Geophysical Research Abstracts,
Vol. 11, EGU2009-9884-2, 2009
EGU General Assembly 2009

Distinct regimes of differentiation in Central Andean magma systems

M. Banaszak (1), G. Wörner (1), R. Botcharnikov (2), F. Holtz (2), and J. Hora (3)

(1) Geowissenschaftliches Zentrum Göttingen, Abt. Geochemie, Goldschmidtstr.1, 37077 Göttingen, Germany, (2) Institut für Mineralogie Universität Hannover, Callinstr. 3, 30167 Hannover, Germany, (3) Department of Geology and Geophysics, University of Wisconsin-Madison, 1215 W. Dayton Street, Madison, WI 53706, USA

Magmas that feed volcanoes in the Central Andes must traverse up to 70 km of continental crust. We observe striking variability in volcano evolution with respect to compositional range and eruption rates. These result from differences in their plumbing systems, specifically magma stagnation depth, recharge frequency, volatile content, reservoir sizes and complexity as well as crustal structure. We combine geochemical and petrological studies for four end-member systems to better constrain these variables: El Misti (<112 ka) and Lascar (<43 ka) are characterized by high eruptive rates (~0.8 km^3/ka) and andesitic to dacitic composition. Parinacota (163 ka) shows low eruption rates which increased in time (0.5 to 1.0 km^3/ka) and consists of five phases, varied from andesite to rhyolite with change to basaltic andesite and andesite compositions after flank collapse. In contrast, the Taapaca dome complex (1270 ka) generated rather uniform dacitic composition with lowest eruptive rates (0.024 km^3/ka). Application of hornblende-plagioclase thermometry, magnetite-ilmenite thermo-oxy-barometry and amphibole barometry in connection with experimental constraints of crystallization conditions (for details see Botcharnikov et al. and Torresi et al., this session) for these volcanoes reveals significant differences in the magma stagnation levels and conditions of magma differentiation (and presumably the plumbing system).

Mineral compositions also reveal differences between investigated volcanoes. The youngest volcanoes El Misti and Lascar demonstrate - at a given magma composition - more calcic plagioclase composition (An40-85) compared to longer-lived Parinacota and Taapaca (An25-65). Tschermakitic amphibole composition dominates in El Misti and Lascar lavas, whereas Taapaca and Parinacota are characterized by magnesio-hornblende and Ti-rich hastingsite. Two amphibole generations with distinct compositions were found in all Taapaca dacites and several samples from Parinacota and Lascar. Depending on the degree of differentiation, magnetite and ilmenite compositions yield lowest Mg/Mn ratios from Taapaca dacites and more evolved Parinacota lavas. Presence of two different Mg/Mn ratios observed in Fe-Ti-oxides from several eruptive units of Parinacota and Lascar indicates crystallization from distinct magma batches.

Hornblende-plagioclase thermometry for El Misti and Lascar gave a large and continuous temperature interval of crystallization from ~850 to 980˚C is in agreement with the range (840-970˚C) obtained from magnetite-ilmenite. Oxygen fugacity estimates show a limited range for both volcanoes from 0.7 to 1.9 log units above NNO. Distinct magma batches at Parinacota, defined by their chemistry, distinct Ar-Ar-ages and eruption characteristics, show three narrow hornblende-plagioclase crystallization temperature ranges around 730˚, 840˚, and 920˚C. Thermo-oxybarometry for Parinacota documents diverse temperature-oxygen fugacity ranges for the different compositional units. 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 most differentiated Parinacota lavas yield oxidized conditions at 1.7 to 2.0 log units above NNO values at temperatures of 780 to 830˚C. At Taapaca units of largely different age, temperatures and oxygen fugacity determined from magnetite-ilmenite vary between 780 and 930˚C at oxidizing conditions from 1.0 to 2.0 log units above NNO. The lowest temperature range obtained from hornblende-plagioclase inclusions in sanidine megacrysts reveals a peak at 730˚C. Temperatures calculated from host hornblende/hastingsite and plagioclase yield three temperature intervals at 730˚, 830˚ and 950˚C. Natural hornblende could be experimentally reproduced from the dacite composition at temperatures range from 720 to 760˚C and pressures between 2 and 3 kb. Hastingsite crystallized only from andesitic composition in our experiments for Parinacota at 950 ˚C and pressure of 3 kb. Al-in-hornblende barometry applied to alkali feldspar-bearing lavas yield pressures consistent with experimental results for Taapaca dacite from 1.2 to 2.8 kb and 0.4 to 2.0 kb

for Parinacota rhyolite. These estimates correspond to shallow magma reservoirs, about 6 to 8 km below Taapaca for all stratigraphical units and 3 to 7 km for most differentiated magmas under Parinacota. Al-Ti thermobarometry on amphibole from more mafic El Misti, Parinacota and Lascar magmas yield crystallization levels $<$20 km depth.

Young and “fast” volcanoes El Misti and Lascar that produce a narrow compositional range of erupted lavas reflect high magma recharge frequency and high water contents and probably have similar feeding systems, and magma stagnation levels of 5 to 10 kb. Long-lived Taapaca volcano with uniform dacitic composition has magma stagnation level of 2 to 3 kb, low water contents and recharge rate. The occurrence of sanidine megacrysts and two amphibole generations in Taapaca lavas suggests mixing between magmas, initially crystallized at different conditions, in a thermally buffered steady state system. In contrast, Parinacota volcano produced broadest compositional spectrum mostly affected by changing of the plumbing system, different magma stagnation levels and recharge through time. Combining estimations of pressure with temperature for all Ar-Ar-dated stages of Parinacota allow the reconstruction of the depth-time-evolution of the magmatic system from deep and varied to shallow and focused.