

Disko Island (Greenland)

Description: The world's largest native iron occurrence is situated on Disko Island, Western Greenland. The famous explorer and geologist A.E. Nordenskiöld (1872) was the first to describe the existence of huge blocks of metallic iron, weighting up to 25 tons, on the island. Native iron is hosted in basaltic volcanic formations which cover more than 90 % of the area of the island, and the estimated iron resources are about 5 Million tonnes (BMP 2000).

The emplacement of the early Tertiary volcanics of the West Greenland Basalt Province was associated with the continental split between Northern America and Greenland, which began in the Paleocene (about 60 Ma ago). The lava flows and related subvolcanic units (e.g. dikes and sills) intruded through, and were contaminated by, carbonaceous Al-rich shales. Reaction between magma and sediments took place at depths of several kilometres at high (>1000° C) temperatures and low oxygen content.

Reduction of iron oxides to elemental iron occurred by a process similar to that used now in the industrial production of the metal: by the heating of carbonaceous sediments in an oxygen-poor environment, organic carbon, graphite, carbonates and water reacted together to form a mixture of volatiles such as CH₄, CO and H₂, which in turn reduced iron compounds to elemental iron with variable carbon content (Goodrich and Bird 1985). Iron in the Disko basalts occurs in various forms from microscopic through spherical inclusions and droplets of millimetre scale up to large, cumulate aggregations. The typical globular form is due to the immiscibility of molten iron in silicate melts, which also results in the accumulation of larger iron masses.

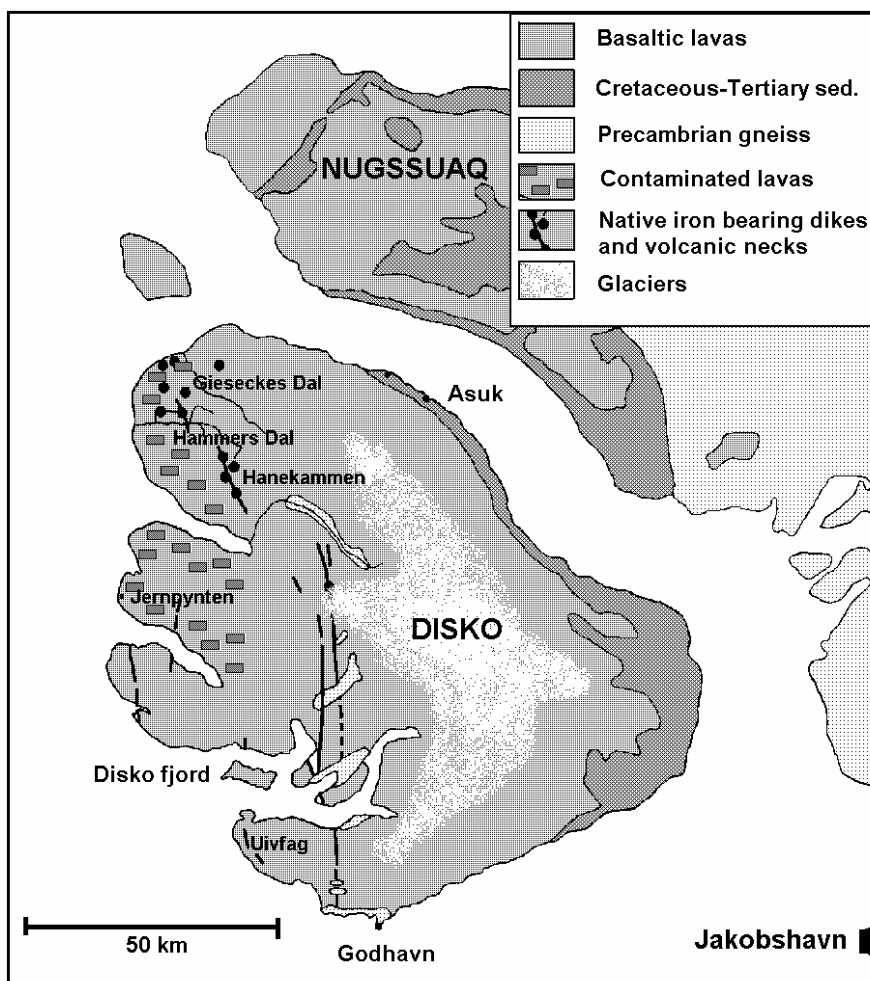


Figure 1. Geology of Disko Island, western Greenland. The figure is compiled and modified from Hellmuth 1991a, Ulf-Möller, F. 1990, Goodrich and Bird 1985.

Volcanic activity at Disko Island ended about 30 Ma ago, followed by a weathering and erosion period in warm, possibly humid, conditions. Several kilometres of the original lavas were eroded away, and large boulders and other forms of native iron were exposed to weathering processes.

Cooling of the climate culminated with the beginning of the Quaternary glaciations of the Northern Hemisphere about 2 million years ago. At that time, the surface level and relief of the island were similar to those of the present day. During the Pleistocene the native iron was subjected to glacial and periglacial processes.

Since the retreat of the Weichsel ice sheets, about 10 000 years ago, only minor climatic and environmental changes have occurred. Currently, the central part of Disko Island is covered by glaciers, while 100-200 metres of permafrost exists in the surrounding areas (Hellmuth 1991b and references therein).

Since the observations of Nordenskiöld at Uigfag area, southwest Disko, numerous surficial occurrences of native iron have been studied and reported. Hellmuth (1991b) studied iron samples from Uigfag and Hammers Dal areas and the Bühl site in Germany. Metallic iron was observed to be coated by magnetite and goethite layers of micrometer scale. The observed alteration was partly attributed to hydrothermal processes. Localized corrosion of studied samples was not conspicuous, deepest pitting depths observed were some millimetres.

Based on knowledge on the achievement of very low redox potentials leading often to the formation of metallic iron in ultrabasic rocks upon reaction with groundwater at low temperatures Hellmuth et al initiated a natural system study at the Lovasjärvi ultrabasic intrusion in Finland and laboratory studies on water-rock interaction and radionuclide sorption properties of that material with the aim to develop the basis for its use as chemically active backfill additive taking advantage of the natural serpentinization process. The work was terminated unfinished due to lack of funding.

Position(s) in the matrix tables: Mechanical integrity of barriers=>corrosion=>

Limitations: The composition of the natural iron will not be the same as that of the technical steels used in repository construction.

Quantitative information: None applicable to PA.

Uncertainties: Boundary conditions to the natural system.

Time-scale: Geological, millions of years, Quaternary

PA/safety case applications: Demonstration of long-term behaviour of metallic iron.

Communication applications: Demonstration of metallic iron in near-surface oxidising conditions.

References:

BMP 2000; Bureau of Minerals and Petroleum (BMP). Mining Journal Greenland Country Supplement (February 2000).

Goodrich, C.A. and Bird, J.M. 1985; Formation of iron-carbon alloys in basaltic magma at Uivfaq, Disko Island: The role of carbon in mafic magmas. J. Geol. 93 (4), 475 – 492.

Hellmuth, K.H. 1991a; The existence of native iron – implications for nuclear waste management. Part I: Evidence from existing knowledge. Report STUK-B-VALO 67. Finnish Centre for Radiation and Nuclear Safety.

Hellmuth, K.H. 1991b; The existence of native iron – implications for nuclear waste management. Part II: Evidence from investigations of samples of native iron. Report STUK-B-VALO 68. Finnish Centre for Radiation and Nuclear Safety.

K-H. Hellmuth 1992 Natural analogue study on native iron. In: H. von Maravic, J. Smellie (eds.) 5th CEC Natural Analogue Working Group Meeting and Alligator River Analogue Project Final Workshop, Proceedings of an International Workshop held in Toledo, Spain on 5-9 October 1992. Report EUR 15176 EN (1994), 333-342, (ISBN 92-826-7091-0).

Nordenskiöld, A.E. 1872; Account of an expedition to Greenland in the year 1870. Geol. Mag. 9, p. 289 – 306, 355 – 368, 409 – 427, 449 – 463, 515 – 524.

Ulf-Möller, F. 1990; Formation of native iron in sediment-contaminated magma: I. A case study of the Hanekammen Complex of Disko Island, West Greenland. Geochim. Cosmochim. Acta 54, 57 – 70.

Added value comments: None

Potential follow-up work: None suggested

Keywords: near-field, metals, iron

Reviewers and dates: Lasse Ahonen, GTK (April, 2004)