MICROFOSSIL-LIKE TOURMALINE MICROLITES IN EARLY PROTEROZOIC NODULAR CHERT AT KIIHTELYSVAARA, EASTERN FINLAND

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Many Proterozoic silicified sedimentary carbonates have been reported to contain remains of early micro-organisms. One of these localities in the Fennoscandian Shield is the village of Hyypiä at Kiihtelysvaara in eastern Finland, where a nodular chert contains microfossil-like objects, named *Hyypiana jatulica* n. gen., species R. Tynni.

The original thin sections and grain mounts from Kiihtelysvaara were reinvestigated petrographically, and similar objects in a new grain mount from the original drill core specimen were analysed using microprobe. Petrographical and geochemical results prove that the microfossil-like objects in these samples from the nodular chert at Kiihtelysvaara are mineralogic pseudomicrofossils consisting of tourmaline microlites. Their chemical composition is similar to dravitic tourmalines from a cherty dolomite formation located in Kuusamo, eastern Finland.

Key words: microfossils, pseudomicrofossils, *Hyypiana jatulica*, tourmaline, dravite, chert, dolostone, Proterozoic, Hyypiä, Kiihtelysvaara, Finland.

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Introduction

Tynni and Sarapää (1987) described small bacteria-shaped objects in chert nodules from an early Proterozoic dolomite formation in the village of Hyypiä at Kiihtelysvaara, eastern Finland. The most characteristic form of the objects is a 15—40 µm long cylindrical rod containing abundant spiral chains or swarms of small dots less than 1 µm in diameter. Based on the morphology, Tynni and Sarapää (1987) suggested that the microfossil-like objects may be early sulphur bacteria resembling the extant *Beggiatoa* bacteria and named them *Hyypiana jatulica* n. gen., species R. Tynni.

Given that our knowledge of the types of Proterozoic micro-organisms that existed is very limited, the suggestion of Tynni and Sarapää (1987) was reasonable. However, many inorganic objects effectively mimic biogenic morphologies and make identification difficult. According to Hofmann and Schopf (1983) at least 40 occurrences of microfossils or microfossil-like objects are known from early Proterozoic rocks, but of these only 24 contain unequivocal microfossils. Schopf and Walter (1983) discuss reports on Archean microfossils and mention that a vast majority of them are now considered to be non-fossils of four possible types: (1) mineralogic pseudomicrofossils including mineralic dendrites and microcrystallites, (2) organic pseudofossils, (3) artifacts of sample preparation and (4) modern micro-organism contaminants.

Here we apply petrographical and geochemical methods to show that the microfossil-like objects described by Tynni and Sarapää (1987) are, in fact, mineralogic pseudomicrofossils consisting of tourmaline microlites.

Geologic setting and sample material

Microfossil-like objects discovered by Tynni and Sarapää (1987) occur in chert nodules within a dolomitic unit of the Viistola Formation (Pekkarinen and Lukkarinen 1991), which forms part of the early Proterozoic cover sequence deposited on the Archean platform. The geology of the area has been described by Pekkarinen (1979) and Pekkarinen and Lukkarinen (1991).

The drill core specimen (R310/185.50m) and thin sections studied by Tynni and Sarapää (1987) were kindly made available by the authors. Unfortunately the original thin sections and grain mount investigated by them did not contain any points suitable for microprobe analysis. Therefore, we used part of the original specimen and prepared a new HF-HCl acid residue, which was mounted on epoxy and polished for analysis by electron microprobe. Figure 1 shows that the microfossil-like objects analysed from the new grain mount correspond to the description and figures in Tynni and Sarapää (1987). In figure 2 these objects are seen between crossed polarizers in the original grain mount (GSF-760) studied by Tynni and Sarapää (1987).

As a comparison we investigated another metamorphosed dolomite rock occurrence at Särkilampi in Kuusamo, northern Finland. Here the dolomite rock contains folded layers of almost pure quartz interpreted as recrystallized chert beds. The stromatolitic dolomite rock at this locality has been described by Pekkala (1985), and the general geology of the area has been presented by Silvennoinen (1972) and Pekkala (1985). The Särkilampi dolomite rock occurs as interlayers in the Sericite Schist Formation lying stratigraphically between Greenstone Formations I and II (Silvennoinen 1972, Pekkala 1985). These formations belong to the early Proterozoic cover sequences deposited on the Archean platform.

Petrography

From the Kiihtelysvaara locality both the original grain mount (GSF-760) of Tynni and Sarapää (1987) and the new grain mount prepared for this study were investigated petrographically. Under a microscope the studied microfossil-like objects in the samples are crystalline in appearance (Figs. 1 and 2) as already noted by Tynni and Sarapää (1987). The 15—40 μm long microlites are usually colourless in thin section, although some grains are weakly pleochroic displaying faintly brownish color perpendicular to the long axis of the cylindrical objects. They show moderate birefringence and straight extinction with negative elongation. These characteristics suggest that the microlites may be tourmaline. Additional features typical

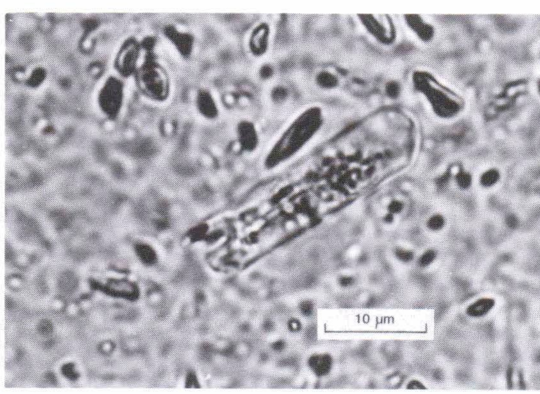

Fig. 1. A typical inclusion-bearing tourmaline microlite in the HF-HCl residue of the nodular chert at Kiihtelysvaara, eastern Finland. The residue was prepared from the drill core sample R310/185.50 studied by Tynni and Sarapää (1987).

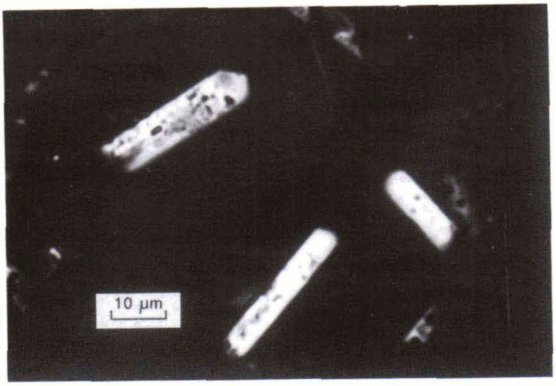

Fig. 2. Inclusion-bearing tourmaline microlites in the original grain mount (GSF-760) studied by Tynni and Sarapää (1987). Note the crystalline appearance and the birefringence of the microlites between crossed polarizers.

for tourmaline are insolubility of the crystals in cold HF and the macroscopic polar properties of the microlites. Prismatic crystals commonly show only a single termination (Figs. 1 and 2) and doubly terminated crystals are hemimorphic showing different forms at opposite ends of the crystals (see Tynni and Sarapää 1987, Fig.5).

The maximum refractive index (ω) of the microlites in the original grain mount is practically equal to that of the mounting medium. The fixing agent used for the grain mount was not mentioned by Tynni and Sarapää (1987), but according to A. Uutela (Geological Survey of Finland, pers. communication, 1992) preparates were very probably made using Clophenharpix as a medium (see also Uutela 1989). We measured a refractive index of 1.639 for Clophenharpix, which is a typical value for ω in tourmalines with low contents of Fe and Mn (Deer *et al.* 1986).

The metachert from Kuusamo contains tourmaline as a relatively abundant accessory mineral. However, here the size of the tourmaline crystals is larger than in the Kiihtelysvaara samples, ranging from less than 10 µm to 100 µm in length, and also pleochroism is distinct with ε = yellowish green and ω = green. Only a few tourmaline grains were observed to contain inclusions and these inclusions were distributed more or less randomly in the crystals.

Analytical techniques

Analyses of the grain mount from the Kiihtelysvaara sample and of the thin section from Särkilampi were carried out at the Geological Survey of Finland in Espoo, using a JEOL 733 electron microprobe. Conditions for microprobe analyses were 15 kV acceleration potential and 15 nA sample current. Standards included natural minerals and oxides. Data were corrected using an on-line ZAF correction program.

Analytical results

The average compositions of five analysed tourmaline microlites from Kiihtelysvaara and

Table 1. Microprobe analyses of tourmaline: mean values for Kiihtelysvaara and Kuusamo

	Kiihtelys-vaara	Kuusamo
SiO_2	36.59	38.67
TiO_2	0.20	0.29
B_2O_3*	10.62	10.86
Al_2O_3	29.83	31.00
FeO	6.31	3.65
MnO	0.06	0.01
MgO	9.80	9.64
CaO	0.57	0.36
Na_2O	3.01	2.75
Total	96.98	97.23
n	5	4
Number of ions on the basis of 29 oxygens		
Si	5.989	6.189
B	3.000	3.000
Al	5.755	5.849
Fe	0.864	0.489
Mn	0.008	0.001
Mg	2.391	2.299
Ti	0.024	0.035
Ca	0.100	0.062
Na	0.956	0.853

* Calculated assuming 3 boron atoms in the structural formula

four tourmaline grains from Kuusamo are given in Table 1. The compositions of the individual tourmaline grains in molecular proportions have been plotted on an Al-Fe(tot)-Mg diagram in Figure 3. The weight percent oxide ratios $Na_2O/(Na_2O+CaO+K_2O)$ and $FeO/(FeO+MgO+MnO)$ are plotted in Figure 4. On the diagrams the analytical results are compared with the data of Dietvorst (1981) and Haataja (1987) on dravites from metamorphic supracrustal formations in southern Finland.

Discussion

Comparison of the analytical results from Kiihtelysvaara to those from Kuusamo and to analytical data from the literature confirms that the microlites in the Kiihtelysvaara nodular chert are dravite crystals (Figs. 3 and 4). It follows that the abundant dot swarms and spiral chain colonies of small dots described by Tynni and Sarapää (1987) are best interpreted as inclusion chains. The physical state and composition of these inclusions, however, is still not known.

Inclusions of tourmaline have been studied especially in tourmaline gemstones, in which the crystal growth is not strictly comparable to the diagenetic or metamorphic crystallisation at Kiihtelysvaara. In tourmaline gemstones various mineral, fluid and multiphase inclusions have been recorded (Dietrich 1985). The most typical of these are threadlike, fluid or multiphase inclusions, so called trichites (Gübelin 1979). They may either occur singly or form complex net-

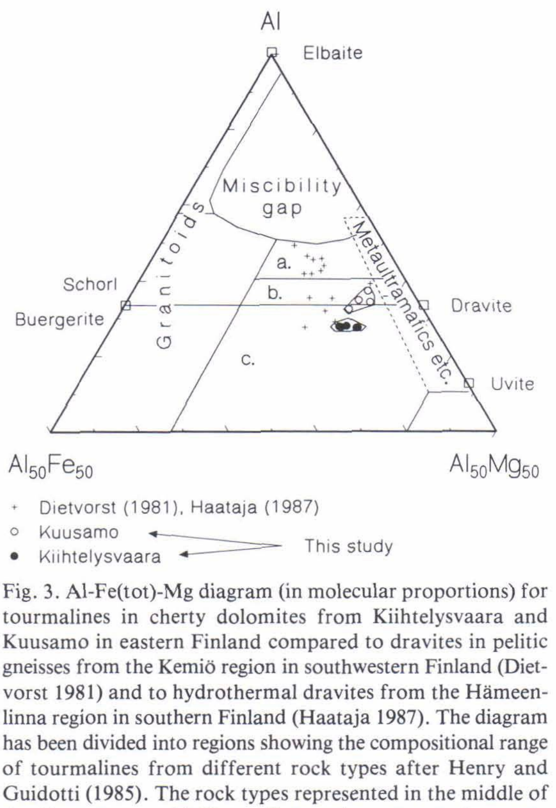

Fig. 3. Al-Fe(tot)-Mg diagram (in molecular proportions) for tourmalines in cherty dolomites from Kiihtelysvaara and Kuusamo in eastern Finland compared to dravites in pelitic gneisses from the Kemiö region in southwestern Finland (Dietvorst 1981) and to hydrothermal dravites from the Hämeenlinna region in southern Finland (Haataja 1987). The diagram has been divided into regions showing the compositional range of tourmalines from different rock types after Henry and Guidotti (1985). The rock types represented in the middle of the diagram are : (a) Metapelites and metapsammites coexisting with an Al-saturating phase, (b) Metapelites and metapsammites not coexisting with an Al-saturating phase and (c) Fe^{3+}-rich quartz-tourmaline rocks, calc-silicate rocks and metapelites. Pure end-member compositions are given for reference.

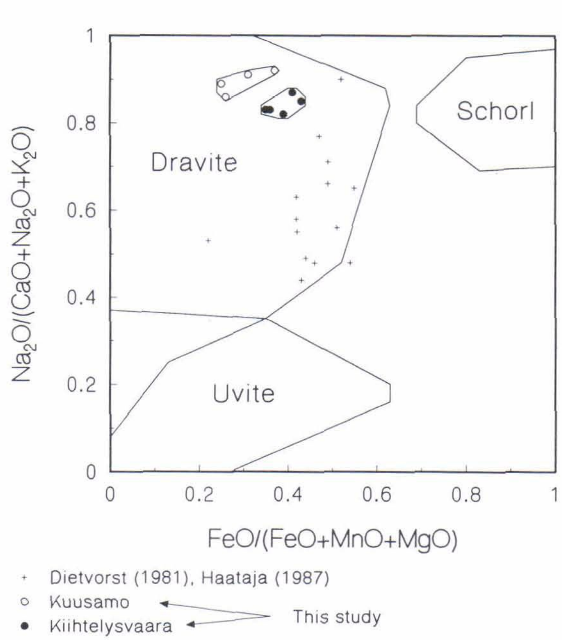

Fig. 4. Compositions (in weight ratios) of tourmalines in cherty dolomites from Kiihtelysvaara and Kuusamo in eastern Finland compared to dravites in pelitic gneisses from the Kemiö region in southwestern Finland (Dietvorst 1981) and to hydrothermal dravites from the Hämeenlinna region in southern Finland (Haataja 1987). The compositional fields for dravite, schorl and uvite have been drawn to include all analytical data on these minerals in the compilation of Deer *et al.* (1986).

works. However, in the tourmaline grains from Kiihtelysvaara, the inclusions are composed of single subspherical dots, clearly differing from trichites.

Schmetzer *et al.* (1977) described a spiral inclusion of unknown identity winding parallel to the c-axis within a gem-type dravite crystal, and explained it as a spiral growth structure. Although the appearance of the inclusion described by Schmetzer *et al.* (1977) is different, we suggest a similar origin for the spiral dot filaments of the Kiihtelysvaara tourmalines.

Compared to the tourmalines from Kuusamo and Kiihtelysvaara, many of the tourmalines analysed by Dietvorst (1981) and Haataja (1987) show higher relative Al-contents. On the Al-Fe(tot)-Mg diagram they fall in the field (Fig. 3, field a) typical for metapelites and metapsammites coexisting with an Al-saturating phase (Henry and Guidotti 1985). Also the ratio of Fe to Mg is higher in the Dietvorst (1981) and Haataja (1987) data, indicating a higher content of schorl end-member in these tourmalines.

All Kiihtelysvaara dravites are low in Al and fall in a region (Fig. 3, field c) which is typical for various Fe^{3+}-rich rocks, for instance Fe^{3+}-rich calc-silicate rocks (Henry and Guidotti 1985). This may indicate a small ferridravite component, in which Fe^{3+} is substituting for Al in the Z-site. In the Kiihtelysvaara stratigraphic section the abundance of Fe^{3+} is demonstrated by a compact hematite rock unit of the Annala Formation lying stratigraphically immediately above the Viistola formaton (Pekkarinen 1979, Pekkarinen and Lukkarinen 1991).

The ratio of Ca to Na is very low in the dravite crystals from Kiihtelysvaara and Kuusamo (Fig. 4), and the calculated uvite end-member is below 10% in both cases. This is contrary to what is normally found in tourmalines within metamorphosed limestones (Dunn *et al.* 1977). However, dravite grains in Kiihtelysvaara and Kuusamo are enclosed in cherts within metamorphosed dolomite units, which may explain this feature.

Conclusions

Petrographical investigation of the microfossil-like objects in the original grain mount (GSF-760, Tynni and Sarapää 1987) and microprobe analyses of similar objects in a new grain mount prepared from the same drill core specimen lead to the following conclusions:

1. The identification of the small HF resistant objects in the Kiihtelysvaara chert as microfossils by Tynni and Sarapää (1987) seems to be incorrect. Petrographic characteristics and microprobe analyses suggest that they all, in fact, are inclusion-bearing tourmaline microlites.

2. Their chemical composition is similar to that found in tourmalines from a chert occurrence within a dolomite formation located in Kuusamo.

3. Tourmaline species within the cherty dolomites from Kiihtelysvaara and Kuusamo is dravite, in which the proportions of uvite and schorl end-members are lower than in dravites from metamorphic supracrustal formations in southern Finland.

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