

Origin of Mississippi Valley-type deposits in the Ozark and Interior Low Plateaus, U.S. mid-continent: constraints from fluid inclusions

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Mississippi Valley-type (MVT) deposits have long been understood to be products of sedimentary basinal brines based on the bulk salinity, temperature, and major element composition of their fluid inclusions. Whether MVT mineralizing fluids resemble typical sedimentary brines with respect to ore metal content has until recently been far less certain and was a major concern of the present study. A further motivation for determining ore metal content in MVT mineralizing fluids is that ore metal content, together with pH, redox potential, and sulfur content, largely governs precipitation mechanism, which is also uncertain for many MVT deposits. Major element concentrations in MVT fluids reported in previous studies have largely been determined from bulk leachate analysis of fluid inclusions, where mixing of primary and secondary fluid inclusions and mineral matrix contributions are likely to have affected the reported results. Thus, another goal of the present study was to obtain improved measurements of major element concentrations, along with ore metal concentrations, through in situ analysis of individual fluid inclusions. These major element concentration data provide additional constraints on precipitation mechanism, fluid flow paths, and genetic relationships among deposits.

The focus of the present study was on fluid inclusions from the Southeast Missouri, Tri-State, Northern Arkansas, and Central Missouri districts of the Ozark Plateau, and the Illinois-Kentucky district of the Interior Low Plateau. A consistent feature found for these districts is that they contain populations of Pb-rich sphalerite-hosted fluid inclusions (containing 100's to 1000's of ppm Pb) that probably reflect the intermittent invasion of Pb- and possibly overall metal-rich ore fluid into the districts during sulfide mineralization. High methane concentrations in both sphalerite- and gangue-hosted fluid inclusions indicate that mineralizing conditions were predominantly reducing, such that sulfide mineralization was probably caused by mixing of Pb-rich ore fluid with a sulfide-rich fluid. Methane concentrations in fluid inclusions could be used to calculate minimum mineralization depths, which yielded a range from about 100 to 1500 m. Pb-rich ore fluids in all of the districts had dolomitizing Ca/Mg ratios, indicating that the fluids did not travel very far through the predominantly limestone aquifers in which sulfide mineralization is presently hosted. The Pb-rich ore fluids in the districts differed from one another with respect to major element composition, indicating that although all of the districts may have been formed from the same physical flow system, this fluid was chemically heterogeneous. In the Illinois-Kentucky district, the compositional distinctives of the ore fluid are consistent with inputs expected from local igneous activity contemporaneous with MVT mineralization.

Pressure dependence of enthalpy, viscosity and diffusivity of olivine and its constituent minerals near melting

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Introduction

Olivine, the major mineral of the Earth's upper mantle, plays a key role in the mineralogical models for the Earth's mantle. It is greatly appreciated that rheological properties of olivine are important ingredients in modeling the geodynamic processes in the upper mantle such as convective flows, evolution of subduction zones, deep seismicity patterns and post-seismic mantle relaxation. Our knowledge of crystallographic orientation of olivine can help interpret the seismic anisotropy of the upper mantle in terms of mantle flow [1]. The physical and chemical conditions of deformation mechanisms control the crystallographic and shape preferred orientations of olivine.

We have derived a mathematical expression for the melting temperature, T_m and its pressure dependence by extending the Lindemann's melting law. Seismic p- and s-wave velocities and density data as a function of pressure were used as inputs to compute Debye temperature, θ_D , which forms the important ingredient of the empirical relation for the melting temperature. We have applied the formalism to estimate T_m and its pressure dependence, which in turn has been used to estimate enthalpy, viscosity and diffusivity of olivine and its constituent minerals such as forsterite (Mg_2SiO_4) and fayalite (Fe_2SiO_4).

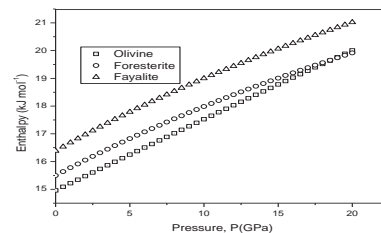


Figure 1: Enthalpy of olivine and its constituent minerals as a function of pressure

Results and discussions

We present here in Figure 1 only a part of the results. Our preliminary results show linear increase of enthalpy, viscosity and diffusivity for olivine and non-linear increase for forsterite and fayalite with increasing pressure. At room temperature and atmospheric pressure, the values of enthalpy, viscosity and diffusivity are found to be $14.96 \text{ kJ mol}^{-1}$, 2.58 mPa s and $1.69 \times 10^{-4} \text{ m}^2 \text{ s}^{-1}$ for olivine, $15.50 \text{ kJ mol}^{-1}$, 2.58 mPa s and $1.75 \times 10^{-4} \text{ m}^2 \text{ s}^{-1}$ for forsterite and $16.38 \text{ kJ mol}^{-1}$, 3.07 mPa s and $1.53 \times 10^{-4} \text{ m}^2 \text{ s}^{-1}$ for fayalite respectively.

1] Kneller (2005) Earth Planet. Sci. Lett., 237, 781-797