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2012AGUFM.V23G..04R

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- Abstract
- References
- Citations
- Co-Reads
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- Graphics
- Table of contents

Dissolved, Exsolved and Re-dissolved H<sub>2</sub>O in Volcanology: Rheology, Glass Transition, and Thermodynamics

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American Geophysical Union, Fall Meeting 2012, abstract #V23G-04

Published in Dec 2012

All natural magmas originate with dissolved H<sub>2</sub>O. All such magmas degas during transport and

and the transition temperatures (T<sub>g</sub>), and controls the temperature and nature of crystallization. The effects of exsolved water are also substantial in terms of modifying the bulk transport properties of the magma, facilitating egress of volatiles and, thus, promoting crystallization. Of great interest is the coupling this component (H<sub>2</sub>O) creates between the thermodynamic processes (i.e. cooling, crystallization, vesiculation) and the properties (i.e. density, viscosity) controlling the mechanical behaviour (i.e. flow and fracture) of magma during transport and eruption. The coupling allows for strong feedbacks between system variables. The component H<sub>2</sub>O also has a retrograde solubility in silicate melts wherein H<sub>2</sub>O solubility in the melt increases with decreasing T. Here, we explore some of the consequences of retrograde solubility of H<sub>2</sub>O for volcanic systems using a new preliminary

experimental dataset. These data establish the 1-atmosphere solubility limits of H<sub>2</sub>O in silicic melt at volcanic temperatures and are complementary to the growing literature on the low pressure (<50 MPa) solubility of volatiles in silicate melts (e.g., Behrens et al. 2009; DiMatteo et al. 2004; Liu et al. 2005; Zhang 1999). We specifically look at the implications of these data, especially the retrograde solubility limits, for welding of pyroclastic deposits (e.g. ignimbrites, conduit fill, fall out). The cessation of welding and compaction processes in pyroclastic deposits is reached when deposits cool below T<sub>g</sub>. However, the fact that H<sub>2</sub>O has a retrograde solubility means that inter- and intracrust water will be resorbed by vitric pyroclasts as the deposit cools (regardless of load). This has the immediate consequence of reducing the viscosity of the pyroclasts and, more importantly, reducing T<sub>g</sub>. The reduction in pyroclast viscosity facilitates sintering, welding and compaction processes. The reduced T<sub>g</sub>, due to resorbed H<sub>2</sub>O, extends the T-time window for porosity reduction via viscous flow. Variations in welding intensity can, therefore, be an expression of the competition between cooling of the deposit and the re-hydration of vitric pyroclasts during cooling driven by retrograde solubility of H<sub>2</sub>O. In essence, the temperature of the cooling deposit chases a descending T<sub>g</sub>; once the deposit temperature catches and drops below T<sub>g</sub>, viscous deformation processes are quenched. This allows for the H<sub>2</sub>O contents of vitric pyroclasts to preserve higher water contents that they had at the time they erupted. The analysis of the relationships between eruptive, emplacement and glass transition temperatures are discussed further. References Cited: Behrens H. et al. 2009: Am Min 94, 105-120. Di Matteo V. et al. 2004: Chemical Geology 213, 187-196. Liu Y et al. 2005: J Volc Geotherm Res 143, 219-235. Zhang Y 1999: Rev Geophys 37, 493-516.

Keywords:

Free Keywords: [8411] VOLCANOLOGY / Thermodynamics; [8439] VOLCANOLOGY / Physics and chemistry of magma bodies; [8445] VOLCANOLOGY / Experimental volcanism

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