

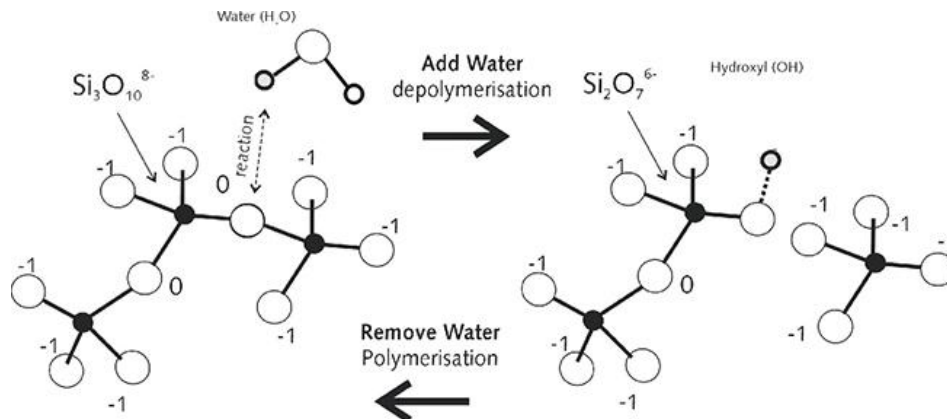
### **SOLUBILITY OF H<sub>2</sub>O AND CO<sub>2</sub> IN SILICATE MELTS**

The interactions of geological fluids with silicate melts (magmas) can significantly modify the physical properties of magmatic systems, and affect the chemical evolution of ascending magmas through degassing processes. H<sub>2</sub>O and CO<sub>2</sub> are the two most important components of fluids in the upper mantle and crust (White and Montana, 1990) and their solubilities in silicate melts control or affect many processes, including generation, migration, saturation and crystallization of magmas, as well as exsolution of bubbles, thus also ultimately volcanic eruption.

The solubility of H<sub>2</sub>O and CO<sub>2</sub> in silicate melt is a complicated function of pressure, temperature and composition. Over the last half century, experimental scientists have carried out extensive experimental measurements of solubility for a large variety of silicate melts (from ultramafic, mafic to silicic) over a wide temperature–pressure range.

#### **Water**

In the below diagram is represented the reaction mechanism by which water dissolves in a silicate magma. The hydrogen of the H<sub>2</sub>O molecule reacts with a bridging oxygen of the silicate network to form a hydroxyl (OH) molecule which is hydrogen bonded to a bridging oxygen. The reaction of the H<sub>2</sub>O molecule causes depolymerisation. Adding water to a silicate melt will, therefore, decrease its viscosity. The viscosity of polymerised melts, such as acidic melts, decreases more significantly with water content than less polymerised (basic) melts.



The degree of polymerisation also controls the amount of water that can be dissolved in a magma. Polymerised magmas (acidic) can dissolve large amounts of water since they have more bridging oxygens. The solubility of water in magmas, therefore, decreases with SiO<sub>2</sub> content due to the decrease in polymerisation (i.e. acid magmas can contain more dissolved water than basic magmas). The highest water solubility is evidently characteristic of alkaline magmas.

With decreasing pressure the solubility of water in a magma decreases because of the decrease in polymerisation. The explosive volcanism of acid magmas is a result of this behaviour since as they rise through a conduit the pressure decreases until the water can no longer be dissolved in the magma

and exsolves as water vapour. The large expansion of the vapour causes the explosive nature of the eruption.

### Carbon Dioxide

Carbon dioxide ( $\text{CO}_2$ ) dissolves in a magma by reacting with a non-bridging oxygen of the silicate network to form a carbonate molecule ( $\text{CO}_3^{2-}$ ). The removal of the non-bridging oxygen causes polymerisation of the network as shown and thus increases in viscosity. Because  $\text{CO}_2$  solubility is dependent on non-bridging oxygens it is higher in depolymerised magmas. The  $\text{CO}_2$  content of basic magmas is, therefore, higher than acidic magmas.

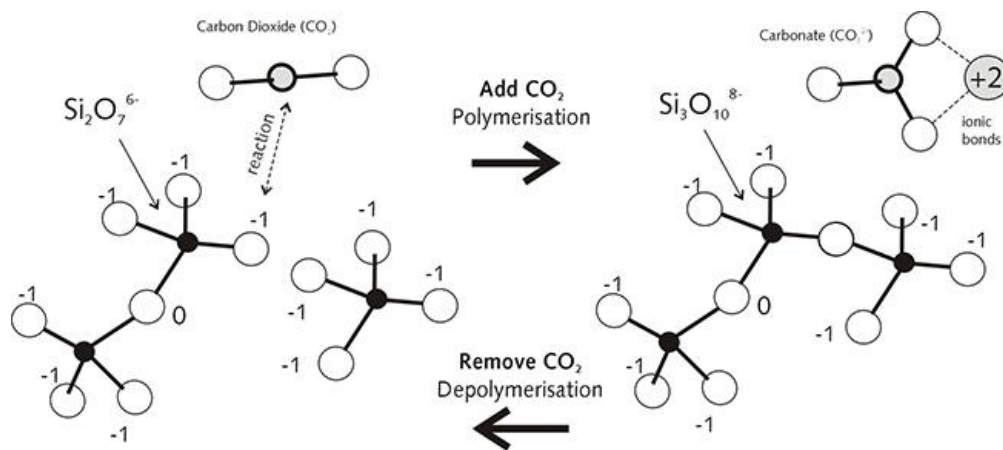


Figure- Reaction mechanism by which Carbon Dioxide dissolves in a silicate magma.

The  $\text{CO}_2$  solubility in melts of basaltic composition is slightly higher than in granite melt whereas  $\text{CO}_2$  solubility appears to increase with increasing melt alkalinity (Huaiwei, N. and Keppler, H., 2013).

A complication is in the presence of  $\text{Al}^{3+}$  as a network former (i.e. in the tetrahedra) since the carbonate ion formed by the reaction of  $\text{CO}_2$  forms a complex with a divalent cation which can no longer balance the charge of the Al in the network. In the case of Al-rich magmas  $\text{CO}_2$  can cause depolymerisation.

### Reference-

Huaiwei, N. and Keppler, H., (2013). Carbon in Silicate Melts. Reviews in Mineralogy & Geochemistry, Vol. 75, pp. 251-287.

<https://www.alexstrekeisen.it/english/vulc/index.php>