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Role of differentiation and mixing processes in the evolution of Central Andean magma systems: An experimental approach

R.E. Botcharnikov (1), C. Bonecke (1), F. Holtz (1), G. Torresi (1), M. Banaszak (2), and G. Wörner (2)

(1) Institut für Mineralogie Universität Hannover, Callinstr. 3, 30167 Hannover, Germany (r.botcharnikov@mineralogie.uni-hannover.de), (2) Geowissenschaftliches Zentrum Göttingen, Abt. Geochemie, Goldschmidtstr.1, 37077 Göttingen, Germany

The compositional evolution of magmatic systems is controlled by many factors, numerous processes and prevailing conditions at depths of magma generation, storage and ascent. The most important processes responsible for the chemical variations observed in most erupted magmas are magma differentiation during crystallization and magma mixing/hybridization.

We present preliminary results of the crystallization experiments on the two magma compositions representative of the least evolved basaltic andesite magmas from Parinacota volcano and of the dacitic magmas from Taapaca volcano (N.Chile). Although both volcanoes are related to the Central Andean magma systems, the geochemical characteristics of erupted materials from these two volcanoes represent distinct magmatic regimes and processes, occurring at depth of magma generation and storage (for details see Banaszak et al., this session). The lavas of Taapaca have relatively uniform dacitic compositions over a long period of volcanic activity (ca. 1270 ka) and low eruptive rates (0.024 km3/ka). In contrast, the rocks from Parinacota are younger (163 ka), and they have been produced in five stages of volcanic activity with eruptive rates that are at least one order of magnitude faster (0.5-1 km3/ka) than those of Taapaca. The compositional variations cover a range from rhyolites to basaltic andesites. The major element compositions of Parinacota lavas produce continuous trends as a function of MgO and K2O, which are typically used as differentiation indexes, indicating that magmas could be generated by differentiation and/or hybridization. Remarkably, the dacitic composition of Taapaca lies exactly on the compositional trend of Parinacota.

The experiments for natural dacite samples from Taapaca volcano have been conducted in a temperature range from 725 to 850°C, at pressures 200 and 300 MPa and at redox conditions corresponding to ca. Ni/NiO oxygen buffer (NNO) whereas experiments with natural basaltic andesite of Parinacota have been done at temperatures of 900 – 1050°C, 300 MPa and log fO2 from NNO to NNO+1. Water activity in the system was varied using various proportions of H2O and CO2 in the coexisting fluid phase. The results of the experiments show that the liquid lines of descent in magmas, undergoing close-system differentiation are significantly different from the natural trends. In particular, the SiO2 vs. MgO trend has a well-developed concave shape for the experimental residual liquids whereas bulk rock compositions of Parinacota and Taapaca lie along almost a linear trend. This discrepancy clearly indicates that the compositions of natural magmas from Parinacota are strongly affected by hybridization/mixing processes and they are presumably overprinted by crystal fractionation processes as well. Thus, the compositions of erupted magmas represent different extent of such hybridization/differentiation processes between different end member magmas. The relatively constant composition of Taapaca lavas over a long time is presumably related to a steady-state interaction and hybridization of magmas at depths of magma stagnation. Ongoing experimental investigations are performed to determine the volatile compositions of possible end-members and the pressure of magma storage.