Tourmaline in Precambrian supracrustal rocks from Aasiaat, central West Greenland

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Close to the town Aasiaat/Egedesminde supracrustal rocks outcrop on some small islands situated around the position 68°46′N and 52°38′W. The largest of these islands, Isuamiut, is barely a few kilometres long and the islands are situated more than 10 km from the mainland.

On Isuamiut two tourmaline-rich layers or tourmalinites have been found (Ellitsgaard-Rasmussen, 1954). Tourmalinite is a peculiar rock type consisting mainly of tourmaline together with quartz, feldspar or mica, sometimes with appreciable amounts of sulphides and/or scheelite. The chemical composition of the tourmaline in tourmalinites is to some extent indicative of the genesis of the boron. I therefore decided to collect some samples of tourmaline on Isuamiut when passing the area on a boat journey along the west coast of Greenland during July 1987.

Geology of the islands

The islands have been mapped in detail by Ellitsgaard-Rasmussen (1954). The following brief description of the geology is based on his work, but includes some further information gathered during the short visit to the islands.

The supracrustal rocks consist largely of metasediments and some metavolcanics which have been intruded by metagabbros. The metasediments comprise a surprisingly wide sedimentological set of rocks, ranging from very fine-grained black shales to coarse-grained metaconglomerates together with metamorphosed sandstones, quartzites and carbonate layers. The black shales which are found in layers up to tens of metres wide are rusty-weathering rocks sometimes stained with malachite and locally with appreciable amounts of graphite, pyrrhotite and small amounts of chalcopyrite. These layers can be traced for hundreds of metres along strike. The metamorphosed sandstones occur as metre-wide light grey to white layers with occasional clasts. The conglomerate layers are up to one metre wide with rounded to slightly angular pebbles which are up to 30 cm long. The carbonates occur as yellowish weathering layers up to one metre wide.

On the south-western part of Isuamiut a sequence of green mica schists, tens of metres thick with scattered grains of hornblende occur in which tourmaline-rich layers are seen (see below).

A thick sequence of staurolite-rich metasediments occurs on a small island south-east of Isuamiut. The staurolite crystals are up to 10 cm long and locally make up more than 50% of the rock. Staurolite has not been observed on the other islands.

Intercalated in the metasediments are frequent thin amphibolites which are locally quite rich in garnets. These amphibolites may represent basic tuffs.

The supracrustals have been repeatedly folded and metamorphosed under low- to medium-grade amphibolite facies. Subsequent to the deformation some carbonate and quartz veining has taken place.

Tourmalinites

Tourmalinites occur as layers up to a few tens of centimetres wide in the green mica schists of south-western Isuamiut. They are stratiform (Ellitsgaard-Rasmussen, 1954) and can be traced for some tens of metres along strike. The mica schists have up to 30% tourmaline. The tourmaline is black and often appears as clusters up to 5 cm long containing almost 100% tourmaline as fine crystals.

The tourmaline-bearing chlorite schists are cut by carbonate veins near which calcic amphiboles and thin massive tourmalinites are found. The carbonate veins have been deformed and at a later stage the tourmaline-rich schists have been cut by quartz veins. These quartz veins contain no tourmaline, but thin massive tourmalinites have been developed along their contacts.

On some foliation planes of the green mica schists very coarse-grained black tourmaline occurs. The tourmaline is up to 10 cm long sub- to euhedral crystals which have been broken up during deformation. These coarse tourmaline crystals and the tourmaline clusters are surrounded by a tourmaline-free halo of green mica schist.

In thin section the tourmaline is mostly brown to brownish green without any zonation. However, in some of the massive tourmalinite next to quartz and carbonate veins many of the tourmaline crystals display a well-developed zonality. These tourmalines consist of a light bluish centre surrounded by a brownish rim, and have sharp borders between the centres and rims.

Table 1. Microprobe analyses of homogeneous tourmalines

Sample No. (No. of analyses)	341214A (10)	341214 (11)	341215 (10)	341217 Centre (15)	Rim (15)
SiO_2	36.12	35.88	36.31	36.37	35.90
TiO_2	0.80	0.51	0.26	0.43	1.13
Al_2O_3	30.70	30.33	30.47	31.70	29.82
FeO	7.07	6.94	6.02	7.57	7.97
MgO	7.11	7.21	8.21	6.31	6.91
CaO	1.20	1.32	1.59	0.76	1.34
Na_2O	1.91	2.02	2.01	1.96	2.00

341214, 321214A, 341215 homogeneous tourmaline.
341217 zoned tourmaline.

All results in percent.

Chemistry of the tourmalines

Tourmalines from three samples of chlorite schist and one sample of massive tourmalinite next to a quartz vein have been analysed on a Jeol Super 733 microprobe using olivine, corundum, wollastonite and hematite as standards at 15 kV and 20 nA.

A total of 61 microprobe analyses were carried out where each analysis is an average of four analyses carried out 10 μapart. The results are listed in Table 1. The tourmalines have also been analysed for potassium, manganese and chromium, all of which appear in quantities at or below the detection limit.

The chemical composition of the tourmalines compares fairly well with that of tourmalines in tourmalinites from the Malene supracrustal rocks in the Nuuk area (Appel & Garde, 1987). The optical zonality observed in the tourmalines from the massive tourmalinites next to quartz veins is obviously due to significant differences in chemical composition between centres and rims of the tourmalines as shown in sample 341217 (Table 1). Sodium occurs in the same concentrations in the centres and rims, whereas MgO, CaO, TiO_2 and FeO are enriched in the rims of the zoned tourmalines and Al_2O_3 and SiO_2 show highest concentrations in the centres of the zoned tourmalines compared with the rims. These relationships correlate very well with the chemical zonation in zoned tourmalines from the Malene supracrustal rocks (Appel & Garde, 1987).

Conclusion

Until recently tourmaline was regarded as a mineral of granitic pedigree, but during the last decade it has become increasingly recognised that tourmaline can also be formed by other processes. In greenstone belts in North America and in Australia stratiform tourmalinites have been recognised and have been interpreted as products of submarine exhalative activity (Slack, 1982; Plimer, 1983). Recently similar stratiform tourmalinites have been recognised in the Malene supracrustal rocks of the Nuuk area, West Greenland (Appel, 1985; Appel & Garde, 1987) where they have been interpreted as exhalites which were precipitated on the sea floor contemporaneously with the deposition of the mafic tuffs which are frequently their hosts.

In his detailed description of the tourmaline-rich rocks in the supracrustals at Isuamiut, Ellitsgaard-Rasmussen (1954) interpreted the tourmalines as stratiform and suggested that the boron was derived from sea water and scavenged by precipitating clay minerals. His suggestion, which was quite controversial in the fifties, is in close agreement with the most recent theories regarding formation of tourmalinites.

The geological setting and the chemical composition of the Isuamiut tourmalines correspond very well with the composition of tourmalines found in metamorphosed pelitic sediments in the Archaean Malene supracrustal rocks (Appel & Garde, 1987).

The following mode of formation of the Isuamiut tourmaline-rich rocks is proposed. Boron, possibly of submarine exhalative origin, in sea water was scavenged by clay minerals. This first step is substantiated by the fact that certain clay minerals are able to scavenge appreciable amounts of boron, resulting in a pelite with up to 1000 ppm boron (Reynolds, 1965). After deposition of the boron-rich clay minerals at Isuamiut, tourmaline was formed during diagenesis at an early stage of metamorphism, resulting in fine-grained tourmaline crystals, more or less evenly distributed throughout the mica schist.

During prograde metamorphic conditions when the temperatures reached 400 to 500°C (Weisbrod, 1987) the solubility of tourmaline increased considerably, during which period the tourmaline-rich clusters and fairly coarse-grained tourmalines, which appear brownish in thin section, were formed. After the first deformation the tourmaline-rich mica schists were intruded by thin carbonate veins followed by thin quartz veins, the tourmaline then migrated at high temperatures to low pressure zones in the vicinity of the carbonate and quartz veins, and the bluish cores of the tourmalines were formed. The brownish rims around the bluish cores were formed at a later stage.

The presence of tourmaline-rich rocks and tourmalinites in supracrustal rocks has often been taken as an indication of economically interesting mineralisation such as the tourmalinites associated with the Broken

Hill ore body, Australia (Plimer, 1983). It seems therefore worthwhile to look closer at the supracrustal rocks at Isuamiut and at their conterparts on the mainland in order to locate interesting mineralisation such as massive sulphide ore bodies.

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Corundum crystals with blue-red colour zoning near Kangerdluarssuk, Sukkertoppen district, West Greenland

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Results are presented of field work at a corundum locality near the head of Kangerdluarssuk, east of Maniitsoq/Sukkertoppen, West Greenland. The authors carried out geological mapping and sampling over four days in August 1987 to evaluate the quality of the corundum as a possible gemstone.

Previous investigations

The corundum locality has probably been known to the local population for a long time. It was first visited by geologists in 1977 during reconnaissance mapping by GGU. The locality is mentioned by Secher *et al.* (1982), and by Petersen & Secher (1985) who reported rose red bipyramidal corundum crystals up to 15 cm long.

General geological setting

The Sukkertoppen district, which is part of the Archaean of southern West Greenland, has only been covered by reconnaissance geological mapping at a scale of 1:500 000 (Noe-Nygaard & Ramberg, 1961; Allaart *et al.*, 1978; Allaart, 1982). The area consists of granulite and upper amphibolite facies, quartzofeldspathic gneisses and supracrustal rocks, mostly amphibolites and their granulite facies equivalents, as well as clastic metasediments which are common in this part of the Archaean basement, e.g. on Hamborger Land north of Maniitsoq. Pods and lenses of ultrabasic rocks, sometimes several hundred metres long, occur within the supracrustal sequences and most commonly consist of ortho- and clinopyroxene and lesser olivine, together with Mg-rich amphibole and various low-grade alteration products.

Country rocks at the corundum locality

In the vicinity of Kangerdluarssuk there are several sequences of supracrustal amphibolites and metasediments with local ultrabasic lenses in the gneisses. The structural trend is persistently north-east with sub-vertical dips and a strong planar fabric particularly well developed in the metasediments.

The corundum locality occurs within one of these supracrustal sequences at the contacts between two small lensoid ultrabasic bodies and a spectacular horizon of bluish and rusty kyanite-garnet schist (fig. 1). The ultrabasic bodies are situated entirely within the metasediments which are in turn intercalated between calc-silicate banded and veined amphibolites. Pegmatites composed of quartz, feldspar, mica and occasionally black tourmaline occur within the amphibolites in the vicinity of, but not immediately adjacent to, the corundum locality.