

GEOLOGY AND ORE

Exploration and Mining in Greenland

GEMSTONES of GREENLAND

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Gemstones of greenland

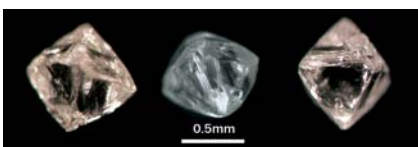


Renewed focus on Greenland gemstones has been experienced since the turn of the century.

Two gemstone companies have demonstrated solid and continued interest in the potential of classical gemstones in Greenland in this period. Diamonds and rubies are definitely now in focus with the size of diamonds growing almost with every new exploration event. The largest diamond to date has just been reported at 0.122 carats.

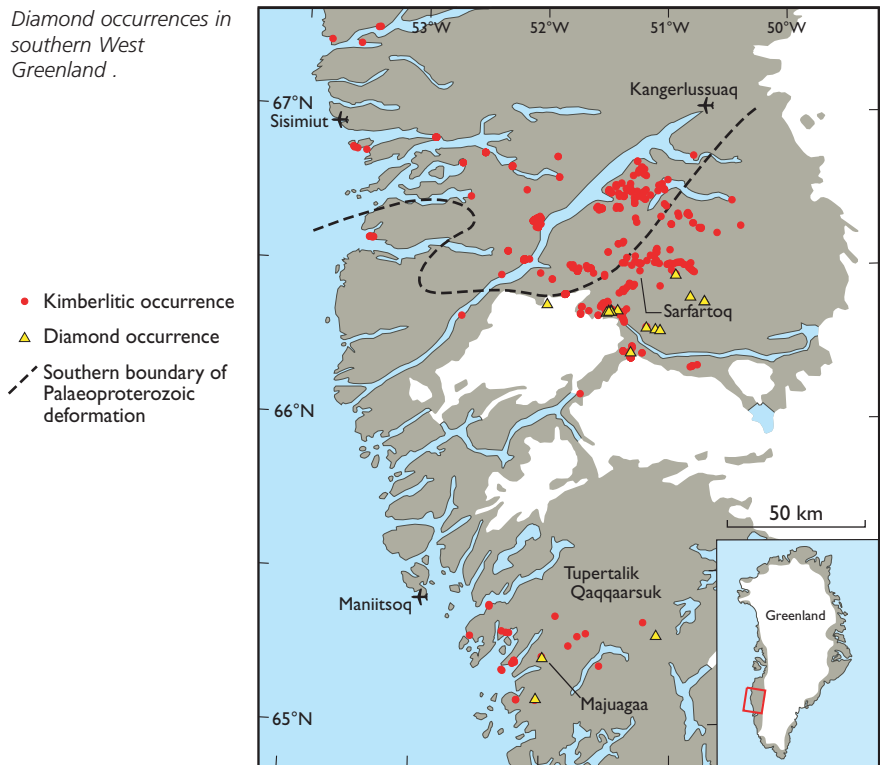
Rubies and pink sapphires are now at hand with large, high-quality stones in faceting as well as in carving types. Exploration activity targeted at both commodities may be approaching the next stage, with pre-feasibility studies and production considerations. A number of other species of coloured gemstones and generally lower-priced semi-precious gem material have also been found, and these are often very much in demand locally as well as internationally. Well-known examples are *kornerupine*, *tugtupite*, *lazurite* and *amazonite*. Several multi-coloured rock types have been produced on a small scale locally for many years and have gained high popularity among tourists and collectors, with the famous *nummite*, *greenlandite* and 'ice blue' *chalcedony* being the most favoured.

A number of additional classical coloured gemstones such as beryl, cordierite, peridot, tourmaline, garnet, spinel and topaz are known from scattered occurrences, but their potential has never been tested. The variety in the Greenland geological environment, not least the pegmatite occurrence, is definite justification for more systematic exploration for such stones.



Colourless and pinkish diamonds from Garnet Lake.

Diamond occurrences in southern West Greenland.



Diamonds

Exploration

Diamonds are well-known from the 600 Ma old North Atlantic province of carbonatites and ultramafic alkaline magmatism in southern West Greenland, which has been a target for commercial exploration since the mid-1990s. So far this has resulted in numerous finds of ultramafic lamprophyre and kimberlite dykes and micro/macro diamonds have been recovered from many of these rocks. All work by active companies is still at the exploration stage.

On 24 October 2006 Hudson Resources Inc. announced the diamond results of the 2006 exploration drill core program. The highlight was the recovery of 35 diamonds, including the largest diamond ever found in Greenland. A sample of a 14.6 kg core sample taken from a 4.5 m kimberlite intercept in the Garnet Lake dyke in the Sarfartoq area yielded the largest stone weighing 0.122 carats.

The Geological Survey of Denmark and Greenland (GEUS) recently published a new digital compilation of all the diamond

exploration data gathered to date. This compilation is the common knowledge base for diamond exploration in West Greenland. The compilation (on DVD) contains:

- 164 scanned reports in Adobe PDF documents from company reports submitted to the Bureau of Minerals and Petroleum. There are approximately 96 150 mineral analyses from 15 295 samples of till or stream sediment covering 4563 localities.
- 2780 mineral analyses representing 31 kimberlitic rock samples.
- 560 classification diagrams on which analysed kimberlite indicator mineral grains have been classified and plotted. All mineral chemistry data have been examined.
- All available geophysical maps. These have been scanned in large format, and are presented in Adobe PDF documents.
- Approx. 2700 observations of kimberlitic rocks.
- Topographic data at 1:100 000 scale for the regions of diamond exploration as at 2004.



The Majuagaa kimberlite dyke in the Maniitsoq area.

Potential

The Greenland diamond potential is concentrated in swarms of ultramafic dykes in the Sisimiut–Sarfartoq–Maniitsoq region in southern West Greenland. Fieldwork in 2006 resulted in the recognition of much larger kimberlite dyke systems in the Maniitsoq area than had previously been reported. The Majuagaa dyke in this area is a diamond-bearing and phlogopite-poor ultramafic dyke, which is considered an archetypical kimberlite. The number and size of finds combined with the knowledge of existence of true kimberlites supports expectations of a reasonable potential for diamonds in the province.

In the Sarfartoq area the 2006 results illustrate the highly diamondiferous nature and coarse diamond distribution of the kimberlite dyke at Garnet Lake in the Sarfartoq area. To date, a total of 357kg of kimberlite from the Garnet Lake dyke has yielded nine commercial-sized stones

(+0.85mm) totalling 0.31 carats or a nominal 0.87 carats/tonne. Similarly, the drilling results confirm the Garnet Lake dyke as being a significantly diamondiferous body, which can be followed over a strike length of 900 m, with 450 m down-dip.

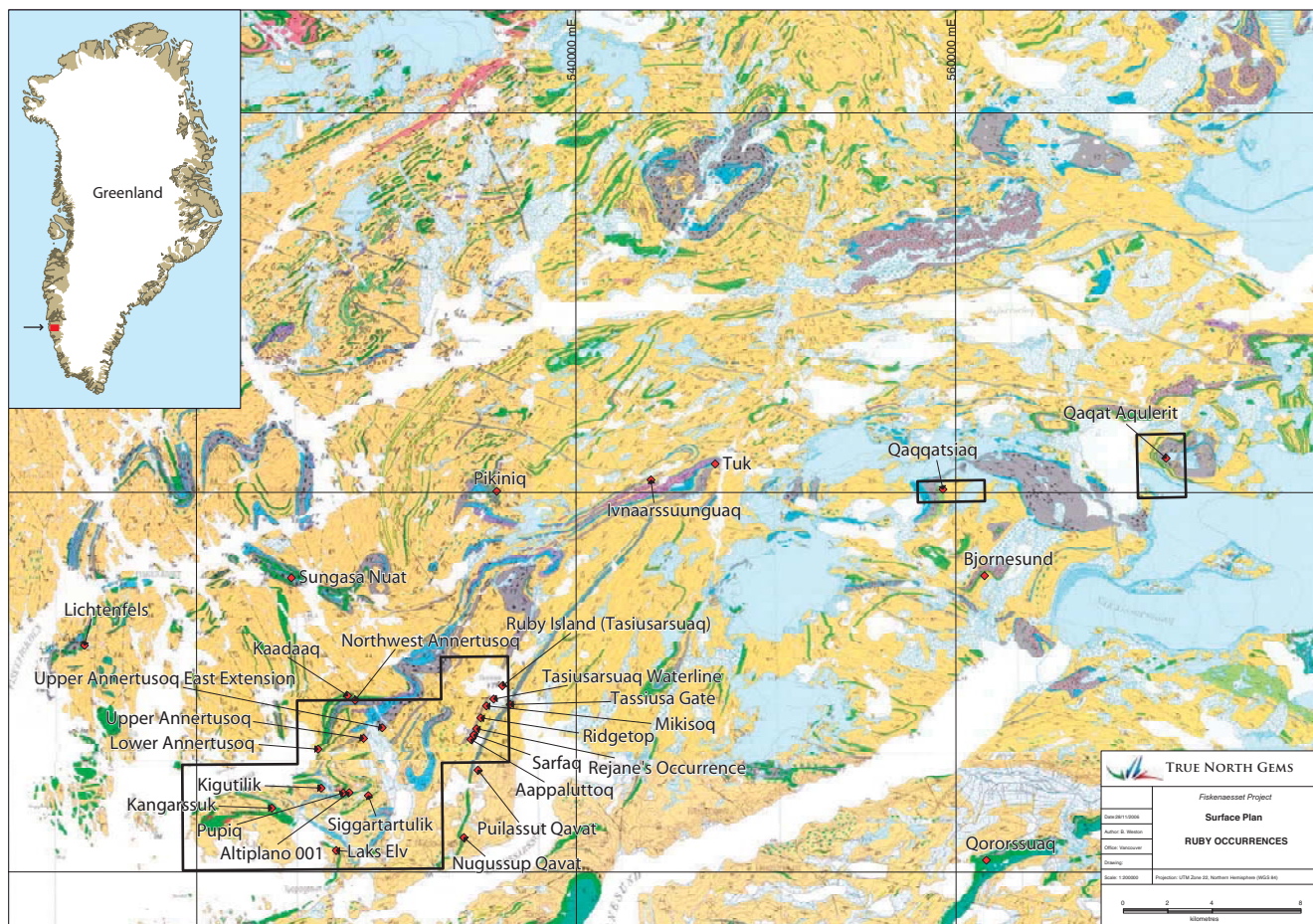
Many of the kimberlite localities in the Maniitsoq area contain abundant diamond-favourable peridotitic and eclogitic garnets, along with diamond-favourable chromites and clinopyroxenes. Mineral chemistry data for these occurrences, along with several occurrences in the Sarfartoq area, became available only recently, and it is now possible to address the provenance of the indicator minerals from till and stream sediment.

In the field area just east of Maniitsoq, around the mountain Sillissannguit, new dykes with a combined length of more than 10 km were found in 2006, and in another area, Timitta Tasersua East near the coast, a system of what is believed to be one of the largest kimberlite dyke

exposures known in Greenland was found in a steep gully above a stream with numerous large boulders of kimberlite. Most of the dyke systems in the Maniitsoq area are expected to be archetypical kimberlites.

Quality

Quality evaluation of the huge amount (more than 1000) of micro and macro diamonds recovered to date from Greenland is scarce. However, the quality of the diamonds recovered from the Garnet Lake area at Sarfartoq has undergone preliminary evaluation by the Hudson Resources company. The recovered stones typically have good colour (colourless to pink) and shape (octahedron). The pink diamonds are always of interest to the gem industry, as noted by the company at the presentation.



Map of ruby occurrences in the Fiskenæsset area. Courtesy: True North.

Rubies and pink sapphires

Exploration

The first rubies were discovered in the West Greenland region of Fiskenæsset/Qeqertarsuaq in 1966 on a small island, subsequently named Ruby Island. In the late 1970s and early 1980s Greenland rubies caught commercial interest. Prospecting of ruby-bearing zones, mapping and bulk sampling was carried out by the Canadian exploration company Platinomino A/S. Shortly after the turn of the century the Greenland rubies captured renewed commercial interest from Brereton Engineering & Developments Ltd. with True North Gems Inc. as operator.

Detailed exploration for rubies was conducted by Platinomino A/S in the 1980s. Detailed mapping of the Siggartartulik zone was made and prospective zones in that area were scrutinised. As a result of this, several new ruby-bearing zones were

discovered. However, only limited further work was done within the concession and the activity ceased after a couple of years.

In 2004 True North Gems Inc. obtained an exclusive exploration licence of a 3600 km² area and commenced prospecting in the area. In 2005 True North collected 3 tonnes of mini bulk samples at five different localities. The ruby ore was processed at various laboratories in Canada, the UK and Germany. The rubies were sorted into three quality classes: gem (transparent and semitransparent), near-gem (translucent and semi-translucent) and non-gem (opaque). Another ruby showing at Aappaluttoq yielded 533 grams of gem including a 20-gram single stone, all derived from a 100-kilo outcrop sample.

In 2006 True North concentrated their efforts on the two most promising ruby localities discovered to date: Aappaluttoq and Kigutilik. A 30-tonne bulk sample was

collected from each of the two sites. Much of the sampling was carried out by diamond-tipped chain saws and samples were flown to Fiskenæsset, where a small processing plant was established. The rocks were gently crushed and the heavy minerals were separated. The ruby concentrates were hand-picked for the largest, best quality rubies.

Prospecting of the area surrounding Aappaluttoq led to the discovery of a band of multiple ruby-bearing horizons, extending for 2 km from the historic locality of Ruby Island to Aappaluttoq. This region will be the focus of planned diamond drilling in the future.

Geological environment

The Fiskenæsset region is dominated by extensive gneiss tracts with enclaves of greenstone belts. A large, layered anortho-



Rubies from Aappaluttoq. From left to right, stones weigh 0.43, 0.42, 0.77, 0.43, and 0.22 carats. Courtesy: True North.

site complex with a total length of more than 200 km intruded into pillow-structured amphibolites in the greenstone belts. The Fiskenæsset complex comprises anorthosites, gabbros and ultrabasic rocks. Minor components are banded chromitites which are up to a few tens of metres in thickness and can be traced at intervals for many kilometres. The region has been repeatedly deformed and metamorphosed under amphibolite facies, locally up to granulite facies conditions.

The ruby-bearing rocks are very distinct and often revealed by the abundance of bright green tschermakite amphibole. The mineral assemblage comprises red corundum, red spinel, sapphirine, kyanite, kornepine and tourmaline in a groundmass of tschermakite, phlogopite, anorthite and dolomite. These minerals occur in different proportions. The ruby-bearing zones always occur either at or close to the contact between anorthosite and amphibolite/ultrabasic. Since the anorthosites stand out with no vegetation due to rapid weathering, it is fairly easy to prospect the region for ruby occurrences.

Ruby showings vary considerably in size from a few square metres in outcrop to about ten metres in width and traceable for more than a hundred metres. The largest ruby showing is the so-called Siggartartulik showing and several tonnes of ruby-bearing material have been extracted from this locality.

Ruby occurrences have also been recorded elsewhere in West Greenland, although only very limited prospecting for ruby-bearing rocks has been carried out. In the inland area east of Nuuk extensive anorthosite bodies have been found including several ruby showings. Most of these occur near the contact between anorthosite and amphibolite/ultrabasic. One of the showings is on Storø, where up to 10 cm large

euhedral barrel-shaped crystals have been found in a biotite matrix. These rubies are red but neither transparent nor translucent. In areas close to the Inland Ice rubies have been found in similar environments.

Near Maniitsoq north of Nuuk, red corundum crystals have been found. They have developed as barrel-shaped crystals, often very large (up to 1 kg) and embedded in biotite and thus easy to release. The colour is, however, not quite as intense the other material described above.

Considering the close geological resemblance between the Fiskenæsset region and the area further north, it seems appropriate to assume that the ruby-potential near Nuuk and further north is promising.

Gem types and processing

The coloured gems so far recovered have been classified as rubies and pink sapphires. In 2005 True North established a small cutting and polishing centre in the

village of Fiskenæsset in order to teach the local residents how to cut and polish cabochons of ruby. In the early spring 2006 a team of teachers and machinery were introduced for courses in faceting rubies. The courses were successful and some of the residents proved to have the potential for faceting gem stones.

A piece of ruby rough discovered in 2005, approximately 4 cm x 5.5 cm with a maximum thickness of 3 cm, has been graded as near-gem with gem segments. The material is a polycrystalline form, displaying good natural red colouration throughout, with mostly translucent to near-transparent sections. This gem piece has been carved yielding a stone of 302 carat which is estimated to have a value of around 1.5 million CAD.

True North has carried out a number of beneficiation tests on the rubies, some using automated optical sorting devices originally constructed to separate reusable glass. Tests have also been made to heat-treat fractured and very pale rubies in order to obtain better colour and less fractures. The results are promising and the activity in the Fiskenæsset region is probably approaching the exploitation stage.

Canadian gem cutting expert Brad Wilson demonstrates the faceting equipment in Fiskenæsset. Courtesy: True North.



Cluster of ruby crystals, Fiskenæsset, West Greenland. Size of cluster: 2,8 x 4, 2 cm. Courtesy: Geological Museum.



Exploitation of other gemstones

Kornerupine

Kornerupine has been known since 1884, when the mineral was found and described from a locality near Qeqertarsuaat (Fiskenæsset). The mineral was hosted in a sequence of anorthosite within the folded chromite-anorthosite igneous complex of the area. Kornerupine is associated with a suite of spectacular minerals such as sapphirine, ruby, cordierite, tschermakite, spinel and tourmaline. The normal shape of kornerupine is radiating aggregates but locally single crystals with a distinctly prismatic habit have developed. In 1975 a new site in the area delivered giant crystals of kornerupine measuring up to 23 cm (9 inch) in length.

The usual colour of the mineral from the West Greenland area is greyish-greenish with a brownish tint and with a non-transparent appearance. The giant crystals display a clear blue-green colour, scattered with smaller areas with sufficient clarity and freedom from flaws to allow faceted gems to be made. Altogether 21 stones were cut from this material, including 14 faceted gems and 7 cabochons. The largest examples of 5.88 and 1.72 carats are displayed at the Geological Museum of Copenhagen. The material has never been traded or otherwise commercially tested.

Although none of the faceted examples are completely flawless, the clear colour and the pleochromism from dark green to light blue is convincing and renders the Greenland kornerupine with promising possibilities as an attractive coloured stone. The number of localities is rather limited and until 1975 only the type specimens from 1884 were known. However, the find of the single crystals points to a potential for new finds.

Tugtupite

Tugtupite was introduced as a new mineral from Greenland in 1965. However, it was discovered as early as 1957 at a site along the shore of the Tunulliarfik fjord in South Greenland. Material from the locality was described as white and it was mentioned that the colour changes to pale



Above: Faceted kornerupine from the Fiskenæsset area. Stones of 1.72 ct (top) and 0.68 ct (bottom). Courtesy: Geological Museum.

Left: Giant kornerupine crystal (23 cm in length) from the Fiskenæsset area. Courtesy: Geological Museum.

Below: Rough sample of tugtupite in vein with white albite and brown spahlerite from the Narsaq area. Size of sample: 8 x 10 cm.



pink after exposure to daylight. In 1965 the tugtupite with a dark crimson red colour was found on the Kvanefjeld mountain near the town of Narsaq, and since then this strong coloured type has been the most sought after by collectors and tourists. A light blue variety is also known from this locality. Tugtupite is found within the peralkaline igneous llimaussaq Intrusion and it is confined to late hydrothermal veins, often associated with albite, analcime, aegirine, sphalerite, neptunite and pyrochlore. Most tugtupite is massive, and developed crystals are extremely rare. Since the presentation in 1965, several new showings have been discovered in the area. Many of these

have been emptied and to day proper showings of tugtupite albite veins are hard to find.

As tugtupite is typically found in massive, polycrystalline pieces, the typical cut of the stone has been as cabochons or as shaped pieces, intended for mounting in precious metal frames. Tugtupite is mostly cut and polished by local craftsmen in a kind of lapidary home industry. The cabochons are sold by local dealers and in tourist shops and in airports. The mineral is well known outside Greenland and also traded internationally at jewellers and at trade shows. The potential for larger production is limited. The area with the known occurrence is small and on top of

this the local municipality has issued administrative regulations concerning commercial collecting.

Tugtupite has gained a reputation as the Greenland gemstone par excellence. The colour change from red to pink or white and back to red after being exposed to daylight (or ultraviolet radiation) after being in the dark (in the jewel case), is more of a curiosity, not known in other gemstones, and maybe not really a marketing issue. On the other hand tugtupite is renowned for its intense glowing dark red fluorescence, when it is exposed to short-wave UV-light. Accurate pricing of tugtupite is difficult to obtain because of the great range of quality from different showings, however, it is one of the highest priced Greenland stones.

Lapis lazuli

Around 60 km east of the town of Maniitsoq at a locality named Tupertalik after the 980 m a.s.l. mountain nearby, lapis lazuli (lazurite) has been known since the 1960s. At that time the area was being prospected by Kryolitselskabet Øresund A/S, which did not find it of commercial interest. The locality was sampled and mapped in 1979 and 1981 by GEUS. After that time local lapidarians showed some interest in the area. It is located along the margin of a slightly folded and metamorphosed Archaean carbonatite sheet within the basement. As a result of reaction between the carbonatite and the basement gneisses, new minerals such as skapolite and lazurite have developed. The skapolite is white and the lazurite is pale ultramarine blue, and therefore pieces cut from the material have the characteristic combination of blue ground-mass with irregular white spots. Specks of sulphides are never found in Greenland material. The size of the carbonatite is around 200 x 500 m, which represents the surface exposure of the margins of the slightly folded sheet. Lazurite from

Cabochon cut tugtupite from the Narsaq area. Largest cabochon: 2.5 cm.



*Lazurite crystal from the Maniitsoq area.
Sample size: 5 x 5.5 cm. Courtesy:
Geological Museum.*



Cabochon cut lazurite from the Maniitsoq area. Size of cabochon: 2 x 4 cm.

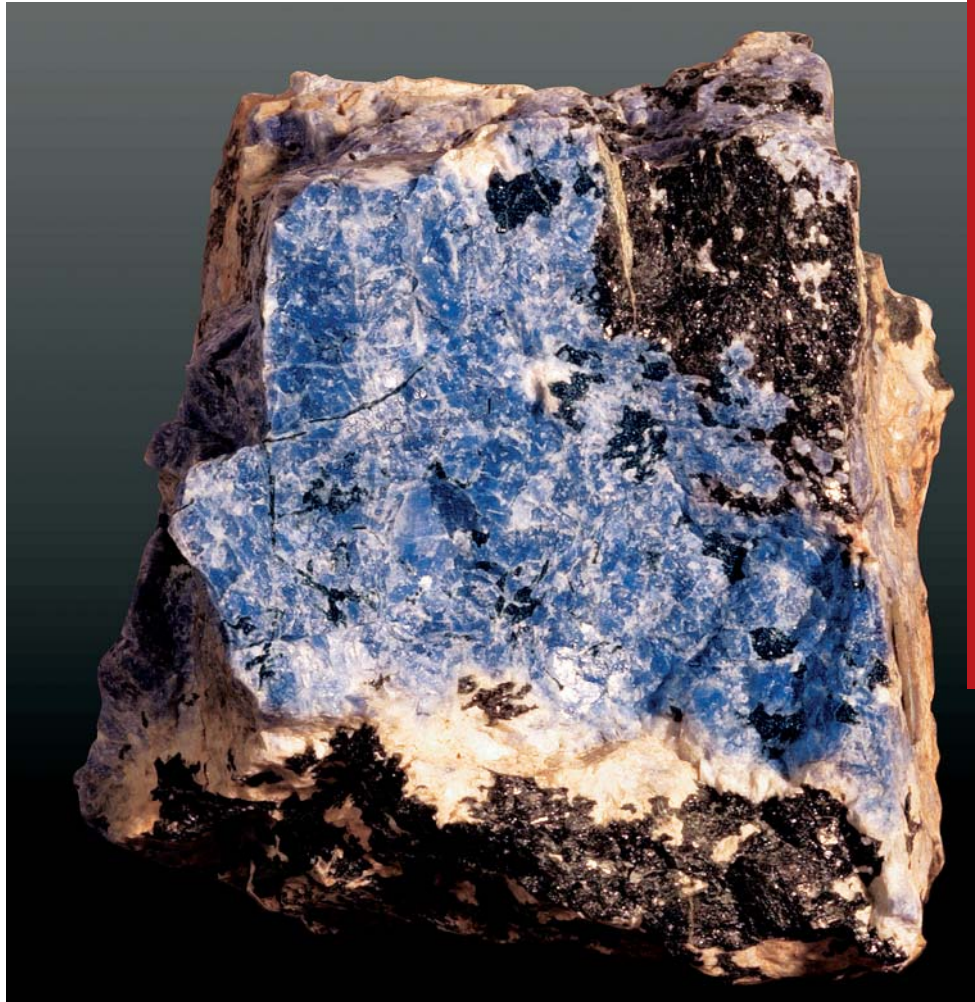
Greenland is only known from this locality.

Lazurite is normally observed cut and polished by local craftsmen in a kind of lapidary home industry. Chacochons and plane polished slabs are most popular, typically in various mounts of silver. It is not unusual to see jewellery where lazurite is combined with other coloured Greenland gemstones such as tugtupite and amazonite. The potential for further finds is limited to the size of the carbonatite exposure. Greenland lazurite has never been a target for commercial exploration. One prominent use of the material is as a part of the decoration of the neck chain insignia of the mayor of Maniitsoq.

Amazonite

Within the Nunarsuit intrusive complex in South Greenland a number of pegmatite dykes have been found at several localities in the westernmost 'main granite'. The complex is of Mid Gardar age (1150 Ma), it is composed of suites of granites and syenites and is located on the Nunarsuit

Amazonite crystal in pegmatite from the Nunarsuit area. Length of crystal: 15 cm.



peninsula. The complex is well-known for its pegmatites, often located in sequences of microgranite. The amazonite is nicely developed together with coarse quartz and biotite in dykes of up to 1-2 m width. Graphic granite is frequently seen border-

ing the pegmatites. Amazonite crystals are up 5 x 15 cm.

Granitic pegmatites in the Tasiilaq area of East Greenland have been reported to contain well developed amazonite crystals, but the colour of the Tasiilaq material is



pale blue-green compared to the Nunarssuit crystals.

The Nunarssuit amazonite has the characteristic silvery internal reflections, which are enhanced by polishing, either as cabochons or as plane slabs. The Nunarssuit occurrence has been quarried for pilot uses under an exploitation license held in 1986 by the municipality of Qaqortoq. The municipality intended to establish work shops in the town. Here residents could use the material from the quarry and learn to cut and polish gemstones of local heritage, so called unique 'town gemstones'. However, the initiative was closed in 1987 after several attempts to create treated gemstones and the quarried amazonite was dispersed among town collectors. Eventually the license was relinquished. The potential has been evaluated as good, as the pegmatites are found at several places in the area.

Nuummite

Nuummite is a gemstone formed from a mixture of two minerals from the amphibole group: anthophyllite and gedrite. The name nummrite (meaning 'from Nuuk') is derived from the name of the Greenland capital, Nuuk, where the stone was dis-

covered in 1982 by GEUS. Some might claim that nummrite was in fact rediscovered, since the mineralogist K.L. Giesecke had collected similar specimens in 1810. The two minerals are found at several localities in the Nuuk area.

Nuummite is thought to be of volcanic origin and was formed about 3 billion years ago. Metamorphic alteration of the rock resulted in the striking mixture of crystals which gives nummrite its unique appearance. Nuummite has an overall hardness of 5–6 and constitutes a mixture of elongated crystals, often in sheaf-like groups. In the transition between the individual crystals (and especially the thin ones), an optical effect is created which causes them to display a particular 'inner' golden glow, almost like flames in a fire. This effect is known as iridescence, and is very distinctive on polished surfaces. The colours vary somewhat between reddish, greenish and bluish nuances.



Cabochon cut nummrite (3.5 cm) from the Nuuk area.

Nuummite is typically treated by local lapidarians and has created a base for a solid home business. It is generally easy to polish, even though it can be difficult to

avoid holes and cracks in certain

qualities of stones with

many parallel crystals.

The usual shape is

cabochon, but other

convex finishes also

produce attractive

shapes. In larger pieces

it is possible to retain most

of the colours of the irides-

cence, so that one end of

the cabochon has a golden

colour while the opposite end has a bluish hue.

The marketing of nummrite immediately after its discovery was quite intense, with a successful initiative to introduce it on the international market. The municipality of Nuuk carried out exploitation of the material for a short period in the mid 1980s. The potential for finding more showings seems to be good.

Greenlandite

The rock greenlandite ('grønlandite') was given this grandiose, unofficial name to



Sample of rough greenlandite from the Nuuk area. Size of sample: 7 x 8 cm.

mark Greenland's new interest in its rocks. The stone was discovered in the 1960s during the survey of the large iron deposit, Isukasia north of Nuuk and it was subsequently discovered at several localities in the Nuuk area. It was later established that the geological environment in which greenlandite was formed was in the order of 3.8 billion years old. This makes it one of the earth's oldest formations and accordingly the oldest gemstone in the world.

As a result of the dominant quartz with a hardness of 7, greenlandite is fairly hard and can readily be polished to a smooth surface which is often done as cabochons and plane slabs. Varying green and white streaks in the same piece can produce many variants of the stone. Thin slices are partially translucent, and are therefore well-suited to uses requiring light to pass through. Greenlandite is also well-suited as a dimension stone for use in decorations.

Greenlandite consists of quartzite with a green chromium-bearing mica, fuchsite, evenly distributed throughout, giving the stone a fresh green colour. Quartzite is made of fine-grained quartz, while the fuchsite resembles glitter with fine, small spangles distributed throughout the rock. It has a metallic inner glow deriving from its many spangles. This type of stone is also known among the jewellers as green aventurine quartz, also reported from Brazil and southern African localities. Experts will note that the colour of greenlandite is more bluish green than the foreign types. The potential of finding more raw material in Greenland is good in the Nuuk area. There has been no attempt to exploit greenlandite commercially so far.

Other semi-precious gems

Small occurrences of other traditional gemstones are also known in Greenland: Beryl (bluegreen), chalcedony (red, brown, green, blue and white), cordierite (dichroite), feldspar ('moonstone'), garnet,

peridot (olivine), quartz (rocky, smoky, amethyst), spinel (red), topaz (microcrystalline) and tourmaline (black) have been found in sporadic showings, some of them already popular as gem material and others still with an unproven potential as gems. Medium-hard minerals like cancrinite, natrolite, prehnite, sodalite (blue, yellow, green) and thulite are often used by local lapidarians in areas where they are familiar to the rock hounds. Like nummrite and greenlandite, a number of rocks have been polished and cabochon cut and have gained a reputation and trade status as unique Greenland gemstone souvenirs. Examples are graphic granite, kakortokite (eudialyte-rich nepheline syenite), naujaite (pokillitic nepheline syenite), tschermakite with ruby, and 'satellitestone' (a polychrome mixture of natrolite and sodalite). Such materials probably have a steady or slightly rising potential within a local home handicraft industry.



Concluding remarks

Greenland gemstones have played a quiet but important role as the bearer of a public understanding of mineral exploitation. With new opportunities for including precious gems such as diamond and ruby in this context, mineral exploitation of gemstones is moving from local scale to a much more widespread and important mineral resource business. The potential for such a development is certainly possible, at least based on recent exploration results. Additionally, Greenland could encounter more diversity in gemstone exploration, if the obvious potential for gem material in hard rock deposits is fully exploited.

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A 302 carat ruby chunk carved into various figurines. Carved by Thomas McPhee. Courtesy: True North.



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Front cover photograph

Exploration for rubies at Mikisoq near Appaluttoq. The field team examines a ruby rich horizon. Courtesy: True North.

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