

The formation of ikaite (CaCO₃·6H₂O) in hyperalkaline springs associated with the leaching of lime kiln waste

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Ikaite, (CaCO₃·6H₂O), is a rare hydrated calcium carbonate mineral known only from low-temperature sedimentary environments in the Arctic, and Antarctic, permafrost, sea-ice, cold saline lakes and cold deep marine environments. Although known previously from laboratory experiments, naturally-forming ikaite was first discovered from Ikka Fjord in southwestern Greenland, where it forms tufa columns as a result of alkaline Na-HCO₃ brines (pH 10.2-10.5) discharging from submarine springs into seawater.

Ikaite is metastable with respect to calcite and aragonite in the presence of liquid water but precipitates from alkaline waters at temperatures <4 °C, although some studies suggest that ikaite may be metastable up to 7 °C. Because of the very restricted temperature limits for ikaite stability, and its widespread occurrence in a range of modern cold-climate waters and sediments, there is interest in ikaite as a robust indicator of cold conditions. Although, the mineral is not preserved in the geological record it has a very distinctive crystal morphology which may be preserved as calcite or aragonite pseudomorphs (“thinolites” or “glendonites”).

During a recent study of a hyperalkaline spring site associated with groundwater leaching of an old industrial lime kiln waste site in Derbyshire, central England, ikaite was observed to actively precipitate within tufa deposits during cold autumn and winter weather (<10 °C). The ikaite forms in two different environmental settings: (1) where Ca(OH)₂-saturated hyperalkaline leachate (pH12.5) mixes with Ca-HCO₃-type streamwater (pH ~7) draining into the site, and; (2) on the crests of tufa barrages where turbulent flow mixes atmospheric CO₂ into the hyperalkaline streamwater as it cascades over the barrage. During summer months the ikaite decomposes and dissolves. However, observations at this site show that ikaite can still persist into the summer months, suggesting that under hyperalkaline conditions ikaite is stable to warmer temperatures than previously reported. The occurrence of ikaite in this unusual hyperalkaline environment is described.