A NOTE ON THE SYSTEM FeO-Fe$_2$O$_3$-SiO$_2$-H$_2$O

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Introduction

The system FeO-Fe$_2$O$_3$-SiO$_2$-H$_2$O was studied at liquidus temperatures and 2000 bars to determine the effect of water on the large region of immiscibility in the "dry" system and the liquidus—lowering effect of water in a system containing iron and silica.

Experiments were carried out in an internally heated pressure vessel modified from Yoder (1950). A platinum or molybdenum resistance furnace is placed inside the pressure vessel which has an internal diameter of $1\frac{5}{8}$ inches. The water content of each charge is controlled by weighing known amounts of water into 2.0 mm silver-palladium capsules and welding them closed with a carbon arc. The total pressure on the system is applied to the outside of the charge with a gas mixture of argon and hydrogen. The partial pressure of hydrogen is controlled by mixing various proportions of argon and hydrogen but the actual fugacity within the charge is not known. It is assumed that the silver-palladium capsules are permeable to hydrogen and impermeable to oxygen and argon. The volume of the system outside of the capsules is many orders of magnitude greater than the volume of the capsules so that the partial pressure of the hydrogen outside the capsules is for all practical purposes, unaffected by the loss or gain of a small amount of hydrogen from or to the charge.

The fugacity of hydrogen in the gas mixture will vary from place to place in the pressure vessel, because the temperature varies from a maximum near the windings (a temperature somewhat higher than the run temperature) to approximately room temperature at the walls of the pressure vessel (water cooled). Experience has shown that the iron oxide-silica-water mixtures will oxidize or reduce in runs of normal length (4 hours) to a constant FeO/Fe$_2$O$_3$ ratio regardless of whether the mixture contains all Fe^{2+} or Fe^{3+} at the beginning. The runs are therefore at a constant but unknown fugacity of hydrogen. We are now calibrating the gas mixtures with typical buffers (Eugster, 1957).

Starting materials for all the runs were mixtures of cristobalite, hematite or wüstite and distilled water. Cristobalite was prepared by firing Cab-o-sil in platinum crucibles at 1200°C for several hours; the hematite

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by firing Bakers' analyzed Fe_2O_3 in iron-saturated platinum crucibles at 600°C for 12 hours. Wüstite was prepared in two steps: first hematite was heated in an iron container for 9 hours at 900°C, converting the hematite to magnetite, then the magnetite was heated at 1200°C for one hour and air-quenched, the final charge consisted of wüstite. The mixtures were weighed and then ground under acetone to homogenize them. Capsules of Ag_{40}-Pd_{60} 2.0 mm in diameter, having a wall thickness of 0.01 mm were loaded with water and the mixture; the total weight of the charge being about 10–15 mg. The sealed capsules were placed in a molybdenum sample holder which is in turn placed in the pressure vessel after thoroughly flushing the pressure vessel with the gas mixture being used. Temperature was measured by platinum Pt-Pt:10 percent Rh thermocouples and controlled by Honeywell circular scale controllers. The temperature variation was less than ± 10°C; and the temperature measuring system was calibrated frequently at the melting point of gold (1063°C). Pressure was measured by Bourdon tube gauges. Charges were examined microscopically in grain mounts and polished section and by X-ray diffraction.

RESULTS

A schematic isobaric-isothermal (2000 bars p_{total}, 1120°C) projection onto the anhydrous base of tetrahedron of the 25 percent water isopleth is shown in Figure 1.

The most interesting aspect of the hydrous system is the existence of two liquids over much of the compositional range studied. The siliceous liquids always quench to a glass having an index of refraction ranging from 1.464 to 1.476, whereas the index of refraction of silica glass saturated with water at 2 kb. is about 1.461 (Kennedy *et al.*, 1962); the liquid must contain a very small amount of iron. The composition of the siliceous liquid is exaggerated in Figure 1 to show the probable phase relations. The second liquid phase is close to fayalite in composition in the 10 percent hydrogen mixes as it quenches to a fine grained mass of acicular fayalite crystals. At higher oxygen fugacities the liquid may quench to a mixture of fayalite and magnetite or fayalite and cristobalite or both. Over much of the range of compositions studied with the 10 percent and 1 percent hydrogen gas mixtures, the iron-rich and silica-rich liquids coexisted with textural relations identical to these described by Greig (1927) in silicate systems without water vapor present. The iron-rich liquid persists at temperatures as low as 1060°C.

The iron-rich liquid may have a composition approaching (anhydrous) 80 percent magnetite-20 percent silica at 1120°C and 2000 bars with the 99:1 gas mixture. This liquid, saturated with water vapor and perhaps other volatiles as well, may offer an explanation for the magnetite flow
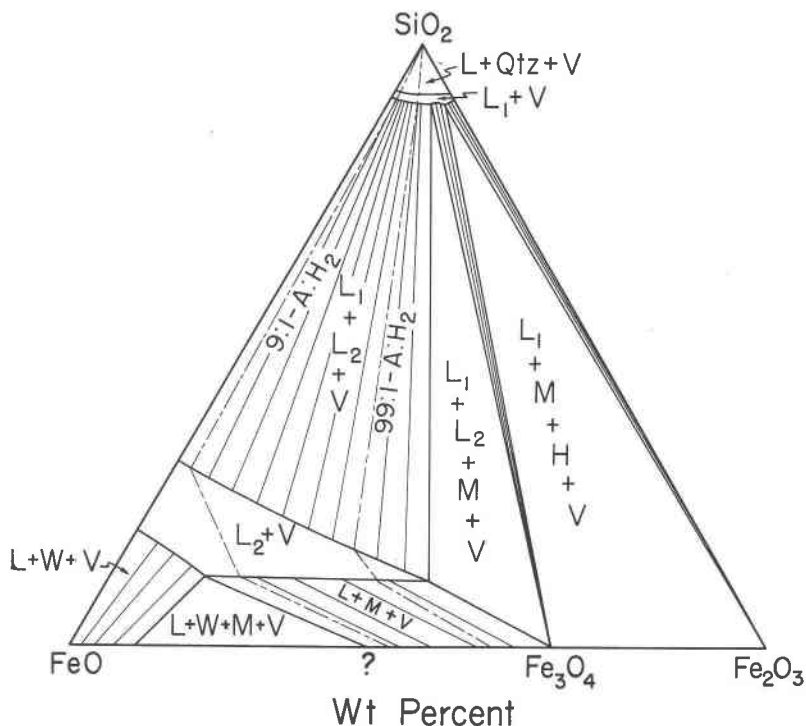
Fig. 1. A schematic isothermal-isobaric projection (2000 bars and 1120°C) onto the anhydrous base of the tetrahedron for the system FeO-Fe_2O_3-SiO_2-H_2O, of the phase relations for the 25 per cent H_2O isopleth. The water content of the liquid phase is unknown. The region near the silica apex is exaggerated to show the probable relations between the siliceous liquid and the phases with which it co-exists. Three different gas mixtures were used: 9:1, 99:1 and pure argon. Wüstite was not detected as a phase using these gas mixtures. Two analyzed magnetite samples prepared with the 9:1 gas mixture gave the composition shown in Figure 1; the possibility must be considered that the samples are a mixture of wüstite and magnetite, with the wüstite being either (1) too fine grained to be detected by the x-ray or (2) oxidized during the quenching procedure. L=liquid, V=vapor, Qtz=quartz, W=wüisitite, M=magnetite, H=hematite.

described by Park (1961). Analyses of the flow have not been published, but optical examination indicates that it is predominantly magnetite and hematite with only minor amounts of other minerals. Dikes of magnetite often have the appearance of a magmatic intrusion but few geologists have maintained that they represent magnetite liquid because of the high melting temperature of magnetite. Perhaps volatile substances such as water and carbon dioxide together with a small amount of silica will lower the liquidus of magnetite to reasonable temperatures and pressures in compositions approaching closely that of magnetite.

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ARTINITE FROM GABBS, NEVADA: A CORRECTION IN LOCATION

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Artinite has been reported as occurring in the "workings of Basic Magnesium Inc. at Luning, Nevada" (Hurlbut, 1946). The specimens of artinite, and associated brucite and hydromagnesite, described in the above article definitely must have come from the brucite deposits at Gabbs, which is 32 miles northeast of Luning. There are no known brucite deposits at or near Luning. Luning is the railhead for Basic Inc. mining and calcining operations at Gabbs, and the company maintains loading facilities there, which probably explains the confusion in assigning the locality.

The brucite bodies are in the north-central part of Sec. 35, T. 12 N., R. 36 E. on the west flank of the Paradise Range, about a mile and a half east of Gabbs in northwesternmost Nye County. The artinite and more abundant hydromagnesite are weathering products derived from the brucite, and are present as a 10- to 15-foot blanket over the brucite, and as veinlets extending to much greater depths. The geology of the Gabbs magnesite-brucite deposit is described in the *AIME Graton-Sales Volume, Ore Deposits of the United States,* 1933–1965 (in press).

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