Ikaite - the rapid solution for carbon sequestration?

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RA 3 and RA4

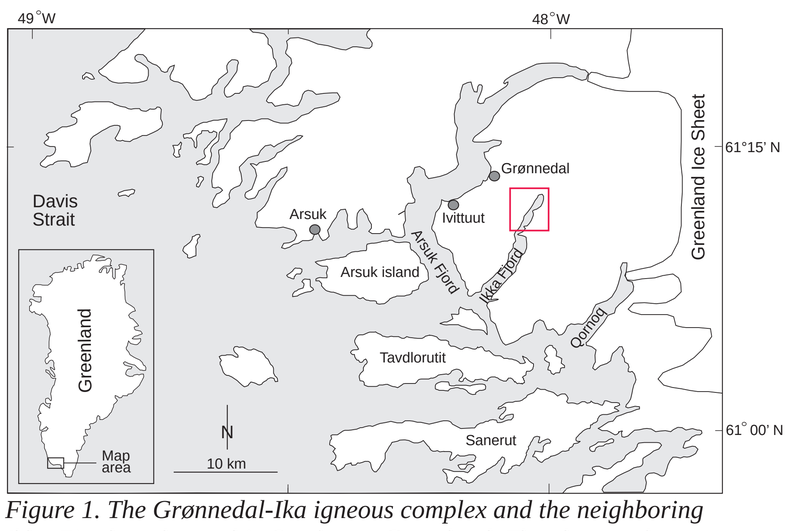


Figure 1. The Grønnedal-Ika igneous complex and the neighboring Ikka Fjord are located in Southwest Greenland. The close to thousand ikaite columns are all restricted to the inner part of the fjord (red box).

Introduction

A new Bolin Centre-associated project (RA3 and RA4) was launched this summer entitled "Low-temperature geologic sequestration of carbon by ikaite formation". The aim of this project is to 1) unravel the link between the alkaline-carbonatitic Grønnedal-Ika igneous complex and a spectacular collection of submarine tufa columns made of the rare mineral ikaite ($CaCO_3x6H_2O$) in SW Greenland (Fig. 1), and 2) investigate the potential for rapid carbon sequestration offered by ikaite formation as illustrated by the extremely high growth rate of ikaite columns in Ikka Fjord (~50 cm/year). The Grønnedal-Ika rocks encompass Na-rich nepheline syenites and almost pure $CaCO_3$ carbonatites. There is a clear correlation between the occurrence of ikaite columns and the outcrop of the Grønnedal-Ika complex (Fig. 2), but the coupled process of dissolving igneous rocks and precipitating ikaite is not yet fully understood.

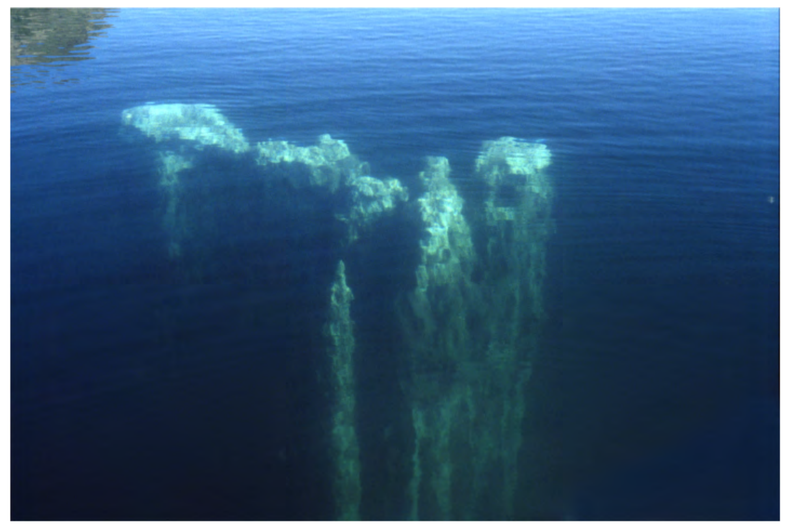


Photo: The Ikka Project. The inuit in Greenland called the ikaite columns "The frozen Vikings" and they believed the columns to be drowned Norsemen, killed by the inuit and now looking for revenge.

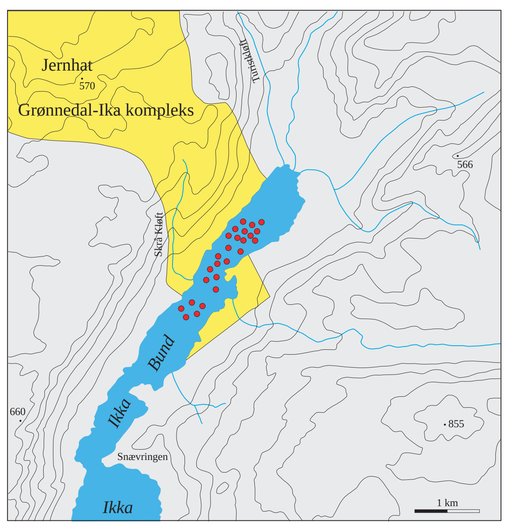


Figure 2. Zooming in on the inner part of Ikka Fjord where all the ikaite columns are found.

Ikaite, a peculiar metastable mineral!

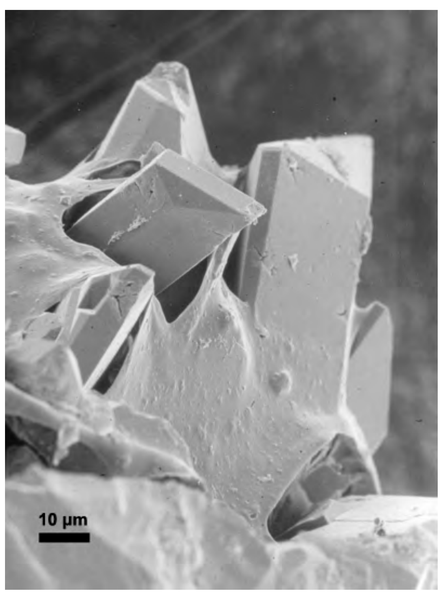
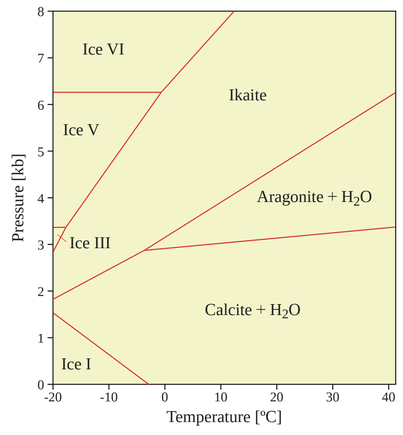


Photo: Bjørn Buchardt



Ikaite is a hydrated form of calcium carbonate. Its presence is generally restricted to cold-water environment at temperatures < 6 °C. Phosphate can inhibit calcite and aragonite, and favor ikaite formation, but even biofilm can help preserve ikaite crystals (see photo).

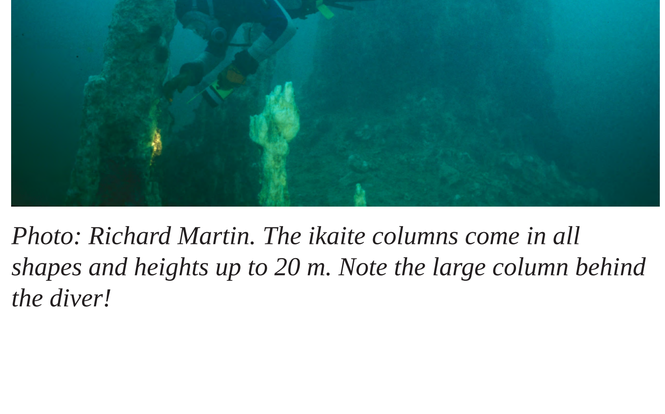


Photo: Richard Martin. The ikaite columns come in all shapes and heights up to 20 m. Note the large column behind the diver!

Photo: Erik Sturkell. Gabrielle sampling water at Xenolith Sø.

	Springwater from Grønnedal-Ika complex	Columnwater from inside ikaite column	Seawater, Ikka Fjord
Temp, °C	4	3	5
pH	8.2	10.3	8.1
Salinity, ‰	0	9.2	32.5
Alkalinity, mmol/kg	2.4	179	2.1
Na^+, mmol/kg	0.11	198	437
Ca^{2+}, mmol/kg	0.96	0.17	8.83
SiO_2, mmol/kg	0.054	b.d.	0.002
Sr^{2+}, mmol/kg	0.029	0.007	0.1
PO_4^{3-}, mmol/kg	b.d.	0.26	b.d.
∂^2H‰, VSMOW	-97.3	-95.7	-14.2
$\partial^{18}O$‰, VSMOW	-13.10	-13.42	-1.13

Table comparing spring, column and seawater chemistry

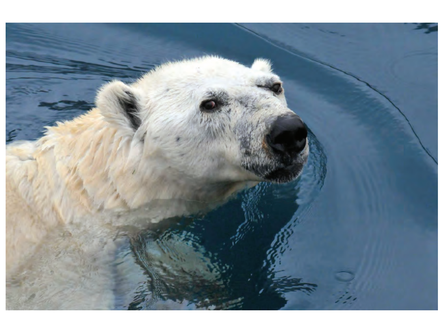
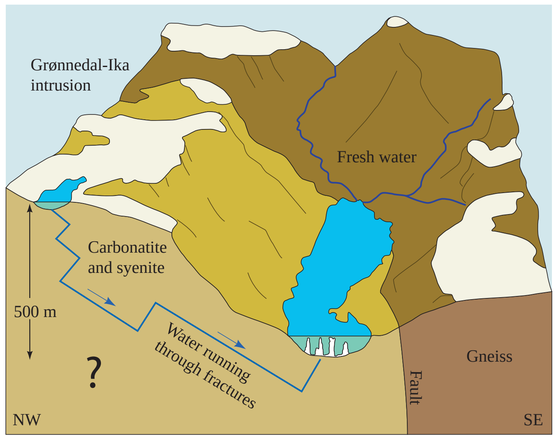


Photo: Uffe Wilken. An unexpected, uninvited visitor during field season 2014!

Photo: Erik Sturkell. Alasdair, Elin, Lena and Gabrielle trying to solve question/mystery:



How does a Ca-rich carbonatite rock turn into a Na-carbonate liquid?

Does it involve fluid-rock/mineral interaction of carbonatite ($CaCO_3$), nepheline ($Na_3KAl_4Si_4O_{16}$), aegirine ($NaFeSi_2O_6$) and/or secondary Na carbonates? Is the carbonatite intrusion like a karst landscape?

Photo: Lena Lundqvist. Erik at a carbonatite bending around a dike.

Concluding remarks

- 100 kg of igneous rocks from the Grønnedal-Ika complex have been brought home to Sweden
- + 15 kg of drill cores from the area
- Water from springs and lakes have been sampled
- Fluid-rock interactions represented by the rocks brought home from Greenland are to be studied
- Studies of the ikaite columns were carried out by Gabrielle Stockmann and co-workers on the Ikka Project 1995-2007 [1,2]
- The aim is to invite Emeritus Reader C.H. Emeleus, who mapped the Grønnedal-Ika complex in 1956-1962 [3], to Stockholm to share his knowledge with us

References

[1] Buchardt, B., Seaman, P., Stockmann, G., Vous, M., Wilken, U., Düwel, L., Kristiansen, A., Jenner, C., Whiticar, M.J., Kristensen, R.M., Petersen, G.H. and Thorbjørn, L. (1997) Submarine columns of ikaite tufa. Nature 390, 129–130.
[2] Buchardt, B., Israelsson, C., Seaman, P. and Stockmann, G. (2001) Ikaite tufa towers in Ikka Fjord, Southwest Greenland: Their formation by mixing of seawater and alkaline spring water. Journal of Sedimentary Research 71, 176-189.
[3] Emeleus, C.H. (1964) The Grønnedal–Ika alkaline complex, South Greenland: Copenhagen. Meddelelser om Grønland 186, 75 pp.