Experimental constraints on fluorine and chlorine partitioning in the pseudosystem apatite-silicate melt-fluid(s) and applications to magmatic degassing

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Hydrothermal experiments were conducted to determine the partitioning of Cl between rhyolitic to rhyodacitic melts, apatite, and aqueous fluid(s) and the partitioning of F between apatite and these melts at 200 MPa and 900-924° C. The number of fluid phases in the experiments is unknown; a single fluid and/or vapor plus saline liquid may have been stable. The partitioning behavior of Cl between apatite and melt is non-Nernstian and is a complex function of melt composition. Values of $D_{Cl}^{apat/melt}$ (i.e., the wt. fraction of: Cl in apatite/Cl in melt) vary from 0.5 – 3.8 and are largest when the Cl concentrations of the melt are at or near the Cl-saturation value of the melt. The Cl-saturation concentrations of silicate melts are lowest in evolved, silica-rich melts, so with elevated Cl concentrations in a system and with all else equal, the maximum values of $D_{Cl}^{apat/melt}$ occur with relatively felsic melts. In contrast, values of $D_{F}^{apat/melt}$ range from 16-39 for these felsic melts, and they are as much as an order of magnitude greater than those applying to basaltic melts at 200 MPa and 1066-1150° C. The concentration of Cl in the fluid(s) is a simple and linear function of the Cl concentration of apatite. Values of ($D_{Cl}^{fluid/apat}$) for these experiments range from 15 – 44, and are nearly an order of magnitude greater than those for 200 MPa experiments involving basaltic melts at 1066-1150° C.

In order to determine the F and Cl contents and interpret volatile behavior in magmas, the experimental data have been applied to the halogen concentrations of apatite grains from chemically evolved rocks of Augustine volcano, Alaska; Krakatau volcano, Indonesia; Mt. Pinatubo, Philippines; Mt. St. Helens, Washington; Mt. Mazama, Oregon; Lascar volcano, Chile; Santorini volcano, Greece, and the Bishop Tuff, California. The F concentrations of these magmas estimated from apatite-melt equilibria range from 0.05–0.13 wt.% and are generally equivalent to the concentrations of F determined in corresponding melt inclusions. In contrast, the Cl concentrations of the magmas estimated from apatite-melt equilibria greatly exceed those determined in the melt inclusions from all of these volcanic systems except for the Bishop Tuff where the agreement is good. This discrepancy in estimated Cl concentrations of melt could result from several processes, including that apatite chemistry represents an earlier stage of magma evolution – prior to the sequestration of Cl by coexisting magmatic fluid(s).

Microbial activity associated with asphalt volcanism at the Campeche Knolls, Gulf of Mexico

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The Campeche Knolls are characterized by active oil and methane seepage, and spectacular asphalt flows covering the seafloor. We studied the biogeochemistry of this extreme environment at 3000 m water depth during METEOR cruise M67/2 with ROV QUEST.

The asphalt flows on Chapopote, one of the Campeche knolls, show a variety of surface patterns including densely populated areas hosting deep water corals, chemosynthetic bivalves and giant tubeworms, wide flat zones covered by bacterial mats and some grazers, and regions devoid of any visible life.

Here we will present the first in situ measurements of oxygen consumption, sulfate reduction and methane turnover associated with asphalt volcanism. A central question is the source of energy to the abundant life at the asphalt flows. We found indications of high methane and sulfide fluxes, as well as extremely high oxygen consumption rates associated with the asphalt flows and will discuss the proportions of microbial and chemical processes associated with these fluxes.