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Title: Mineralogical and chemical investigations of a sample from the Seqi olivine deposit, Greenland				
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<p>Summary:</p> <p>This report describes the mineralogical characteristics of a sample from the Seqi olivine deposit and presents chemical analyses of the same rock.</p> <p>The Seqi rock is a dunite with a grain size that varies from 0.2 to about 2 mm. The grain boundaries are regular and almost straight (granoblastic texture) indicating crystallization under static conditions. The rock is fresh with little serpentinization. Individual olivine grains are homogeneous with little internal fractures. The rock contains 96% olivine, 2% enstatite, 1.5 % chromite and 0.5 % chlorite. Chemical analysis show that the rock contains 49.4% MgO, 0.7% Na<sub>2</sub>O+K<sub>2</sub>O and LOI is 0.60 %. Density measurements are in the range 3.27-3.28 g/cm<sup>3</sup>, confirming that the rock has a low degree of serpentinization.</p> <p>Some older and open data on the general geology of the Seqi area and analytical data from GEUS, Denmark are also presented.</p>				
Keywords:		Enstatite		
Industrial minerals		Chromite		
Olivine				

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Summary of open information on the Seqi deposit; source GEUS, Denmark.

## 1. INTRODUCTION

This report was made on the request by North Cape Minerals (NCM), which also supplied the samples and bulk chemical analyses.

This report purposely repeats some information that has been presented earlier (Gautneb 2004), to keep all available open information about the Seqi deposit within one report.

### 1.1 Nomenclature and source of information

The name **Seqi** olivine deposit has led to confusion by some readers. It is the same occurrence that was previous called **Itipilua** by various mining companies and in earlier reports (Kalvig , 1994, Gautneb & Nilsson 1997). Why Minelco, have chosen to give the occurrence a new name is not known (Per Kalvig pers. comm.). Readers that search for open information on the Seqi deposit should be aware of this confusion in geographical names.

## 2. GEOLOGICAL SETTING

The Seqi olivine deposit is located adjacent to Tasiusarsuaq, a branch of Fiskefiord about 35 km west of the settlement Atammik, and about 90 km north of the capital Nuuk. No infrastructure is available at the site area. The site can be reach by a chartered helicopter from Nuuk, or by a chartered boat. In general, the fjords are navigable except for a few narrow inlets dominated by strong currents (Kalvig 1994).

The distance between the dunite and the shoreline is about 0.5 km. The dunite covers an area of about 1100 x 450 m and has a maximum elevation of about 140 m a.s.l. The area of exposures consists of abundant dunite outcrops and talus and debris slopes, with almost no soil and vegetation (Fig. 1 and 2). As a result of erosion a considerable accumulation of unconsolidated olivine sand has been formed adjacent to the intrusion covering an area of about 200.000 m<sup>2</sup>.

The company *Kryolittselskapet Øresund A/S* explored the dunite and the surrounding region in the 1970s. This work included geological mapping, drilling and ore beneficiation test. Regional geological studies were undertaken by the Geological Survey of Greenland (now GEUS). Summary of some analysis from these investigations is given in the appendix.

### 2.1 Geological description

The Seqi dunite is one of a series of Archean ultrabasic intrusions in the Archean gneisses of the Fiskefiord area. The Seqi massif is a elongated and concentric intrusion composed of a central dunite, rimmed by peridotites and amphibole-pyroxene rock (pyribolite). A geological map is shown on Fig. 2. According to Kalvig (1994) serpentized alteration zones are wide spread, up to 50 cm thick and traceable for up to 25 m. The peridotites generally appear as massive rocks. Some faults are seen, and fracture and joint patterns occur everywhere.

The dunite is present as a) massive dunite, b) rhythmic layered dunite with metre thick chromite layers. The overall texture is massive and medium grained. Kalvig (1994) lists the following composition for the massive dunite: 75-85 vol.% forsterite (Fo 94-91) and 5-15 vol.% plagioclase. Accessory minerals are pyroxene, biotite, chromite, rutile and serpentine. Layered dunite contain up to 3 vol.% of chromite, locally developed as up to 2 m thick layers. Serpentine minerals are confined to narrow alterations zones, frequently associated with tremolite and talc.



*Figure 1 Aerial photo of the Seqi deposit (source GEUS web page, view towards west)*



*Figure 2 The first blasting of the Seqi deposit (source, MINELCO web page)*

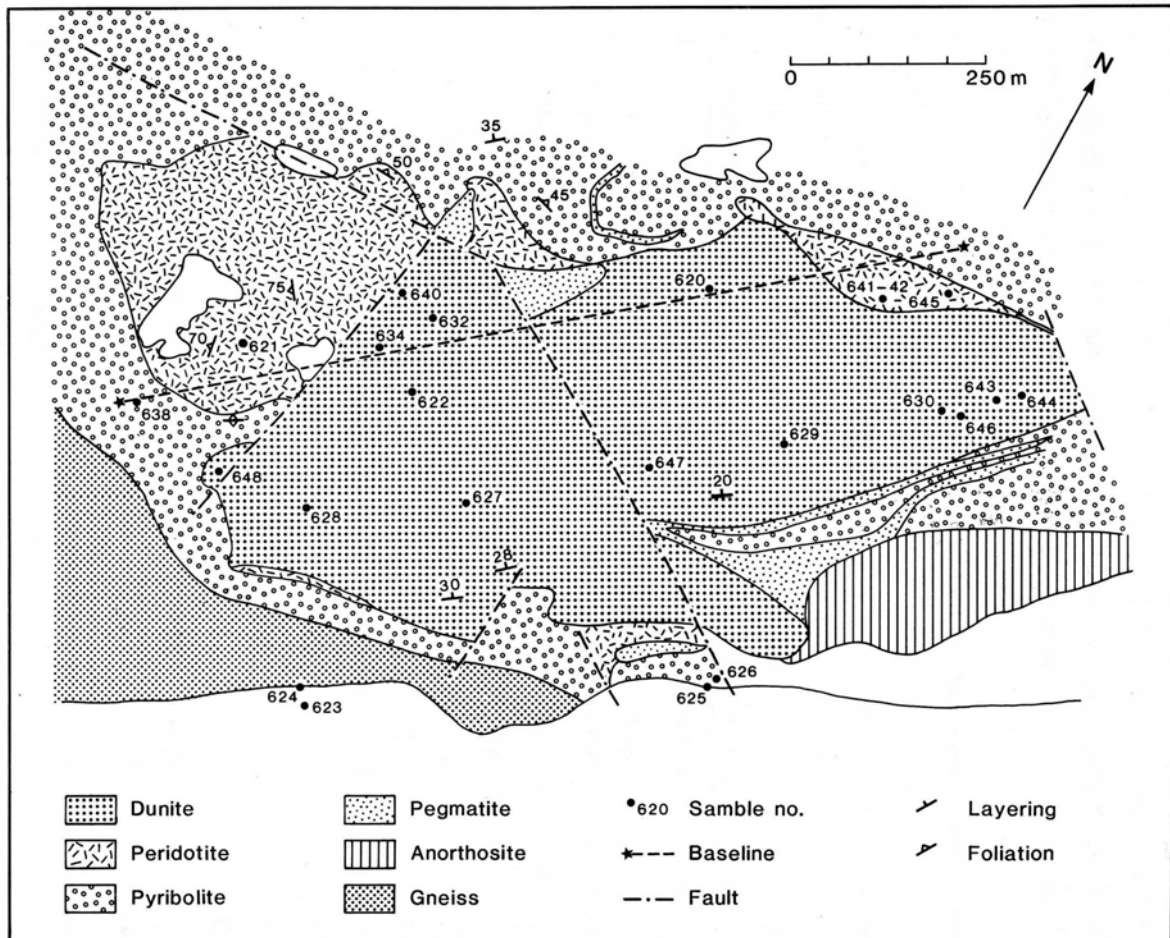


Figure 3 Geological map of the Seqi deposit (from Kalvig 1994), by rotating the map approx. 90° clockwise it will be orientated the same way as the areal photo of figure 1.

### 3. ANALYSES

#### 3.1 Thin section descriptions

A sample marked "Arctic Trader" (a transport vessel) was sent to NGU and a polished thin section was made.

The sample is a typical fresh dunite with a grain size that varies from 0.2 to 2 mm (Fig 4). The grain boundaries are regular and almost straight, indicating crystallization during static conditions. The rock shows a very low degree of serpentinization, and individual olivine crystals are fresh and homogenous with some internal fractures. In general the Arctic Trader sample is internally more homogenous than the Åheim dunite (Figs.5 and 6). The mineral content is listed in Table 1.



Figure 4 Micro photo in polarised light at 12.5x magnification. Note the low degree of serpentinization and low enstatite and chlorite content.

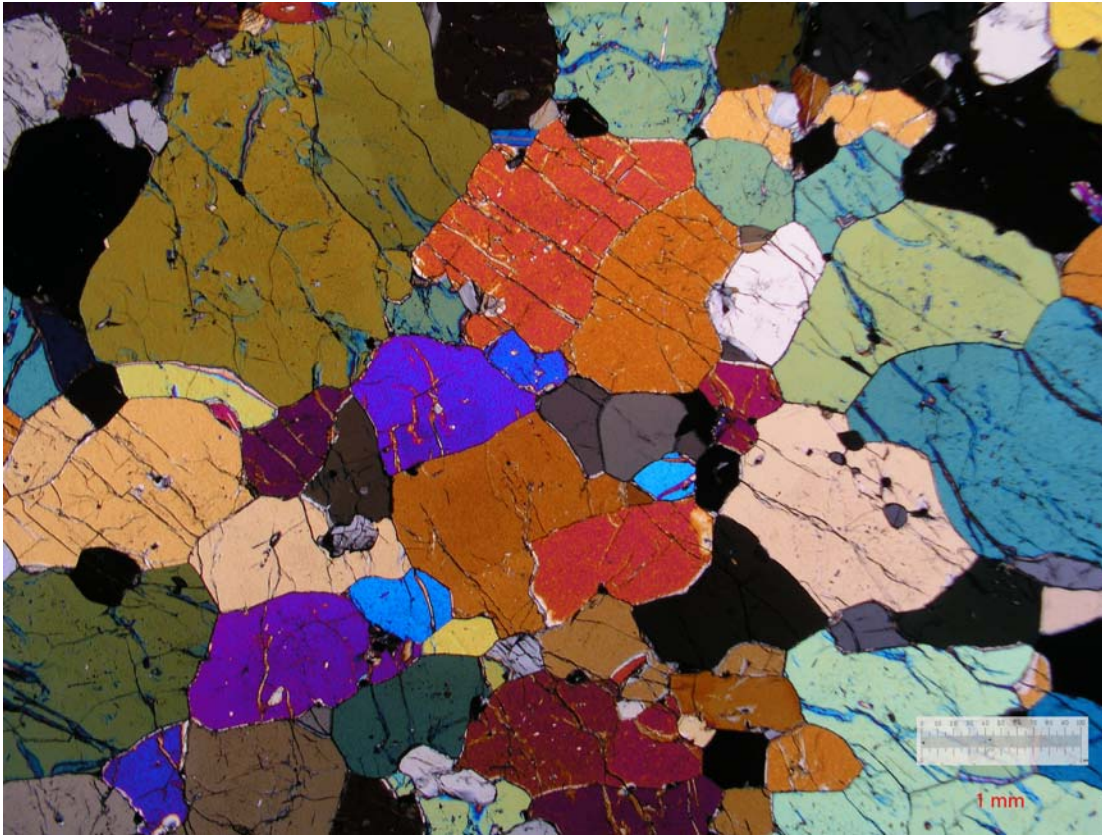


Figure 5 Micro photo of Seqi rock at 25x magnification, compare the texture and mineralogy with Åheim rock (Fig. 6).

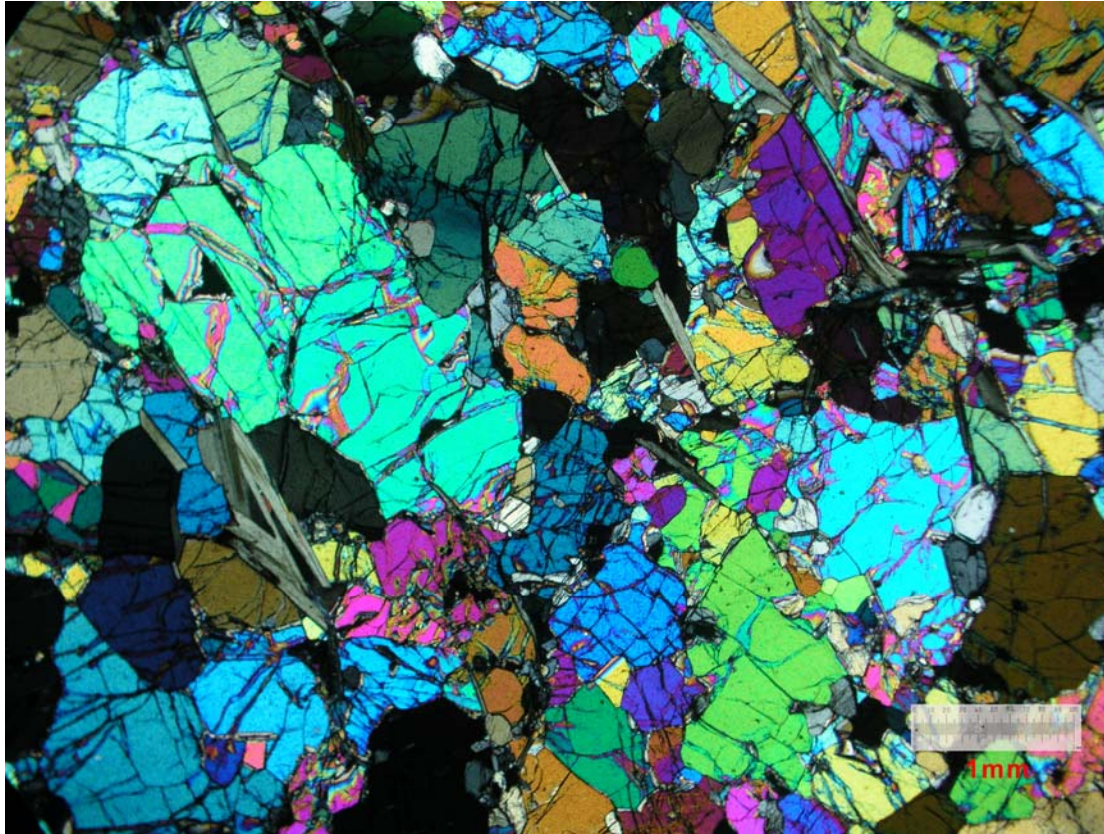


Figure 6 Micro photo of Åheim rock presented for comparison. This rock has a higher content of chlorite and more fractured olivine grains.

Table 1 Mineral content of the investigated sample ("Artic Trader ")

<i>Mineral</i>	
<i>Olivine</i>	96
<i>Enstatite</i>	2
<i>Chromite</i>	1.5
<i>Chlorite</i>	.05



### 3.2 Chemical analyses

A hand specimen and a sample of sand both marked "MV Artic Trader" was analysed at NCM laboratory facilities Åheim. The results is listed in Table 2.

Table 2 Chemical analyses of investigated samples

Sample marked	"Singel-prøve fra	"Finere korngradering
	MV Artic Trader	MV Artic Trader
	Seqi-Grønland"	Seqi-Grønland"
<b>Chemical composition</b>		
MgO	49.4	49.1
SiO <sub>2</sub>	41.1	41.1
Fe <sub>2</sub> O <sub>3</sub>	7.9	7.8
Cr <sub>2</sub> O <sub>3</sub>	0.31	0.32
Al <sub>2</sub> O <sub>3</sub>	0.65	0.77
NiO	0.34	0.34
MnO	0.09	0.10
CaO	0.16	0.22
L.O.I.	0.60	0.84
Na <sub>2</sub> O	0.06	0.03
K <sub>2</sub> O	0.01	0.02

These results are within the variation that has been reported earlier (Kalvig 1994, see also appendix and Gautneb 2004). They show that the Seqi deposit is a pure and relatively MgO-rich rock of high quality.

### 3.3 Density measurements

Several density measurements show that the Seqi rock has a density in the range 3.27-3.28 g/cm<sup>3</sup>. These results confirms the low degree of serpentinization in the Segi rock,

## 4. SUMMARY

A sample from the Seqi Olivine deposit was investigated in thin section and compared to typical samples from the Gusdal quarry Åheim. The Seqi rock is distinguished from Åheim olivine by beeing fresher and with less degree of serpentinisation. It is more homogeneous in mineral content, with less content of enstatite and chlorite. The individual olivine grains show less internal fractures. The chemistry is similar to Åheim rocks with high MgO and low LOI levels.

The report also summarizes some older open information from GEUS Denmark, in the appendix.

## 5. REFERENCES

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Kalvig. P. 1994: Industrial mineral occurrences in Greenland- a review. Geological survey of Greenland, open file serie 94/4.

MINELCO webpage: Minelco celebrates olivine mine opening in Greenland

<http://www.minelco.com/index.asp?Id=11>.

MINEX: Greenland online database <http://www.geus.dk/minex/minex-27-dk.htm#02>

## 6. APPENDIX (open information from GEUS)

Open analytical data from the Seqi deposit, based on information from Denmark & Greenland Geological Survey (GEUS). The information is based on Kalvig (1994) and on online databases (MINEX)

Chemical analysis

Kalvig (1994) reports the following chemical analysis from the Seqi deposit (Tab. 3)

**Table 3 Chemical analyses of samples from the Seqi deposit from Kalvig (1994)**

Elements	Sample A	Sample B
SiO <sub>2</sub>	40,98%	40,45%
Al <sub>2</sub> O <sub>3</sub>	0,28%	1,74%
Fe <sub>2</sub> O <sub>3</sub>	0,96%	0,92%
FeO	6,28%	6,46%
MgO	49,89%	47,94%
CaO	Trace	0,30%
Cr <sub>2</sub> O <sub>4</sub>	<0,10%	<0,10%
NiO	0,38%	0,38%
CuO		0,02%
CoO		0,02%
MnO		Trace
LOI	0,44%	2,00%
Total	99,31%	99,04

*Sample A is a single analysis from the massive dunite. Sample B is an average analysis of 30 samples, collected by Kryolittelskapet Øresund A/S.*

### 6.1 Technical testing

Kalvig (1994) described that the Seqi deposit has been drilled in five drill holes (total length 300m) and resources has been estimated to 52 million tons. The tonnages of the olivine sand have been estimated to be 800.000 tons of which 400.000 tons are on the bottom of the lake. The company *Kryolittelskapet Øresund* performed some technical tests (Table 4) and concluded that the commercial specifications of sand blasting products and foundry sand can be met.

**Table 4 Technical specifications of Seqi olivine (from Kalvig 1994)**

Refractory grade Rock type	Method	Refractory temperature (°C)
Massive dunite	Cone-fall	1705-1710
Olivine sand	Cone-fall	1540
Massive dunite	Sintering point	1300-1400
Olivine sand	Sintering point	1300

## DATA ON THE SEQI DEPOSIT FROM GEUS ONLINE DATABASE

**Locality name: Seqi (Seqinnersuusaaq)**

**Area: Maniitsoq**

**GSC deposit type: 28.0 – Mafic/ultramafic rocks and related minerals**

**Commodities: Olivine**

### **Geological characteristics**

**Description of occurrence:** Within the Fiskefjord area, several lens-shaped olivine rich peridotite (dunite) bodies occur, sized up to 0.5 x 1.5 km as the Seqi body. The Seqi rocks are homogeneous, granular, medium-grained olivinite and olivine rich peridotite. Layering with chromite and magnetite is common in selected parts of the dunite body. (Garde 1997a; Keto & Turkka 1967).

**Geotectonic setting:** In relation to deep-rooted shear zones within the Archaean basement.

**Depositional environment/Geological setting:** Ultrabasic igneous complex suggested to be crystallised as a part of an ophiolitic suite.

**Age of mineralisation:** As a part of a continued crustal accretion in the area the age around 3.0 Ga is determined (Garde 1977).

**Host/Associated rock types:** Dunitic rocks are situated in a basement of leucocratic orthogneisses and amphibolites with gradational transition from olivine poor peridotite to olivinite (dunite). Metamorphism has reached granulite facies, which invariably is overprinted by phases of amphibolite facies retrogression in the Fiskefjord area (Garde 1977).

**Deposit form:** The peridotite body is oval shaped, demonstrating a core of 0.3 x 1.1 km of massive dunite, with the long axis trending NE-SW.

**Texture/Structure:** In brief the body is composed of three varieties of olivine rich rock. Dominating is a homogeneous monomineralic rock, which is underlain by varieties of dunite with chromite layering, and porphyritic dunite, as a part of a suggested layered complex. The body is divided in two halves by a NW-SE trending steep fault.

**Ore mineralogy:** Olivine (forsterite) make up 98 % of the ore. Accessoric minerals are chromite and locally magnetite (Keto 1967).

**Weathering:** Olivine is weathering into a yellowish brown sand and partly decomposed (residual) dunite. Because of the colour the ore body is easily distinguished from the country basement rocks.

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**Ore controls:** Layered igneous complex.

**Genetic models:** Cumulate from an ultrabasic magmatic intrusion, folded and metamorphosed after or during the emplacement.

### **Exploration**

The Seqi olivine occurrence is fully exposed and has been subject to exploration with limited drilling and surface sampling by KØ (Keto1967), who also mined a test bulk sample of 12,5 t in 1971 (under the name Itipilua). NunaOil A/S prospected the area a couple of

years and from 2003 and onwards Crew Development Ltd. (Seqi Olivine A/S) conducted a renewed exploration and a drilling programme with 22 holes and a large number of assays. Combined geological and geophysical studies have outlined a resource potential in excess of 100 million tonnes (Christiansen 1997; Lappalainen 1971; Nielsen 1973).

In June 2004 the LKAB board authorised Minelco to proceed with the commercial arrangements with Crew and to place the olivine deposit into production. Following this decision, Seqi Olivine A/S has been formed as an operating company that will be jointly owned by Minelco and Crew and arrangements made to finance the company in accordance with the agreements between the companies. The company now has an exploitation licence.

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