Water and magma: New insights into an old problem

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Although not for the right reasons, the fundamental importance of water in volcanic processes was already recognized in Antiquity. At the end of the 18th century, the role played by water solubility was correctly perceived and the problem of the source of magma raised. Even though much progress has of course been made since then, it can be said that much of the work currently done is still addressing questions posed two centuries ago. For example, water solubility has long been studied thanks to the possibility of quenching hydrous melts as glasses. By contrast, the influence of water on melt properties used to be much less well known because of the great difficulties of making measurements at the high pressures at which water solubility is significant.

The slowness of water exsolution close to the glass transition makes it in fact possible to perform at room pressure accurate physical measurements on water-bearing supercooled liquids, a major advantage being that only hydration has to be performed at high pressure. This procedure has allowed a wealth of information to be gathered during the past decade and, thus, to complement the limited high-pressure information available.

Much effort has been devoted to viscosity, a property for which the depressing effects of water clearly increase with the degree of polymerization of the anhydrous liquid. Besides, the fragile character of melts increase with water content and can be accounted for with the configurational entropy theory of relaxation processes. Contrasting with this strong influence, the heat of mixing between water and aluminosilicate melts is almost ideal. As for volume properties, water exerts a moderate influence on thermal expansion whereas its effects on compressibility are strong and markedly different for felsic and mafic magmas. The effects of water on physical properties are thus complex. They may give rise to unexpected contrasts between silica-rich and silica-poor melts, for instance in terms of rheology or rate of ascent.

A tale of two liquids: Kinetic isotope fractionation in water and in silicate melts

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Isotope Fractionation by Chemical Diffusion

Recent experimental results [1-3] regarding kinetic isotope fractionations by chemical diffusion in water and in molten silicates will be reviewed. One might have thought that the isotopic fractionations would be larger at the low temperatures of liquid water than in the high temperatures of molten silicates. But this is not the case. As a general rule, isotopic fractionations by chemical diffusion in molten silicates are much larger than in water.

Isotope Fractionation by Evaporation

Evaporation of water or a silicate melt can result in isotopic fractionation. Recent results [4] of the isotopic fractionation of silicon and magnesium of evaporation residues relevant to the interpretation of the thermal history Ca- Al-rich inclusions in primitive meteorites will be reviewed.

Isotope Fractionation by Thermal (Soret) Diffusion

I will present new laboratory data documenting that a temperature difference of only 100°C across molten basalt fractionates the isotopes of all the major elements (except of course aluminum) by many per mil.

Molecular Calculations

I will illustrate the potential of molecular calculations [5] to explain what we observe during the diffusion of ionic species in water.

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