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The activity of silica, water, and the equilibration of intermediate and silicic magmas

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ABSTRACT

Although many hydrous magmas may have phenocrysts that define silica activity (a_{SiO_2}) (e.g., quartz or olivine + orthopyroxene), it is only possible to determine γ_{SiO_2} and X_{SiO_2} if the concentration of water in the magma can be established when the phenocrysts equilibrated. Thus experiments on hydrous magmas with known water concentrations are essential if $RT\ln\gamma_{SiO_2}$ is to be quantified. Using the relationship between $RT\ln\gamma_{SiO_2}$ and the composition of the magma, including water, the activities of silica in magmas can be set equal to either those defined by a mantle source, or to a phenocryst assemblage such as quartz. For intermediate magmas (52–63 wt% SiO_2) from the Mexican volcanic belt, it can be shown that hydrous magmas with less than ~56 wt% SiO_2 and more than 6.5 wt% MgO, could have equilibrated with a mantle source, as represented by olivine + orthopyroxene in lherzolitic nodules carried to the surface by an andesitic lava. These limits are imposed by water saturation of magmas at 10 kb, which is a poorly known quantity. So indeed is the partial molar entropy of water that controls the thermal response to the exsolution of a fluid phase on magma ascent.

In magmas bearing quartz phenocrysts, quartz can be used as a geobarometer, and the indicated pressures (±1.2 kb) for three samples of the Bishop Tuff agree with the water saturation curves at the temperatures of the Fe-Ti oxides, which indicate a pre-eruption magma column of ~1.5 to 3.3 kms. For Katmai rhyolitic ejecta, there are inconsistencies between the measured water concentrations of the glass inclusions, the pressures derived from the water saturation curves at the Fe-Ti oxide temperatures, experimental phase equilibria, and the pressures derived from the proposed quartz barometer.