

H₂O and CO₂ in silicate melts

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H₂O and CO₂ are two of the most abundant volatile components in terrestrial magma. In silicate melts, each component can form an ionic species (OH⁻ or CO₃²⁻), and the speciation is essential for shaping its solubility and the transport properties of melts. Relative to the neutral molecules, OH⁻ is favored at low concentration, high temperature and high pressure, whereas CO₃²⁻ is favored at low *T* and high *P*. H₂O solubility is proportional to the square root of *P* at low concentration (when OH⁻ dominates) and increases linearly with *P* at high concentration (when H₂O dominates). By contrast, CO₂ solubility, which is significantly lower than H₂O solubility, is always proportional to *P*. Solubility does not change significantly along the calc-alkaline series. The effect of H₂O and CO₂ in reducing melt density is rather insensitive to speciation.

The traditional view holds that the molecular species dominates diffusion. However, there is recent evidence suggesting that the mobility difference between the molecular species and the ionic species narrows in depolymerized melts at high temperature. By depolymerizing the silicate network and increasing the ionic porosity, H₂O decreases melt viscosity and increases atomic diffusivities and electrical conductivity. CO₂ has similar yet generally much weaker influence on the transport properties of silicate melts. The influence of CO₂ cannot be explained by the hypothesis that the reaction from CO₂ to CO₃²⁻ consumes non-bridging oxygen and enhances polymerization, but may be attributed to increased ionic porosity.

The combined effects of H₂O and CO₂ on speciation, solubility, and physical properties of silicate melts require more systematic investigation.