Precambrian Stratigraphy in the Masi Area, Southwestern Finnmark, Norway

ARNE SOLLI

Solli, A. 1983: Precambrian stratigraphy in the Masi area, southwestern Finnmark, Norway. *Norges geol. Unders. 380,* 97–105.

The rocks in the Masi area consists of a comformable stratigraphic sequence containing three formations. The lowest is the Gål'denvarri formation, mainly containing metamorphic basic volcanics. Above this is the Masi Quartzite with a conglomerate at its base. The upper formation in the Masi area is the Suoluvuobmi formation containing metamorphic basic volcanics, metagabbros, mica schist, graphitic schist and albite fels. The eastern part of the area is dominated by granites which have an intrusive relationship to all three formations. Remnants of the Archean basement situated further to the east probably occur within the younger granites. Nothing conclusive can be said about the ages of the rocks, but for the Gål'denvarri formation an Archean age is considered most probable. The ages of the Masi Quartzite and Suoluvuobmi formation may be Svecokarelian, but based on correlation with rocks in Finland, Archean ages also seem likely for these units.

A. Solli, Norges geologiske undersøkelse, P.O.Box 3006, N-7001 Trondheim, Norway.

Introduction

The central part of Finnmarksvidda is occupied by a dome structure of Archean granitic gneisses (Fig. 1). On each side of the dome are supracrustal rocks. To the east is the Karasjok region, and to the west is the Kautokeino–Masi region with the same types of rocks even though no direct correlation has yet been established between the two regions. Greenstones, quartzites and mica schist are the dominating rock types. A brief summary of the geology of Finnmarksvidda is given by Skålvoll (1978), and Fig. 1 mainly follows his map.

The Archean age of the central gneiss dome is indicated by a U/Pb whole-rock age determination of 2800 m.y. (Skålvoll 1972, Meriläinen 1976). Just to the south of Skoganvarre (Fig. 1) the gneiss is overlain by a quartzite unit which has a conglomerate at the base with pebbles similar to the underlying gneiss. Skålvoll (1978) interprets this conglomerate as the lowest part of the Proterozoic on Finnmarksvidda. The greenstones in western Finnmark are commonly said to be of Karelian age, with ages of 1800–2000 m.y. (e.g. Oftedahl 1980), but this must be reconsidered.

The geology of the Kautokeino–Masi region is mainly known due to the work of Holmsen et al. (1957). In 1980 remapping in the Masi area started as a part of a resource investigation for the Finnmark county. The work is still in progress, but some of the new results, mainly those concerning stratigraphy within the map-sheet Masi 1:50,000 (Fig. 2), are presented here.

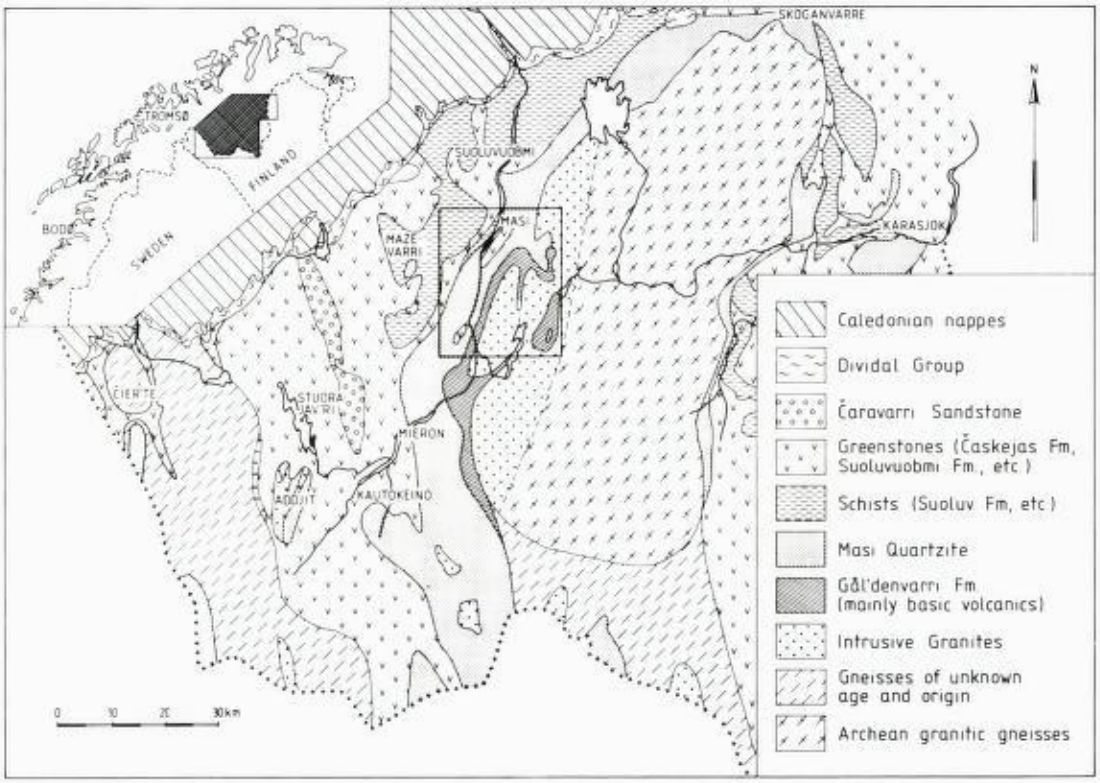

Fig. 1: Geological map of Finnmarksvidda. Location of Masi area shown by frame.

Geological setting

The lowest supracrustal formation found in the Masi area is a series of metavolcanics which is informally called the Gål'denvarri formation. It is succeeded upwards by the Masi Quartzite. This quartzite, the name of which was introduced by Holmsen et al. (1957), has a conglomerate at its base that seems to rest unconformably on the Gål'denvarri formation. The conglomerate has pebbles of granitic gneiss and has a strong resemblance to the conglomerate at Skoganvarre. According to new field work in the area between Skoganvarre and Masi there can be little doubt on the correlation of these two conglomerates. To the west and stratigraphically above the Masi Quartzite is the Suoluvuobmi formation containing mainly basic metavolcanics and mica schists. The Suoluvuobmi formation is probably an equivalent to the Časkejas Group of Holmsen et al. (1957). The latter term has been used as a loose designation for all basic metavolcanics on western Finnmarksvidda, but its type area is around Bied'djuvaggi Mine (Hagen 1982), west of the Čarravarri Sandstone (Fig. 1). Since the correlation between rocks there and in the Masi area is not obvious, the new term Suoluvuobmi formation is introduced. As may be seen from the map, Fig. 1, no attempt is made to differentiate between the regional distribution of these two units.

The eastern part of the Masi area is occupied by granite rocks. Formerly, these were thought to belong to the Archean basement, but the new mapping has shown that they are younger intrusives. Remnants of the basement may, however, be preserved in the granites.

Gål'denvarri formation

The rocks of the Gål'denvarri formation were included in the Časkejas Group by Holmsen et al. (1957), but more detailed mapping has clearly shown its position below the Masi Quartzite. It is mainly composed of amphibolites which are interpreted as metabasalts. A faint layering may be seen in the amphibolites, mainly due to differences in grain size and mineral composition, but also some porphyritic layers and schist horizons occur. Primary volcanic structures are difficult to recognize; most convincing is a fragmental amphibolite, interpreted as a volcanic breccia. It is found at several localities, and seems to occur at different levels in the stratigraphy. Some ultrabasic rocks occur in very elongated lenses, up to 30–40 m thick and 2–300 m long. The main minerals are amphibole and chlorite, but also olivine is found. Total thickness of the formation is about 1–1,5 km.

Chemically the amphibolites are classified as tholeiitic basalts. Characteristic is a low TiO_2 content (mean 0.5% for 16 samples) compared to the amphibolites of the Suoluvuobmi formation (mean 1.5%, 21 samples) which are also tholeiitic. Also characteristic is a relatively high MgO content (mean 12.3%) in relation to the SiO_2 content (mean 52.5%). In the Suoluvuobmi formation these concentrations are 8.5% and 47.3%, respectively. There are also significant differences in trace elements between the two formations, especially in Cr and Ni contents which are much higher in the Gål'denvarri formation.

Schists are a minor component of the Gål'denvarri formation, but in some of these layers the minerals garnet, staurolite and sillimanite are found. The paragenesis cordierite–anthophyllite is found both in basic rocks and in quartz-rich schist. Except for garnet, none of the other minerals is found elsewhere in the Masi area. Many of the minerals listed above are typical for thermal metamorphism, and the apparent higher grade of metamorphism in the Gål'denvarri formation could be ascribed to contact metamorphism from the intrusive granite to the east. However, except for sillimanite the mineralogical textures indicate that the minerals are formed at an early stage by regional metamorphism.

The lower parts of the Gål'denvarri formation are invaded by younger granites and the base of the formation is not found. At one single locality east of Gål'denvarri (Fig. 2) a poorly sorted conglomerate occurs as the lowest exposed member of the formation. Well rounded pebbles of granitic gneiss ranging in size up to 30 cm occur rather scattered in an arkosic matrix. This conglomerate may represent a basal layer on an old gneiss basement, even if there is little evidence for such an assertion.

Masi Quartzite

The Masi Quartzite is a relatively thick and homogeneous formation of widespread distribution, and may represent one of the most important formations regarding correlation of geological units in different parts of Finnmarksvidda.

The quartzite has a white, grey-white or pink colour and commonly shows a fine lamination caused by differences in feldspar content or heavy mineral dust. It is recrystallized so that primary sedimentary grains are usually not seen. Cross-bedding is observed at several localities. Much of the Masi Quartzite could be classified as a feldspathic quartzite. Total thickness is about 500–1000 m.

At the base of the Masi Quartzite there is usually a conglomerate with pebbles of granitic gneiss and quartz. Other types of pebbles are rarely found, even where the conglomerate rests directly on the amphibolites of the Gål'denvarri formation. The conglomerate has a calcareous arkosic matrix. The pebbles are normally less than 5 cm in diameter, but at several localities, especially in the northern areas, pebbles up to 30 cm in diameter are observed.

Another conspicuous feature of the Masi Quartzite is the occurrence of the chrome-bearing mica fuchsite. It is especially abundant in impure zones, but it may also be evenly distributed in the quartzite, giving it a green colour. Fuchsite is a common mineral in sandstones and quartzites of Archean age, and may be formed as an alteration product after detrial grains of chromite (Schreyer 1982).

Suoluvuobmi formation

The Suoluvuobmi formation is dominated by amphibolites and mica schists. The amphibolites appear to be of two types (Fig. 2), which may be of different origin. One type is relatively fine grained, dark green and foliated. Although no primary structure are preserved, this rock is thought to represent metabasalt. Another rock variety that probably originally was a lava, is an ultrabasic rock, now consisting of amphibole and chlorite.

The other type of amphibolite has a gabbroic texture. In the field the boundaries of this type seem to be parallel to the layering of other rocks, but on a regional scale they appear to be discordant. These amphibolites are therefore thought to represent metadolerites or gabbros. The geochemistry of both kinds of amphibolite, however, is identical with regard to both major and trace elements, so they may be closely related. This type of gabbro seems to be limited to the Suoluvuobmi formation.

Mica schist is the other dominant rock type. It is often characterized by a porphyroblastic growth of biotite, the dominating mica. The total thickness of the formation is difficult to estimate, but is certainly more than 1 km.

Two other characteristic rocks of the Suoluvuobmi formation are graphitic schists and a rock that in Finnmark has traditionally been called albite fels or quartz-albite rock. These two rock types are often connected and seem to

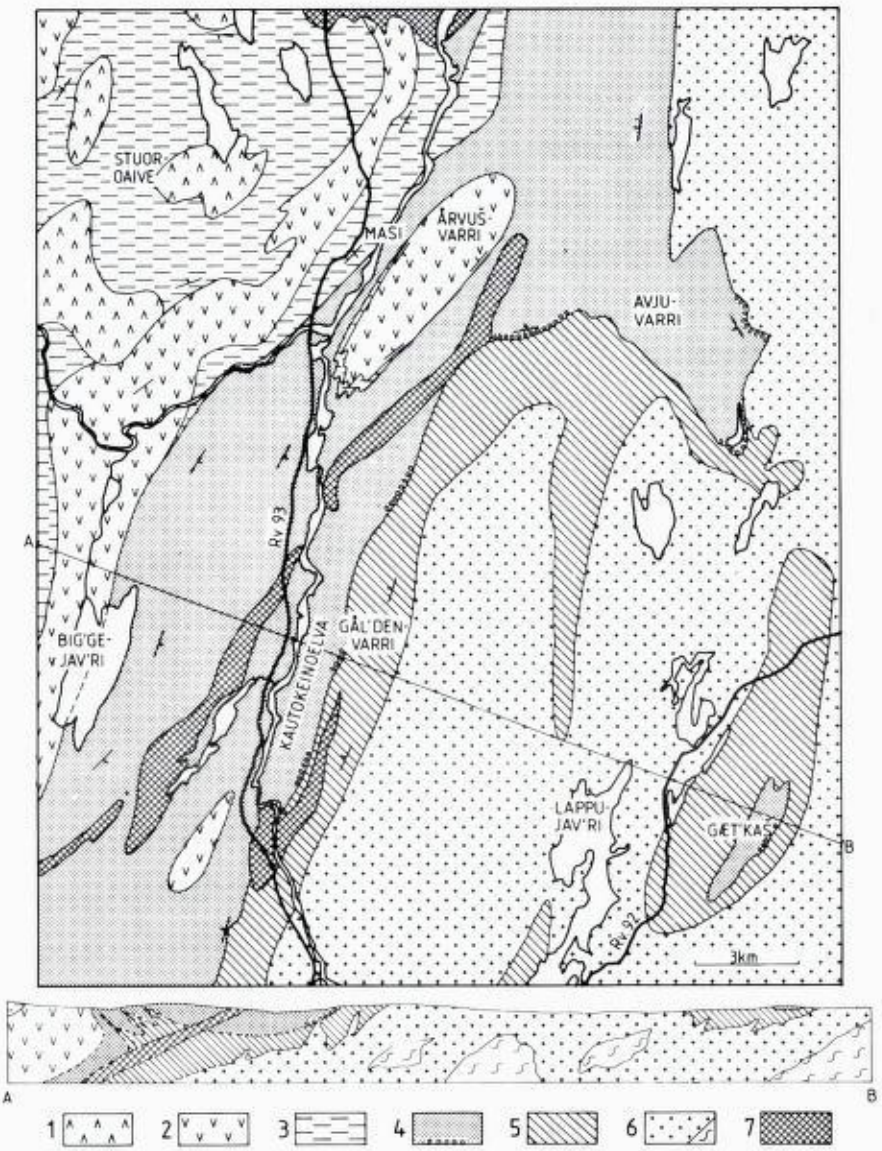

Fig. 2: Simplified geological map of the Masi area.
1–3: Suoluvuobmi formation; 1. Metagabbro. 2. Metabasalt. 3. Mica schist. 4. Masi Quartzite. 5. Gål'denvarri formation; Metabasalt. 6. Intrusive granite. Remnants of Archean gneisses are indicated. 7. Albite diabase.

have a preferred occurrence in the contact zone between amphibolite and mica schists. They are of special interest because there are ore minerals associated with them. On Finnmarksvidda they are particular well known from the Bied'djuvaggi Mines (Hagen 1982), but they are also known from mines in northern Sweden and Finland (Inkinen 1979). The origin of these rocks has been discussed for a long time, and both a metasomatic and a volcanic origin has been proposed; the latter is favoured by the present author.

The contact relations between the Suoluvuobmi formation and the underlying Masi Quartzite are generally very complicated. The Masi Quartzite is locally inverted and thrust above the Suoluvuobmi formation, especially in the area south of Masi, and it is easy to get the impression of an important break between these two formations. At other localities like the Årvusvarri syncline east of Masi (Fig. 2) and east of Mazevarri (Fig. 1) where the Masi Quartzite is deformed in an antiform beneath the Suoluvuobmi formation, there seems to be a normal stratigraphic sequence from the Masi Quartzite up to the Suoluvuobmi Formation. This relationship is further supported from evidence in the Addjit area to the south (Fig. 1) where a probable equivalent to the Masi Quartzite underlies the geenstones of the Časkejas Group (Holmsen et al. 1957).

Basement and granite intrusions

The geological map, Fig. 2, gives the impression of a concordant boundary between the Gål'denvarri formation and the granite to the east. However, at several localities it can be demonstrated that the granite has an intrusive relationship to both the Gål'denvarri formation and the Masi Quartzite. Granitic intrusions are not common in the Suoluvuobmi formation, but at least two larger massifs occur (Holmsen et al. 1957; and Fig. 1), and veins are observed at several localities. There are also many xenoliths, especially of the Gål'denvarri formation, in the granite. These relations seems to be even more abundant to the south of the Masi area, and were also recognized by Holmsen et al. (1957).

Large parts of the granite are a rather homogeneous red to white biotite granite; but within the granite there are also areas of strongly foliated rocks of granitic, granodioritic and tonalitic compostion. These gneisses are thought to be remnants of the Archean basement; and it seems that in the Masi area there was originally a gneissic basement which was later intruded by granite. Conclusive proof that the gneisses are xenoliths is, however, difficult to find, both due to the general lack of exposures and because the intruding granite also has a marked foliation. An important reason for the suggestion of the gneisses being basement is therefore the situation in Skoganvarre, where a gneissic basement for the supracrustals is present. Since the intrusive granite is so dominant in the Masi area, only this is shown on the map (Fig. 2). The boundary between the granite and real Archean basement shown in Fig. 1 is not known in detail.

Albite diabase

Albite diabase is an intrusive rock commonly occurring in the Masi area as well as in the Precambrian of northern Finland and Sweden. Meriläinen (1961) gave a complete description of the rock type. It is characterized by preserved igneous texture and a high content of albite (up to 60%) that seems

to be of primary origin. Dark minerals are generally biotite and hornblende, but also clinopyroxene may occur. Magnitite, up to 10%, is present; this make the rock easy to recognize from aeromagnetic maps. The high albite content also produces a high Na_2O content (mean nearly 7%), and this is probably why the albite diabases have been confused with the albite felses that also commonly occur on Finnmarksvidda, but these rocks seeem to have a totally different origin.

Discussion and regional correlations

Mapping in the Masi area has shown that the basic metavolcanics are not restricted to one single unit in the stratigraphy on Finnmarksvidda. They occur in the Gål'denvarri formation below the Masi Quartzite and in the Suoluvuobmi formation above. Recent mapping to the west of Mazevarri (Fig. 1) has also revealed a low-metamorphic greenstone sequence where primary volcanic structures are well preserved. This greenstone has a distribution east of and parallel to the Čaravarri Sandstone, and could represent an even younger sequence than the Suoluvuobmi formation. Low-metamorphic greenstones are also found to the west of and below the Čaravarri Sandstone, which is thought to represent the youngest rock unit of the Precambrian on Finnmarksvidda.

The correlation between the Kautokeino–Masi region and the tectonic windows of Alta–Kvænangen and Komagfjord about 50–100 km to the north is based on both geophysical (Åm, 1975) and lithological evidence. The section from the Kvænvik Greenstone up to the Skoadduvarri Sandstone at Alta (Zwaan & Gautier 1980) corresponds very well with the section from the low-metamorphic greenstone up to the Čaravarri Sandstone on Finnmarksvidda.

Even if no direct correlations can be made between Finnmarksvidda and northern Finland, very similar rocks occur there. It is mainly based on this long distance correlation that the basic metavolcanics in western Finnmark are considreed to be of Karelian age (e.g. Oftedahl 1980, Zwaan & Gautier 1980). However, the volcanics in Finland vary in age from Archean to Proterozoic (e.g. Silvennoinen et al. 1980), and since it is now apparent that the volcanics within the Masi area are not restricted to one single unit, differences in age are considered to exist here too.

A short comment should here be given on the term Karelian, which has been used for the rock sequences in western Finnmark. In Norway, Karelian until recently has been used for the period from 1800 m.y. to 2000 m.y.; see for instance Oftedahl (1980) and Zwaan & Gautier (1980). This is not in accordance with modern Finnish use. Originally, Karelian was used for rocks in the eastern and northern part of Finland which were thought to represent a younger orogenic belt than the Svecofennian in western Finland. Age determinations and later geological investigations have shown that rocks of the Karelian and Svecofennian orogenic belts are of the same age, and they have

been renamed the Svecokarelian orogeny (Gaal 1982). The most important metamorphic episode in this orogeny occurred about 1800–1900 m.y. ago (Simonen 1980), but the depositional age of rocks involved seems to have been from 2600 to 1800 m.y. (Simonen 1980, Silvennoinen et al. 1980).

Even if a direct correlation with the rock sequences in the Masi area and Finland should be made with great care, there seem to be two reasonable possibilities for correlation. The key horizon for the first possibility is the conglomerate at the base of the Masi Quartzite. In Finland it is well documented that the beginning of the Proterozoic was a period of denudation and peneplanation of the Pre-svecokarelian basement (Meriläinen 1980, Silvennoinen et al. 1980, Simonen 1980). This has resulted in widespread occurrences of conglomerates resting on the basement, which contained rocks like granitic gneisses, greenstones and sediments. The most obvious unit to associate with such an unconformity on Finnmarksvidda would be the conglomerate at the base of the Masi Quartzite, resting partly on the Gål'denvarri formation as in the Masi area, and partly on a gneissic basement as at Skoganvarre. This correlation will be in accordance with that of Skålvoll (1976) and imply that the Gål'denvarri formation is of Archean age. The Masi Quartzite and Suoluvuobmi formation will thus have a depositional age from about 2500 m.y. and younger, and have been deformed in the Svecokarelian orogeny. K-Ar determinations on basic metavolcanics in the Komagfjord tectonic window confirm that there has been a metamorphic event at 1800 m.y. in Finnmark (Pharaoh et al. 1982). As will be seen from stratigraphic sections from Finland (e.g. Meriläinen 1980, Silvennoinen et al. 1980) there are quartzites, greenstones and schists of the same depositional age that could be correlated with the Masi Quartzite, Suoluvuobmi formation and other rocks in western Finnmark.

If the correlations suggested above are accepted, the bulk of the rocks on Finnmarksvidda will be of Proterozoic age. The only Archean rocks, except for the central gneiss dome, would be the Gål'denvarri formation, which seems to have a very limited distribution (Fig. 1). Recently, however, the Proterozoic age of the supracrustal rocks on Finnmarksvidda has been questioned by several workers in the Finnish Precambrian, because radiometric age determinations have proven an Archean age for the Kittilä greenstone (Gaal et al. 1978, Barbey et al. 1981, Gaal 1982). A correlation of the Kittilä greenstone with the greenstones of the Karasjok region, and possibly also those of the Kautokeino–Masi region, seems obvious from existing geological maps. It is also easy to see many similarities between the stratigraphy of the Masi area and the Archean stratigraphy in this part of Finland. According to Rastas (1980) the lowest supracrustal unit above the gneissic basement in the Kittilä area is a volcanic formation, mainly comprising lavas. Above this is a sericite quartzite, occasionally fuchsite-bearing, and this is followed by the Kittilä greenstones with mica schist and graphitic schists. The lithological correlation with the sequence gneissic basement, Gål'denvarri formation, Masi Quartzite and Suoluvuobmi formation is a good one, and if this is

correct it will mean that the only Proterozoic rock unit on Finnmarksvidda is the Čaravarri Sandstone.

The question as to which of the two correlations outlined above is correct, will remain open until age determinations are carried out and more mapping is done. The possibility of an Archean age for the greater part of the rocks on Finnmarksvidda should, however, be kept open.

Acknowledgements. The author is grateful to Allan Krill who critically read early drafts of the manuscript and suggested many improvements in both the content and the English text. Harald Skålvoll is thanked for valuable discussions during the progress of the work. The illustrations were drawn by Bina Øydegard.

REFERENCES

Åm, K. 1975: Aeromagnetic basement complex mapping north of latitude 62 °N, Norway. *Norges geol. Unders. 316,* 351–374.

Barbey, P., Convert, J., Martin, H., Moreau, B., Capdevila, R. & Hameurt, J. 1980: Relationships between granitegneiss terrains, greenstone belts and granulite belts in the Archean crust of Lapland (Fennoscandia). *Geol. Rundsch. 69,* 648–658.

Gaal, G., Mikkola, A. & Søderholm, B. 1978: Evolution of the Archean crust in Finland. *Precambrian Res. 6,* 199–215.

Gaal, G. 1982: Proterozoic tectonic evolution and late Svecokarelian plate deformation of the Central Baltic Shield. *Geol. Rundsch. 71,* 158–170.

Hagen, R. 1982: The Bidjovagge Copper–Gold Deposits of western Finnmark, Norway. *Geol. Rundsch. 71,* 94–103.

Holmsen, P., Padget, P., Pehkonen, E. 1957: The Precambrian geology of Vest-Finnmark, Northern Norway. *Norges geol. Unders. 201,* 106 pp.

Inkinen, O. 1979: Cu, Zn, and U occurrences at Pahtavouma in the Kittilä Greenstone Complex, Northern Finland. *Econ. geol. 74,* 1153–1165.

Meriläinen, K. 1961: Albite diabases and albitites in Enontekiö and Kittilä, Finland. *Bull. Comm. géol. Finlande 195,* 77 pp.

Meriläinen, K. 1976: The granulite complex and adjacent rocks in Lapland, northern Finland. *Geol. Surv. Finland, Bull. 281,* 129 pp.

Meriläinen, K. 1980: Stratigraphy of the Precambrian in Finland. *Geol. Fören. Stockh. Förh. 102,* 177–180.

Oftedahl, Chr. 1980: Geology of Norway. *Norges geol. Unders. 356,* 3–114.

Pharaoh, T. C., Macintyre, R. M. & Ramsay, D. M. 1982: K-Ar age determination on the Raipas suite in the Komagfjord Window, northern Norway. *Norsk geol. Tidsskr. 62,* 51–57.

Rastas, P. 1980: Stratigraphy of the Kittilä area. In Silvennoinen, A. (ed.): Jatulian geology in the eastern part of the Baltic Shield. (Proceedings). The Committee for Scientific and Technical Cooperation between Finland and the Soviet Union, Rovaniemi, 145–151.

Schreyer, W. 1982: Fuchsite-aluminium silicate rocks in Archean greenstone belts: Are they metamorphosed alunite deposits? *Geol. Rundsch. 71,* 347–360.

Silvennoinen, A., Honkamo, M., Juopperi, H., Lehtonen, M., Mielikäninen, P., Perttunen, V., Rastas, P., Räsänen, J. & Väänänen, J. 1980: Main features of the stratigraphy of North Finland. In Silvennoinen, A. (ed.): Jatulian geology in the eastern part of the Baltic Schield. (Proceedings) The Committee for Scientific and Technical Cooperation between Finland and the Soviet Union, Rovaniemi, 153–162.

Simonen, A. 1980: The Precambrian in Finland. *Geol. Surv. Finland, Bull. 304,* 58 pp.

Skålvoll, H. 1972: Geologisk kart over Norge – berggrunnskart Karasjok – 1:250000. *Norges geol. Unders.*

Skålvoll, H. 1978: Berggrunnsgeologi (with map enclosure). In Finnmarksvidda – natur – kultur. Norges off. utredn. 18A, Universitetsforlaget, Oslo. 35–39.

Zwaan, K. B. & Gautier, A. M. 1980: Alta og Gargia. Beskrivelse til de berggrunnsgeologiske kart 1834 I og 1934 IV, M 1:50000. *Norges geol. Unders. 357,* 47 pp.