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A new type of high-pressure low-flow metering valve for continuous decompression: First experimental results on degassing of rhyodacitic melts

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Abstract

A novel type of high-pressure low-flow metering valve has been designed for experiments at continuous decompression in internally heated pressure vessels (IHPV) at pressures up to 500 MPa and temperatures up to 1500 °C. It consists of a modified high-pressure valve coupled with a piezoelectric nanopositioning system. The piezoelectric actuator (1) positions the needle of the valve statically with very high precision on a nanometer scale for infinitesimally slow decompression and, alternatively, (2) opens and closes the valve completely, within milliseconds, to achieve a fast pressure drop only limited by the diameter of the high-pressure tubing and the entire volume of the autoclave system.

The valve connected to an IHPV has been successfully tested to simulate continuous decompression of volatile-bearing magma. Water saturated rhyodacitic melt was synthesized at 1050 °C and 300 MPa and subsequently decompressed to 50 MPa at an integrated decompression rate of 0.28 MPa/s using continuous decompression as well as single-step and multi-step decompression techniques. The experimental results of the three methods show significant differences, having important implications for the interpretation of textures observed in natural volcanic rocks. Bubble number density (BND) values increase from continuous to multi-step and to single-step decompression by two orders of magnitude. Bubble size distribution (BSD) also differs significantly. The BSD curve of the single-step decompression shows largest variation both in size and in population number density, whereas the BSD trend for the sample of multi-step decompression shows the smallest variation between size and population density of bubbles. The BSD of the continuously decompressed sample indicates similar proportions of bubbles with different size. Channel formation in the sample of single-step decompression may indicate fluid escape from over-pressurized bubbles through the melt. Single-step and continuous decompression style represent two extreme cases of magma degassing in which bubble nucleation and bubble growth are predominant processes, respectively, whereas multi-step decompression resembles the intermediate case.

Keywords: Silicate melt, continuous degassing, bubble nucleation, bubble growth, high-pressure valve