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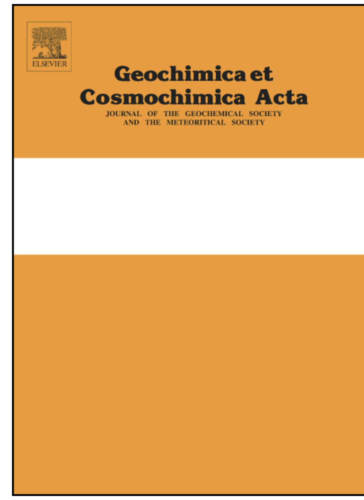

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SOLUBILITY OF WATER IN LUNAR BASALT AT LOW pH_2O

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Abstract

We report the solubility of water in Apollo 15 basaltic 'Yellow Glass' and an iron-free basaltic analog composition at 1 atm and 1350 °C. We equilibrated melts in a 1-atm furnace with flowing H_2/CO_2 gas mixtures that spanned ~8 orders of magnitude in fO_2 (from three orders of magnitude more reducing than the iron-wüstite buffer, IW−3.0, to IW+4.8) and ~4 orders of magnitude in pH_2/pH_2O (from 0.003 to 24). Based on Fourier transform infrared spectroscopy (FTIR), our quenched experimental glasses contain 69–425 ppm total water (by weight). Our results demonstrate that under the conditions of our experiments: (1) hydroxyl is the only H-bearing species detected by FTIR; (2) the solubility of water is proportional to the square root of pH_2O in the furnace atmosphere and is independent of fO_2 and pH_2/pH_2O; (3) the solubility of water is very similar in both melt compositions; (4) the concentration of H_2 in our iron-free experiments is <~4 ppm, even at oxygen fugacities as low as IW−2.3 and pH_2/pH_2O as high as 11; (5) Secondary ion mass spectrometry (SIMS) analyses of water in iron-rich glasses equilibrated under variable fO_2 conditions may be strongly influenced by matrix effects, even when the concentration of water in the glasses is low; and (6) Our results can be used to constrain the entrapment pressure of lunar melt inclusions and the partial pressures of water and molecular hydrogen in the carrier gas of the lunar pyroclastic glass beads. We find that the most water-rich melt inclusion of Hauri et al. (2011) would be in equilibrium with a vapor with pH_2O ~3 bar and pH_2 ~8 bar. We constrain the partial pressures of water and molecular hydrogen in the carrier gas of the lunar pyroclastic glass beads to be 0.0005 bar and 0.0011 bar respectively. We calculate that batch degassing of lunar magmas containing initial volatile contents of 1200 ppm H_2O (dissolved primarily as hydroxyl) and 4–64 ppm C would produce enough vapor to reach the critical vapor volume fraction thought to be required for magma