

Inferring Europa's Ocean Composition from its Surface Chemistry

Understanding the habitability of Europa's ocean is of great interest to astrobiology and is the focus of missions currently being considered for further exploration of Europa, however, direct analysis of the ocean is unlikely in the foreseeable future. As such, our best means of constraining the subsurface ocean composition and its subsequent habitability currently is by further study of Europa's surface chemical composition. Here we take a simplified model Europa's Ocean consisting of Na, Mg, SO₄, Cl and map out the sequence of mineral formation as a function of relative ionic concentration and pH. In performing this exercise, we are able to begin making meaningful links between observations of the surface chemistry and the chemical environment of the internal ocean.



Assuming thermodynamic freezing (and without formation of complex mixed salts), this work indicates that:

- Substantial amounts of Mg on Europa's surface would likely indicate an ocean of pH < 8.4.
- The presence of sodium sulfate alone would be remarkably undiagnostic.
- The presence of magnesium sulfate in conjunction with sodium sulfate, if confirmed to be of endogenic origin, would imply an ocean of low pH, rich in magnesium and sulfate, and relatively poor in sodium.
- An assemblage with sodium chloride and magnesium sulfate would suggest that the latter is of exogenic origin. An assemblage with sodium chloride and magnesium chloride would suggest either that any magnesium sulfate observed elsewhere would be of exogenic origin, or that the chloride assemblage was emplaced too recently to have been extensively subject to sulfur implantation.