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ESRF

Experiment Report Form

The double page inside this form is to be filled in by all users or groups of users who have had access to beam time for measurements at the ESRF.

Once completed, the report should be submitted electronically to the User Office using the **Electronic Report Submission Application:**

http://193.49.43.2:8080/smis/servlet/UserUtils?start

Reports supporting requests for additional beam time

Reports can now be submitted independently of new proposals – it is necessary simply to indicate the number of the report(s) supporting a new proposal on the proposal form.

The Review Committees reserve the right to reject new proposals from groups who have not reported on the use of beam time allocated previously.

Reports on experiments relating to long term projects

Proposers awarded beam time for a long term project are required to submit an interim report at the end of each year, irrespective of the number of shifts of beam time they have used.

Published papers

All users must give proper credit to ESRF staff members and proper mention to ESRF facilities which were essential for the results described in any ensuing publication. Further, they are obliged to send to the Joint ESRF/ ILL library the complete reference and the abstract of all papers appearing in print, and resulting from the use of the ESRF.

Should you wish to make more general comments on the experiment, please note them on the User Evaluation Form, and send both the Report and the Evaluation Form to the User Office.

Deadlines for submission of Experimental Reports

- 1st March for experiments carried out up until June of the previous year;
- 1st September for experiments carried out up until January of the same year.

Instructions for preparing your Report

- fill in a separate form for each project or series of measurements.
- type your report, in English.
- include the reference number of the proposal to which the report refers.
- make sure that the text, tables and figures fit into the space available.
- if your work is published or is in press, you may prefer to paste in the abstract, and add full reference details. If the abstract is in a language other than English, please include an English translation.

ESRF	**Experiment title:** **Density of dry and hydrous andesite magmas and the compositional dependence of the partial molar volume of water in silicate melts**	**Experiment number**: ES 32
Beamline: ID27	**Date of experiment**: from: 11/04/2013 to: 16/04/2013	**Date of report**: 20th Feb 2014
Shifts: 15	**Local contact(s)**: M. Mezouar	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):

Wim Malfait[1]*, Sylvain Petitgirard[2], Carmen Sanchez-Valle[1]*, Rita Seifert[1]*

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Summary:

The goal of the experiments was to provide in-situ density data and to determine the equation of state of dry and hydrous andesitic liquids for the pressure-temperature (P-T) range related to subduction zones using X-ray absorption. During the allocated beamtime at ESRF ID27, experiments were performed using a panoramic Paris-Edinburgh Press (PE Press). We were able to systematically measure the absorption contrast of dry and hydrous andesitic melts as a function of pressure (0.7 to 4.0 GPa) , temperature (1600 to 1930K) and water content of 0, 5.5 and 9.0 wt%. All samples had been synthesized in a piston-cylinder apparatus and characterized (compositional analyses, density measurements and FTIR analyses) prior the beamtime at ETH Zurich. The run products of the experiments have been recovered and analysed with electron microprobe for major element composition, Raman spectroscopy for water content and LA-ICPMS for possible contamination with boron. Thanks to the succesful experiments, we have derived the equation of state for both dry and hydrous andesitic melts from the measured X-ray absorption contrast. We determined the partial molar volume of water in andesitic melts and observed that the partial molar volume of water is independent of silicate composition. A manuscript describing the experiments and results has been accepted by Earth and Planetary Science Letters (Malfait et al., accepted).

Experimental Setup:

High pressure and temperature experiments were generated in a panoramic PE press, using 7 mm tungsten carbide anvils. The sample containers consisted of natural single crystal diamond cylinders (Almax Industries, Belgium) with $Ø_{in}$ = 0.5 mm, $Ø_{out}$ = 1.5 mm and a height of 1.0 mm. The capsule was sealed by Pt disks (200 µm) on both sides and enclosed in an hBN cylinder and two hBN caps were placed on both ends acting as pressure-transmitting medium. The furnace assembly is placed inside a standard 7 mm boron gasket. The absorption scans were collected with two ionization chambers and at a relatively low X-ray energy (Mo edge, 20.0 keV) for an optimal absorption contrast. Two different pressure marker (hBN and Pt) were used to determine the pressure and temperature by X-ray diffraction from the respective equations of state. After verifying the liquid state of the sample by X-ray diffraction, absorption scans of the assembly were collected. The density of the melts was derived from the collected absorption scans.

Results and discussion:

The derived densities and the fitted equation of state are plotted in Fig. 1. As expected, the density increases with increasin pressure, but decreases with increasing water content. By fitting an equation of state to our experimental data, we can now, for the first time, accurately predict the density of andesitic melts as a function of pressure, temperature and water content (Fig. 2).

Fig. 1 (a) Density of dry and hydrous andesitic melts: symbols denote the experimental results, lines correspond to the 1600-2000K isotherms for a 3rd order Birch-Murnaghan equation of state fit to the data, assuming ideal mixing in volume between the silicate and water component. b) The equation of state reproduces the experimental data within 1.3 % (2 s.d.).

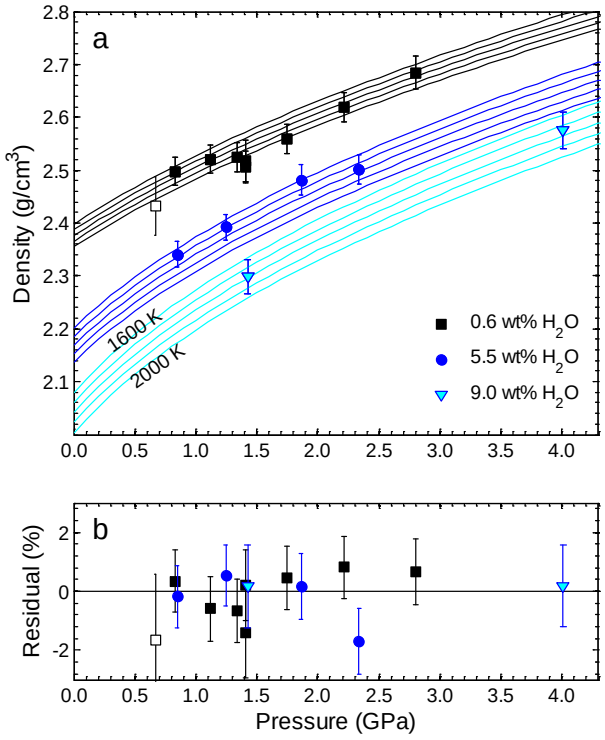
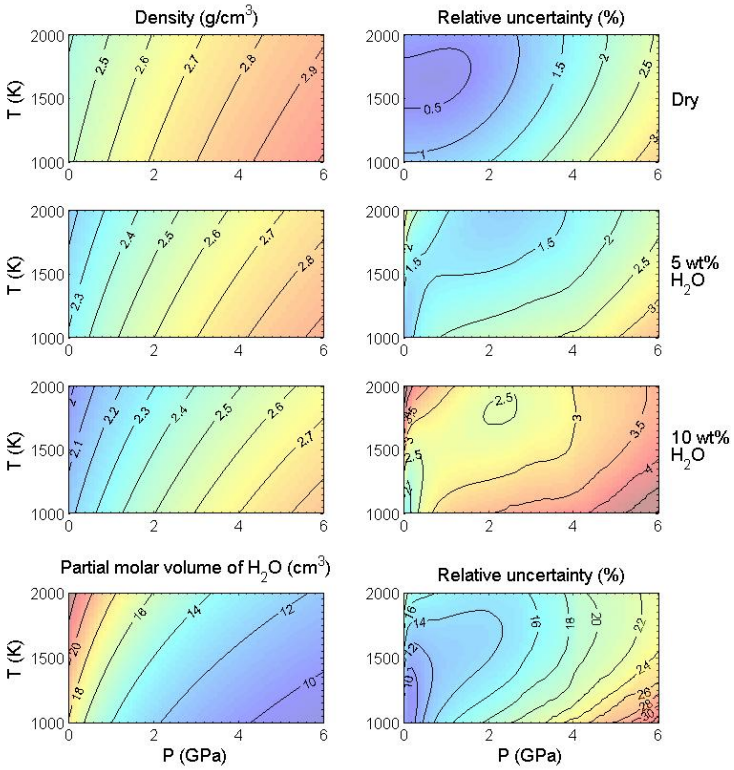


Fig. 2 Predicted densities and partial molar volume of andesitic melts and their 95% confidence interval.



Implications:

Combined with available literature data for other melt compositions, the experimental data collected within this proposal support a compositionally independent partial molar volume of water in silicate melts, at least within the currently attainable precision of the in situ measurements (Malfait et al., accepted). This observation greatly simplifies the construction of future models for magma density. Based on the experimental data collected at ID27 of ESRF over the last couple of years (Seifert et al. 2013; Malfait et al. 2014; Malfait et al., accepted), we have constructed a predictive model for the density of geological melts (Malfait et al., submitted). This model will have a wide range of applications in volcanology and igneous petrology.

References:

Malfait W.J., Seifert R.*, Petitgirard S., Perrillat J.-P., Mezouar M., Lerch P., Ota T., Nakamura E. and Sanchez-Valle C. (2014) Supervolcano eruptions driven by melt buoyancy in large silicic magma chambers. Nature Geoscience 7, 122-125.

Malfait W.J., Seifert R., Petitgirard S., Mezouar M. and Sanchez-Valle C. (Accepted) The density of andesitic melts and the compressibility of dissolved water in silicate melts at crustal and upper mantle conditions. Earth and Planetary Science Letters.

Malfait W.J., Seifert R.* and Sanchez-Valle C. (submitted) A model for the density of volatile-bearing silicate melts at crustal and upper mantle conditions based on high-pressure experimental data. Earth and Planetary Science Letters.

Seifert R.*, Malfait W.J., Petitgirard S. and Sanchez-Valle C. (2013) Density of phonolitic magmas and time scales of crystal fractionation in magma chambers. Earth and Planetary Science Letters 381, 12-20.