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DEPTH TO AND CONCENTRATIONS OF WATER IN LARGE BODIES OF SILICIC MAGMA

Progress Report

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A. T. Anderson

University of Chicago
5801 South Ellis Avenue
Chicago, Illinois 60637

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TECHNICAL PROGRESS REPORT

A. Abstract

Large bodies of silicic magma are potential sources of geothermal energy and ore. They also pose threats of catastrophic eruptions. The depths of such bodies are related to their economic potential and probably to their eruption mechanisms. The concentrations of water in the magmas are important for their eruptive and dynamical behavior and for the development of ores. Estimates of viscosity and density of melt require knowledge of concentration of water. The concentration of water in melt before ascent and eruption can be measured in inclusions of glass which became trapped in crystals before extrusion. The depth of a magma body can be estimated or delimited if we can find out the concentrations of both carbon dioxide and water in the inclusions of glass. Initial results on the Bishop Tuff of Long Valley Caldera, California yield 4.9 ± 0.5 percent H_2O for glass included in quartz from the Plinian air fall pumice. This result is comparable to the estimates of Hildreth (1977) of about 3.5-4.9 percent H_2O in the lowermost part of the Bishop ash flow.

From January 1982 through December 1982, analyses of inclusions of glass in two additional quartz phenocrysts from the Plinian air fall unit of the Bishop Tuff revealed variable H_2O and CO_2. The corresponding partial pressures range between about 2000 and 5000 atmospheres, assuming gas saturation. The variation may be natural or caused by an analytical artifact. Further work is needed on both the analytical method and other inclusions.

In a separate matter a computerized data file has been constructed to facilitate the storage and retrieval of published and unpublished chemical analyses of glasses and minerals. Some data on the Bishop Tuff are presently stored.

B. Review of Progress

i) *Chemical analyses*

Between January and December 1982, a dozen crystals of quartz from a second sample of the Plinian air fall unit of the Bishop Tuff were prepared for analysis of their melt inclusions. The sample was provided by Wes Hildreth (his no. B104). Because we had formerly analyzed inclusions from another air fall sample and found them to have little major element variation, we decided to forego the microprobe analysis in order to try and get results for CO_2 which would not be subject to contamination from the C coat evaporated onto the inclusions to facilitate microprobe analysis. Two of the dozen crystals prepared by Aaron Rourke were run in the gas analyzer by Toya Horn. The results are:

Crystal Number	Glass Mass	CO_2 Mass	H_2O Mass	% CO_2	% H_2O
B104-3	3.63×10^{-6} gm	1.43×10^{-8} gm	7.86×10^{-8} gm	0.39 ± 0.10	2.2 ± 0.6
B104-1	1.21×10^{-5} gm	1.89×10^{-8} gm	12.27×10^{-8} gm	0.16 ± 0.04	1.01 ± 0.3

Both crystals contained fairly dark inclusions, partially devitrified, although most B104 inclusions are completely glassy The largest inclusion (in B104-1) was almost 400 μm diameter and 90 μm thick. No vapor bubble was present in it. The inclusion vesiculated and vitrified, the crystal broke into several pieces through the inclusion. Putting back the pieces, an apparent expansion of volume can be noted, maybe by 30 percent almost all in the thickness dimension. The crystal was held at about 1400°C for three minutes. If the diffusion of H_2O in rhyolite is about 10^{-5} cm^2/sec then the approximate 200 sec heating corresponds to a diffusion distance of about 30 μm for a concentration change of 0.06 gm/cm^3. It is notable that the B104-3 crystal contained three smaller inclusions but two of the inclusions were about as thick as the one in B104-1, and were sectioned on only one side, whereas the big inclusion in B104-1 was sectioned on both sides. In both cases the reheating of the sample yielded a slightly larger H_2O than the blank, but only by about 5 percent of the first run. So we are not getting significantly more H_2O out during the next three minutes time. In part the fragmentation of the inclusion may be a trouble in that pieces scatter out of the hot spot of the tube. The estimates of error include contributions due to uncertainty in the volume (hence mass) of glass as well as blank and pressure measurement. Not included is a major uncertainty related to the pressure measuring system, which required repair shortly after the crystals were analyzed. Our guess is that all the above concentrations should be normalized upwards by a factor of about 1.5 or larger. Mainly new analyses must be performed after the machine is fixed and reassembled.

The significant amount of CO_2 present (note that the CO_2/H_2O ratios obtained are nearly the same), suggest partial pressures of CO_2 of the order of 1000s atm. If this is correct, then the total pressure indicated for the inclusions in the Plinian quartzes is greater than 2 kbar, depending on the effect of H_2O on augmenting the solubility of CO_2 as found by Eggler and Kadik for albite melts. Hildreth estimated a total pressure around 1 kbar for the Plinian (actually earliest ash flow).

ii) *Data storage/retrieval*

A program to store rock and mineral compositional and bibliographical information has been set up by Cathy Smither. This program is on The University of Chicago IBM Amdahl and can be accessed from the outside by telephone. Our aim is to put on the file our glass and mineral compositional data so that anyone can obtain the analyses and use them to calculate temperatures, pressures, and so on for particular rocks. So far we have entered Hildreth's data on the Bishop Tuff.

iii) *Analytical methods*

We have worked to modify the gas analyzer to improve its performance. This work is still incomplete. The vacuum line had to be disassembled in order to send the electronic pressure measuring device to the manufacturer for repair. The device is returned, but we are delaying setting up the system to see if we will have enough funds from NSF to add a residual gas quadrupole mass spectrometer. This will be known by June 1983, at the latest. Such an addition will enable us to be confident of our gas species assignments, and will help us characterize the noncondensible gas (which includes CO, H_2, and CH_4). This will be a valuable check on the whole analytical process because it will permit a consistency comparison with mineralogical estimates of oxygen fugacity during crystallization.