American Mineralogist, Volume 100, pages 2284–2297, 2015

SPECIAL COLLECTION: GLASSES, MELTS, AND FLUIDS, AS TOOLS FOR UNDERSTANDING VOLCANIC PROCESSES AND HAZARDS

Volatiles in magmas related to the Campanian Ignimbrite eruption: Experiments vs. natural findings†

Sara Fanara[1,*], Roman E. Botcharnikov[1], Danilo M. Palladino[2], Franziska Adams[1], Julia Buddensieck[1], Andreas Mulch[3,4] and Harald Behrens[1]

[1]Institut für Mineralogie, Leibniz Universität Hannover, Callinstrasse 3, D-30167, Hannover, Germany
[2]Dipartimento di Scienze della Terra, Sapienza-Universitá di Roma, Piazzale Aldo Moro 5, 00185, Roma, Italy
[3]Biodiversität und Klima Forschungszentrum (BiK-F) and Senckenberg, Senckenberganlage 25 60325 Frankfurt/Main, Germany
[4]Institut für Geowissenschaften, Goethe Universität Frankfurt, 60438 Frankfurt/Main, Germany

Abstract

The solubility of H_2O- and CO_2-bearing fluids in trachytic and trachybasaltic melts from erupted magmas of the Campi Flegrei Volcanic District has been investigated experimentally at 1100 and 1200 °C, respectively, and at 100, 200, 300, 400, and 500 MPa. The solubility of H_2O in the investigated melts varies between 3.48 ± 0.07 wt% at 100 MPa to 10.76 ± 0.12 wt% at 500 MPa in trachytic melts and from 3.49 ± 0.07 wt% at 100 MPa to 9.10 ± 0.11 wt% at 500 MPa in trachybasaltic melts. The content of dissolved CO_2 in melts coexisting with the most CO_2-rich fluid phase increases from 281 ± 24 ppm at 100 MPa to 2710 ± 99 ppm at 500 MPa in trachyte, and from 727 ± 102 ppm at 100 MPa to 3565 ± 111 ppm at 500 MPa in trachybasalt.

Natural samples from the Campanian Ignimbrite eruption (trachyte) and from the Solchiaro eruption (trachybasalt) were collected around the city of Naples and on Procida Island. Deuterium/hydrogen (D/H) ratios were analyzed in natural pumices pre-heated at different temperatures to remove water adsorbed and/or imprinted by glass alteration processes. It has been determined that heating of the glass to 350 °C efficiently removes most of secondary water and the remaining concentrations represent primary magmatic water preserved in the erupted material. Hydrogen isotope composition (with δD values ranging between –70‰ and –110‰) and its correlation with bulk water content in selected pumice samples of the Campanian Ignimbrite eruption are consistent with isotopic fractionation between magmatic fluid and melt during degassing of erupting magma. Hence, the H_2O and CO_2 contents in natural glasses from pumice samples are considered as minimum estimates on volatile concentrations in the melt just prior to the eruption or at the fragmentation event. The water contents in natural glasses vary from 0.83 ± 0.07 to 3.74 ± 0.06 wt% for trachytes from the Campanian Ignimbrite eruption and from 1.96 ± 0.06 to 3.47 ± 0.07 wt% for trachybasalts from the Solchiaro eruption. The CO_2 contents vary from 78 ± 120 ppm CO_2 to 1743 ± 274 ppm for trachytes from the Campanian Ignimbrite eruption and from 240 ± 293 to 1213 ± 250 ppm for trachybasalts from the Solchiaro eruption.

A combination of natural and experimental data provides minimum pressure estimates for the storage and ascent conditions of magmas. The Campanian Ignimbrite magma could have been stored or ponded during its rising path at two different levels: a deeper one corresponding to depth of about 8 to 15 km and a shallower one at about 1 to 8 km. Trachybasalts from Solchiaro erupted from the deepest level of about 11 km with a storage or ponding level at around 2 to 8 km depth. Although an uncertainty of at least a kilometer has to be considered in estimating storage or ponding depths, these estimates point to significantly deeper magmatic sources for both eruptions as those considered previously.

Keywords: Water, carbon dioxide, solubility, hydrogen isotopes, trachyte, trachybasalt, Campi Flegrei Volcanic District, Campanian Ignimbrite eruption, Solchiaro eruption