Modeling C-O-H-S fluids and sulfides in igneous systems

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The program PELE is a simplified MELTS-based phase equilibration routine that now includes, among others, a more advanced C-O-H-S gas phase and sulfide phases. The phase equilibration engine is used in the program IRIDIUM where it is coupled with mass and heat transport equations to model infiltration-reaction-degassing processes in igneous systems.

The silicate liquid component for sulphur is FeS (liquid troilite). Immiscible sulphide liquid is assumed to be an ideal solution of two components, FeS and FeO. Other possible sulphide phases that can precipitate are pyrrhotite, pyrite and troilite. FeS-oxide liquid interaction parameters were calibrated (with some arbitrary adjustment because of uncertain sulphide liquid compositions in the experimental data) from literature data. These are mostly of basalt-intermediate composition, but the lower solubility calculated for more acid compositions appear reasonable. Above ~10 kbar, sulphide saturation values are lower than expected.

CO_2 solubility essentially incorporates the model of Papale (1999). It has been modified as follows: the CO_2-oxide liquid interaction parameters have been recalibrated to the liquid components and interaction parameters used in MELTS/PELE. Also, the thermodynamic properties of pure CO_2 and all other gas species are calculated by the general EOS for supercritical gases of Duan et al. (1996). Gases are otherwise assumed to mix ideally. Possible gas species include H_2O, CO_2, CO, H_2S, and SO_2. Sulphur fugacity is calculated by the method of Wallace and Carmichael (1992). Graphite (C) is a possible precipitating solid.

Examples illustrate the potential of the two programs to model degassing and ore metal transport in igneous systems at upper crustal conditions. These include modeling vapor refining in a solidifying and compacting crystal pile.

References

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Two kinds of plagioclases with discontinuous zoning in the basalt from Okinawa Trough and their tectonic significance

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Electron Microprobe Analysis

There exist two kinds of phenocryst plagioclases with discontinuous zoning consisted of a large core (60~100 μm) and a relatively small rim (<35 μm), coexisting in the basalt from the middle of Okinawa Trough. One (Pl-I) shows a homogeneous An-high core (average An_{86}), a relatively homogeneous rim (average An_{70}), and a narrow edge (<5 μm) with normally zoning (An_{70-60}). The other (Pl-II) exhibits a homogeneous An-low core (average An_{55}), a relatively homogeneous rim (An_{75-70}), and a narrow edge (10 μm) with normally zoning (An_{70-60}). The contact between core and rim is sharp in the two kinds of plagioclases, marked by a sharp increase in anorthite content which can reach 16 mol% An in Pl-I, and a decrease in anorthite content which can reach 20 mol% An in Pl-II.

Discussion

The range of plagioclase compositions in equilibrium with whole-rock compositions calculated using $^{Ca/Na}K_{D\ min/liq}$ values of 0.9-1.7 is An_{65-79}. It is obvious that the rims of the two kinds of plagioclases are essentially in equilibrium with whole-rock compositions. Their cores are in disequilibrium with whole-rock compositions because the core of Pl-I is generally anomalously calcic and the core of Pl-II is sodic.

We consider that the cores of Pl-I are xenocrysts from the mantle, the cores of Pl-II come from the lower crust, and the rims of the two kinds of plagioclases are crystal from the same magma chamber under Okinawa Trough. The edge of the two kinds of plagioclases records the magma process rising from magma chamber to sea floor. Based on the information of plagioclases, it is obvious that the floor under the middle of Okinawa Trough exists the lower crust, and doesn't form new oceanic crust.

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