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**Supporting Information for**

Effect of H2O and oxygen fugacity on magnetite solubility in hydrous silicate melt

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**Contents of this file**

**Text S1. This supplementary material includes:** 1. Experimental Procedures and 2. Analytical Methods.

**Additional Supporting Information (Files uploaded separately)**

**Analytical and calculated data are presented in Tables S1 to S8 in an Excel file:**

**Table S1.** Composition of the synthesized dacitic glass

**Table S2.** Composition of quenched glasses (wt%) analyzed by EMPA

**Table S3.** Composition of quenched glasses on an anhydrous basis

**Table S4.** Composition (wt%) of magnetite analyzed by EPMA

**Table S5.** Sulfide composition (wt%) by EPMA and Au concentration (ppm) by LA-ICP-MS

**Table S6.** Composition of anhydrite analyzed by EPMA (wt%)

**Table S7.** Compositions of silicate minerals and spinel analyzed by EMPA (wt%)

**Table S8.** H2O activity in silicate melt and fO2 estimation

**Text S1:**

1. **Experimental Procedures**

To minimize compositional variability and promote the generation of felsic melts with limited silicate crystallization, two synthetic dacite compositions (Table S1) were employed, differing primarily in FeOT (3.1 wt% vs. 4.8 wt%) and TiO2 (0 wt% vs. 0.4 wt%) contents. The glasses were synthesized following the protocols described in Xu et al. (2022) and Liu et al. (2025). Powdered glass aliquots (10 mg) were loaded into Au capsules with 5–30 wt% H2O. To stabilize Fe-rich phases under experimental conditions, 5–15 wt% of FeS, Fe2(SO4)3, or magnetite (±hematite) was incorporated into the sample capsules (Table 1). A total of 29 experiments were conducted at 1–2 GPa and 850–1000 °C using a piston-cylinder apparatus, including 11 Cu-bearing runs. For the 11 runs, Au95Cu05 alloy chips (1–3 mg) were added to the starting material. Although Cu concentrations in magnetite were not directly analyzed, the low Cu activity in the system is inferred to have negligible influence on magnetite composition. Estimates based on Cu concentrations in silicate melts (Liu et al., 2025) and Fe-Ti oxide/melt partitioning coefficients (Liu et al., 2015) suggest that magnetite Cu concentrations remained below several tens of ppm.

Experimental oxygen fugacity (fO2) was controlled in most runs using a triple-capsule assembly modified from Matjuschkin et al. (2016). The configuration comprised an outer Au capsule enclosing two inner capsules: one Au capsule containing 10 mg of starting material and one Pt capsule loaded with 20–30 mg of solid oxygen buffer and ~3 mg H2O. The inter-capsule space was filled with alumina powder and ~20 mg H2O. Outer and inner Au capsules were hermetically sealed using a precision welder (LAMPERT PUK U3), while the Pt capsule was sealed at one end and crimped at the other to facilitate H2 diffusion. Capsules were weighed pre- and post-welding and after thermal testing (110 °C, several hours) to verify integrity; any leaking capsules were discarded. Five fO2 buffers—cobalt-cobalt oxide (CCO), nickel-nickel oxide (NNO), rhenium-ReO2 (RRO), MnO-Mn3O4 (MMO), and hematite-magnetite (HM)—were employed, enabling experimental fO2 conditions ranging from FMQ−1.5 to FMQ+4.0 (relative to the fayalite-magnetite-quartz buffer). Post-experiment buffer analysis confirmed preservation of buffering assemblages in most runs, with exceptions noted in cases of hematite or nickel metal exhaustion (Table 1). In runs HM20 and RRO30-3, direct incorporation of solid buffer material into the sample capsules provided fO2 control.

High-pressure experiments were conducted at the Guangzhou Institute of Geochemistry using a piston-cylinder apparatus equipped with a 1/2-inch diameter assembly. The assembly consisted of an outer BaCO3/talc sleeve, an inner Pyrex glass liner, a graphite resistance furnace, and crushable MgO spacers. Sample capsules were positioned within MgO spacers at the center of the graphite furnace, which was housed within the pressure cell. Experiments were performed at 1–2 GPa and temperatures of 850–1000 °C, with durations ranging from 14 to 120 hours. Applied pressures incorporated a 13% friction correction (Liu et al., 2014), yielding an uncertainty of <0.1 GPa. Temperature was controlled using a Eurotherm controller and monitored via S-type (Pt-Pt90Rh10) thermocouples calibrated to ±2 °C relative to nominal values, without pressure-dependent corrections. Isobaric quenching was achieved by terminating power to the furnace while maintaining pressure, resulting in rapid cooling rates >60 °C/s. Post-experiment capsules were extracted and longitudinally sectioned using a precision wire saw. One hemisphere was then mounted in epoxy resin for microanalysis. A summary of experimental conditions and results is provided in Table 1.

**2. Analytical Methods**

**2.1 Electron Microprobe (EMP) Analysis**

Following optical microscopy to assess experiment integrity and buffer stability, major element, sulfur, and Cu concentrations in run products were determined using a JEOL JXA-8230 electron microprobe at the Guangzhou Institute of Geochemistry. Analytical conditions included a 15 kV accelerating voltage and 20 nA beam current for glasses and minerals, while sulfides were analyzed at 20 kV and 20 nA. Beam diameters were defocused to 10–20 μm for glasses and 1 μm for crystalline phases. Calibration utilized synthetic and natural standards: Cr-diopside (Si), obsidian (Al), magnetite (Fe), olivine (Mg), albite (Na), orthoclase (K), rutile (Ti), Cr2O3 (Cr), rhodonite (Mn), Ni metal (Ni), Cu metal (Cu), pyrite (FeS2), and barite (BaSO4) for sulfur. Matrix corrections were applied using the ZAF algorithm. Hydrous glasses exhibited measurable Na and K volatilization during analysis, which necessitated mass balance corrections. Both raw and adjusted compositions are archived in Supplementary Table S2.

**2.2 Fourier-Transform Infrared Spectroscopy (FTIR)**

Hydrous glass H2O contents were quantified at the Guangzhou Institute of Geochemistry using a vacuum FTIR spectrometer equipped with a mid-infrared source, KBr beam splitter, and mercury cadmium telluride (MCT) detector. Double-polished glass wafers (200–500 μm thickness) were analyzed in transmittance mode with a 50 × 50 μm2 beam aperture. Spectra were acquired over 128–500 scans at 4 cm⁻¹ resolution. Total dissolved H2O concentrations were derived via the Beer-Lambert law, integrating absorption bands at 5200 cm⁻¹ and 4500 cm⁻¹:

*C*H2Ot = 18.015/(*d* × *ρ)* × (*A*5200 /*ε*5200 + *A*4500 /*ε*4500)

where *C*H2Ot is total H2O (wt%), *A* denotes absorbance (cm-1), *d* is sample thickness (cm), *ρ* represents glass density (g/L), and ε refers to molar absorption coefficients (L mol⁻¹ cm⁻¹) from Mandeville et al. (2002) and Ohlhorst et al. (2001).

**2.3 H2O Activity in Silicate Melts**  
Experiments with initial H2O contents of 5–10 wt% produced clear glasses, allowing determination of H2O contents via FTIR and EMP as 2.3–10 wt% (Supplementary Table S3). Higher initial H2O (15–30 wt%) resulted in vesicular glasses, with H2O concentrations estimated to be 11–30 wt% based on mass balance and extrapolated H2O solubility constraints from basalt and haplogranite systems at 0.5–0.8 GPa (Holtz et al., 1995; Keppler, 2013).

H2O activity (aH2O) was calculated using two approaches:

1. Burnham (1979) Parameterization:
2. for Xm H2O < 0.5, aH2O = *k* (Xm H2O)2
3. for Xm H2O > 0.5, aH2O = 0.25*k* exp (6.52-2667/*T*) (Xm H2O − 0.5)

where Xm H2O is the mole fraction of H2O in the melt, *k* = 1.707 (Burnham, 1979) and *T* is the temperature in Kelvin.

1. Raoult’s Law Approximation:

aH2O = c(H2O)/c(H2O, solubility), assuming that the activity of H2O approaches Raoult's Law at high H2O content and a melt H2O solubility of ~15 wt% at 1 GPa, extrapolated from lower-pressure data (Holtz et al., 1995).

Both methods yielded consistent aH2O values (Table S8), with discrepancies within analytical uncertainty.

**2.4 Oxygen and Sulfur Fugacity Estimations**

Sample fO2 was constrained via two methods (Table S8):

1. Melt H2O Activity and Buffered fO2:

Δlog fO2 = 2 log (aH2O)

where aH2O values derived from Section 2.3 yielded fO2 uncertainties smaller than the experimental fO2 range (ΔFMQ = −1.5 – 4.7).

2. Pyrrhotite-Magnetite Oxybarometry:

Sulfur fugacity (fS2) was calculated from pyrrhotite compositions using the Toulmin and Barton (1964) calibration refined by Mengason et al. (2010). Magnetite-bearing assemblages permitted fO2 determination via the FeS-S2 equilibrium (Whitney, 1984). Uncertainties in fO2 (±0.3 log units) stemmed primarily from EMP analytical errors in pyrrhotite composition. Full methodological details are provided in Xu et al. (2022) and Liu et al. (2025).

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