Sulfur Speciation in Heavily Reduced Mercurian Melts by K-Edge XANES Spectroscopy

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INTRODUCTION

What is the relationship between sulfide speciation, sulfur solubility, and oxygen fugacity in heavily reduced basaltic melts?

• Mercury’s low oxygen fugacity (fO2) is primarily inferred from its high surface sulfur abundance as revealed by the MESSINGER X-Ray Spectrometer (XRS) [1,2].

• High sulfur solubility in melts implies a change in sulfur speciation, which is poorly constrained.

• S K-Edge XANES spectroscopy provides direct insights into sulfur speciation.

We provide the first application of this method to basaltic melts at fO2 relevant for Mercury.

METHODS

S K-Edge XANES Spectroscopy can directly characterize sulfur speciation

- Remote Sensing (XRS, GRS)
- Experimental Analog (PC, TZM)
- Lab Spectroscopy (XANES)

RESULTS

As total sulfur solubility increases due to decreasing oxygen fugacity, the relative proportions of each sulfur species changes

Visual examination of the spectra reveals...

• The contribution from FeS decreases as fO2 decreases (kink in spectra by the blue FeS K-edge).

• The presence of CaS is only obvious in samples at the lowest fO2 (double peak by purple CaS K-edges).

• Some sulfate contribution due to high reactivity of samples in air.

IMPLICATIONS

• Sulfur speciation will affect the viscosity and density of melts, influencing both erupted magma and magma ocean dynamics.

• Bonding of S with Fe, Mg, and Ca changes the activities of FeO, MgO, and CaO and will affect silicate phase equilibria.

• Results further constrain Mercurian mantle fO2 and predicts that MgS is the dominant sulfide on Mercury’s surface.

References:

Research funded by NASA grant NNX15AH63G.