# NOTES · AND · NEW TECHNIQUES

## A NEW GEM MATERIAL FROM GREENLAND: IRIDESCENT ORTHOAMPHIBOLE

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*Orthoamphiboles with pronounced iridescence are found in eight localities in the vicinity of Nuuk, the capital of Greenland. The iridescence, difficult to see on rough samples, becomes clearly visible when the material is cut. This iridescent orthoamphibole is mined by a company wholly owned by Nuuk commune, and is sold under the trade name Nuummite. This orthoamphibole has a composition similar to that of iridescent orthoamphiboles described earlier from Greenland as well as from New Hampshire and Massachusetts, but is believed to be the first such orthoamphibole to be regarded as a gemstone.*

In the early 1980s, the Geological Survey of Greenland had several geologists working the Nuuk area of West Greenland. The first-named author joined the field work in 1982, and devoted his attention to mineral deposits. During the work, some peculiar rusty horizons composed essentially of orthoamphiboles with small amounts of copper and iron sulfides and molybdenite were discovered. Subsequent microscopic investigations of thin sections revealed that the orthoamphiboles in some of the samples exhibited a weak iridescence. When pieces of this material were cut and polished as cabochons, they revealed a spectacular iridescence in different colors. It was thus realized that this type of iridescent orthoamphibole had a potential as a gemstone (figure 1; Appel, 1983).*

After the initial discovery, the authors conducted an investigation of the gemstone. It was decided, however, that the results should not be published internationally before a commercial production had started. Inasmuch as the material was recently introduced on the jewelry market in Greenland under the trade name Nuummite, we are now able to provide the gemological community with the following information on the location and occurrence of the material, its appearance, chemistry, and gemological properties, and the lapidary and commercial aspects.

### LOCATION AND OCCURRENCE

To date, the iridescent orthoamphiboles have been found in eight localities within 50 km (approximately 30 mi.) of Nuuk, the capital of Greenland.

*Orthoamphibole *is a group name for amphiboles that crystallize in the orthorhombic system. Gem-quality amphiboles are relatively uncommon. The best known are actinolite (nephrite) and tremolite.*

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*Acknowledgments: The authors are grateful to J. Lautrup, Geological Survey of Greenland, for photographing the cut and polished stones. The JEOL Superprobe on which the microprobe analyses were carried out was purchased with funds from the Danish Natural Science Research Council, and is operated under the supervision of J. Rønsbo, Institute of Mineralogy, University of Copenhagen, whose assistance with the analyses is greatly appreciated. Thanks are also due to E. S. Leonardsen, Institute of Mineralogy, University of Copenhagen, for performing the X-ray investigation, and to Peter Dawes for kindly improving the English of the manuscript. This article is published with the permission of the director of the Geological Survey of Greenland.*

Figure 1. The 2.8 cm × 3.7 cm cabochon of iridescent orthoamphibole that is shown here mounted in silver exhibits golden and greenish iridescence colors.

Nuummite Nuuk A/S, the company responsible for mining and distributing the gem material, does not wish to make the precise localities and mining operations public at this time.

The iridescent orthoamphiboles are found in a sequence of Precambrian rocks called the Malene supracrustals (figure 2), which are enclosed in extensive gneisses. Isotopic work shows that these rocks are more than three billion years old. The supracrustals comprise a varied sequence of rocks which have undergone strong deformation and metamorphism at temperatures of at least 550°C.

In spite of the metamorphism and deformation, it is possible locally to recognize original sedimentary and volcanic structures, such as sedimentary layering and pillow lava flows. These structures, as well as the chemistry of the rocks, indicate that the depositional environment of the Malene sediments was very similar to present conditions on the ocean floor. Most of the rocks in the Malene supracrustals have modern counterparts. However, some thin layers occur that have a


Figure 2. This map of the Nuuk area, West Greenland, shows the rock units (in gray) in which iridescent orthoamphiboles may be expected to occur.

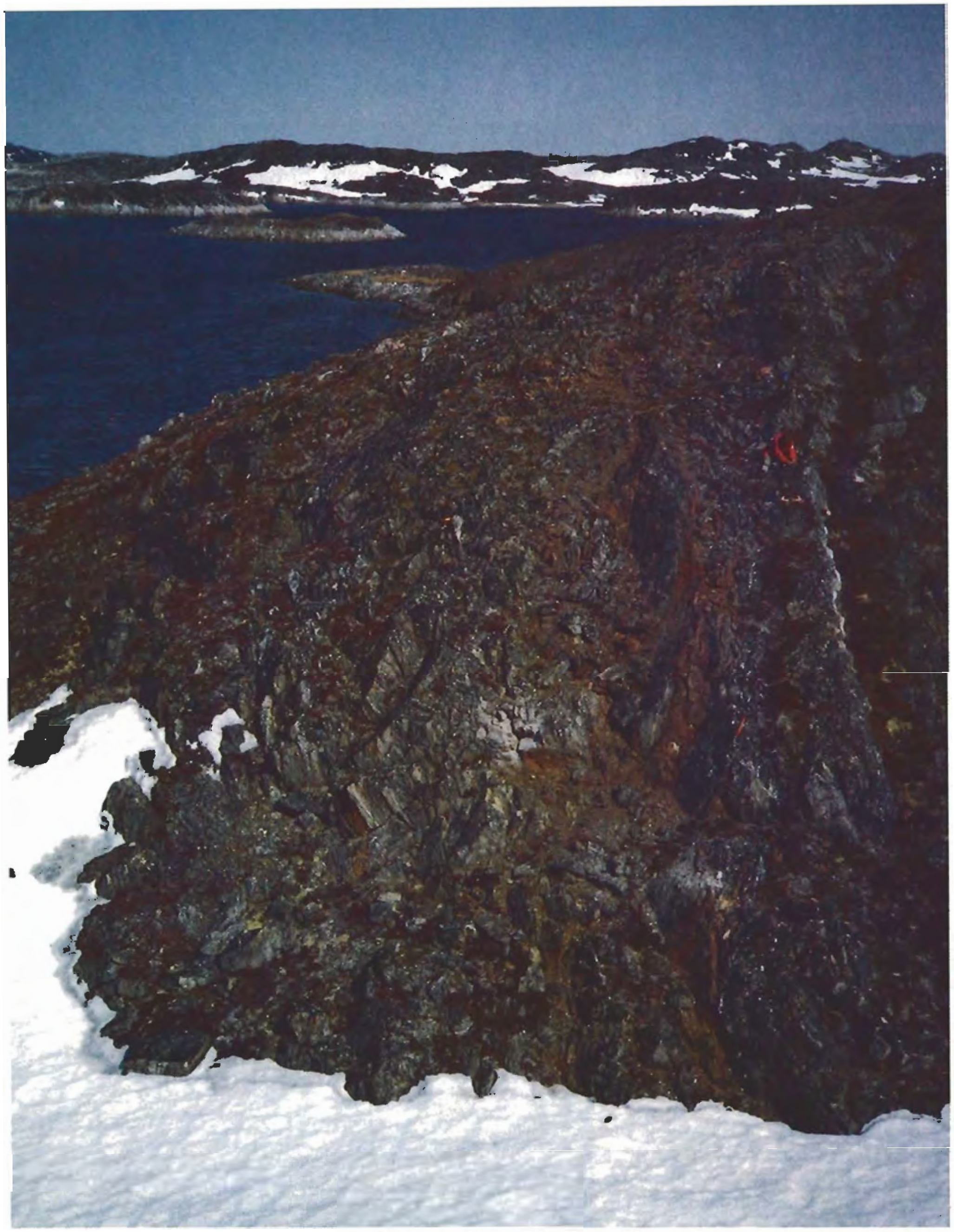

*Figure 3. The first locality where iridescent orthoamphiboles were found. The occurrences form lenses up to one meter wide in the slightly rusty band.*

rather peculiar chemistry: approximately 50% $SiO_2$, 10% $Al_2O_3$, and roughly equal amounts of FeO and MgO (about 18%). Modern counterparts with this chemistry are rare.

These peculiar layers are up to a few meters wide, and can be traced for several hundred meters along the strike. They consist almost exclusively of orthoamphiboles (anthophyllite-gedrite), with small amounts of pyrrhotite, chalcopyrite, magnetite, molybdenite, and gahnite. The amphiboles range in grain size from less than a millimeter to more than 10 cm. The rock is generally dull gray to black in appearance, and is locally slightly rusty because of weathering of the sulfides.

This rock type hosts the iridescent orthoamphiboles. In the field, however, it is very difficult to determine which samples contain the iridescent material. A couple of horizons were trenched by blasting and subjected to detailed sampling, but the quality of the material could only be determined in the field by cutting each sample with a portable diamond saw. The gem-quality material tends to occur as thin bands and lenses up to one meter wide, pinching and swelling along the strike. There is also an apparent tendency for the best-quality material to be situated in areas of high strain such as fold closures.

At present we do not know exactly how much gem-quality material is in the area. Two showings with iridescent orthoamphiboles have been found on the islands south of Nuuk. From one showing (figure 3) about 1200 kg of raw material has been

*Figure 5. This cabochon of iridescent orthoamphibole (4.1 cm × 2.6 cm) is the largest so far produced. It displays the whole range of iridescence colors, from violet at one end to green at the other.*

*Figure 4. As is common with the material, this raw sample of the orthoamphibole displays only weak iridescence.*

mined. Part of this material has been used for marketing studies and the rest will be used in the future production of jewelry. Horizons consisting almost of pure anthophyllite-gedrite are extensive, and there is thus a good possibility that more deposits will be found.

*Figure 6. This cabochon of iridescent orthoamphibole (3.0 cm in diameter) has slightly reddish to greenish golden iridescent colors.*

## DESCRIPTION

Raw samples of this orthoamphibole rarely display iridescence (figure 4); this phenomenon is apparent only when the stone is cut. Cut and polished cabochons show a sparkling iridescence that ranges from green and metallic blue through yellow to golden, reddish, and (rarely) violet colors (figures 5–7). Single cabochons may show the whole range of colors from one end of the cabochon to the other (figure 5). Most commonly, however, cut and polished stones exhibit one or two iridescence colors only (figures 1 and 6). In cabochons with two colors, the colors are usually from the same end of the spectrum, for example, green–

metallic blue or yellow-golden. Only a few stones show contrasting iridescence colors, for example, blue-golden or green-reddish.

The matrix of the iridescent grains ranges from light gray to almost black, in rare instances with a brownish tinge. The individual iridescent grains range in size from a few millimeters up to a couple of centimeters. Most grains show one iridescence color only, but a few large grains have been seen with a core of purple iridescence rimmed by reddish iridescent orthoamphibole.

There is some correlation between the size of the orthoamphibole grains and the iridescence color. Small grains display iridescence of different colors, whereas large grains (between half a centimeter to a couple of centimeters) most commonly show golden to reddish iridescence (figure 7). Still larger grains (up to 15 cm) exhibit no iridescence.

The number of iridescent grains varies from one or two per square centimeter to dozens per square centimeter. This feature implies a lower limit to the size of cabochons. Cabochons less than 0.5 cm long usually have too few iridescent grains to produce attractive jewelry. The largest cabochon produced to date is 4.1 cm × 2.6 cm (again, see figure 5).

*Figure 7. The large orthoamphibole grains in this 2.3 cm × 4.0 cm cabochon exhibit a striking golden iridescence.*

## CHEMISTRY

**Previous Studies.** Iridescent orthoamphibole was first mentioned by Bøggild (1905, 1924), who described a specimen collected in the Nuuk area, West Greenland, by K. L. Giesecke in 1810. Bøggild established that the iridescence occurred parallel to the pinacoid (010). Robinson et al. (1969) showed that some orthoamphiboles from Massachusetts and New Hampshire were composed of lamellae parallel to (010) that were just resolvable at high-power magnification.

The orthoamphiboles are considered to be a solid-solution series between the end members anthophyllite $(Mg,Fe)_7Si_8O_{22}(OH)_2$ and gedrite $Na_{0.5}(Mg,Fe)_{5.5}Al_{1.5}(Si,Al)_8O_{22}(OH)_2$ (Robinson et al., 1971). These authors also showed that blue, green, and yellow iridescence occurs where lamellae are so thin (less than 0.2 $\mu$m) that their presence can only be seen by X-ray data; samples with lamellae thick enough to be seen under the microscope generally have no iridescence. In addition, they showed that gedrite lamellae are coarser (0.8 $\mu$m) than anthophyllite lamellae (0.2 $\mu$m), and that the chemical composition of their iridescent samples is similar to that of the sample that was described by Bøggild (1905): $Na_{0.43}(Mg,Fe)_{6.1}Al_{0.8}(Al_{1.0}Si_{7.0})O_{22}(OH)_2$ with a trace of Ca (0.13) and a ratio of Fe/Mg of 0.45. Christie and Olsen (1974) report blue iridescence in an orthoamphibole with the composition $Na_{0.33}(Mg,Fe)_{6.4}Al_{0.6}(Al_{1.2}Si_{6.8})O_{22}(OH)_2$ with a trace of Ca (0.10) and a ratio of Fe/Mg of 0.69.

The cell dimensions of anthophyllite and gedrite are very similar: $\underline{a}$ and $\underline{c}$ values are practically identical and the difference in the $\underline{b}$ value is in the order of 1%. Ross et al. (1969) report for anthophyllite, $\underline{a} = 18.54–18.58$ Å, $\underline{b} = 17.98–18.11$ Å, $\underline{c} = 5.27–5.30$ Å; and for gedrite, $\underline{a} = 18.54–18.60$ Å, $\underline{b} = 17.76–17.88$ Å, $\underline{c} = 5.27–5.30$ Å.

**Present Investigations.** The X-ray powder diffraction pattern of the material from Nuuk showed the presence of an orthoamphibole with a few weak lines of an unidentified mineral phase. Most of the powder lines could be satisfactorily indexed with the orthorhombic unit cell $\underline{a} = 18.57$ Å, $\underline{b} = 17.77$ Å, $\underline{c} = 5.28$ Å (all $\pm 0.02$ Å), found by the least-squares refinement of 30 unequivocally indexed powder lines. This unit cell indicates that the material is close to gedrite.

Electron microprobe analyses* of the orthoamphibole from Greenland gave a variation from $Na_{0.17}(Mg,Fe)_{6.3}Al_{0.7}(Al_{0.9}Si_{7.1})O_{22}(OH)_2$ to $Na_{0.29}(Mg,Fe)_{6.3}Al_{0.7}(Al_{1.0}Si_{7.0})O_{22}(OH)_2$ with a trace of Ca (0.07) and an Fe/Mg ratio varying from 0.59 to 0.62. According to Leake (1978), the orthoamphibole with $Na_{0.17}$ is an anthophyllite, whereas the one with $Na_{0.29}$ is just on the gedrite side of the border between anthophyllite and gedrite.

The variation found, however, cannot be expected to represent the composition of anthophyllite and gedrite lamellae, respectively, as these lamellae, in the iridescent areas, are less than 0.2 $\mu$m, and the analyzing spot of the electron microprobe is slightly less than 2 $\mu$m.

Thus in an attempt to obtain analyses closer to the composition of the respective anthophyllite and gedrite lamellae, the electron microprobe analyses were extended to include noniridescent areas of the orthoamphibole, inasmuch as the lamellae are known to be broader in noniridescent areas than in iridescent areas. The electron microprobe analyses of noniridescent areas did not result in anthophyllites with a lower Na content than was already obtained from iridescent areas, but to the gedrite side the composition was extended to $Na_{0.38}(Mg,Fe)_{6.0}Al_{1.0}(Al_{1.4}Si_{6.6})O_{22}(OH)_2$ with a trace of Ca (0.04) and an Fe/Mg ratio of 0.58. That the composition could be extended only to the gedrite side is in agreement with the earlier findings that gedrite lamellae are always coarser than anthophyllite lamellae (Robinson et al., 1971; Christie and Olsen, 1974; Spear, 1980).

It is therefore concluded that the orthoamphibole from Greenland consists of alternating anthophyllite-gedrite lamellae and has a composition similar to other iridescent orthoamphiboles described by Bøggild (1905), Robinson et al. (1971), and Christie and Olsen (1974).

*Electron microprobe analyses were carried out with a JEOL Superprobe JCXA 733 using the PACX-program (WDS) as well as the LINK EDS program 4/FLS+, with 15 kV accelerating voltage and 20 respectively 1.0 nA.*

## GEMOLOGICAL PROPERTIES

Refractometer measurements show that the indices of refraction of the orthoamphibole from Greenland average $\alpha = 1.64$ and $\gamma = 1.66$, with a birefringence of 0.02. Material from the locality where the material was initially found (figure 3) has $\alpha = 1.641$ and $\gamma = 1.663$, with a birefringence of 0.022, whereas material from the second locality has $\alpha = 1.635$ and $\gamma = 1.657$, also with a birefringence of 0.022.

The density of the orthoamphibole from the first locality is generally 3.24 g/cm$^3$ but can vary between 3.20 g/cm$^3$ and 3.37 g/cm$^3$, while the density of the material from the second locality is a rather constant 3.18–3.19 g/cm$^3$.

When exposed to ultraviolet radiation, shortwave as well as long-wave, the orthoamphibole fluoresces dark violet.

Cabochons of the orthoamphibole have been placed in a window and exposed to sunshine for more than a year without showing any change in appearance.

It has not been possible to obtain results with the spectroscope when working on cabochons, but spectroscopic investigation in transmitted light on approximately 1-mm thin slices has revealed a general absorption from the blue end to about 485 nm, and two rather broad absorption lines at 505 and 545 nm.

## CUTTING AND POLISHING

Orthoamphiboles have a hardness of 6. The iridescent orthoamphiboles from Nuuk are coarse to medium grained. The crystals have locally a slight tendency to parallel alignment, as a result of which the rock has to be cut in certain specific directions in order to obtain a stone with maximum iridescence.

Polishing of the orthoamphiboles entails no special difficulties, inasmuch as the rock is generally massive with no pervasive cracks occurring in fresh material. However, material near the surface tends to have small cracks. In spite of the rather low hardness of the stone, we found that it cannot be polished satisfactorily with either tin oxide or cerium oxide, and final polishing is best done with diamonds 3 $\mu$m in size.

## COMMERCIAL ASPECTS

The commercial possibilities for the stone have been discussed since 1982, when the gem potential of the iridescent orthoamphiboles was determined.

First, the town council of Nuuk gave the stone the trade name Nuummite, which means "derived from Nuuk" in Greenlandic. Next, the company Nuummite Nuuk A/S, wholly owned by Nuuk commune, was established. The government granted the company an exploration concession for Nuummite in the Nuuk area, as well as permission to manufacture and sell Nuummite jewelry. The company, based in Nuuk, now employs one full-time goldsmith and three to four lapidaries to cut and polish the gem material. A continuous production has not yet been established. The stone was launched on the Greenlandic market before Christmas 1986, and the jewelry will subsequently be marketed in Denmark. The company plans to introduce Nuummite internationally at a later date.

Nuummite Nuuk A/S has so far marketed jewelry with Nuummite mounted in both gold and silver, and has sold unmounted cut and polished cabochons. The most important items are pendants, but some rings have also been produced.

*Editor's Note: The material submitted by the authors to GIA has a spangled pattern associated with aventurescence. Each "spangle" or bright reflection is reminiscent of labradorescence.*

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