite and andesite containing amphibole mainly of xenocrystic origin after flank collapse. Eruption rates increased in time (0.5 to 1.0 km^3/ka). Estimated P-T-fO_2 values correspond to five evolutionary phases of distinct Ar-Ar ages and eruption characteristics. The most differentiated Parinacota lavas yield oxidized conditions at 1.7 to 2.0 log units above NNO values at temperatures of 780°C to 830°C. The highest temperatures and lowest oxygen fugacity appear in lavas erupted after flank collapse (880-1010°C, 0.2-1.1 log units above NNO). The estimated stagnation levels varied from shallow magma reservoirs at 3 to 7 km to deeper reservoirs <20 km depth.

Modelling the impact of biota and increasing atmospheric CO_2 on silicate mineral weathering processes

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Simulation of Weathering Processes in Modern Soils

A mathematical model that couples hydrological, geochemical and biological processes describes weathering processes in modern soils [1]. The model mechanistically simulates the geochemical impact of plants, through the fluxes of nutrient cations and anions associated with plant biomass production and deccomposition by soil microorganisms, and their effect on soil pore fluid composition and abiotic chemical dissolution kinetics.

Biological Feedback to Atmospheric CO_2 levels

The results show a stabilising biological feedback response of silicate weathering to increasing atmospheric CO_2 levels as postulated for atmospheric evolution during the Earth's Phanerozoic CO_2 history [2]. These results agree within a factor of 2 with the biological feedback strength as evaluated in the global models for the evolutionary history of terrestrial plants [1, 2]. The weathering flux of cations from silicate weathering depends strongly on soil structure; soil profile depth, porosity and water content. However, pH and hydrogen ion-accelerated mineral weathering rates are relatively insensitive to greater plant productivity under increasing atmospheric PCO_2.

Biomass decomposition, which accelerates under warmer, wetter conditions associated with elevated atmospheric PCO_2, dampens the effect of hydrogen-ion and organic ligand-accelerated dissolution. This is through the relatively large hydrogen-ion fluxes associated with decomposition, and its impact to actually moderate drops in soil pH and thus organic ligand adsorption and abiotic dissolution rates. Further modelling considers the evolutionary role of soil fungi in silicate mineral weathering, and how this potentially plays a role in the biological weathering feedback response.

[1] Process-based modelling of silicate mineral weathering responses to increasing atmospheric CO_2 and climate change. *Global Biogeochemical Cycles* (in review). [2] Berner (2004). *The Phanerozoic carbon cycle. CO_2 and O_2*. Oxford University Press, Oxford (UK).