Bedrock geology of the Altevatn-Måskanvarri area, Indre Troms, northern Scandinavian Caledonides

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The Altevatn-Måskanvarri area of inner Troms provides a critical link between the more intensively studied areas in northernmost Sweden and Finnmark to the north. It is composed of a stack of far-travelled Caledonian thrust sheets, overlying autochthonous sediments deposited on the Precambrian basement. The thrust sheets can be divided into those derived from the Baltoscandian margin and others representing outboard terranes.
The lowermost thrust sheet in the area, the Målselv Nappe (Lower and Middle Allochthons) is composed of mylonitic metasediments and granitoids. These are overlain by schists and augen gneisses of the Seve Nappe Complex (Upper Allochthon), and a mafic dyke complex (Rohkunborri Nappe) which occupies the upper part of the Seve. There is a general thinning of the Seve Nappe Complex northwards and it wedges out in the northernmost part of the study area. The overlying Vaddas Nappe of the Köli Nappe Complex (Upper Allochthon) is dominated by pelitic and graphitic schists and subordinate amphibolites. Evidence of Neoproterozoic to Cambrian crustal extension, sedimentation in a rift-related basin and subsequent intrusion of mafic dyke swarms is preserved within the Rohkunborri Nappe. The latter is thought to represent the outermost rifted part of the Baltoscandian passive margin and miogeocline closest to the continent-ocean transition zone.
A polyphase tectonothermal history is recognised in the area, involving a Late Cambrian- Early Ordovician (Finnmarkian) event related to the formation of eclogites, found only within the lower parts of the Seve Nappe Complex, and a later Scandian event that affected all units in the area.

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Introduction

The area of study lies in the easternmost parts of Indre Troms, Norway, between Lake Geavdnjajávri in the south and Måskanvarri in the north (Figs. 1 & 2). The Scandinavian Caledonides are characterised by a sequence of thrust sheets (nappes) emplaced onto the autochthonous rocks of the Baltoscandian platform (Strand & Kulling 1972). According to a terminology introduced by Kulling (1972) and Gee & Zachrisson (1979), the thrust sheets can be divided into four major tectonostratigraphic units, the Lower, Middle, Upper and Uppermost Allochthons. The Lower and Middle Allochthons and lower part of the Upper Allochthon are inferred to have been derived from the Baltoscandian margin, and the overlying tectonic units from outboard terranes (Gee 1975, Stephens & Gee 1985, Stephens & Gee 1989).

Previous work by Kalsbeek and Olesen (1967), Gustavson (1963, 1966a, 1969, 1972 &1974, Gustavson & Skålvoll (1977), Mortensen (1972), Olesen (1971) and Kathol (1989), established the regional geology of the Indre Troms area. Compilation maps by Gee et al. (1985), Zachrisson (1986) and Krill et al. (1987) present different interpretations of the tectonostratigraphy of the area; e.g., which units belong in the Middle and Upper Allochthons, and where the boundary between inboard and outboard units of the Upper Allochthon should be drawn. These problems become critical when units cross the political border between Sweden and Norway (Andréasson 1994). In this context the Indre Troms area represents an important link between units in the northernmost Swedish Caledonides and the Caledonian rocks in northernmost Troms and Finnmark in Norway. The area is also important as a northward continuation of dyke-intruded lithologies within the Seve Nappe Complex (SNC) (Andréasson 1986a & b, 1994, Kathol 1989, Svenningsen 1993, Stølen 1994a,) and a key area for understanding their tectonostratigraphic relationship to other units with mafic magmatism, including those that may have originated in outboard terranes e.g. the Kalak Nappe Complex. The SNC, which extends 900 km southwards along the Caledonide orogen, terminates in this area.

The purpose of this paper is to describe tectonostratigraphic relationships in this area, with a focus on those units carrying rocks representing the rift-related magmatism of the Baltica-Iapetus transition. A correlation is also attempted between the Indre Troms units and the established tectonostratigraphy further south and north of the area. For a more comprehensive description of the rift-related mafic dyke swarms in the Indre Troms area and their geochemistry, the reader is referred to Stølen (1994a & b).

Geological setting

The geology of the Indre Troms area is dominated by flat-lying thrust sheets underlain by the Upper Vendian to Middle Cambrian autochthonous sediments of the Dividal Group,

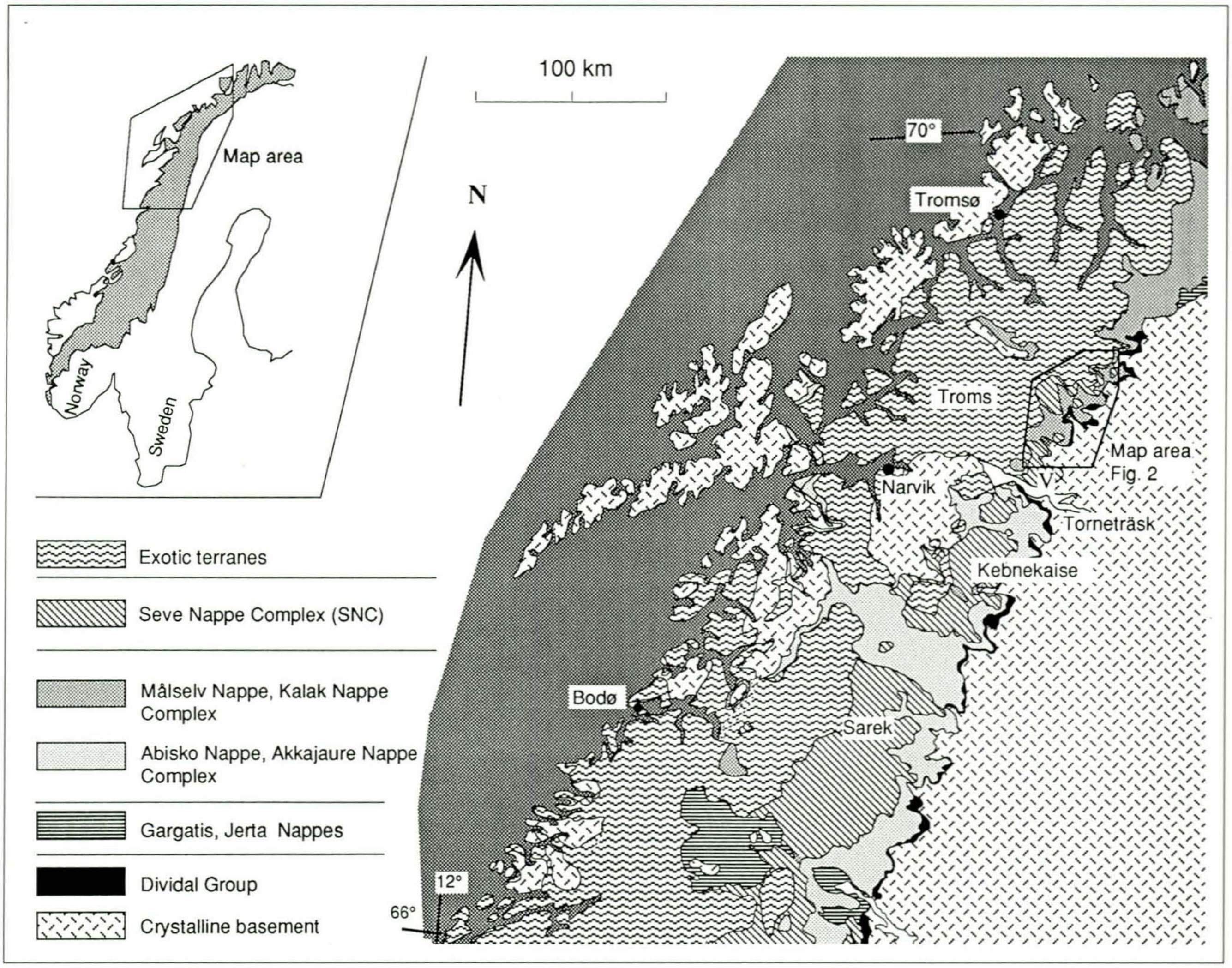

Fig. 1. Simplified geological map of the northern part of the Scandinavian Caledonides. V = Vaivvancohkka. Map based on Krill et al. (1987) and Roberts (1988).

which were deposited unconformably on the Early Proterozoic and Late Archaean granitoid gneisses of the northern part of the Fennoscandian shield (Føyn 1967).

Kalsbeek & Olesen (1967) divided the allochthonous units in the Altevatn-Dividalen area into three units: the lower unit corresponding to the Middle Allochthon and the lower part of the Upper Allochthon, the middle and upper units containing rocks of the Upper Allochthon. Kalsbeek & Olesen (1967), Mortensen (1972) and Gustavson (1974) subsequently showed that the so-called Seve amphibolites in the easternmost part of Indre Troms consisted of foliated amphibolites, commonly with relict igneous textures and containing lenses of marble and schist. However, the primary features of the internal parts of these amphibolite massifs (Stølen 1994a) were not reported.

Regional compilations (Gee et al. 1985, Zachrisson 1986) correlated all the mafic dyke complexes of the Indre Troms area with the Seve Nappe Complex. Some workers (Krill et al. 1987, Roberts 1988, Stephens & Gee 1989, Andréasson 1994) correlated the southernmost outcrop area (Rohkunborri) with the SNC and the rest (Kistefjell, Njunis and Jerta), to the north, as part of the Köli Nappe Complex (KNC).

The description of the different tectonic units in this paper is based on more detailed studies in the Rohkunborri, Kistefjell, Njunis and Pältsa areas and on reconnaissance mapping in the Jerta and Gassavaggi areas (Fig 2).

Tectonostratigraphy of the Altevatn - Måskanvarri area

The autochthonous and allochthonous units of the Altevatn - Måskanvarri area are shown in Figure 2 and described below, along with a presentation of the tectonostratigraphy (Fig. 3).

Autochthonous units

Basement rocks: The autochthonous basement exposed east of the Caledonian front and in windows in the Dividalen area consists of Paleoproterozoic and Late Archaean gneissic and migmatitic rocks, mainly granitoids with sporadic amphibolites (Gustavson 1974). The contact between crystalline basement and overlying cover sediments dips very gently (~2°) towards the northwest.

The Dividal Group: The autochthonous Dividal Group

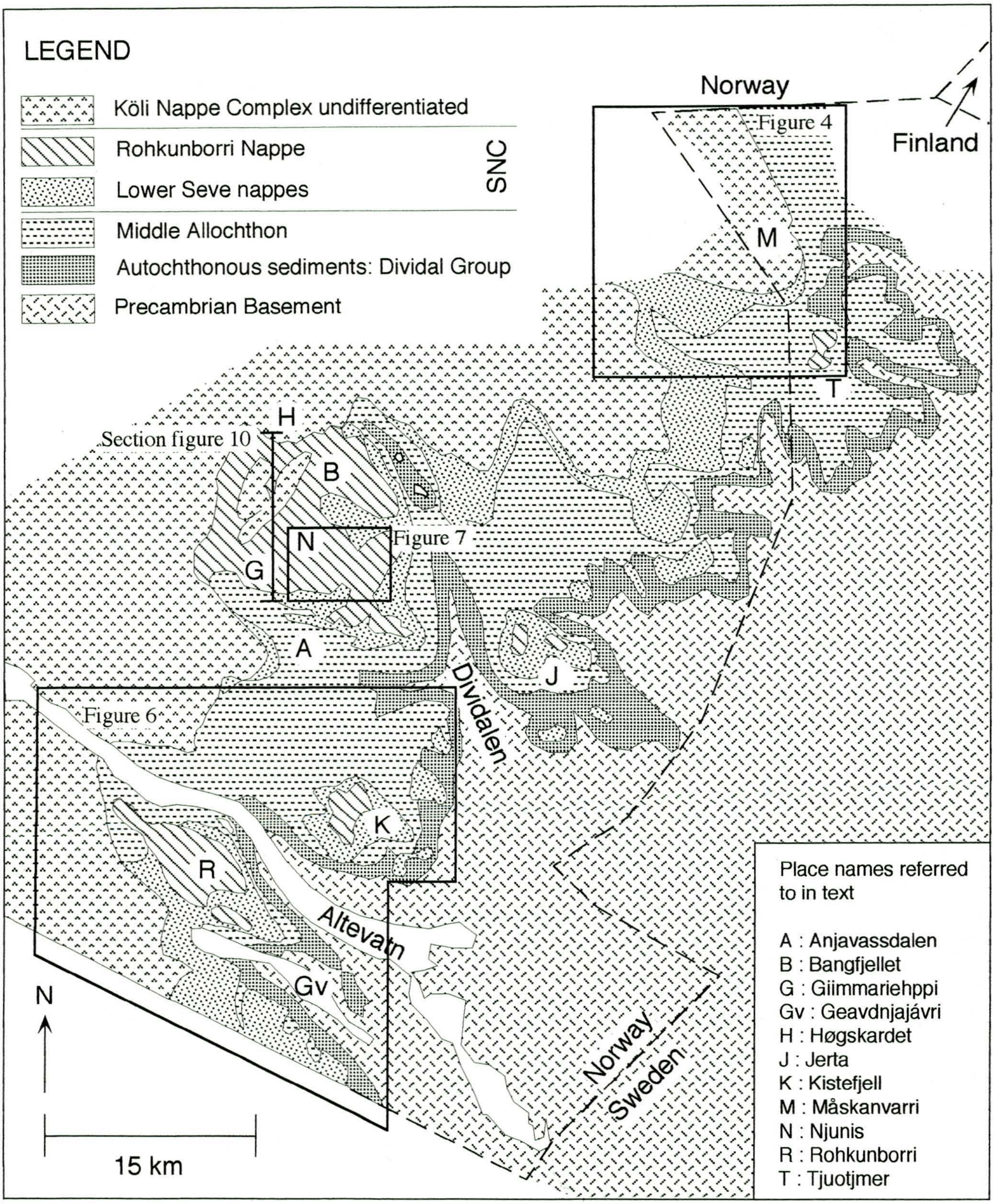

Fig. 2. Geological map of the Altevatn - Måskanvarri area, Indre Troms, northern Norwegian Caledonides. Map partly based on Gustavson (1974) and Gustavson & Skålvoll (1979).

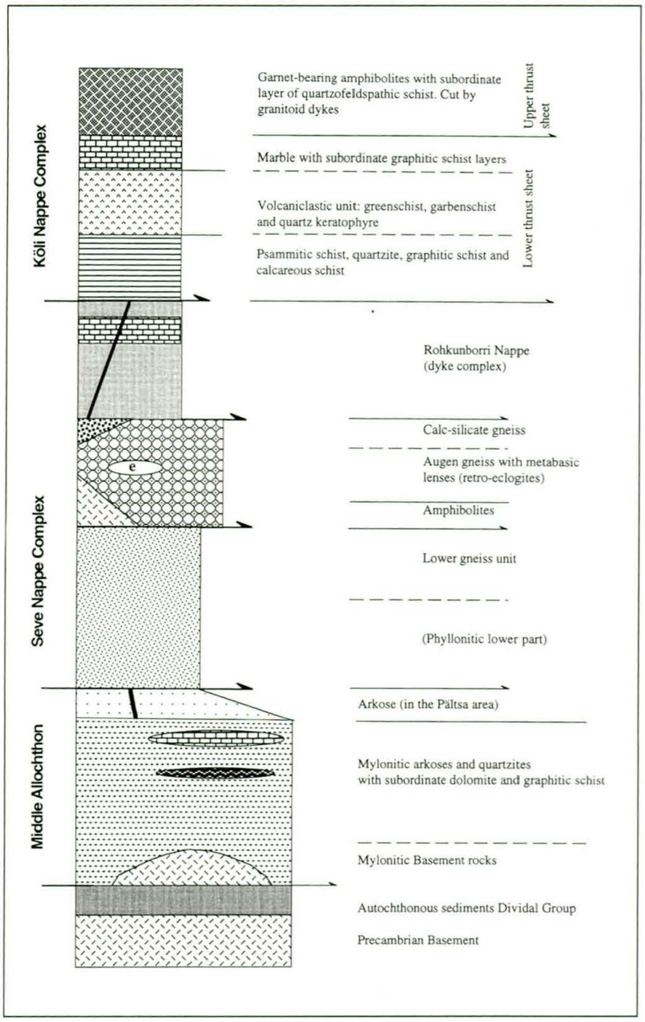

Fig. 3. Tectonostratigraphic column of the Altevatn - Måskanvarri area.

(Pettersen 1878, Føyn 1967) rests unconformably on Precambrian basement along the entire Caledonian thrust front in the study area and in the Dividalen window (Gustavson 1963). The sedimentary rocks are largely undisturbed except in the uppermost parts towards the contact with the overlying allochthonous rocks. The thickness of the Dividal Group varies between 50 and 120 m within the Indre Troms area. The basal part is an arkosic to quartzitic conglomerate, overlain by greenish to reddish shales with subordinate layers of sandstones. The upper parts are dominated by greyish sandstones and quartzites. Cambrian black shales which typify the higher levels of the Dividal Group elsewhere in northern Scandinavia (e.g. Føyn 1967) have not been found in the area.

According to Kulling (1964) there are only a few exposures of autochthonous sediments of the Dividal Group in the Pältsa area. However, exposures are found around lake Kåbmejaure (Fig. 4), along the river flowing northwards to Kåbmejaure, and below the waterfall in the Bealccanjohka river close to the STF Cabin (UTM 34WDB845591). These outcrops consist mainly of basal arkoses, overlain by greenish shales, in places with trace fossils. The maximum recorded thickness of the Dividal Group in the Pältsa area is 12 metres.

Målselv Nappe (Lower and Middle Allochthons)

The Målselv Nappe (Andresen et al. 1985) covers a large part of the Indre Troms area (Fig. 2); it is correlated with the Abisko and Rautas Nappes in the Torneträsk area (Kulling 1964), Nappe 3 (Helligskogen Nappe Complex) of Binns (1978) in northern Troms, and the lower part of the Kalak Nappe Complex in northern Troms - Finnmark. The nappe consists of various phyllites, quartzites, dolomites, mylonitic (basement) rocks and mylonitised clastic sedimentary rocks, the so-called 'hard-schists' of Pettersen (1878). These units dominate the low-lying areas around Altevatn and in Anjavassdalen. A good marker horizon within the Målselv Nappe is the characteristic yellow Abisko dolomite (Kulling 1964) which can be mapped in the southern part of the area.

Basement-derived sheets occur in the lower part of the nappe. One of the best occurrences of the basement-derived rocks is found in the Jerta area (Fig. 2). This rock unit, consisting of mylonitic granitoids, could be part of the Lower Allochthon, correlatable with similar units in the Rautas Nappe Complex (Kulling 1964) in the Torneträsk area. However, since the upper contact between this sheet of granitoid mylonites and the overlying mylonitic arkoses is not exposed, it has been impossible to assess whether or not this unit should be considered as a separate nappe.

Arkoses are found in the upper part of the Middle Allochthon (MA) in the northeastern part of the Pältsa area (Fig. 4), but are absent elsewhere in the Altevatn - Måskanvarri area. Mafic dykes, characteristic of the upper part of the Middle Allochthon (e.g. Särv Nappe (Strömberg 1969)) are seldom seen in the Indre Troms area at this structural level, although cm- to dm-thick fine-grained amphibole, chlorite and epidote layers (possibly representing deformed and attenuated dykes) can be found within both these arkoses and the mylonitic arkoses of the Pältsa area. One cross-cutting coarse- to medium-grained amphibolitic dyke has been found within the mylonitic granitoids. This dyke is found in a stream section in the southern part of the Jerta area (UTM 34WDB520202), where it cuts an early (Precambrian?) gneissic foliation in the granitoids, but was itself deformed together with the host rock during later Caledonian shearing.

The rocks of the Målselv Nappe, especially the granitoids, show excellent evidence of localised deformation. Within metres, deformation varies from brittle crushing to weak shearing; successively increasing deformation has resulted in the formation of completely recrystallised mylonites. The main rock units within the Målselv Nappe are described below.

Mylonitic metasedimentary rocks ('Hardschist'): By contrast with the mylonitic basement-derived rocks, fine-grained metasediments such as arkoses, quartzites, dolomites and graphitic schists have developed an intense planar folia-

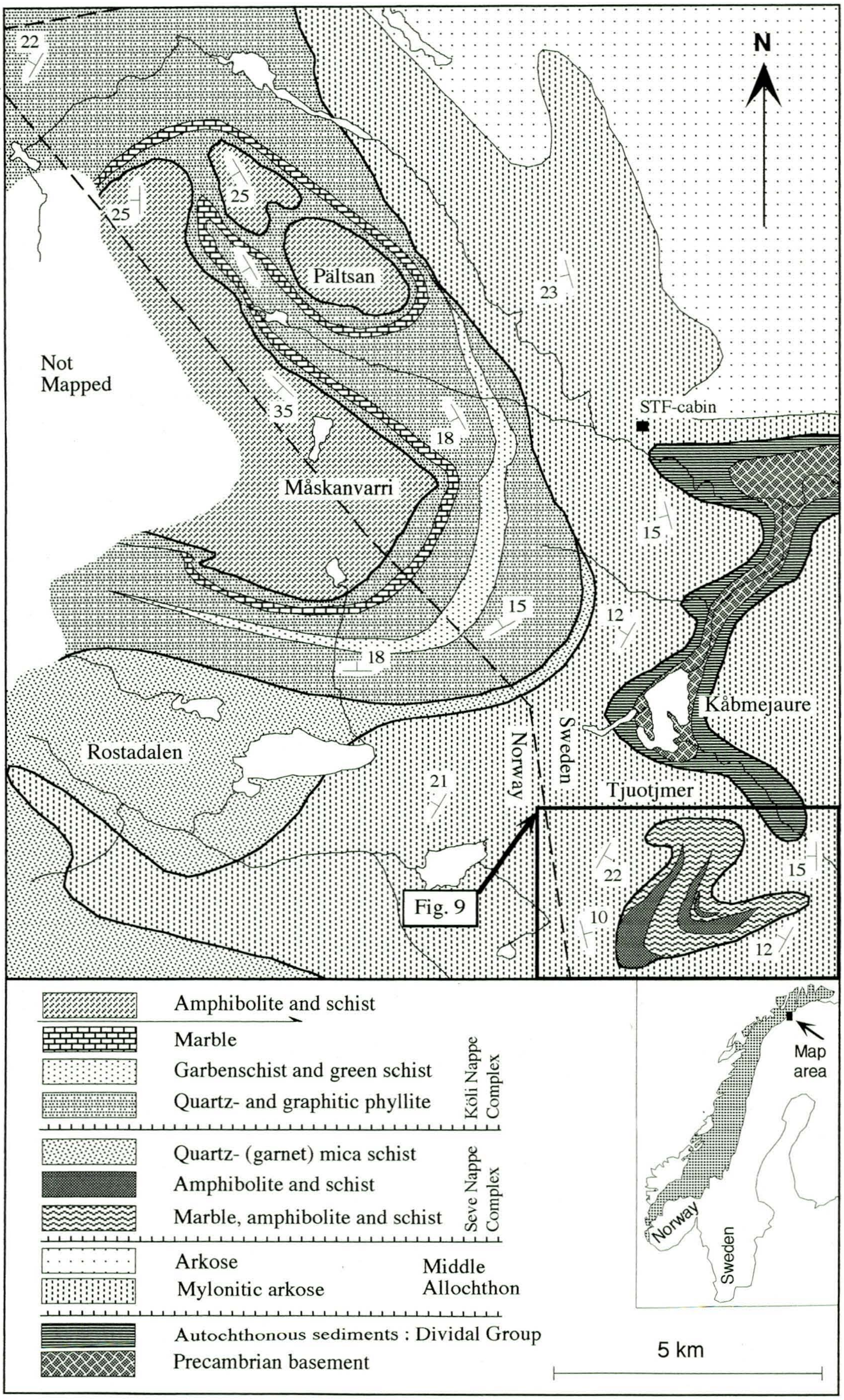

Fig. 4. Geological map of the Pältsa area, northern Swedish Caledonides

tion, commonly with a tectonic banding or mica-rich schistosity; these lithologies have been referred to by previous authors, e.g. (Pettersen 1878, Kulling 1964) as hardschists. Mica-rich rocks display a wavy schistosity, commonly with quartz and carbonate segregations. Intrafolial folds are common in the most intensely deformed rocks (Fig. 5a). Stretching of mineral aggregates forming a NW-SE trending mineral lineation, is common, and there are also folds (often sheath folds) with fold hinges parallel to this lineation. S-C fabrics and mica 'fish' commonly indicate top-to-the-SE movement. Superposition of these top-to-the-SE structures by later top-to-the-NW structures is locally observed in the Kistefjell area. The quartz-rich sediments display elongated sedimentary clasts of quartz, lying parallel to the tectonic banding. Undulose extinction and sub-grain development along deformation bands indicates progressive deformation and recrystallisation of these elongate clasts. Quartz grains within more mica-rich layers generally have a platy or tabular preferred shape fabric, parallel to the white mica.

Granitoid mylonites ('Granitic kakirites'): occurrences of basement-derived units are restricted to the lowermost parts of the Målselv Nappe, close to the floor thrust. Within each sheet, transitions from virtually undeformed to deformed granitoid may be observed over a few metres, particularly within the basement sheet exposed around Jerta (Fig. 2).

The style of deformation associated with basement reworking is typically cataclastic although mylonitic and ultramylonitic varieties also occur, mainly along thrust zones within the 'granitic-kakirites'. Cataclastically deformed granitoids display brittle fractures infilled with quartz, calcite and white mica (Fig. 5b), and individual cataclastic domains are usually isolated within an anastomosing network of fine-grained, well foliated rock comprising white mica, chlorite and epidotite (with sporadic relict grains of quartz and feldspar). Mylonitic varieties commonly carry porphyroclasts, although these decrease with increasing deformation and subgrain development. Brittle fracturing of porphyroclasts is also apparent (Fig. 5c). Fractures generally make a high angle with the external mylonitic foliation and are infilled with mainly strain-free quartz. Several of the larger quartz grains, however, show minor subgrain development.

Upper Allochthon; Seve Nappe Complex (SNC)

The basal thrust of the SNC, the Seve thrust, is easily recognisable over a few tens of metres by the petrological and metamorphic differences between the footwall and hangingwall rocks. The Seve thrust constitutes a marked metamorphic break between the amphibolite facies of the SNC and the greenschist facies of the underlying Målselv Nappe. Garnet is conspicuous within the SNC, whilst lacking in the Målselv Nappe in the Altevatn - Måskanvarri area.

In the Indre Troms area, the SNC has been divided into three main structural units: a lower gneiss sheet; an amphibolite and augen gneiss sheet; and the Rohkunborri Nappe (Fig. 3), comprising a metasedimentary succession which has been divided into four formations (Stølen 1994a). The most complete sequences in the study area are found south of Lake Geavdnjajávri (Fig. 6) and in the Njunis - Bangfjellet area (Fig. 7). However, the entire complex is cut out northwards, disappearing entirely immediately east of Måskanvarri (Fig. 4).

Lower gneiss sheet: These gneisses are pale grey to red-

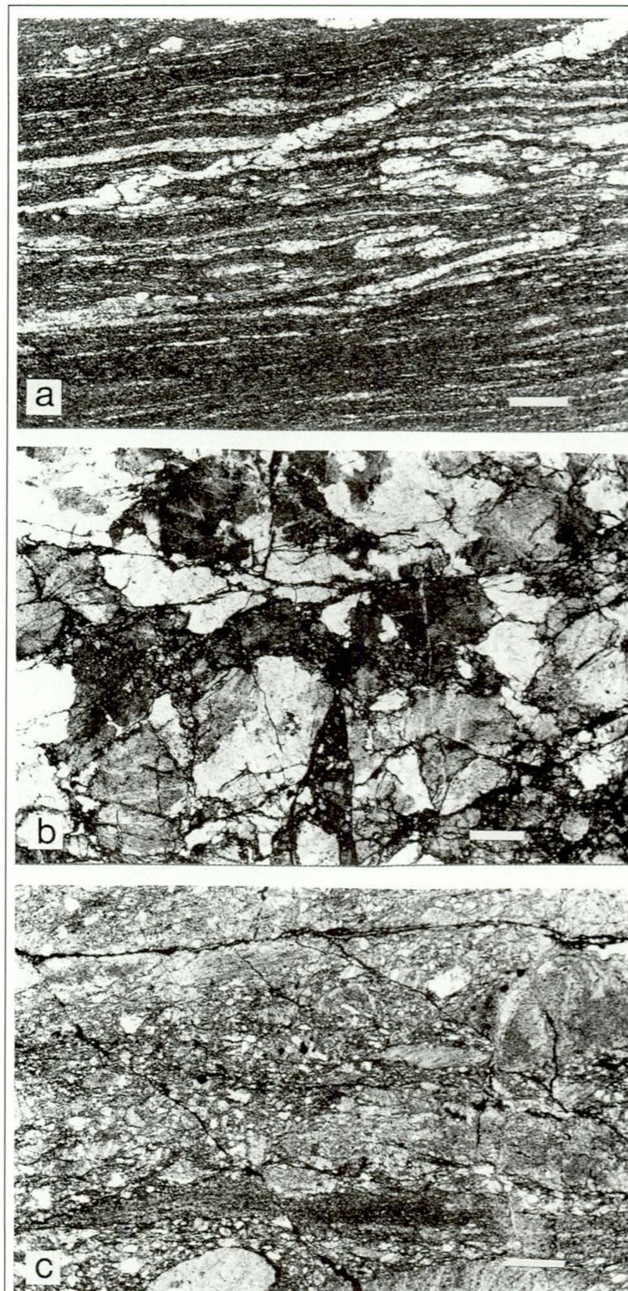

Fig. 5. (a) Typical 'hardschist' from the Målselv Nappe: note small-scale isoclinal fold hinges. Scale-bar 1 mm. Locality, Gistatcohkka (UTM 34WDB392096). (b) Brittle deformation fractures within basement sheet close to the base of the Målselv Nappe. The protolith is a granitoid gneiss. Scale-bar 1 mm.. Locality, Jerta (UTM 34WDB520202). (c) Mylonitic granitoid gneiss from the Målselv Nappe. Scale-bar 1mm.. Locality, Pältsa area (UTM 34WDB742511).

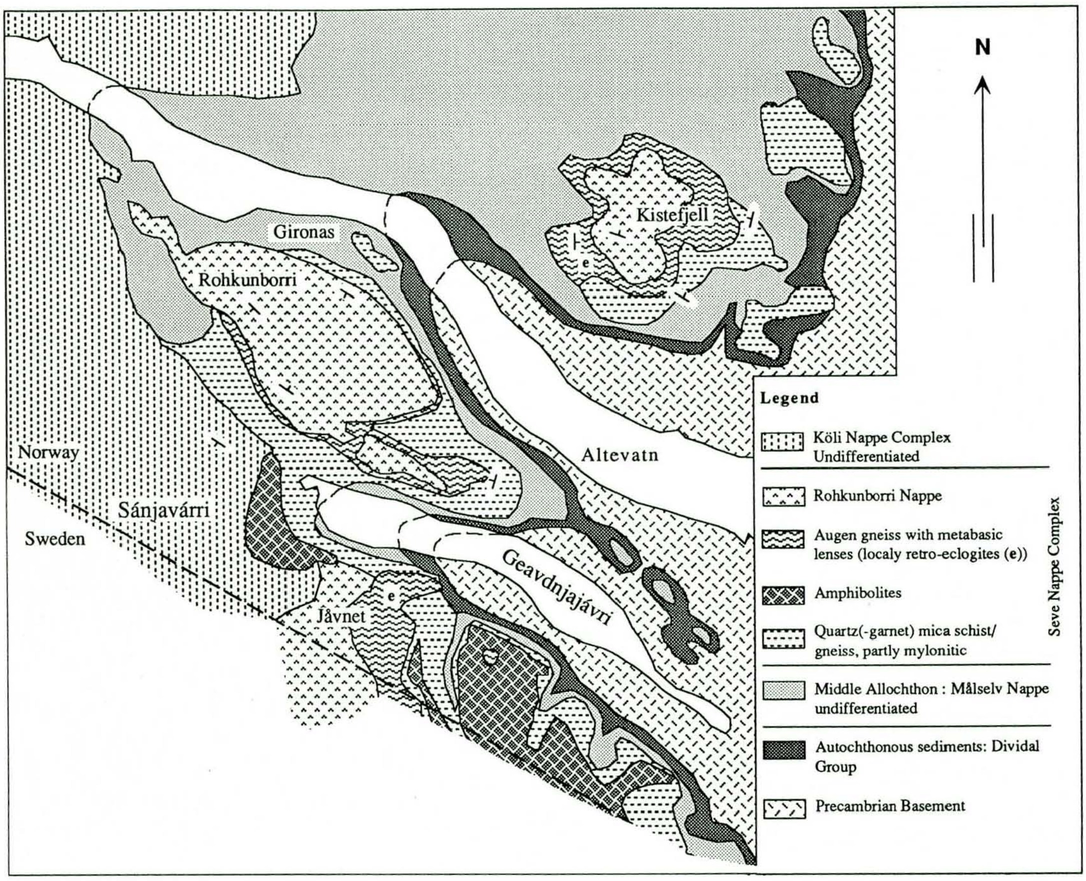

Fig. 6. Geological map of the Jåvnet - Kistefjell area. Information south of lake Geavdnjajávri based on Andréasson (pers. comm. 1996) and on the Swedish side of the border, Kathol (1989).

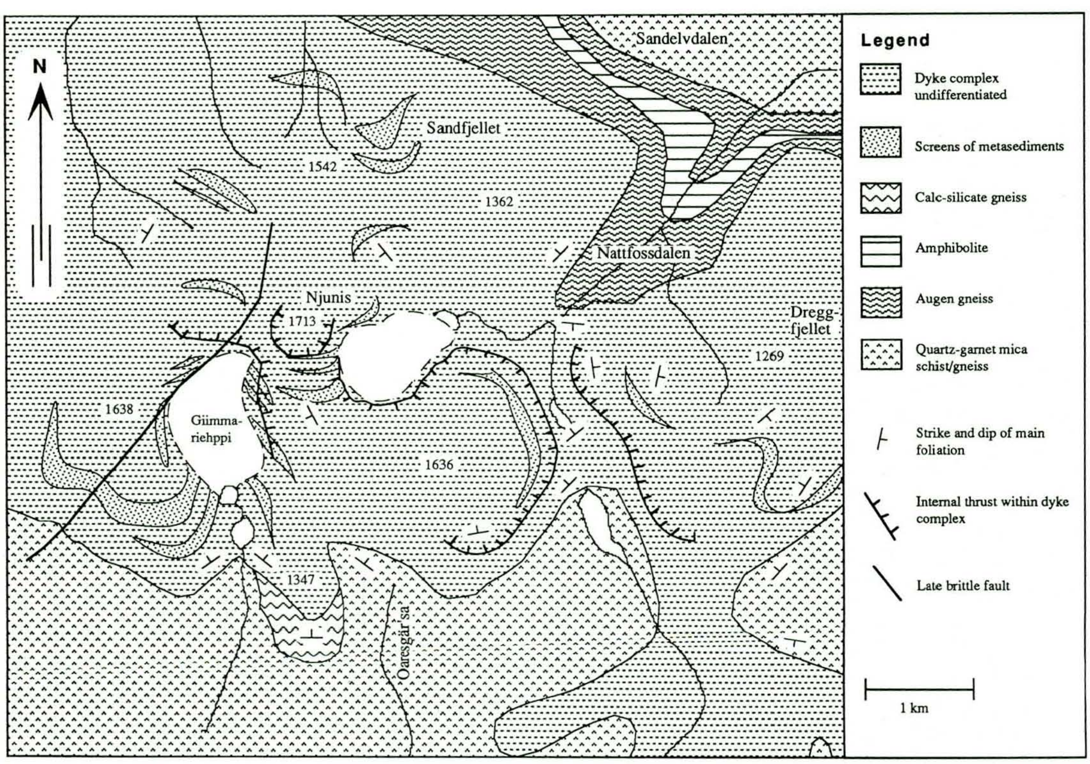

Fig. 7. Geological map of the Njunis area.

dish grey in colour and are strongly mylonitic/phyllonitic in their lower part. A well developed planar foliation is locally overprinted by a later crenulation cleavage. The gneiss varies between muscovite-rich and quartzofeldspathic(-garnet-mica) varieties, consisting of quartz + plagioclase + white mica (muscovite) ± garnet (commonly replaced by chlorite) + biotite + epidote +chlorite + zoisite ± calcite + sulphides and oxides. A compositional layering is defined by mica-rich layers and more quartzofeldspathic layers. Due to the penetrative deformation, no evidence regarding the protolith of the gneisses has been found; the prominent layering probably results from Caledonian metamorphism/deformation. S-C fabrics and mica fish indicates a general top-to-the-east sense of movement.

Amphibolite and Augen Gneiss sheet: The amphibolites within this unit are fine- to medium-grained and dark green to black in outcrop. No primary igneous textures have been observed which suggests that there has been a total recrystallisation of the protolith. The rocks are foliated and the following mineral assemblage is common : hornblende + plagioclase ± garnet + oxides + sphene + calcite and zoisite. In addition, mylonitic and retrogressed variants contain large amounts of chlorite + actinolite and epidote. A banding composed of hornblende-rich and plagioclase-epidote-zoisite layers is common.

A conspicuous kyanite-bearing augen gneiss unit is found throughout most of the mapping area (Fig. 8a), locally reaching a thickness of 200 metres. In field appearance it is a greyish to pale red augen gneiss with pink garnets. The typical mineral assemblage is quartz + plagioclase + garnet ± hornblende + muscovite ± sillimanite ± chlorite ± epidote (in retrogressed variants) + biotite ± kyanite + opaques, indicating a medium to high amphibolite- facies metamorphism. The mylonitic foliation is composed of bands and blades of quartz surrounding porphyroclasts of feldspar, garnet, white mica and kyanite (Fig. 8a & b). Kinematic indicators, i.e. rotated porphyroclasts, S-C structure and mica fish are common, all indicating top-to-the-east movement. Sheath folds occur quite commonly in this unit, indicating a high simple-shear strain.

Metabasite lenses (locally with retro-eclogitic mineral asssemblages) are common within this unit, especially in the Jåvnet area (Kathol 1989). These occur as 1-10 m-long and up to 3 m-thick lenses with foliated rims and cores that preserve relict subophitic textures. One large sheet of metabasite occurs in the Gisttatcohkka area; this sheet is a ~100 m long and 15-20 m-thick, medium- to coarse-grained metabasite with retro-eclogitic mineral assemblages.

Sillimanite-bearing gneisses with calc-silicates and skarn occur locally above the augen gneisses in the Jåvnet and Njunis areas (Figs. 6 & 7). It is suggested that the augen of the present study are are correlatives of the Storglaciären gneiss in the Kebnekaise area (Andréasson & Gee 1989) and part of the 'upper gneiss unit' of Kathol (1989) in the Torneträsk area.

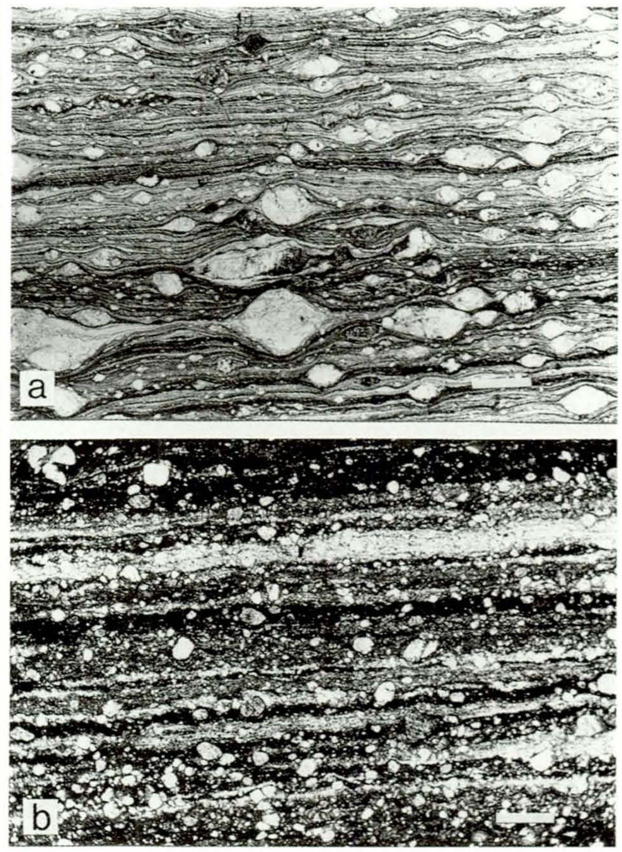

Fig. 8. Examples of the characteristic augen gneiss of the SNC: a) augen gneiss with quartz bands. Scale-bar 1 mm.. Locality, Kistefjell (UTM 34WDB402080); (b) fine-grained augen gneiss with rounded porphyroclasts. Scale-bar 1 mm.. Locality, Jerta (UTM 34WDB532198).

Rohkunborri Nappe: The Rohkunborri Nappe composes the uppermost part of the SNC in the Indre Troms area. A general description of this tectonic unit with its mafic dyke complexes is given in Stølen (1994a), and the geochemistry of the mafic dyke swarms is treated in Stølen (1994b). This thrust sheet crops out as a klippe in the Rohkunborri, Kistefjell, Jerta and Tjuotjmer areas and makes up a large part of the Njunis - Sandfjellet area in Dividalen valley (Fig. 2). The best exposures are found in the Rohkunborri and Njunis areas, whereas the other areas consist of more deformed and amphibolitised lithologies.

The Rohkunborri area (Fig. 6) represents a critical region for correlation of the rocks in Indre Troms and the Vaivvancohkka Nappe (Kathol 1989) further south in the Torneträsk region. It is not possible to map the Rohkunborri Nappe directly into the Vaivvancohkka Nappe, but some of the underlying SNC sequences can be mapped through. A correlation between the internal units of the Rohkunborri Nappe and the Vaivvancohkka Nappe is considered further below.

The northernmost exposure of the Rohkunborri Nappe occurs in the Tjuotjmer - Tjuoljevare area (Fig. 9). Here, it is exposed in an open synform with a tectonostratigraphic

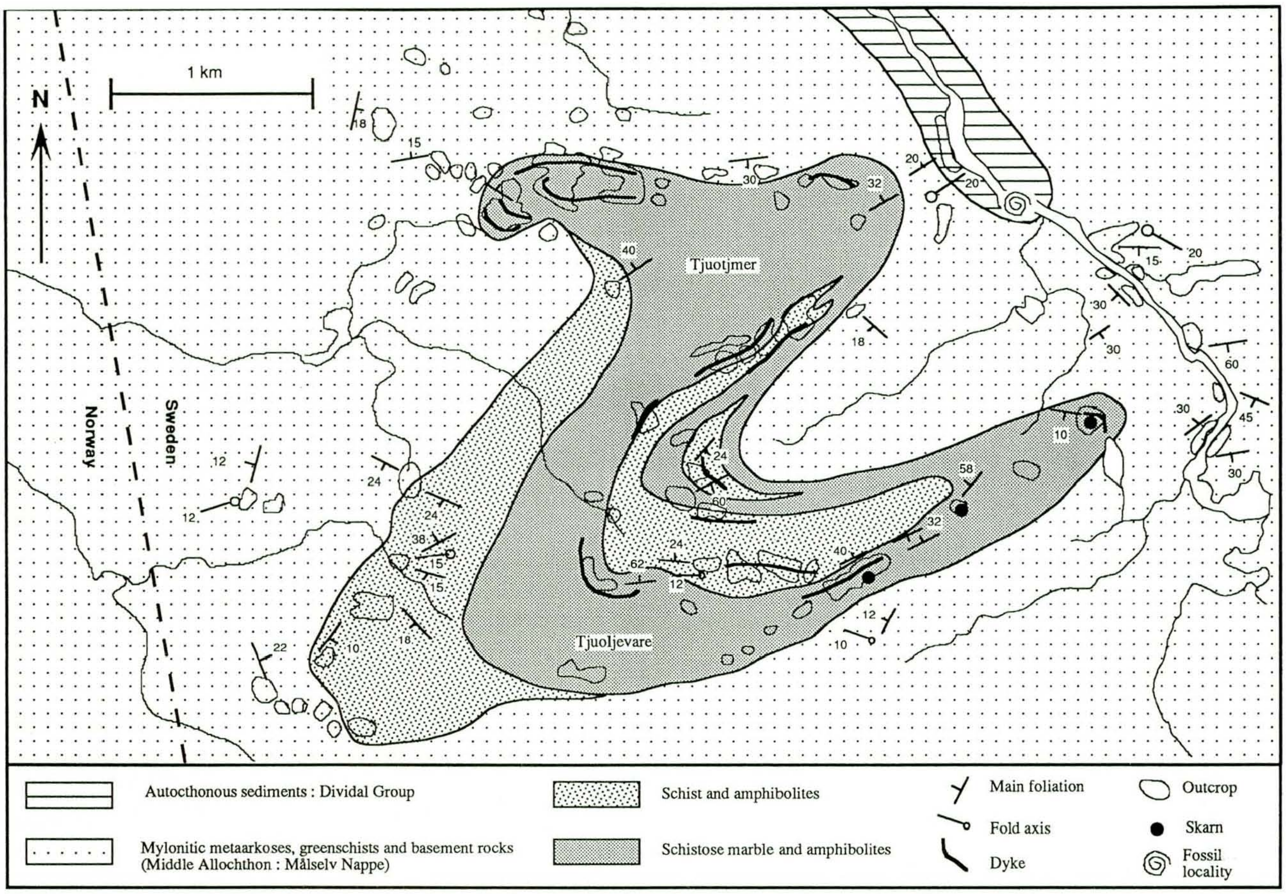

Fig. 9. Map of the Rohkunborri Nappe in the Tjuotjmer area, Pältsa, northern Sweden.

thickness of less than 100 m and is made up of amphibolitised dolerite dykes, psammitic schists and marbles. Skarns are common, usually occurring as layers and lenses. Although the nappe is extensively deformed in this area, chilled margins and relict ophitic textures are found locally within the amphibolitised dolerite dykes.

The Rohkunborri Nappe is made up of 65-70 % mafic dykes and 30-35 % sedimentary rock screens and occurs as a klippe in the Rohkunborri, Kistefjell, Jerta and Tjuotjmer areas (Fig. 2); only in the Njunis - Bangfjellet area are the contact relationships to the overlying rock units of the KNC exposed. Due to glacial erosion, the exposures of the Rohkunborri Nappe in the Rohkunborri and Njunis areas are extremely good and most of the key localities are found within these areas. The much larger tectonostratigraphic thickness of the Rohkunborri Nappe in these two areas is accompanied by good preservation of pre-Caledonian intrusive relationships.

The sedimentary succession of the Rohkunborri Nappe; the Njunis Group

The dyke-intruded metasedimentary succession recognised within the Rohkunborri Nappe has been referred to as the Njunis Group by Stølen (1994a). This comprises four formations in the type area between Njunis and Högskardet (Figure 10). The metasediments dip steeply towards the southeast and young in the same direction. The upper parts of the succession are also recognised in the Rohkunborri area. However, although lithological similarities do exist, it has not been possible to correlate the succession recognised in the Njunis and Rohkunborri areas with sedimentary rocks of the Rohkunborri Nappe elsewhere in the Indre Troms area. A particularly problematical unit comprises a series of rusty quartzites that occur as subordinate concordant lenses within foliated amphibolites close to the floor thrust of the Rohkunborri Nappe. These rocks have been heavily deformed and their relationship to the Njunis Group remains unclear. Thickness estimates of the various formations are difficult to give since they occur as screens between great numbers of dykes, but the total tectonostratigraphic thickness of the Rohkunborri Nappe is ~ 2500 metres in the Rohkunborri area; of this, 65-70 % is represented by dykes and 30-35 % by sediments. This rough estimate suggests that the Njunis Group has a thickness of ~800 metres in the Rohkunborri area.

Høgskardet formation: The only exposures of the Högskardet formation are found in stream sections on the northern side of Høgskardet, where continuous sections through the lower parts of the SW-dipping formation and the discordant, northerly dipping, thrust contact to the KNC can be observed. The upper contact to the formation is not exposed.

The Høgskardet formation consists of horizons of graph-

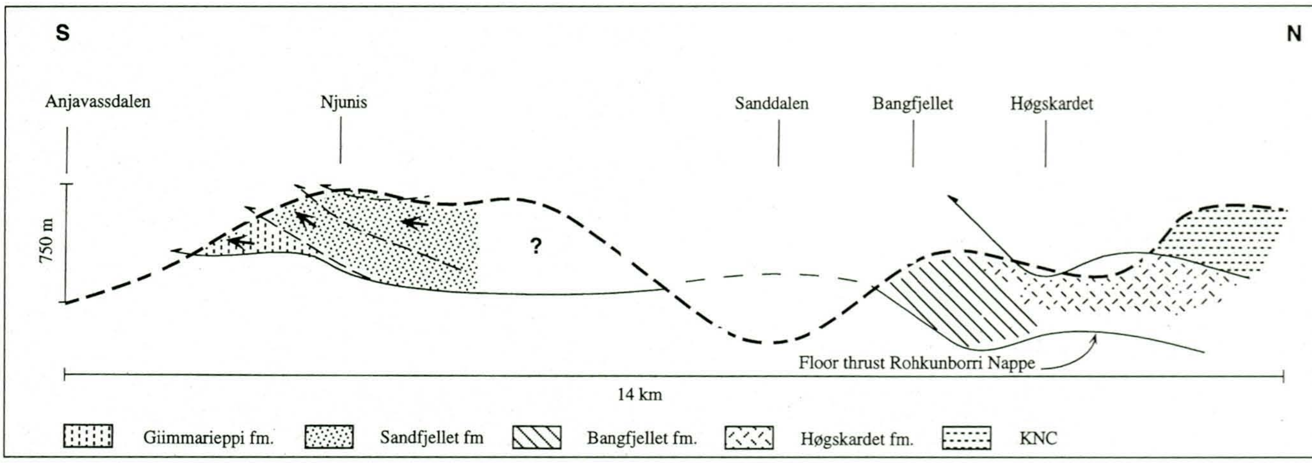

Fig. 10. Schematic section of the Njunis - Högskardet area showing the distribution of various formations of the Njunis Group (grey double-sided arrows). Thick arrows indicate younging direction. Location of the section is shown in Figure 2. Thick dashed line = topography.

itic and psammitic schist interbedded with a dark homogenous, medium- to coarse-grained calcitic marble. Skarn assemblages (grossular, diopside and calcite) are found within impure marble horizons close to dyke contacts. Since the formation occurs close to the contact to the KNC, it is more deformed than the others, and no sedimentary structures have been observed.

Bangfjellet formation: This formation is found only in the Njunis-Høgskardet area. The lower contact is not exposed, whereas the upper contact can be found locally in the Giimmariehppi area (see below). The type area is well exposed in the western part of the summit area of the mountain Bangfjellet (UTM34WDB385335). This formation contains fewer dykes than the other formations, constituting only 30-40 % of the total exposed rock volume.

The dominant rock-type is a c. 400 m-thick, yellow to grey, calc-silicate-bearing dolomitic marble. Laterally persistent calc-silicate layers (dominantly scapolite) are 2 - 8 cm thick and make up more than 50 % of the rock volume. Due to the ductility contrast between the marble and the calc-silicate layers, the latter are often disrupted during syn-magmatic and/or Caledonian deformation. Scapolite also occurs as fracture infill and as crystal aggregates growing on bedding surfaces.

Sandfjellet formation: Excellent exposures of this formation can be found in the 350 m-high eastern wall of Njunis in the Giimmariehppi glacier cirque. The estimated thickness of this formation is c. 400 m. The lower boundary is a local angular unconformity between a marble, correlated with those of the Bangfjellet formation and overlying fine-grained psammites of the Sandfjellet formation. The latter are overlain by arkoses and quartzites. A layer containing a few granitoid pebbles in a pelitic matrix is found within the lower part of the formation. Cross bedding (Fig. 11a) and graded bedding are found within the arkoses and quartzites, all younging to the southeast. The arkoses are medium- to thick-bedded and the bedding has a uniform thickness within each screen of sedimentary rocks. The upper two-thirds of the formation are made up of calcareous schists and impure marble with scapolite bands. Skarn assemblages (grossular, diopside and calcite) are common found within the impure marble layers. All rocks of the Sandfjellet formation have a rusty appearance due to sulphide impregnation (pyrite, pyrrhotite and galena). The upper part of this formation is also exposed in the Rohkunborri area.

Giimmariehppi formation: This formation makes up a large portion of the easternmost part of the Rohkunborri massif and the southernmost part of Giimmariehppi glacier cirque. It reaches an estimated thickness of c. 350 metres although the boundaries of this formation are not exposed. The unit is made up of a medium- to coarse-grained, grey, banded marble with alternating calc-silicate and scapolite bands. Marble layers as well as calc-silicate layers are uniform in thickness, although calc-silicate bands are usually disrupted and folded. Scapolite bands occur less frequently (less than 20% of the total rock volume) than in marbles of the other formations within the Njunis Group. No primary structures have been found within the grey marble.

Contact metamorphism of the Njunis Group

Contact-metamorphic skarns are common within the dyke complex. These vary from centimetre-scale hornfels screens at the margins of single dykes to more extensive screens of contact-metamorphic rocks occur where metasediments are intruded by numerous dykes. Metasediments close to small dykes are not contact metamorphosed, reflecting a low heat capacity and magma flow within these dykes.

Many of the hornfelses are very fine grained and the primary bedding may be totally absent close to the dyke margin (Stølen 1994a). The hornfelses are bright red and green in colour due to the large contents of diopside and garnet, although a general rusty appearance is common. Growth of garnet in spots, dendritic patterns (Fig. 11b), aggregates and layers (Fig. 11c) indicates contact-metamorphic growth under low-pressure static conditions. A common skarn assemblage is diopside + garnet (grossular) + calcite + plagioclase

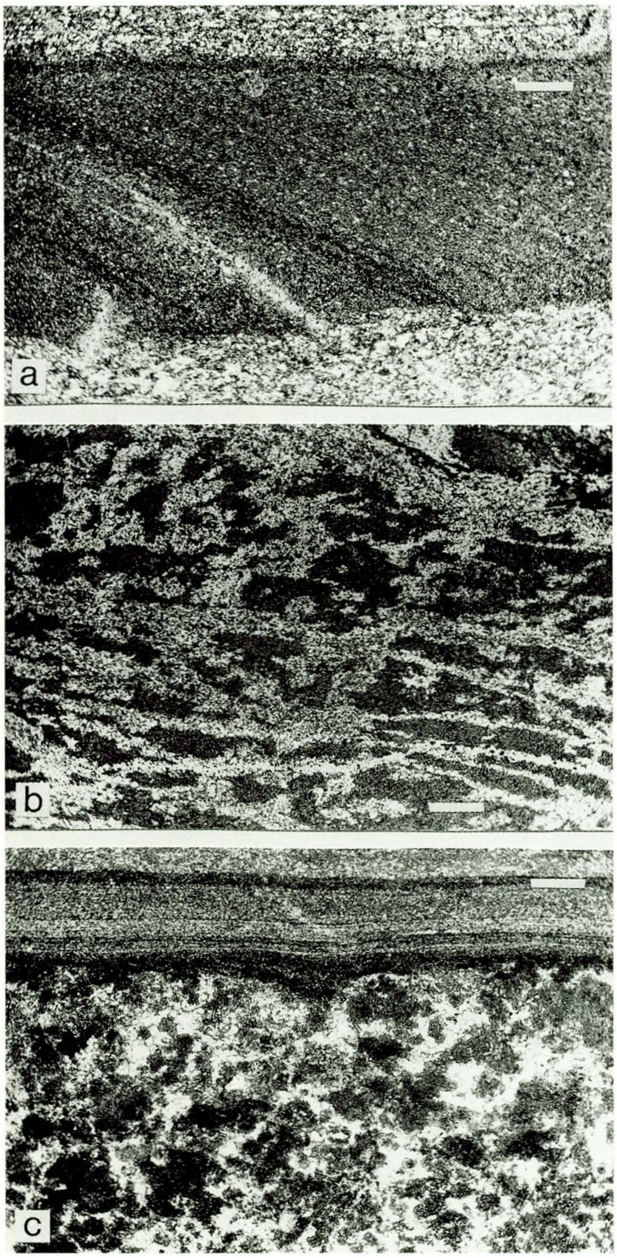

Fig. 11. Examples of sedimentary structures and contact-metamorphic textures found within the sedimentary rock sequence of the Njunis Group. (a) Thin section photo of small-scale cross bedding between alternating sandy and clay-rich layers. Scale-bar 1 mm.. Locality, Njunis (UTM 34WDB391271). (b) Dendritic garnet growth pattern producing massive garnet layers in garnet - diopside - calcite scarn rock from the Giimmariehppi Formation. Scale-bar 1 mm.. Locality, Giimmariehppi (UTM 34WDB379256). (c) Cloud-like growth of garnet in marble layers between calc-silicate layers in marble from the Giimmariehppi Formation. Scale-bar 1 mm.. Locality, Giimmariehppi (UTM 34WD B374258).

± scapolite ± chlorite ± pyroxene ± sulphides.

For most of the impure marbles within the dyke complex, quartz and calcite are stable suggesting that contact-metamorphic conditions remained below those necessary for wollastonite formation; the typical assemblage is calcite + quartz + diopside ± garnet. Within the interior parts of the Njunis dyke complex, however, the assemblage calcite + diopside + wollastonite occurs, indicating that temperatures were high enough for the reaction quartz + calcite = wollastonite + CO_2, to proceed. Local flow folds in marbles and back-veining (see below) indicates even higher contact-metamorphic conditions. In metasediments where there are only a few dykes, or at a distance of several metres from sheeted dyke complexes, the assemblage quartz + calcite + tremolite is also found. Precise mineral assemblages and textures therefore appear to be dependent on the distance from the dyke rim and the number of dykes per volume of rock. Contact metamorphic parageneses are distributed heterogeneously within the marbles, possibly due to calc-silicate layers acting as barriers for fluid transport (Heinrich 1993) during the contact metamorphism.

Back-veining is found at several localities within the dyke complexes, where temperatures in the screens were high enough to cause local melting of pelitic sediments with their quartz, plagioclase, biotite and white mica parageneses. The actual melting temperatures depend on several factors, such as pressure, magma flow and rock-water interaction. The veins consist of quartz, feldspar, biotite and amphibole and they are generally more coarse grained than the wall-rock from which they were derived. Back-veining of this material may be preserved in the first few centimetres of a dyke margin, indicating interaction between magma and wall rock material.

Mafic dykes of the Rohkunborri Nappe

Dykes occur both as solitary intrusions within sedimentary rock screens and as sheeted complexes. They are well preserved, medium- to fine-grained greyish dolerites with ophitic to subophitic texture. Plagioclase laths, 0.5 - 1.5 mm long, dominate together with pyroxene, occurring as phenocrysts in an interstitial fine-grained groundmass. Plagioclase shows normal igneous zonation (decreasing An content from core to rim), but a reverse zonation, interpreted to reflect metamorphic growth, can be found in some dykes. Crysotile pseudomorphs after olivine are found in a few dykes. Most of the dykes are equigranular, although porphyritic varieties also occur. Accessory minerals are ilmenite, magnetite, hematite, pyrite and apatite. Near the floor and roof thrusts and in internal shear zones, the dykes are strongly amphibolitised. The amphibolites are foliated and the main minerals are hornblende and plagioclase with minor amounts of quartz, zoisite and garnet.

Early, coarse-grained and gabbroic dykes are found in a few places and coarse gabbroic xenoliths are also identified in younger dykes. In the Njunis area, sills occur along lithological contacts and local unconformities. Scapolite is found dispersed along the margins of the dykes, and also as fracture fillings, both in dykes and metasediments. At one locality in the Rohkunborri area, an early dyke with scapolite-filled fractures is intruded by a later plagioclase-porphyritic dyke without scapolite-filled fractures (Fig. 12), indicating a pause between the two intrusive events enabling the first dyke to cool and the fracture to be filled with scapolite-bearing fluids before the next magma injection.

Fig. 12. Early dyke with scapolite-filled fractures intruded by later plagioclase-porphyritic dyke without scapolite-filled fractures. Arrow indicates contact between dykes (pencil for scale, 15 cm). Locality: SE side of Rohkunborri (UTM 34WDB 338042).

The dykes usually form sheeted complexes, with some dykes being intruded in their central parts by later dykes, producing one-sided chilled margins. One-sided chilling may persist over at least six contacts, with the chilling direction towards the screens of metasedimentary rocks. The chilled margins contain euhedral phenocrysts of plagioclase in a fine-grained to aphanitic groundmass (Fig. 13). Fluidal arrangements of plagioclase laths may be oriented parallel to the margin, indicating magma flow. Small amounts of flaky biotite can also be found along the margins of the dykes.

Several generations of dykes occur, with older dykes cutting the bedding in the sedimentary rocks at high angles and the younger dykes cutting the older ones at angles of up to 40°; these relationships suggest intrusion during active faulting and block rotation (Stølen 1994a).

Fig. 13. Thin-section photo (crossed nicols) of fluidal structures at the contact between dolerite dyke and calcareous meta sediments (to the right). Plagioclase laths are oriented parallel to the contact. Scale-bar 1 mm.. Locality, NW side of Njunis (UTM 34WDB366306).

Upper Allochthon: Köli Nappe Complex (KNC)

Not being a primary concern of this study, the rocks of the Köli Nappe Complex (KNC) have not been studied in detail and only the basal parts have been mapped.

Throughout much of the Scandinavian Caledonides, the basal thrust of the KNC is regarded as the boundary between indigenous terranes and outboard terranes, based on differences in age, origin, and metamorphic and structural histories (Andréasson 1994). In the Pältsa area, there is a distinct thrust contact between the SNC and the KNC and also a metamorphic break between amphibolite-grade schists of the SNC and greenschist-facies schists of the KNC. Similar relationships exist in the Njunis area, where kinematic indicators show a top-to-the-east movement sense along this contact.

The best section through the KNC is found in the Pältsa area (Fig. 4), where it has been divided into two thrust sheets (Fig. 3). Phyllites and marbles, overlain by volcaniclastic rocks and marble, compose the lower sheet, whereas garnet amphibolites and subordinate quartz-garnet-mica schists make up the upper sheet.

Lower thrust sheet

Schist unit: This is a heterogeneous unit with quartz schists, graphitic schists, quartzites and subordinate calcareous schist. Quartz schists have the mineralogy quartz + plagioclase + muscovite ± biotite; psammitic schists quartz + plagioclase + muscovite ± garnet ± biotite ± opaques; whilst graphitic schists comprise quartz + muscovite + graphite ± sulphides + feldspar.

Volcaniclastic unit: This unit consists of greenschists, garbenschists with subordinate layers of quartz keratophyres, and calcareous schist. The greenschists consist of actinolite + zoisite + epidote + chlorite + white mica + quartz and opaques, whereas the typical mineral assemblage of the garbenschists is hornblende + calcite + garnet + white mica + opaques.

Marble unit: A dark, medium- to coarse-grained, foliated marble with subordinate graphitic schist layers makes up the upper part of the lower thrust sheet. It reaches a maximum thickness of 50 m and is mylonitic/phyllonitic in its upper part.

Upper thrust sheet

Amphibolite unit: This unit consists of dark foliated amphibolites with subordinate coarse-grained metagabbros and gabbro-pegmatites. Quartzofeldspathic and pelitic schists, sometimes garnet-bearing, occur locally within the amphibolite unit. A typical mineralogy for the amphibolites is hornblende + plagioclase + garnet + oxides + sphene + calcite and zoisite. Rusty zones with impregnations of Fe-sulphides are found at several localities within the amphibolite unit. Granitoid dykes cutting the main foliation of the amphibolites are found both in the Måskanvarri area and northwest of Høgskardet, in the Njunis area.

Tectonothermal history

The tectonothermal history of the Scandinavian Caledonides has been divided into two major events, an early Finnmarkian phase (Sturt et al. 1978, Mørk et al. 1988, Dallmeyer & Gee 1986, Dallmeyer 1988, Dallmeyer et al. 1991) of Early Ordovician age (c. 510 - 480 Ma) thought to be associated with the collision between and the Baltoscandian margin and an island arc (Roberts et al. 1985, Dallmeyer & Gee 1986), and a later (c. 430 - 390 Ma) Scandian phase (Gee 1975) related to the final closure of the Iapetus Ocean and Laurentia - Baltica collision. An extensive description of the relationship between Finnmarkian and Scandian tectonothermal activity is found in Andréasson (1994).

Several phases of deformation, here abbreviated D1 - D6, have been recognised in the Indre Troms area (Table 1). Locally, it has been possible to determine the transport direction for nappe emplacement with the help of S-C fabrics, sheath folds and shear bands. Structures related to pre-orogenic extension (i.e. rifting of the Baltoscandian margin) have been treated by Stølen (1994a) and are not included here.

Tectonothermal activity associated with eclogite-grade metamorphism

The first tectonothermal event, $D1_{SNC}$, in the Altevatn - Måskanvarri area is deformation associated with eclogite-grade metamorphism. This deformation is found within the SNC only in the Jåvnet area (Kathol 1989) and is probably related to thickening and subduction of the Baltoscandian margin. There is no age evidence available on the eclogite-grade metamorphism from the Indre Troms area, but correlations with other parts of the SNC in northern Sweden (Mørk et al. 1988) suggest that the eclogites were formed during the Finnmarkian deformation phase.

Evidence for pre-Scandian tectonothermal activity in other units has not been found in the study area. The early foliation within the granitoid rocks of the Målselv Nappe is of pre-Scandian origin, but it is impossible to determine if the deformation that caused this fabric was Finnmarkian or earlier.

Contractional event (Scandian)

Polyphase contractional deformation histories, $D2\text{-}6_{SNC}$, $D1\text{-}5_{KNC}$ and $D1\text{-}3_{MA}$, are recognised in each structural unit (Table 1). Since there is no dating of the deformation available from the Indre Troms area, it is suggested that these deformation phases were part of the polyphase Scandian contractional

	SEVE NAPPE COMPLEX (SNC)	KÖLI NAPPE COMPLEX (KNC)	MIDDLE ALLOCHTHON (MA)
	$D1_{SNC}$ Deformation associated with eclogite grade metamorphism.		
Contactional event (Scandian ?)	$D2_{SNC}$ Development of the main isoclinal axial planar foliation. Medium-grade metamorphism.	$D1_{KNC}$ Development of a main isoclinal axial planar foliation. Medium-grade metamorphism, main porphyroblast growth.	
	$D3_{SNC}$ Juxtaposition of SNC and KNC, transposition of the main foliation. S-C fabric, sheath folds and shear bands indicates SE-movement.	$D2_{KNC}$ Juxtaposition of SNC and KNC, transposition of the main foliation. S-C fabric indicates SE movement.	
	$D4_{SNC}$ Juxtaposition of the SNC and KNC onto the MA.	$D3_{KNC}$ Juxtaposition of the SNC and KNC onto the MA.	$D1_{MA}$ Juxtaposition of the SNC and KNC onto the MA. Development of main foliation. Isoclinal folding. Low-grade-metamorphism.
	$D5_{SNC}$ Inclined, close to tight regional folds on N-S Trending axes. Locally a penetrative crenulation cleavage.	$D4_{KNC}$ Inclined, close to tight regional folds on N-S Trending axes. Locally a penetrative crenulation cleavage.	$D2_{MA}$ Inclined, close to tight regional folds on N-S Trending axes. Locally a penetrative crenulation cleavage.
	$D6_{SNC}$ Mesoscopic open to box shaped, assymmetric folding with vergence towards SE.	$D5_{KNC}$ Mesoscopic open to box shaped, assymmetric folding with vergence towards SE.	$D3_{MA}$ Mesoscopic open to box shaped, assymmetric folding with vergence towards SE.
Late-orogenic extension			$D4_{MA}$ Extensional structures related to late orogenic extensional collapse.

Table 1. Deformational events in the Altevatn - Måskanvarri area.

deformation event, although the possibility does exist that pre-D2_{SNC} deformation within the SNC, evident as inclusion trails in garnets, could be partly of Finnmarkian origin.

Seve Nappe Complex

D2_{SNC} is the main deformational and metamorphic phase within the SNC. This deformation generated a penetrative foliation that is coeval with the development of WNW- or ESE-plunging isoclinal folds. Mineral lineations and intersection lineations are plunging parallel to these fold axes (Fig. 14a). Isoclinal folding has only been observed on a mesoscopic scale.

D3_{SNC} involves juxtaposition of the SNC and KNC and transposition of S2_{SNC} in discrete narrow thrust zones, along which nappe transport occurred. S-C fabrics, shear bands and mineral lineations indicate a southeasterly transport direction. Sheath folds are common in high-strain zones.

D4_{SNC} is related to the emplacement of the SNC and KNC onto the MA and involved a continued southeasterly piggy-back nappe transport. Common structures related to this phase are WNW - ESE stretching lineations.

Köli Nappe Complex

D1_{KNC} deformation dominates the KNC and is characterised by the development of a pervasive axial planar foliation related to isoclinal folding. Deformation occurred under medium-grade conditions of metamorphism with the widespread development of syn-kinematic porphyroblasts.

D2_{KNC} and D3_{KNC} represent the phase of juxtaposition of the KNC with the SNC and subsequently with the MA. Nappe transport occurred along narrow high-strain zones in which a strong WNW-ESE trending lineation was developed. Shear bands and S-C fabrics indicate a southeasterly transport direction.

Middle Allochthon

D1_{MA} is represented by a non-penetrative foliation S1_{MA}, which probably formed at higher crustal levels (low-grade metamorphism) than in the case of the main foliations within the SNC and KNC. The foliation is axial planar to isoclinal folds and is probably related to the juxtaposition of SNC / KNC and MA during continued southeasterly transport onto the Baltoscandian margin/platform. Sheath folds (Fig. 15) are common in high-strain zones near the base of the nappe.

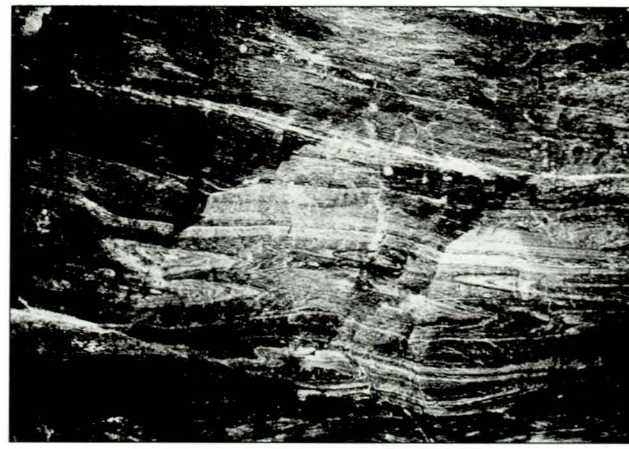

Fig. 15. Sheath folds (below arrow) in quartzo-feldspathic mylonites from the base of the Målselv Nappe in the Kåbmejaure area (UTM 34WDB732458). Width of the section is 150 cm.

Deformational events that involve all thrust sheets

Deformation phases D5-6_{SNC}, D4-5_{KNC} and D2-3_{MA} post-date the amalgamation of the thrust sheets. Thrust contacts are folded in tight to open regional folds with N - S to NW - SE axes respectively (Fig. 14b). F5_{SNC}, F4_{KNC} and F2_{MA} folds are inclined and close to tight. Locally, a penetrative S5_{SNC}, S4_{KNC} and S2_{MA} crenulation cleavage is developed. D6_{SNC}, D5_{KNC} and D3_{MA} deformation is dominated by mesoscopic, open to box-shaped, asymmetric folding with vergence towards the southeast. Kink banding and crenulation cleavages are commonly developed and locally the crenulation cleavage is penetrative.

Late-orogenic extensional structures

Evidence for structures related to late-orogenic extension and top-to-the-west movement have been found within the lower part of the MA in the Kistefjell area. This is generally

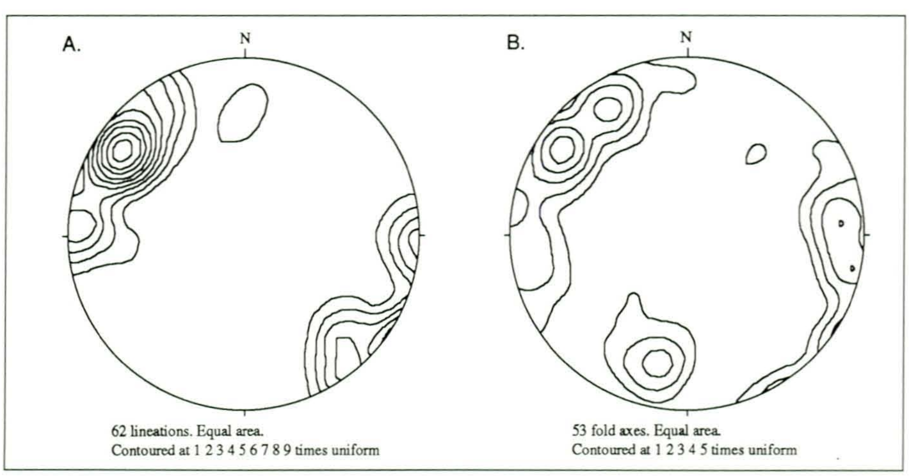

Fig. 14. Contoured equal area nets of structural data from the SNC in the Rohkunborri and Njunis areas: (a) Stretching lineations and intersection lineations. (b) Minor fold axes of folds that deform thrust contacts in the Rohkunborri and Njunis areas.

seen as a superimposition of top-to-the-west shear structures ($D4_{MA}$) upon earlier top-to-the-east shear bands and S-C structures ($D1_{MA}$).

Tectonostratigraphic correlations

The tectonostratigraphic relationships between different thrust sheets in the Troms and northern Norrbotten area have been reviewed in recent papers by Binns (1978, 1989), Andresen et al. (1985), Stephens et al. (1985), Barker (1989), Stephens & Gee (1989), Andréasson (1994), Andresen & Steltenpohl (1994) and Stølen (1994a). Table 2 shows regional correlations in the region between northern Norrbotten and northern Troms.

Termination of the Seve Nappe Complex in the Indre Troms area

Different opinions exist about the lateral continuation of the SNC north of the Indre Troms area: (1) the SNC terminates (Hossack 1983, Gee et al. 1985, Krill et al. 1987); (2) the SNC continues northwards as a part of the Kalak Nappe Complex (Zachrisson 1986); (3) the SNC and MA are regarded as one thrust sheet of basement-derived rocks from the same part of the Baltoscandian margin (Hossack & Cooper 1986, Barker 1989). The third interpretation is probably based on a common misconception that all rocks within the SNC are similar to the lithologies of the SNC in Jämtland, Sweden. Basement-derived crystalline sheets make up a very small part of the SNC (Andréasson & Gee 1989), whereas they dominate in much of the MA (e.g. the Akkajaure Complex (Björklund 1985, Björklund 1989) and the Jotun Nappe (Hossack & Cooper 1986)). The Seve rocks that were derived from the outermost part of the Baltoscandian margin (i.e. the Sarektjåkkå Nappe (Andréasson 1986a, Svenningsen 1993, Svenningsen 1994a), the Tsäkkok Nappe (Stephens & van Roermund 1984, Kullerud et al. 1990), the Vaivvancohkka Nappe (Kathol 1987, 1989) and the Rohkunborri Nappe (Stølen 1989, 1994a, b & c and this paper)) are very different from the crystalline rock units of the Middle Allochthon and should therefore not be reassigned to the Middle Allochthon as suggested by Barker (1989) on the basis just of lithological similarity.

Mapping of the SNC in the Altevatn - Måskanvarri area has revealed a general attenuation of the nappe complex northwards and it is not possible to recognise any parts of the SNC north of this area. The termination of the SNC in this

	Norrbotten	Torneträsk - Ofoten	Altevatn - Måskanvarri	Northern Troms
Outboard terranes	Uppermost Allochthon	Niingen Nappe		Tromsø Nappe Complex
	Upper Köli	Salangen (Bogen Group)		Balsfjord group
		Evenes Group		
	Middle Köli	Gratangseidet mafic complex		Lyngen magmatic complex
		Narvik Nappe Complex		Nordmannvik Nappe
				Kåfjord Nappe
	Lower Köli	Høgtind Nappes (Köli Nappe Complex)	Köli Nappe Complex (VaddasNappe)	VaddasNappe
Baltoscandian margin	Tsäkkok Nappe	Upper gneiss unit		
	Sarektjåkkå Nappe	Vaivvancohkka Nappe	Rohkunborri Nappe	
	Vaimok Nappe	Lower gneiss unit	Lower Seve Nappes	
	Akkajaure Complex	Abisko Nappe Complex	Målselv Nappe	Måselv Nappe
		Rautas Nappe Complex		
Autochthon	Dividal Group	Dividal Group	Dividal Group	Dividal Group
	Basement	Basement	Basement	Basement

Table 2. Correlation of thrust sheets in the Altevatn - Måskanvarri area with northern Troms, the Ofoten Torneträsk area and the northern Norrbotten areas. Data from the Ofoten - Torneträsk area based on Kathol (1989) and Andresen & Steltenpohl (1994), northern Troms based on Andresen & Steltenpohl (1994), and the northern Norrbotten area based on Zachrisson & Stephens (1984) Björklund (1985) and Svenningsen (1993).

area could be caused by the rejoining of trailing and leading branch lines to the SNC in the vicinity of Treriksrøysa (Zachrisson 1973, Hossack 1983); or it may be that the distribution of the SNC is controlled by major structural breaks in the basement (Romer & Bax 1992). Although there is a distinctive thinning of the SNC in this area, major units (e.g. the Rohkunborri Nappe and the lower gneisses) can still be recognised. This may be due to a general thinning of the whole nappe due to late-orogenic gravitational collapse (Gee 1978) rather than to the basal KNC thrust cutting down into the SNC.

Correlation of the Köli Nappe Complex

A threefold division of the Köli Nappe Complex into Lower, Middle and Upper Köli Nappes is commonly used in many parts of the Scandinavian Caledonides (Stephens 1980, Stephens et al. 1985, Stephens & Gee 1989). In the case of the rocks of the Altevatn - Måskanvarri area, it has not been possible to establish any definite correlation with the above-mentioned units of the KNC. However, a general wedging out of the Lower Köli Nappes northwards in the Scandinavian Caledonides has been described by Zachrisson (1986). It is therefore suggested that the KNC of the Altevatn - Måskanvarri may belong to the Middle or Upper Köli Nappes. This suggestion is supported by a strong correlation between the amphibolite unit in the uppermost part of the Pältsa and the Vaddas Nappe (Nappe 5 of Binns (1978)). Roberts (1988) correlated rocks of the Vaddas Nappe (Vaddas Terrane) with rocks within the Sulitjelma Igneous Complex of the Middle Köli in the Sulitjelma area in the central Scandinavian Caledonides. Although the lower part of the KNC in the Pältsa area shows similarities with a typical Lower Köli stratigraphy, with alternating quartz-mica schists, graphitic schists, quartzites, marble and quartz-keratophyres, it could equally well represent part of the Middle Köli Nappe stratigraphy.

Tectonic evolution of the Rohkunborri Nappe

The sedimentation of the Njunis Group is thought to have started during the Neoproterozoic in rift-related extensional basins along the Baltoscandian passive margin. Evidence for crustal extension includes normal faults and early boudinage found within the meta sediments of the Njunis Group. Furthermore, intense dyke intrusion (60-70% dykes in some places) demonstrates that the continental margin has experienced a large amount of extension.

Quartzitic to quartzo-feldspathic metasediments probably originated in low-energy fluvial or shallow-shelf environments, whereas the marbles and dolomites of the Njunis Group possibly represent a carbonate platform.

The extensive scapolite deposits within the Njunis Group are thought to have formed through metamorphism of marine evaporites, a process seen in other areas with scapolite deposits (Serdyuchenko 1975, Kwak 1977, Vanko & Bishop 1982, Ortega-Gutierrez 1984, Svenningsen 1994b). This suggests that parts of the Njunis Group were deposited in evaporite basins, but it does not exclude the possibility that some of the scapolite, particularly that associated with dykes, may be of magmatic origin.

The Rohkunborri Nappe as part of the rifted Baltoscandian margin

Stratigraphical and sedimentological studies (Kumpulainen 1980, Kumpulainen & Nystuen 1985) indicate that the clastic wedge that was deposited in rift-related basins along the thinned Baltoscandian margin, during Neoproterozoic to Early Cambrian time, now found within the autochthon and the Lower and Middle Allochthon, can be divided into three informal units: a thick, lower, mainly fluviatile unit, a middle glacial unit (Varangerian) and an upper fluviatile and shallow-marine unit of Late Vendian to Early Cambrian age.

Correlation of the Njunis Group with the above-mentioned units of Kumpulainen & Nystuen (1985) is not possible. The former contains considerably more carbonate material than any of those defined by Kumpulainen (1980) and Kumpulainen & Nystuen (1985), probably due to its depositional environment being nearer to the outermost part of the Baltoscandian passive margin.

Based on lithological similarities, a correlation is drawn between the calc-silicate bearing dolomites of the Bangfjellet formation and the Baddus carbonate formation of the Vaivvancohkka Nappe (Kathol 1989). The Baddus limestone (Kulling 1964) at its type locality south of Lake Torneträsk is also similar to the carbonates of the Bangfjellet formation.

It does not seem possible to correlate units within the Sarektjåkkå Nappe (Svenningsen 1993) and the Vaimok Lens (Zachrisson & Stephens 1984) with units of the Njunis Group, although evaporites within the Njunis Group may suggest a correlation with parts of the Spika Formation (Svenningsen 1994b) in the Sarek area. The Tsäkkok Nappe (Stephens & van Roermund 1984, Kullerud et al. 1990,) contains quartzitic to quartzo-feldspathic metasediments and a substantial carbonate component, as well as rocks intermediate between quartz- and carbonate-rich varieties, and is considered to originate from the outermost edge of the Baltoscandian margin. A lithostratigraphic correlation between parts of the Njunis Group and the Tsäkkok rocks is suggested here. Nevertheless, major differences should be emphasised: (1) the Njunis Group has escaped the high-P metamorphic event found in the Tsäkkok Nappe; and (2) the Tsäkkok Nappe does not contain the characteristic sheeted dyke complexes of the Rohkunborri Nappe.

It is probable that the Rohkunborri and Tsäkkok Nappes represent a more oceanward segment of the Baltoscandian passive margin than the Sarektjåkkå and Vaimok Nappes, i.e. each successively higher tectonic unit represents a more oceanward part of the margin. However, the first three nappes must have originated further out on the margin than the Vaimok Nappe (Andréasson 1994). Meta-evaporites are found in several thrust sheets derived from the Baltoscandian passive margin (Kumpulainen 1980, Nystuen 1980, 1987, Kumpulainen & Nystuen 1985), but most of them are magnesite deposits within dolomites. Scapolite deposits within the Sarektjåkkå Nappe (Andréasson 1986a, Svenningsen 1994b) might have the same origin as the scapolite rocks of the Njunis Group, although the magnesite deposits found in association with the scapolite deposits in the Sarek area have not been observed in the Indre Troms area.

The rift event

The sedimentary succession of the Rohkunborri Nappe has been interpreted to represent the outermost part of the Baltoscandian miogeocline. Furthermore, mafic dyke swarms intruding these sediments have a transitional (T-MORB) to normally depleted (N-MORB) geochemistry, probably representing generation in a transitional setting between continental and oceanic crust (Stølen 1994b). Field relationships suggest that dyke intrusion occurred during crustal extension as the sediments accumulated in actively subsiding rift basins.

The petrochemistry of the Rohkunborri Nappe dolerites shows similarities with dyke swarms within the Vaivvancohkka, Sarektjåkkå and Tsäkkok Nappes (Stølen 1994b), and the Corrovarre nappe in North Troms (Roberts 1990). A modern analogue would be the Tertiary volcanites found on the Vøring Plateau which is situated on an extensively thinned continental crust close to the transition zone between continental and oceanic crust (Viereck et al. 1988). It seems likely, therefore, that the rift magmatism of the Rohkunborri Nappe was produced contemporaneously with a continuous rifting of the Baltoscandian passive margin during the opening of the Iapetus Ocean. Age determinations discussed in Stølen (1994b) suggest a possible age of ~ 600 Ma for the intrusion of the mafic dykes of the Rohkunborri Nappe. This age is similar to the 573±74 Ma (Sm-Nd) date obtained for the mafic dykes within the Sarektjåkkå Nappe (Svenningsen 1994a), and the age of 582±30 Ma (also Sm-Nd) for the dyke in the Corrovarre Nappe (Zwaan & van Roermund 1990). These ages are slightly younger than the ca. 650 Ma age of the Ottfjäll dolerites (Claesson & Roddick 1983) which probably represent an earlier stage in the multistage rift magmatism along the Baltoscandian margin (Andréasson 1994). Thus, the dyke swarms of the Rohkunborri, Vaivvancohkka and Sarektjåkkå Nappes, as well as those in the Corrovarre Nappe, probably express a later stage of the Iapetan rift magmatism recorded within the Scandinavian Caledonides.

A correlation between the evolution along the Baltoscandian margin and the Laurentian margin is not attempted here since recent palaeomagnetic evidence (Torsvik & Trench 1991, Torsvik et al. 1991, 1995) indicates that the Baltoscandian margin probably did not face the Laurentian margin in Late Precambrian - Early Cambrian time.

Summary and conclusions

The Altevatn - Måskanvarri area consists of a stack of far-transported thrust sheets emplaced over autochthonous sediments (Dividal Group) which unconformably overlie the Precambrian crystalline basement rocks. The allochthon can be divided into those thrust sheets derived from the Baltoscandian margin (Målselv Nappe and the SNC) and those representing outboard terranes (KNC). There is a general wedging out of the SNC northwards in the study area towards the Tjuotjmer area, close to the three-nation border point Treriksrøysa.

The upper part of the SNC is represented by the Rohkunborri Nappe wherein dolerite dykes, commonly seen as sheeted dyke complexes, form a major part (up to 70 %).

The sedimentary succession of the Rohkunborri Nappe, the Njunis Group, was deposited in a platformal environment, including a carbonate platform and marine evaporite basins, along the outer part of the Baltoscandian passive margin during the Late Precambrian to Early Cambrian. Scapolite deposits were formed through metamorphism of marine evaporites. Evidence of extensive contact metamorphism (garnet-diopside-calcite skarns) can be found close to dolerites within the calcareous sediments of the Njunis Group. The rift magmatism within the Rohkunborri Nappe probably represents the last stage of Iapetan rift magmatism in the Scandinavian Caledonides.

A polyphase tectonothermal history is recognised in the area, involving a probable Late Cambrian - Early Ordovician event related to the formation of eclogites, found only within the lower parts of the SNC, and a later Scandian event that has affected all units in the area. The interior parts of the Rohkunborri Nappe have escaped the high-P metamorphic event that affected parts of the SNC and no evidence of eclogite-grade metamorphism has been found within this nappe.

Due to the deep erosional level and good exposure, the segment of the ancient Baltoscandian passive margin found within the Rohkunborri Nappe represents a good example of a part of a rifted passive margin closest to the continent-ocean transition zone. Thus, this tectonic unit provides structural, sedimentological and petrological data from a paleogeographic setting that is generally not accessible in comparable modern environments.

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