

Stratigraphic overlap of the late Proterozoic Vadsø and Barents Sea Groups and correlation across the Trollfjorden–Komagelva Fault, Finnmark, North Norway

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New data from western Varangerhalvøya, Finnmark, North Norway, show that the stratigraphic sequences on either side of the Trollfjorden–Komagelva Fault overlap. In the Manjunnas area, the Ekkerøya Formation (top Vadsø Group) overlies the Båtsfjord Formation (middle Barents Sea Group) along an unconformity, locally angular, marked by an intermittently preserved sedimentary breccia. As the Vadsø Group is part of the stratigraphic sequence found to the south of the Trollfjorden–Komagelva Fault, and the Barents Sea group part of the sequence found to the north of the fault, these data confirm that the area north of the fault (the North Varanger Region) is an integral part of Baltica and cannot be regarded as a distinct terrane from stratigraphic criteria; it does not, however, place any constraint on the likely displacement along the Trollfjorden–Komagelva Fault.

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The Varanger Peninsula in northeast Finnmark, Norway (Fig. 1) is divided into two parts by the WNW–ESE trending Trollfjorden–Komagelva Fault. To the south lie the East Finnmark Autochthon and Gaissa Thrust Belt, forming, respectively, part of the Autochthon and Lower Allochthon mapped throughout the Scandinavian Caledonides. To the north of the fault lies the North Varanger Region (previously called the Barents Sea Terrane or Region), the affinities of which remain uncertain, with some authors regarding it as a distinct terrane (Gee et al. 1985; Roberts 1988) and others as part of the Lower Allochthon (Rice et al. 1989a, b; Gayer & Rice 1989).

Although Siedlecka & Siedlecki (1967, 1972) suggested that the Trollfjorden–Komagelva Fault was a SSW directed thrust, later models of the region have concentrated on potential strike-slip displacements (Harland & Gayer 1972; Roberts 1972), apparently confirmed by palaeomagnetic data which indicated a minimum of 500 km dextral movement (Kjode et al. 1978), although subsequently Pesonen et al. (1989) have estimated the displacement at ca. 600 km, either dextral or sinistral. Since 1978 interpretations of the geology of Varangerhalvøya have been based on the premise that although the stratigraphic sequences on opposite sides of the Trollfjorden–Komagelva Fault are of similar ages, they cannot be accurately correlated in detail and were not necessarily deposited in closely adjacent areas.

Siedlecka (1985) argued for an early extensional history on the Trollfjorden–Komagelva Fault, accounting for the threefold change in sediment thickness across the fault (see below), followed by strike-slip movement; the

fault was interpreted as an early structure developed during the formation of the Timanian Aulacogen, a failed arm in the 'Iapetus' rift system (Siedlecka 1975). Rice et al. (1989a) used the epizone metamorphic grade of the rocks north of the fault to propose a dextral displacement of 415 km, by loosely correlating the rocks of the North Varanger Region with other epizone grade and more internal units within the Finnmark Caledonides (Laksefjord Nappe Complex and Komagfjord Antiformal Stack), using the restoration of Gayer et al. (1987).

New data presented here from the Manjunnas area in western Varangerhalvøya have shown that the contact between the Barents Sea and Vadsø Groups is an unstrained unconformity, rather than a segment of the Trollfjorden–Komagelva Fault as proposed by Johnson et al. (1978), and supports the argument that the North Varanger Region is part of the Lower Allochthon. This article presents the evidence supporting this revision, which requires a reappraisal of the regional significance of the Trollfjorden–Komagelva Fault.

Stratigraphy of the Varangerhalvøya Region

In the *North Varanger Region* a 14.5 km thick succession comprising the Barents Sea and overlying Løkvikfjellet Groups has been documented (cf. Johnson et al. 1978; Siedlecka & Roberts 1992), while in the Gaissa Thrust Belt and East Finnmark Autochthon the Vadsø, Tanafjorden and Vestertana Groups have been recog-

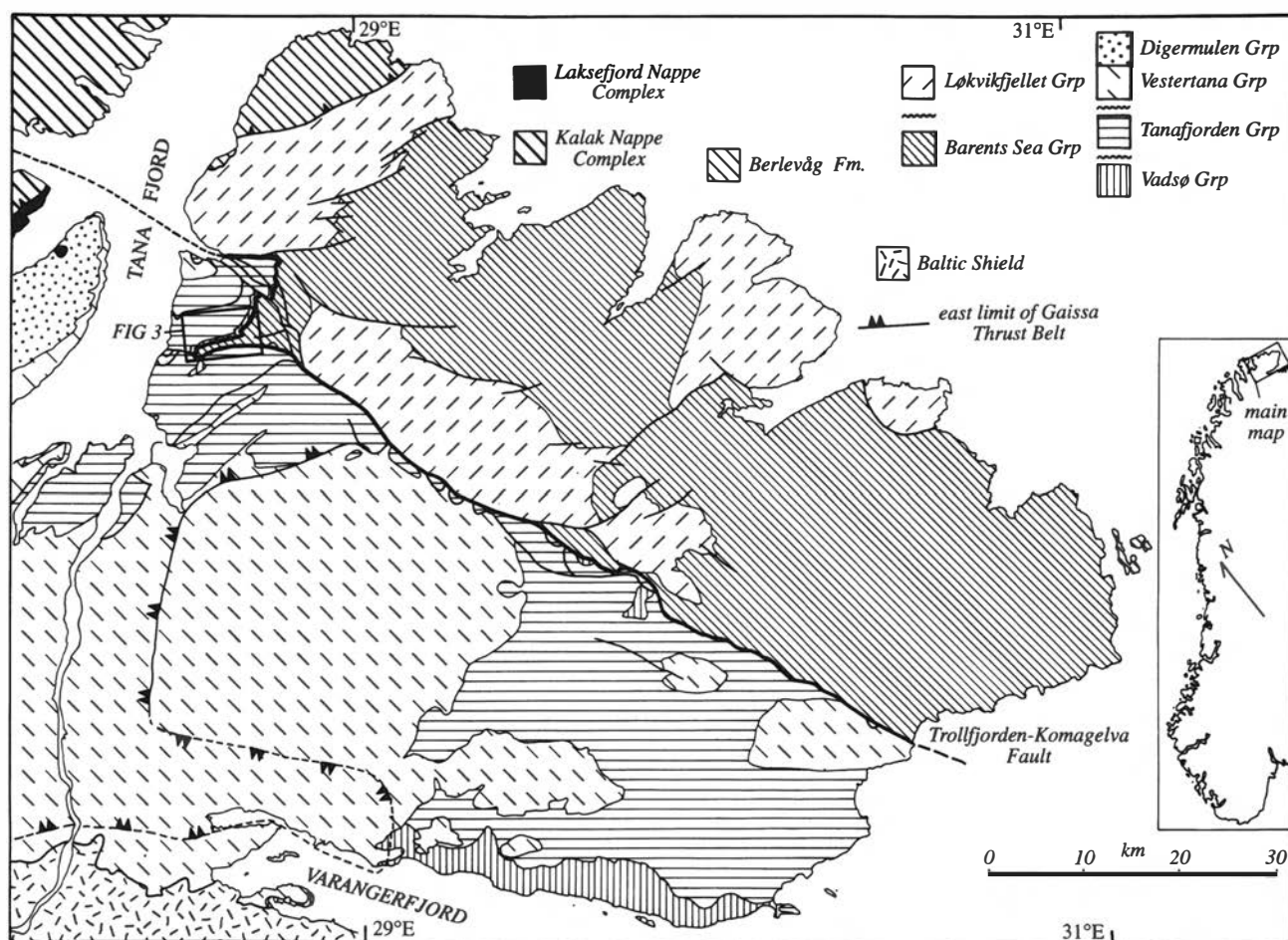


Fig. 1. Geological map of eastern Finnmark, mostly after Siedlecki (1980), but with area of outcrop of Ekkerøya Formation south of the Trollfjorden–Komagelva Fault after Siedlecki (1987). Area of Fig. 3 shown. Inset shows locality of main map.

nized (Siedlecki & Siedlecki 1971; Johnson et al. 1978). The age of both sequences has been estimated using acritarchs (Fig. 2; Vidal 1981; Vidal & Siedlecki 1983) and stromatolites (Bertrand-Sarfati & Siedlecki 1980) and is constrained by sparse radiometric dating (Pringle 1973; Beckinsale et al. 1976) to be late Riphean to Cambrian.

The Barents Sea Group is a 9 km thick late Riphean to Sturtian sequence passing from turbiditic submarine fan facies (Kongsfjord Formation) through deltaic facies (Båснаeringen Formation) to intertidal/supratidal and thence to shallow-marine facies (Båtsfjord and Tyvjoffjellet Formations; Johnson et al. 1978; Siedlecki 1985). The unconformably overlying Løkvikfjellet Group is a 5.6 km thick Vendian to ?lower Cambrian sequence dominantly comprising marine clastic sediments with fluvial deposits (Siedlecki & Levell 1978). Progressively older rocks of the Barents Sea Group underlie the unconformity to the west, cutting down to the lower part of the Båснаeringen Formation.

In the extreme west of the North Varanger Region the 2.65 km thick turbiditic rocks of the Berlevåg Formation are thrust over the Løkvikfjellet Group (Fig. 1; Levell & Roberts 1977). These metasediments may be correlatives of either the turbidites in the Middle Allochthon lying to

the west of Tanafjord (Fig. 1; Levell & Roberts 1977; Siedlecki 1985) or of the Kongsfjord Formation (Siedlecki & Siedlecki 1972; Rice et al. 1989b), or possibly both.

South of the Trollfjorden–Komagelva Fault, in the *Gaissa Thrust Belt and East Finnmark Autochthon*, the maximum stratigraphic thickness recorded on Varangerhalvøya is 3.84 km (Johnson et al. 1978). The Vadsø Group (0.8 km in the type area) comprises late Riphean predominantly fluvio-deltaic facies overlain unconformably by Sturtian shallow marine deposits of the Ekkerøya Formation (Johnson 1978). The unconformably overlying Tanafjorden Group consists of shallow-marine to coastal sediments (Siedlecki & Siedlecki 1971; Johnson 1978), with stromatolithic dolomites in the upper part (Bertrand-Sarfati & Siedlecki 1980).

The base of the Vendian to Cambrian Vestertana Group cuts across the Vadsø and Tanafjorden Groups on a major unconformity, which is more profound towards the south, such that to the SW of Varangerfjord the group rests on the Baltic Shield. The lower ca. 0.45 km of the Vestertana Group consists of two glaciogene formations separated by an interglacial marine succession (Edwards 1984). This is overlain by 1.09 km of shallow-marine siliciclastic sediments.

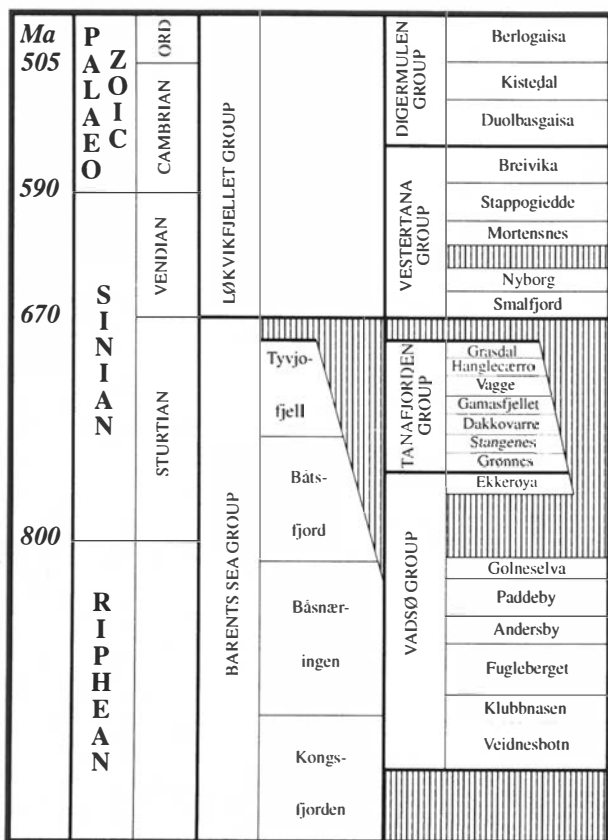


Fig. 2. Chronostratigraphic correlations of sequences across the Trollfjorden–Komagelva Fault, based on acritarch data (Vidal & Siedlecka 1983).

A variety of correlations of the lithologies on either side of the fault have been proposed; these are discussed later.

The Manjunnas area

In the westernmost part of Varangerhalvøya a wedge-shaped outcrop of the Barents Sea Group lies south of the general trend of the Trollfjorden–Komagelva Fault (Figs 1 and 3; Siedlecka & Siedlecki 1972). This area was termed the Manjunnas Lens by Townsend et al. (1990). Within the Manjunnas Lens the Båtsfjord and Båsnæringen Formations have been mapped, although the detailed lithostratigraphy is different from that in the type area (Siedlecka & Siedlecki 1972); minor outcrops of the Løkvikfjellet Group have also been mapped (Siedlecka 1987).

Along the northern side of the Manjunnas Lens a ca. 0.25–3 km thick sequence of finely interbedded sandstones and black silts/shales crops out, with several 10–30 m thick, massive, grey, quartzite bands (Siedlecka & Siedlecki 1972). These rocks were originally termed the Lille Molvik Formation, but have subsequently been correlated with the Ekkerøya Formation at the top of the Vadsø Group (Johnson 1978). The Ekkerøya Formation

is overlain by the basal conglomerate of the Tanafjorden Group (base of Grønnes Formation; Siedlecka & Siedlecki 1971). The base of both the Ekkerøya Formation and the Tanafjorden Group strike essentially parallel to the margin of the lens, as do the underlying rocks of the Båtsfjord Formation. On the southern side the margin of the lens cuts across the Vadsø and Tanafjorden Groups, although the published maps (Siedlecki 1980, 1987) are not entirely correct (cf. Fig. 3).

Structurally, the Manjunnas Lens is an asymmetric anticline, with an overturned southern limb at the western end, forming one of a series of large SSE facing folds in this area (Siedlecka & Siedlecki 1971; Siedlecka 1987).

Determination of the orientation of the major fold axis from the pole to the best fit great circle through bedding poles (Fig. 4a) yields the same orientation for data from both the Barents Sea Group (axis plunges 27° towards 264°) and the combined Tanafjorden and Vadsø Groups (axis plunges 24° towards 262°). The combined data give an orientation of 25° towards 263°; this is sub-parallel to the mean orientation of minor folds within the area (Fig. 4b). These datasets all have $K > 1$, indicating cluster distributions, and with $C > 2$. This is as expected for the minor folds, but is relatively unusual for the bedding data and reflects the preponderance of data from the northern fold-limb and the overturning of the limited data from the southern fold-limb, so that most of the data dip towards the north. This parallelism of the fold axes determined from the bedding poles demonstrates that on the regional scale the bedding in the Barents Sea Group is parallel to that in the overlying units.

The nature of the boundary of the Manjunnas Lens was naturally a major problem in the region, although never explicitly stated as such. Siedlecka & Siedlecki (1972) noted that the Båtsfjord Formation 'passes upwards into' the Ekkerøya Formation (Lille Molvik Formation) but gave no details whatsoever of the nature of the contact. Johnson et al. (1978) proposed that the boundary was a folded portion of the Trollfjorden–Komagelva Fault, and described a 10 cm thick tectonic breccia along the contact. The model of Johnson et al. (1978) inferred that the rocks of the Manjunnas Lens were derived from a compressional bend on the south side of the Trollfjorden–Komagelva Fault, which was subsequently caught up in thrusting within the Gaissa Thrust Belt and folded and squeezed some 10 km WSW of the main fault strand.

Townsend et al. (1990) and Rice & Townsend (1991) pointed out the manifest impossibility of this model. Any rocks caught up within the brittle deformation of the Gaissa Thrust Belt would have been imbricated and shortened parallel to the transport direction, which is locally complex in that area (Townsend 1987), and not squeezed normal to the shortening vector. Further, these authors noted that both the parallelism of the rocks on either side of the northern margin and the low strains

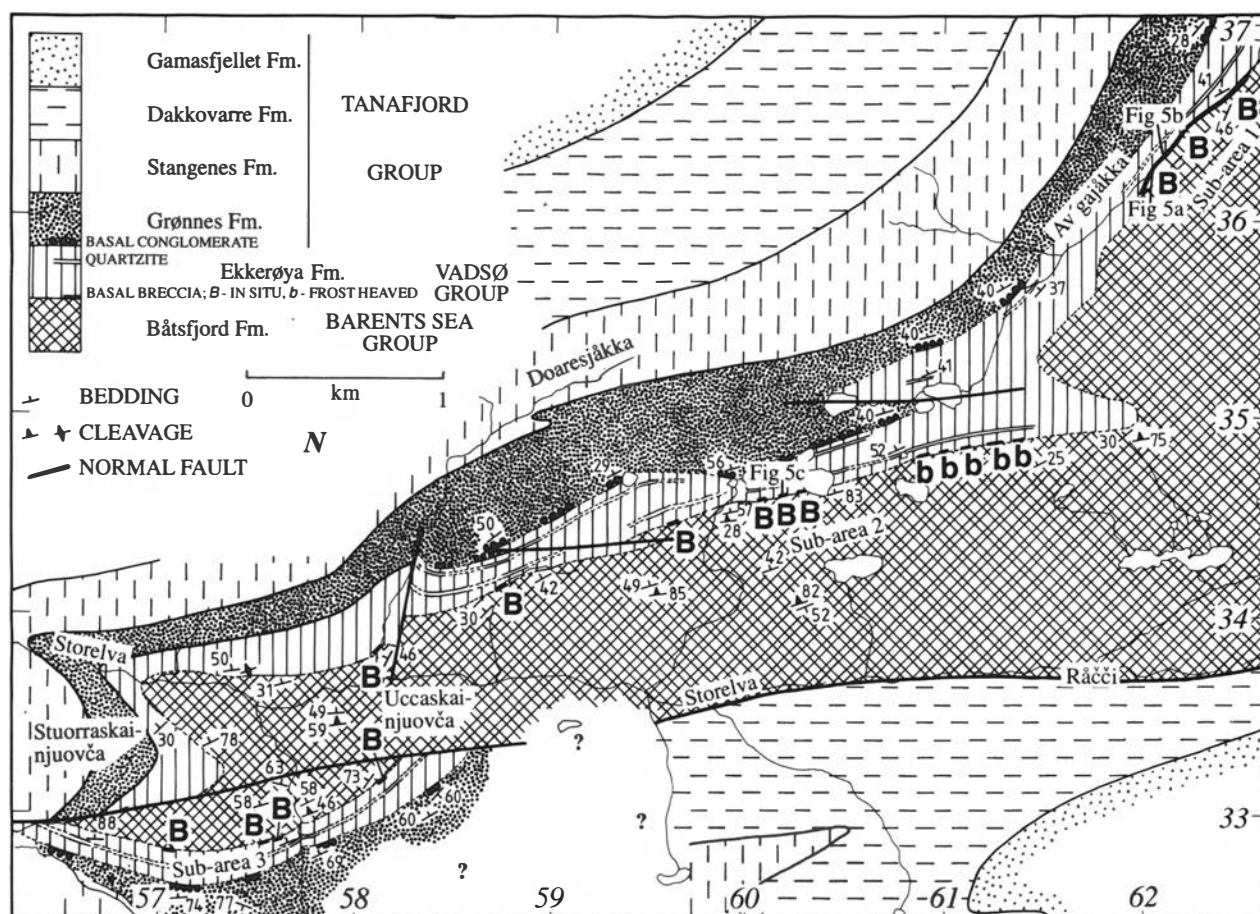


Fig. 3. Geological map of the Manjunnas Lens, largely taken from Siedlecka (1987), but modified after the present work. Locations of Sub-areas and Fig. 5 shown. All outcrops (in situ and frost heaved) of the sedimentary breccia at the base of the Ekkerøya Fm. are shown with an exaggerated thickness. Numbers at margin of map refer to the grid line on the 1:50,000 map sheet Trollfjorden 2336 III ? refers to areas where the outcrop pattern is uncertain.

within the Manjunnas Lens were entirely incompatible with the model of Johnson et al. (1978).

Margin of the Manjunnas Lens

Three segments of the margin of the Manjunnas Lens have been investigated: the southern and northern margins near the coast at Lille Molvik and the northern margin further inland, in a good section along the Av'gajåkka (Fig. 3). The contact has not been investigated in the Stuorraskainjuovea area, between the northern and southern sides of the lens, which is heavily wooded and poorly exposed.

Sub-area 1

Between grid reference 6175 3595 and 6260 3680 (map-sheet 2336 III), the Av'gajåkka forms a straight, slightly incised valley along the northern margin of the Manjunnas Lens (Fig. 3). To the north the thinly bedded sandstones and black shales/silts of the Ekkerøya Formation are continuously exposed and ubiquitously folded into close to tight structures, except immediately adjacent to

the contact with the massive sandstones and occasional red siltstones of the Båtsfjord Formation. Aerial photographs show that the strike directions of the two formations are at an apparent angle of ca. 12°, with the Ekkerøya Formation lying on younger rocks to the west. At twelve localities the bedding below and *immediately* above the contact was measured (Fig. 4c). This shows that the bedding in the Vadsø Group has a more E–W strike and dips at a slightly steeper angle than the bedding in the Båtsfjord Formation. Rotation of the mean Ekkerøya Formation bedding to the horizontal about the regional fold axis which plunges at 25° towards 263°, from all three sub-areas, gives a syn-Ekkerøya Formation deposition orientation of the Båtsfjord Formation bedding of 119/19°S.

Within the river valley the contact has been continuously followed in a series of asymmetric erosional depressions, typically <3 m, but in some places 6 m deep in the Båtsfjord Formation, with long slopes parallel to the bedding in the Båtsfjord Formation and irregular steep slopes, locally undercut, roughly normal to the bedding and facing eastwards (Fig. 5A, B); Fig. 6 shows a measured section at the western end of the river exposure. The base of most erosional depressions was filled by a <1.5 m thick sedimentary breccia consisting of

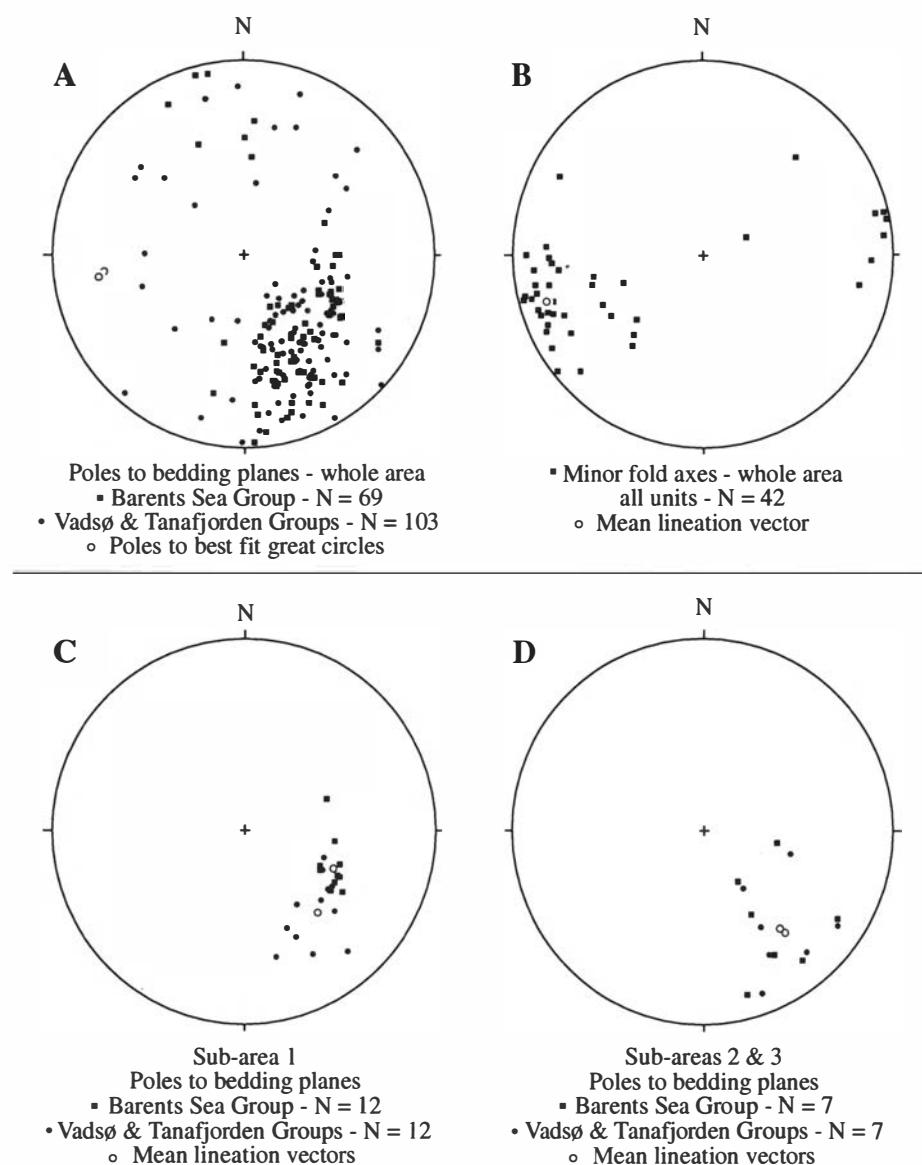


Fig. 4. Equal area nets of structural data from the Manjunnas Lens area: A. Poles to bedding, with determined fold axis orientation of the major fold. B. Minor fold axes. C and D. Poles to bedding where measured immediately above and below the Ekkerøya–Båtsfjord contact at localities where the breccia is present. C. Data from sub-area 1. D. Data from sub-areas 2 and 3.

rounded to sub-angular, poorly sorted fragments of vein quartz up to 5 cm long, somewhat larger (typically <8 cm long) sub-angular to angular clasts of blue-grey Båtsfjord Formation sandstone and well sorted and rounded <1.5 mm diameter quartz grains. At one locality 1.0 m angular blocks of the Båtsfjord Formation were found within a chaotic sedimentary breccia (Fig. 6). The breccia has a hematite-red coloured matrix, possibly derived from the red siltstones within the Båtsfjord Formation.

The sandstones and mudstones of the Ekkerøya Formation overlie the breccia with a sharp boundary filling the erosional depressions. An intermittently developed better sorted conglomerate, containing <10 cm diameter, rounded, sub-spherical clasts of sandstone, presumed to be derived from the Båtsfjord Formation, was found within the main part of the Ekkerøya Formation; in some instances this lay directly on the Båtsfjord Formation between depressions (Figs. 5B and 6).

Sub-area 2

This area lies to the west of sub-area 1 (Fig. 3), within relatively well-exposed ground in the west, but eastwards the rocks are all marginally disturbed by frost heave. Measurement of bedding immediately above and below the Båtsfjord–Ekkerøya Formations contact where the breccia is present in this sub-area indicate that there is no statistically valid angular discordance (Fig. 4D). The variations observed may have come from the unevenness of the bedding surfaces and measurement error. At six localities the same basal breccia as previously described has been found, 2–50 cm thick and rusty coloured. In some of these cases it is clear that the breccia is preserved in a slight topographic low within the Båtsfjord Formation (Fig. 5C).

In the east, where frost heave has affected the rocks, small loose blocks of the same rusty coloured breccia were found extensively along the buried contact east of



Fig. 5. Detailed line drawings made from field photographs of three exposures of the basal conglomerate/breccia of the Ekkerøya Formation. Dark shading – Båtsfjord Formation, light shading – Ekkerøya Formation, fish scale shading – conglomerate in Ekkerøya Formation, cross-dashes – breccia at base of Ekkerøya Formation. Locations given in Fig. 3. (A) Sub-area 1; looking west. A large channel within the Båtsfjord Formation (see Fig. 6 for cross-section), which forms all the bedded rocks, is shown. The hammer is lying on the top of the Båtsfjord Formation at the base of the channel and Rafael Herrgåß is standing on the top of the breccia. The rubbly area on the opposite side of the channel (X) is an overhang in the Båtsfjord Formation also filled by sedimentary breccia. (B) Sub-area 1; looking east. Typical erosional depression in the Båtsfjord Formation (bedded rocks on left and bottom right). The hammer is lying on the top of the breccia. Christa Hofmann stands at a crest between two depressions, with one foot on a well-sorted conglomerate within the Ekkerøya Formation and with the other on the Båtsfjord Formation. (C) Sub-area 2; looking east. The breccia is exposed here, again in a palaeodepression in the Båtsfjord Formation, which forms the exposed ground to the right. No breccia is found higher up the hill, although the contact is well exposed.

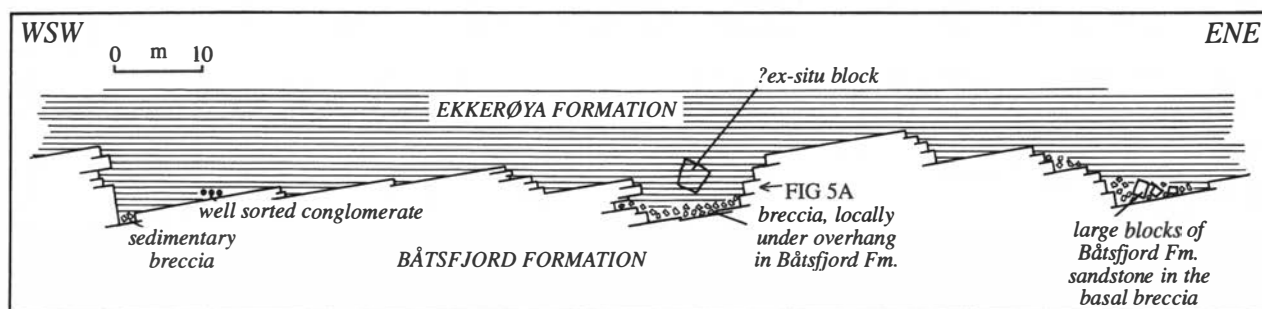


Fig. 6. Sketch of paced out segment of erosional depressions at the western end of sub-area 1; see Fig. 3 for location. Location of Fig. 5A is shown.

grid reference 5830 3310. The frost action is not thought to have caused significant transportation and the ex situ material is presumed to reflect buried in situ material.

Sub-area 3

This lies at the SW margin of the Manjunnas Lens (Fig. 3). The work undertaken so far shows significant discrepancies with Siedlecki's 1980 and 1987 maps, which also differ in their estimation of the local extent of the Ekkerøya Formation. In this area the Båtsfjord, Ekkerøya and basal Tanafjorden Group are all overturned in the steep middle limb of a south-facing large-scale tip-fold. As far east as due south of Uccaskainjuovca (grid reference 5830 3310), the Ekkerøya Formation has been found between the basal conglomerate of the Tanafjorden Group and the Båtsfjord Formation; thus the margin of the Manjunnas Lens is further north than shown in previous maps. Since the outcrop pattern east of sub-area 3 is unknown, but must differ from the published maps, this area has been left blank on the map (Fig. 3).

The data available indicate that the bedding in the Båtsfjord and Ekkerøya Formations is parallel, as in sub-area 2 (Fig. 4D), and no evidence has been found so far to indicate that the contact of the Manjunnas Lens tectonically cuts across the Ekkerøya Formation in this sub-area, as illustrated by previous authors. Although not mapped in detail, the complete stratigraphic sequence is probably continuous between sub-areas 2 and 3 (Fig. 3).

At four localities the same rusty weathering breccia as described above has been found, although in all cases it is <5 cm thick and exposed over very short distances.

Petrography and source of the breccia clasts

Johnson et al. (1978) gave an accurate petrographic description of the breccia, although their interpretation of the textures as having a tectonic origin is erroneous. Tectonic breccias are characterized by progressive clast and grain size reduction with increasing strain, seen in a gradient from microbrecciation in the essentially undis-

turbed country rocks to cataclasite/ultracataclasite in the highest strain zone. High finite strains result in the development of a cataclastic foliation, with relatively isolated porphyroclasts set within and wrapped around by a fine-grained matrix. These textures have not been seen in the Ekkerøya Formation breccia.

The breccia is dominated by three rock types. The fragments of the Båtsfjord Formation are typically elongate and tabular, presumably reflecting the bedding surfaces. As with the in situ Båtsfjord Formation these clasts comprise abundant poorly sorted, but generally small, angular to sub-rounded, sub-spherical to elongate grains. Quartz is the dominant grain mineral, with less common feldspar and lithic fragments. These are set in a chloritic matrix of variable modal concentration within individual clasts. Altogether, these textures are suggestive of a turbiditic deposit. Evidence of tectonism in the Båtsfjord Formation clasts is restricted to one example showing minor quartz veining prior to sedimentation. In comparison, in the in situ Båtsfjord Formation, pressure solution at grain boundaries and extension, with fibrous clay-mineral growth between grains, is ubiquitous; this deformation must have been post-breccia formation.

The abundant fragments of quartz comprise large, variably strained quartz crystals showing evidence of ductile deformation; sub-grain formation and recrystallization are common, although not pervasive, and the boundaries of the strained crystals are sutured. In some instances mylonitic textures are developed. In all cases the clasts are essentially monomineralic. In the Båtsfjord Formation, under the breccia syntaxial quartz veining is common. In these veins blocky and elongate quartz crystals thicken away from the vein walls, with thin peels of the wall material locally incorporated into the veins during crack-seal growth. Mylonitic textures have not been found in these quartz veins. In the quartz blocks within the breccia no evidence of such syntaxial crack-seal growth, or of a metasedimentary banding, has been observed. These textural differences indicate that the quartz veins in the Båtsfjord Formation are most unlikely to have been the source of the quartz in the breccia, confirming the structural observations that deformation in the Båtsfjord Formation post-dated the breccia deposition. This is supported by rare observations of the quartz veins cutting the breccia.

The third component in the breccia is well-sorted spherical and rounded quartz grains up to 1.5 mm diameter. Most of these are set within the amorphous reddish material which gives the rock its characteristic colour. In some areas, however, these quartz grains have a quartz cement which has recrystallized around the grains, forming texturally stable 120° grain boundaries. Subsequent deformation has strained both grain and matrix. Saddle dolomite has locally replaced the quartz matrix and host grains, but no carbonate clasts were found in the sections examined, although reported by Johnson et al. (1978). The size of these quartz grains is greater than the quartz grains in the underlying Båtsfjord Formation, which is therefore excluded as a source.

The above data clearly show that the breccia had three source rocks; the subjacent Båtsfjord Formation; a relatively proximal source for the large angular vein quartz fragments which are locally mylonitic; a distal source for the mature, rounded quartz grains. The latter material most probably came from fluvial systems derived from the Baltic Shield. The vein quartz clasts are suggestive of a nearby basement source, but the locality and cause of uplift lies outside the scope of this article.

Discussion

The observations made along the boundary of the Manjunnas Lens clearly demonstrate that the contact between the Barents Sea Group and the Vadsø Group (Ekkerøya Formation) is an unconformity, locally angular. Nowhere has any evidence of tectonic movement along the contact been found; neither fault plane, slickensides, nor cataclasites have been observed in any part of the three sub-areas. However, it is not disputed that in the SE in the Råcci the contact between the Båtsfjord Formation and the Tanafjorden Group is tectonic and is a fault, either a thrust (Siedlecka 1987), so that locally there may also be a thrust contact between the Båtsfjord and Ekkerøya Formations, or, more probably, a continuation of the late normal fault to the south of Stuor-raskainjuovca (Siedlecka pers. comm. 1993). In sub-areas 2 and 3 the breccia has been found at ten localities in ca. 6 km of the boundary of the Manjunnas Lens. In contrast, in sub-area 1 the breccia has been found in ten erosional depressions along only 1 km of the contact. This reflects the greater probability for coarse-grained material to be retained within erosional depressions during sedimentation.

From this it is clear that the stratigraphic sequences on either side of the Trollfjorden–Komagelva Fault can be linked. Previously, correlations have been made by Siedlecka & Siedlecki (1972) and Siedlecka (1973), who proposed that the Lille Molvik Formation (equivalent to the Ekkerøya Formation) was a chronostratigraphic, but not lithostratigraphic, equivalent to the Tyvjofjellet Formation and that the Tanafjorden Group was younger than both. Similarly, Siedlecka (1975, her Fig. 3) sug-

gested that the lower part of the Tanafjorden Group was equivalent to the upper part of the Tyvjofjellet Formation. In this scheme, correlation of the Lille Molvik Formation with the Ekkerøya Formation (Vadsø Group) was also proposed and both chronostratigraphically correlated with the Tyvjofjellet Formation.

The correlations of Vidal & Siedlecka (1983), based on acritarch assemblages, is shown in Fig. 2. The Ekkerøya Formation (Lille Molvik Formation) is chronostratigraphically correlated with the upper part of the Båtsfjord Formation and the Tanafjorden Group with the Tyvjofjellet Formation. This scheme also makes a *general* correlation of the major unconformities found within sequences on both sides of the fault and, further, it chronostratigraphically correlates the fluvio-deltaic rocks of the sub-Ekkerøya Formation part of the Vadsø Group with rocks of the same sedimentary facies in the Båsnæringen Formation; they may also be lithostratigraphic correlatives in a broad sense. The Båtsfjord Formation is taken to be equivalent to the time gap between the Ekkerøya Formation and the Golneselv Formation, such that essentially continuous sedimentation occurred in the Manjunnas area whilst elsewhere south of the Trollfjorden–Komagelva Fault there was a lengthy break in deposition (Fig. 7). However, the evidence for any of these correlations is not strong; the only unequivocal facts are that at the border of the Manjunnas Lens there is a sedimentary sequence passing up from the Båtsfjord Formation, through the Ekkerøya Formation to the Tanafjorden Group, with unconformities at the base of both the Vadsø and the Tanafjorden Groups, locally angular in the first case.

The significance of this for the regional tectonics is less clear cut. An obvious conclusion is that the Trollfjorden–Komagelva Fault must lie to the NE of the Manjunnas Lens; work on identifying the precise location is in progress. Siedlecka (1987) shows a number of fault strands trending between NNW–SSE and W–E in the area between Trollfjord and east of Manjunnas (Fig. 1).

The rocks of the Barents Sea Group south of the Trollfjorden–Komagelva Fault are somewhat different from those to the northeast (p. 356 in Siedlecka & Siedlecki 1972). Despite the differences, both Townsend et al. (1990) and Rice & Townsend (1991) argued that it was unlikely that such similar sequences would have been deposited far apart and then juxtaposed on opposite sides of a strike-slip fault of major displacement. From this it was argued that a relatively short displacement along the Trollfjorden–Komagelva Fault was more probable; Townsend et al. (1990) suggested in the order of 50 km \pm 50 km. This argument, however, is specious. Stratigraphic successions *may* remain essentially the same over very long distances along depositional strike, especially parallel to passive continental margins; the Trollfjorden–Komagelva Fault is probably a reactivated extensional structure which formed during the formation of the Timanian Aulacogen (Siedlecka 1975, 1985) and thus the strike-slip movement was probably parallel to the

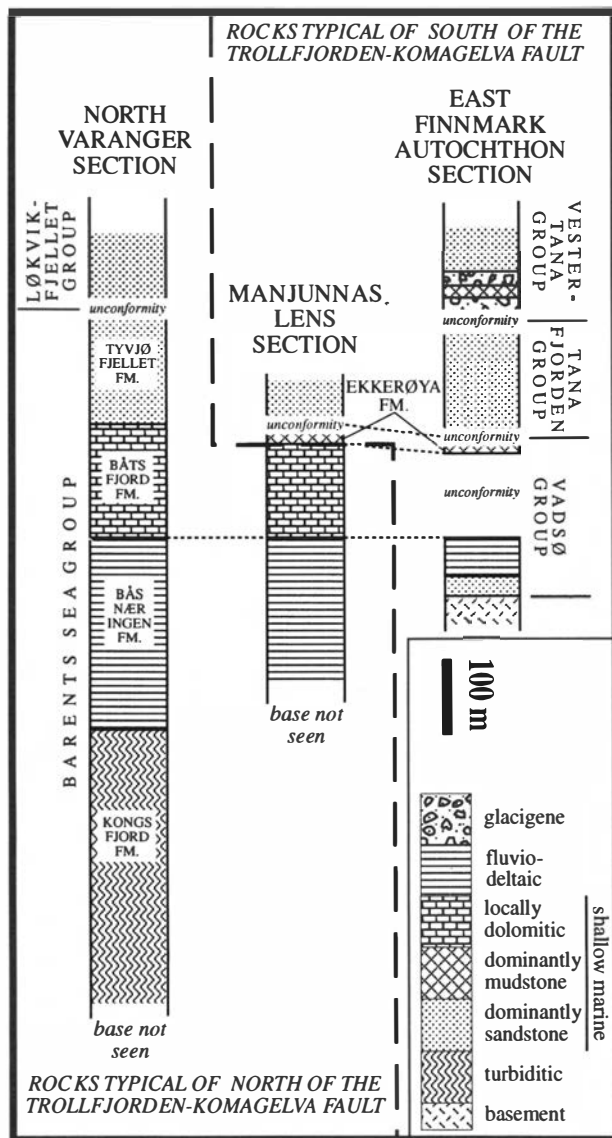


Fig. 7. Simplified scaled log-sections of the stratigraphies of the North Varanger Region, Manjunnas Lens and East Finnmark Autochthon. Data from Siedlecka & Siedlecki (1972), Johnson et al. (1978), Vidal & Siedlecka (1983).

basin margin (Siedlecka 1985; Rice et al. 1989b). Within the Scandinavian Caledonides, for example, the Dividal Group can be traced for over 300 km from Andabakoaivi to Torneträsk (Føyn 1967; Lindström et al. 1985), while the overlying Alum Shale has been traced from Torneträsk southwards and laterally across much of the Autochthon, Parautochthon and Lower Allochthon in central and southern Scandinavia, an along-strike length of ca. 1000 km and a restored width of ca. 200 km (Kumpulainen & Nystuen 1985; Gayer & Greiling 1989; Gee 1980; Lindqvist 1990). Thus correlation of the successions across the Trollfjorden–Komagelva Fault provides no real constraint on the displacement along the fault. However, as a result of the correlation, lithostratigraphic data can no longer be used to argue that the North Varanger Region and Baltica are different terranes, although this may be established from other criteria.

Finally, as the North Varanger Region is part of the Lower Allochthon, the significance of the Berlevåg Formation as a potential link between the Lower Allochthon (via the turbidites of the Kongsfjord Formation) and Middle Allochthon (Kalak Nappe Complex) west of Tanafjord (Fig. 1) becomes considerably more important, and needs to be examined in detail.

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References

- Beckinsale, R. D., Reading, H. G. & Rex, D. C. 1976: Potassium-argon ages for basic dykes from East Finnmark: stratigraphical and structural implications. *Scottish Journal of Geology* 12, 51–56.
- Bertrand Sarfati, J. & Siedlecka, A. 1980: Columnar stromatolites of the terminal Precambrian Porsanger Dolomite and Grasdal Formations of Finnmark, north Norway. *Norsk Geologisk Tidsskrift* 60, 1–27.
- Edwards, M. B. 1984: Sedimentology of the upper Proterozoic glacial record, Vestertana Group, Finnmark, North Norway. *Norges geologiske undersøkelse* 394, 1–76.
- Føyn, S. 1967: Dividal Gruppen (<Hyolithus Zonen>) i Finnmark og dens forhold til de eokambrisk-kambriske formasjoner. *Norges geologiske undersøkelse* 249, 1–84.
- Gayer, R. A. & Greiling, R. O. 1989: Caledonian nappe geometry in north-central Sweden and basin evolution on the Baltoscandian margin. *Geological Magazine* 126, 499–513.
- Gayer, R. A. & Rice, A. H. N. 1989: Palaeogeographic reconstruction of the pre- to syn-Iapetus rifting sediments in the Caledonides of Finnmark, North Norway. In Gayer, R. A. (ed.): *The Caledonide Geology of Scandinavia*, 127–139. Graham & Trotman, London.
- Gayer, R. A., Rice, A. H. N., Roberts, D., Townsend, C. & Welbon, A. I. F. 1987: Restoration of the Caledonian Baltoscandian margin from balanced cross-sections: the problem of excess continental crust. *Transactions of the Royal Society of Edinburgh* 78, 197–217.
- Gee, D. G. 1980: Basement-cover relationships in the central Scandinavian Caledonides. *Geologiska Föreningens i Stockholm Förhandlingar* 102, 455–474.
- Gee, D. G., Kumpulainen, R., Roberts, D., Stephens, M. B. & Zachrisson, E. 1985: Scandinavia: Caledonides – Tectonostratigraphic Map. *Sveriges Geologiska Undersökning Series Ba, Nr 35*.
- Harland, W. B. & Gayer, R. A. 1972: The Arctic Caledonides and earlier oceans. *Geological Magazine* 109, 289–314.
- Johnson, H. D. 1978: Facies distribution and lithostratigraphic correlation in the late Precambrian Ekkerøya Formation, east Finnmark, Norway. *Norsk Geologisk Tidsskrift* 58, 175–190.
- Johnson, H. D., Levell, B. K. & Siedlecki, S. 1978: Late Precambrian sedimentary rocks in East Finnmark, North Norway, and their relation to the Trollfjorden–Komagelva Fault. *Journal of the Geological Society of London* 135, 517–533.
- Kjøde, J. K., Storvedt, M., Roberts, D. & Gidskehaug, A. 1978: Palaeomagnetic evidence for large-scale dextral movement along the Trollfjorden–Komagelva Fault. *Physics of the Earth and Planetary Interiors* 161, 132–144.
- Kumpulainen, R. & Nystuen, J. P. 1985: Late Proterozoic basin evolution and sedimentation in the westernmost part of Baltoscandia. In Gee, D. G. & Sturt, B. A. (eds.): *The Caledonide Orogen – Scandinavia and Related Areas*, 213–232. Wiley, Chichester.
- Levell, B. K. & Roberts, D. 1977: A re-investigation of the geology of northwest Varanger Peninsula, East Finnmark, North Norway. *Norges geologiske undersøkelse* 334, 83–90.
- Lindqvist, J.-E. 1990: Thrust related metamorphism in basement windows of the Central Scandinavian Caledonides. *Journal of the Geological Society of London* 147, 69–80.

- Lindström, M., Bax, G., Dinger, M., Dworatzet, M., Erdtmann, W., Fricke, A., Kathol, B., Klinge, H., Von Pape, P. & Stumpf, U. 1985: Geology of a part of the Torneträsk section of the Caledonian front, northern Sweden. In Gee, D. G. & Sturt, B. A. (eds.): *The Caledonide Orogen – Scandinavia and Related Areas*, 507–513. Wiley, Chichester.
- Pesonen, L. J., Torsvik, T. H., Elming, S. A. & Bylund, G. 1989: Crustal evolution of Fennoscandia – palaeomagnetic constraints. *Tectonophysics* 162, 27–49.
- Pringle, I. R. 1973: Rb–Sr age determinations on shale horizons associated with the Varanger Ice Age. *Geological Magazine* 110, 465–472.
- Rice, A. H. N., Bevins, R. E., Robinson, D. & Roberts, D. 1989a: Evolution of low-grade metamorphic zones in the Caledonides of Finnmark, N. Norway. In Gayer, R. A. (ed.): *The Caledonide Geology of Scandinavia*, 177–191. Graham & Trotman, London.
- Rice, A. H. N., Gayer, R. A., Robinson, D. & Bevins, R. E. 1989b: Strike-slip restoration of the Barents Sea Caledonides terrane, Finnmark, North Norway. *Tectonics* 8, 247–264.
- Rice, A. H. N. & Townsend, C. 1991: Comments on the geology of the North Varanger Region, Finnmark, N. Norway. *Terra Abstracts* 3, Supplement 4, 26.
- Roberts, D. 1972: Tectonic deformation in the Barents Sea Region of Varanger Peninsula, Finnmark. *Norges geologiske undersøkelse* 282, 1–39.
- Roberts, D. 1988: The terrane concept and the Scandinavian Caledonides: a synthesis. *Norges geologiske undersøkelse Bulletin* 413, 93–99.
- Siedlecka, A. 1973: The late Precambrian Øst-Finnmark Supergroup – a new lithostratigraphic unit of high rank. *Norges geologiske undersøkelse* 289, 55–60.
- Siedlecka, A. 1975: Late Precambrian stratigraphy and structure of the northeastern margin of the Fennoscandian Shield (East Finnmark-Timan Region). *Norges geologiske undersøkelse* 316, 313–348.
- Siedlecka, A. 1985: Development of the upper Proterozoic sedimentary basins of the Varanger Peninsula, East Finnmark, North Norway. *Geological Survey of Finland, Bulletin* 331, 175–185.
- Siedlecka, A. 1987: Trollfjorden berggrunnskart 2336 3, 1:50,000. *Norges geologiske undersøkelse*.
- Siedlecka, A. & Roberts, D. 1992: The bødrock geology of Varanger Peninsula, Finnmark, North Norway: an excursion guide. *Norges geologiske undersøkelse Special Publication* 5.
- Siedlecka, A. & Siedlecki, S. 1967: Some new aspects of the geology of Varanger Peninsula (Northern Norway). *Norges geologiske undersøkelse* 247, 288–306.
- Siedlecka, A. & Siedlecki, S. 1971: Late Precambrian sedimentary rocks of the Tanaffjord–Varangerfjord Peninsula, Northern Norway. *Norges geologiske undersøkelse* 269, 246–294.
- Siedlecka, A. & Siedlecki, S. 1972: Lithostratigraphical correlation and sedimentology of the late Precambrian of Varanger Peninsula and neighbouring areas of Finnmark, Northern Norway. *24th International Geological Congress, section* 6, 349–358.
- Siedlecki, S. 1980: Geologiske karte over Norge, berggrunnskart VADSØ – M. 1:250,000. *Norges geologiske undersøkelse*.
- Siedlecki, S. & Levell, B. K. 1978: Lithostratigraphy of the late Precambrian Løkvikfjell Group on Varanger Peninsula, East Finnmark, North Norway. *Norges geologiske undersøkelse* 343, 73–85.
- Townsend, C. 1987: Thrust transport directions and thrust sheet restoration in the Caledonides of Finnmark. *Journal of Structural Geology* 9, 345–352.
- Townsend, C., Rice, A. H. N. & Jones, J. 1990: The Trollfjord–Komagelva Fault: a large displacement, dextral, strike-slip fault? *Geonytt* 17, 117–118.
- Vidal, G. 1981: Micropalaeontology and biostratigraphy of the Upper Proterozoic and Lower Cambrian sequence in East Finnmark, Northern Norway. *Norges geologiske undersøkelse* 362, 1–53.
- Vidal, G. & Siedlecka, A. 1983: Planktonic acid-resistant microfossils from the upper Proterozoic strata of the Barents Sea Region of Varanger Peninsula, East Finnmark, North Norway. *Norges geologiske undersøkelse* 382, 45–79.
- Woodcock, N. H. 1977: Specification of shape fabric using an eigenvalue method. *Geological Society of America Bulletin* 88, 1231–1236.