Ordovician lithistid sponges and gastropods from the Snåsa Limestone, Nord-Trøndelag, Norway

DAVID ROBERTS

Roberts, D. 1998: Ordovician lithistid sponges and gastropods from the Snåsa Limestone, Nord-Trøndelag, Norway. *Norges geologiske undersøkelse Bulletin 434*, 77-82.

Fossils occurring in the Snåsa Limestone, observed in new road-cuts along the main E6 road near Snåsavatnet, Nord-Trøndelag, are illustrated and briefly described. Although the effects of Scandian deformation and crystallisation have made identification difficult, it seems clear that the fauna consists mainly of macluritid gastropods and related forms, and lithistid sponges of the genera *Archaeoscyphia, Rhopalocoelia*, possibly *Hudsonospongia* and either *Anthaspidella* or *Zittelella*. There is also a possibility that stromatoporoids and, less likely, a rugose coral may be represented. The fauna is of mainly North American aspect and is considered to be of Middle, or possibly Late Ordovician age.

David Roberts, Norges geologiske undersøkelse, Post-Box 3006, 7002 Trondheim, Norway.

Introduction

Within the metamorphic allochthon of the Norwegian Caledonides, the Støren Nappe of the western Trondheim Region is by far the most prolific of the Köli Nappes (Upper Allochthon) in terms of known fossil occurrences and faunal diversity. The low-grade metasedimentary rocks of the Hølonda district, for example, have yielded a rich variety of brachiopods, molluscs, trilobites, graptolites, corals, conodonts and echinoderms (e.g., Berry 1968, Neuman & Bruton 1974, 1989, Bergström 1979, 1997, Ryan et al. 1980, Bruton & Bockelie 1982, Neuman et al. 1997) of Early to Middle Ordovician age. Further north, in the Snåsavatn district, fossils are known only from the Snåsa Limestone, one of several formations of greenschist-facies metasedimentary and metavolcanic rocks which have been considered to represent a northerly extension of the Støren Nappe (Carstens 1960, Wolff 1979), or conceivably a separate nappe (Tietzsch-Tyler 1983).

Carstens (1956, 1960) first reported the occurrence of fragments of Ordovician gastropods in the Snåsa Limestone in a stream section near the southwestern end of lake Snåsavatnet but gave no details about the locality. Spjeldnæs (1985), in a review article, noted that the fauna consisted mostly of large gastropods, and added that he too had found gastropods, cephalopods and colonial or multicellular organisms (corals or stromatoporoids) in road sections along the northwestern side of Snåsavatnet. A broad Middle Ordovician age was inferred. In a doctoral thesis, Tietzsch-Tyler (1983) also noted the occurrence of spiral, conical and elliptical 'cellular' markings of white carbonate in several places in this same metalimestone, and assumed that they represented gastropods. A few conodonts have also been extracted from the Snåsa Limestone from near the southwestern end of Snåsavatnet (Bergström 1997) but they are poorly preserved.

Earlier, in the autumn of 1978, the present author had recorded abundant deformed gastropods and other shelly fossils in newly blasted road-cuts along the main E6 road in this same general area. During the following summer, a closer inspection revealed a diversity of forms, photographs of which formed the basis of a short, internal NGU report (Roberts 1980). In view of the renewed interest in the significance of faunas and their comparative rarity in the metamorphic allochthon, this short contribution aims at presenting a series of field photographs which may prove to be helpful to future geologists and palaeontologists working in comparable carbonate formations.

The fossil locality and host rock

Although there are now many new road-cuts along this section of the E6, not all preserve well defined fossil forms. The road-cut locality described here is approximately 5 km northeast of Kvam, 300-800 m south-southwest of the farm Nesjan, Nødalbukta, Snåsavatnet (Fig.1). This is on the 1:50,000 map-sheet 'Snåsavatnet' 1723 II (M711 series, 3-NOR edition, blue grid), between coordinates (32WPS) 370192 and 369187. Note that the new E6 trasé is not shown on the topographic map. Fossils were also observed and photographed on ice-polished and striated surfaces within 20 m of the actual road-cuts. These surfaces were, at that time, newly exposed after the soil- and vegetation-stripping operations along the trasé of the new road. In the course of just 2-3 years, however, these surfaces acquired a uniform grey film as a result of oxidation and air pollution, and over subsequent years many have been concealed by a thin carpet of new soil and vegetation. The road-cuts themselves have suffered over the years, as a result of general air and traffic pollution, but many ghost-like fossil forms are still visible today.

The lithology of the Snåsa Limestone in this area is a medium-to thick-bedded, dark blue-grey, medium- to coarse-grained metalimestone with sporadic, darker blue-grey to grey, micaceous laminae a few millimetres in thickness. The

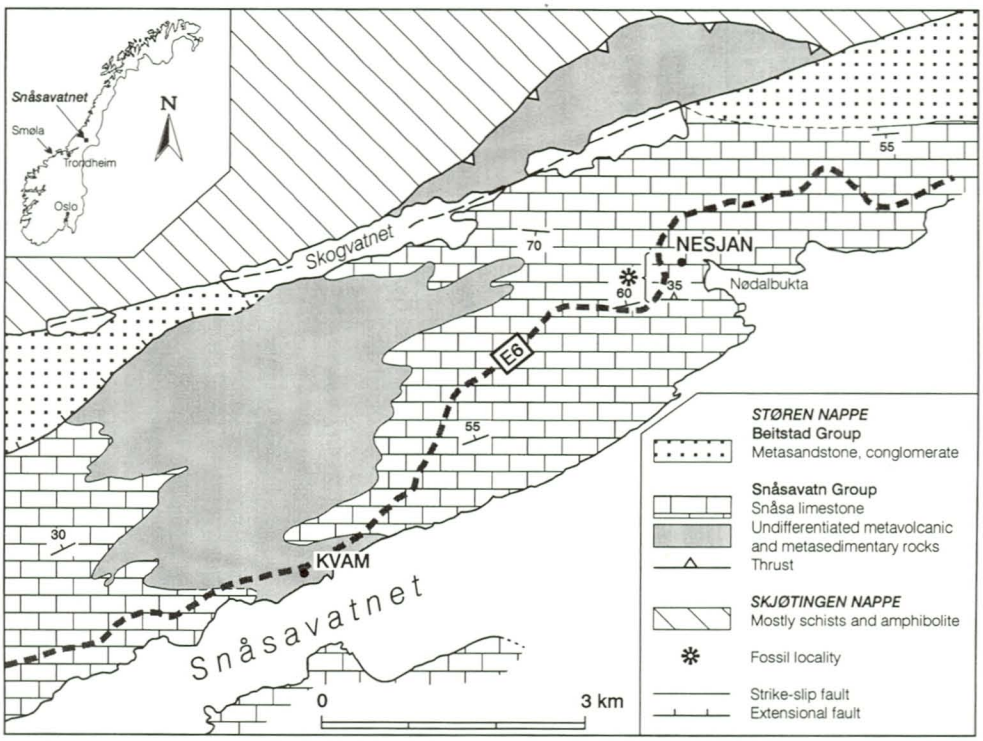


Fig.1. Simplified geological map of the Kvam-Nødalbukta area, Snåsavatnet, showing the fossil locality. The 'locality' refers to a c. 400 m stretch of almost continuous road-cut on the west side of the E6, and a c.100 m-long section on the east side of the road.

formation has been involved in at least three Caledonian (Scandian) fold phases at a peak metamorphic grade of upper greenschist facies (Roberts 1967, Tietzsch-Tyler 1983), the evidence of which is clearly reflected in the distorted shapes of the fossil remains. The limestone itself was thoroughly recrystallised during the polyphase Scandian deformation and the original skeletal remains of the fossils are picked out as white carbonate against the uniform blue-grey background. No silicified shell remains have been observed, such that it has proved impossible to extract any of the fossils from the rock. Some of the fossil forms are truncated, either along minor, schistosity-parallel, shear-surface offsets or by the effects of pressure solution.

The fossils

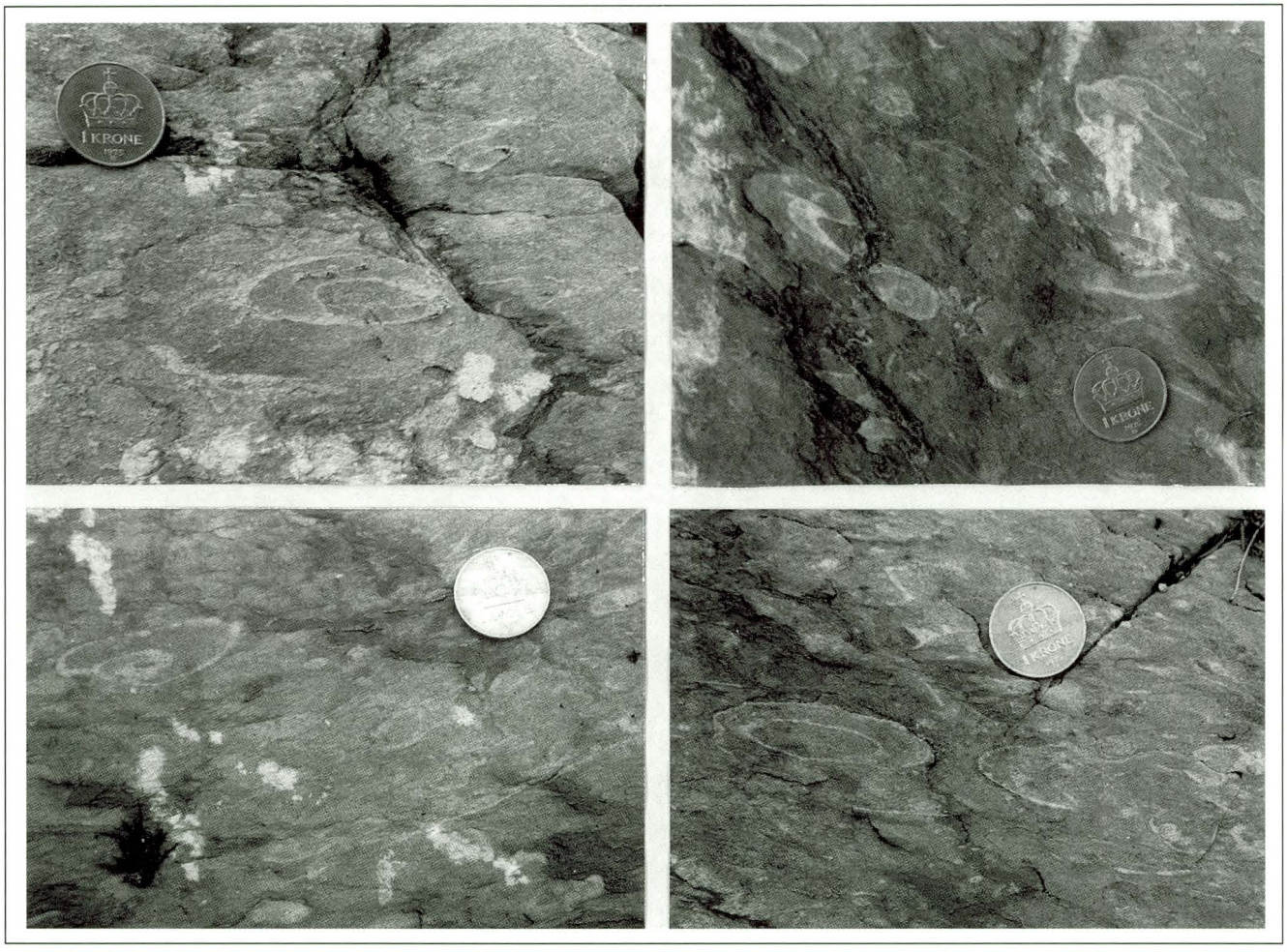
The majority of the fossils represented at this locality are **gastropods**. On comparing the forms with those described and illustrated in the Geological Society of America monograph on Mollusca (Moore 1960), most appear to belong to the genus *Maclurites* or types closely related to this (Fig. 2). Both 'low-spired' and 'high-spired' varieties of gastropods are present.

This preliminary identification was confirmed by Dr.Ellis Yochelson (pers. comm. 1980), who added that it is quite possible that several other genera may be represented. A more precise identification is precluded by the state of deformation of the fossils and also because the photographs show only profiles through the unextractable forms. Some of the photos show high-spired gastropod forms which are not of macluritid type, but whose generic affinity is uncertain. It is also possible that a few low-spired lenticular gastropods may be present.

According to Ellis Yochelson these particular gastropod forms range in age from Mid to Late Ordovician, but in this case they are most probably Mid Ordovician. Such types of gastropods are known from three other areas in Norway – from the Skjølberg Limestone on the island of Smøla (cf. Bruton & Bockelie 1979), from the Otta Conglomerate (Yochelson 1963) and from Ashgill carbonate units in the Oslo district (Brenchley & Newall 1975, Owen et al. 1990).

The second most prominent group of forms represented at this locality appear to belong to the phylum Porifera — the **sponges**. Although the state of strain of the material is again a hinderance to precise identification, the shapes outlined by the white carbonate in, e.g., Figs. 3 and 4 are reminiscent of genera in the order Lithistida (de Laubenfels 1955), one of the many orders in the class of Demospongea. In terms of sponge morphology, the so-called 'rhagon' structure characterises c.98% of all sponges, fossil or present-day, and the architecture of the lithistids is of a compact, generally thick-walled rhagon type. This is an internal, complex organisation of micro-sized flagellate chambers with an intricate aquiferous system of inhalant and exhalant canals, which is supported by a solid, internal, skeletal framework of discrete, interlocked, opaline spicule elements. Sponges with such skeletons will readily fossilize, without becoming disintegrated.

Examination of several of the field photographs by Drs. Keith Rigby and Barry Webby has led to the conclusion that the annulate subcylindrical to curved, vase-shaped sponge forms shown in Figs. 3 and 4 are almost certainly of the lithis-



Figs. 2. Sections through diverse, deformed macluritid gastropods. In these and other photographic figures the coin is 2.5 cm in diameter.

tid genus *Archaeoscyphia*, even though there is now no sign of the spicules which formed part of the original skeleton. The annulated exterior of the walls is quite characteristic of this Ordovician sponge (Fig. 5). Although *Archaeoscyphia* was a siliceous sponge, most specimens are commonly altered to calcareous impressions (K.Rigby, pers. comm.). Some representatives of the family Anthaspidellidae, like *Archaeoscyphia*, were moderately large sponges, 10-20 cm in height and nearly as wide (de Laubenfels 1955). Others, however, are quite small and stick-like, e.g. as in *Dunhillia* (Rigby & Webby 1988).

Fig. 3. View of a longitudinal to longitudinal-oblique section through a markedly deformed lithistid sponge, in all probability *Archaeoscyphia*, showing the typically annulate external structure.

Fig. 4. A longitudinal to longitudinal-oblique section through another lithistid sponge, also probably *Archaeoscyphia*.

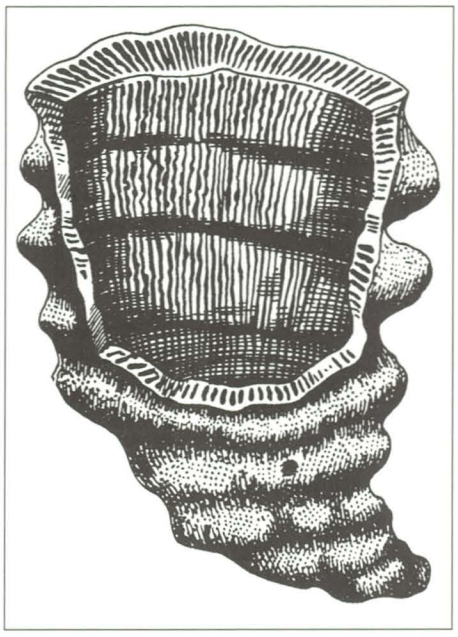


Fig. 5. Reconstruction of the Ordovician lithistid sponge *Archaeoscyphia minganensis* (side view), with part of the wall removed; from de Laubenfels (1955, p.E53). Reproduced with permission of the University of Kansas Press.

Forms which are perhaps less easy to identify are shown in Figs. 6 & 7. One suggestion (K. Rigby, pers. comm.) is that they may also belong to the Anthaspidellidae and could possibly be *Hudsonospongia* or a related genus (e.g. *Anthaspidella* or *Zittelella*). These smaller, funnel- or cone-shaped forms lack the conspicuous annulate structure of *Archaeoscyphia*. A third, more cylindrical form may be the anthaspidellid *Rhopalocoelia* (Figs. 6a & 7) . It lacks the annulations of *Archaeoscyphia*, is cylindrical or club-shaped with a spongocoel reaching near to the base, and is more thin-walled than *Hudsonospongia*. It is interesting to note that Baltic representatives of *Archaeoscyphia, Anthaspidella* and *Hudsonospongia*, as well as many other anthaspidellid genera, have been recorded from cobble- and pebble-size erratics in Pleistocene fluvial deposits in the Netherlands and NW Germany (van Kempen 1978, Rhebergen & Hacht 1996, Hacht & Rhebergen 1997).

Another suggestion for the forms with the radiate structure illustrated in Figs. 6b & 6c has been that they could conceivably represent early rugose **corals** (David Bruton, pers. comm. 1980). Some of the original photographs were examined (in 1980) by Björn Neuman who expressed a certain measure of doubt, noting that while the radiate structure could possibly be interpreted as representing the septa of a solitary coral, the irregular nature of the cavities between the 'septa' is not typical of rugosans. However, the shear deformation and recrystallisation of the fossils may have partly destroyed and modified the original internal structure. Acccepting, for the sake of discussion, that we may be dealing here with a rugose coral, then the features would suggest that all the sections are fortuitously high up in the calyx and that the forms may be representative of Streptelasmatidae (B.Neuman, pers. comm.1980). Such corals are known in Scandinavia mainly from Upper Ordovician strata. Since it has not proved possible to extract these fossils from the pervasively recrystallised metalimestone and study them in de-

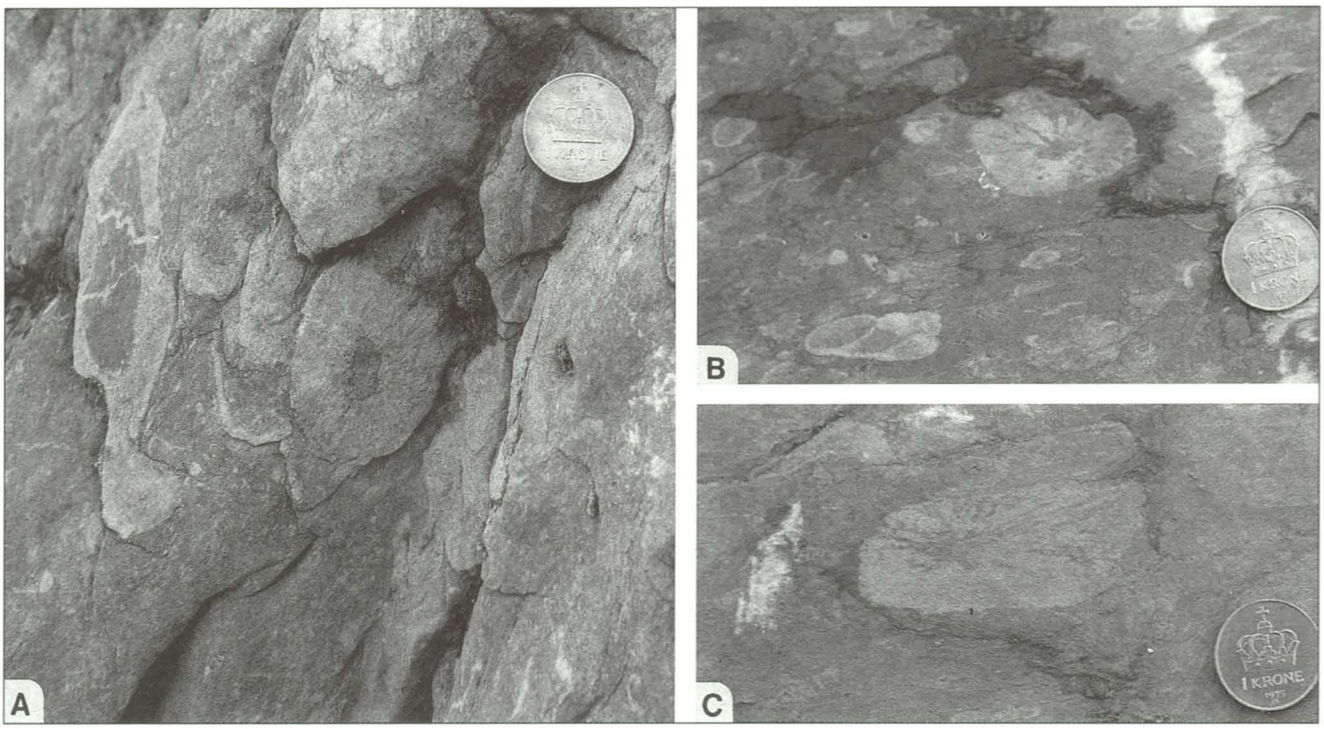


Fig. 6. The forms with the internal, radiate structure and darker grey, central area in all three photos are probably sections through anthaspidellid sponges, possibly *Hudsonospongia* or *Zittelella*. The vertically elongate form to the left in Fig. 6a, with the large infilled internal cavity - the spongocoel - is reminiscent of the anthaspidellid sponge *Rhopalocoelia*. Sections through gastropods and diverse shell fragments can also be seen in Fig. 6b.

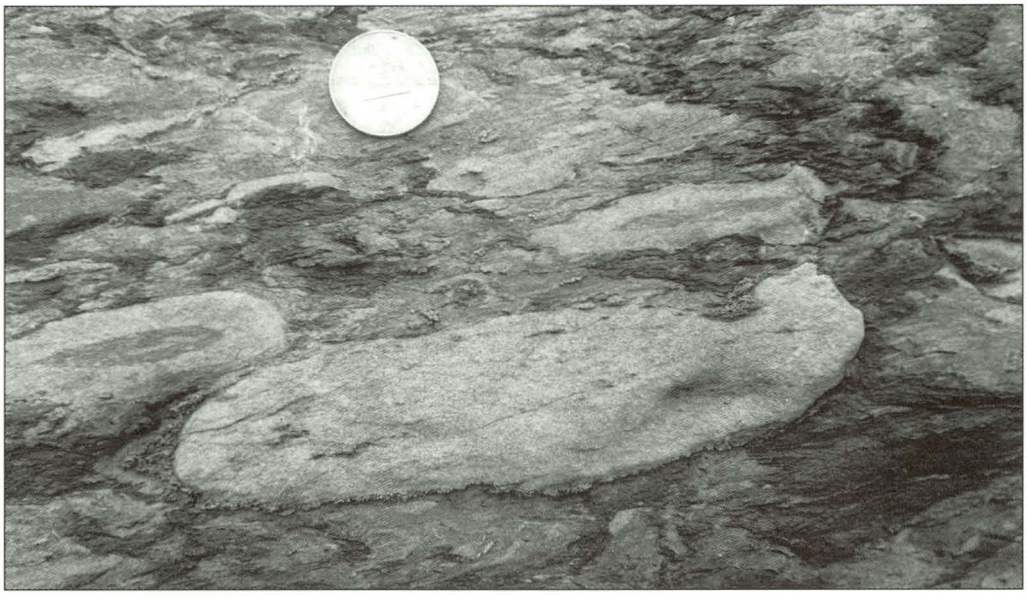


Fig. 7. Strongly sheared, prolate sections through forms which may represent 3 specimens of the anthaspidellid demosponge Rhopalocoelia. In the two smaller specimens, the section exposes the sediment-infilled spongocoel cavity.

tail, it is difficult right now to decide one way or the other – anthaspidellid sponges or rugose corals. However, in the opinion of B.Webby (pers. comm. 1998) the structures are more characteristic of demosponges than of rugosans; a view to which B.Neuman (pers. comm. 1998) also subscribes after having seen the originals to Fig.6.

The possibility that some of the elliptical or rounded forms (e.g. Fig. 7 and left part of Fig. 6a) present at this locality may be representative of **stromatoporoids** has been suggested by both David Bruton and Björn Neuman. The possible presence of stromatoporoids in the Snåsa Limestone, at another locality, had also been suggested earlier by Spjeldnæs (1985). Examination of most of the photographs shown here, and in an earlier report (Roberts 1980), or additional photos not published, did not, however, convince either K.Rigby or B.Webby (pers. comm.) that stromatoporoids were present.

Discussion

Although the strong Scandian deformation and pervasive recrystallisation precludes any detailed study of these fossils, palaeontologist colleagues do agree that gastropods and sponges of Ordovician age are present. Whether or not solitary corals and multicellular stromatoporoids are represented is more conjectural. Both Ellis Yochelsen and Nils Spjeldnæs (pers. comm. 1980 and 1998) have suggested that the age of the fauna is Middle Ordovician, perhaps just a little younger, based on the gastropods and the various, multicellular, frame-building organisms, respectively.

Fossils comparable to some of those present in the Snåsa Limestone, though without the sponges, occur further southwest in Trøndelag on the island of Tautra (Spjeldnæs 1985). In terms of provinciality, the faunas on Tautra and those in the Snåsa Limestone are considered to be largely of North American aspect (Spjeldnæs 1985). Southwest of the Trondheim Region proper, on the island of Smøla in the county of Nord-Møre (inset, Fig. 1), fossils in the Skjølberg Limestone include macluritid and other gastropods, brachiopods and a trilobite and are of Late Arenig-Early Llanvirn age (Bruton & Bockelie 1979, Harper 1981). A few conodonts have also been retrieved (Bergström 1997), but sponges have not been reported from this formation. The fauna in the Skjølberg Limestone is also of North American (Whiterockian) aspect. Despite the similarities in faunal affinity, the ages of the fauna in these two areas, Smøla and Snåsa, are noticeably different and this is also reflected in significant differences in the geology. The Smøla area has been considered to be part of a separate terrane, characterised by a Mid Ordovician, Taconic-equivalent deformation and a subsequent, Mid Ordovician to Early Silurian, calc-alkaline magmatic arc (Hall & Roberts 1988, Roberts 1988).

Considering that the sponges represent an essentially warm-water, subtropical to tropical fauna, then their appearance in carbonate formations peripheral to the palaeocontinent Laurentia might be expected at any time during the Ordovician, since Laurentia was positioned fairly stably at equatorial latitudes throughout this period. Refined palaeomagnetic data for Baltica, on the other hand, have indicated that this paleocontinent moved, and gradually rotated, from high and intermediate latitudes in Early Ordovician times to a more equatorial position by the Late Ordovician (Torsvik et al. 1995, Torsvik 1998). Consequently, the sponges would presumably be expected to have been more prolific, in diversity and number, on the Baltican plate in Mid Ordovician to Early Silurian times. The Baltic anthaspidellids, for example, dominated many reefs and bioherms by Mid Ordovician times, but by the Early Silurian they had been largely replaced by stromatoporoids and corals (van Kempen 1981). Lithistid sponges of late Middle to Late Ordovician age also constitute abundant erratic material in Pleistocene fluvial deposits of parts of mainland northwestern Europe (e.g., the Netherlands, NW Germany, N.Poland), and have been inferred to have derived from northernmost Baltica or Siberia

(Rhebergen & von Hacht 1996). Based on the most recent palaeomagnetic reconstructions (Torsvik 1998), northern Baltica and NW Siberia were indeed almost juxtaposed, and along the palaeo-equator, during this interval of time. Moreover, Late Ordovician brachiopod faunas in the central Taimyr Peninsula of NW Siberia are of Baltic affinity and favour the view that the central block of Taimyr formed part of Baltica at this time (Cocks & Modzalevskaya 1997). As yet, however, there is no record of any occurrence of sponges in the Ordovician rocks of the Taimyr Peninsula (V.Moralev, pers. comm. 1998). A more likely source for the erratic Ordovician sponge material in the Pleistocene river deposits may therefore have been the Gulf of Bothnia region and surrounding areas (then marine) to the east.

Acknowledgements

Discussions over the years on Norwegian Caledonide geology and especially on the dearth of fossil remains in many of the allochthons, finally persuaded me that it is better to publicise the few forms that have been encountered during fieldwork rather then 'forget' them in photographic files or unnumbered open-file reports. A special debt of gratitude is owed to Keith Rigby and Barry Webby for their help with suggested identifications of the strongly sheared sponges, based solely on the photographic material. Their helpful comments on the manuscript are also much appreciated. Ellis Yochelson, Bjørn Neuman, David Bruton and Nils Spjeldnæs also contributed suggestions when the initial NGU Report was written some 18 years ago, and Professors Bruton and Spjeldnæs kindly reviewed the manuscript to this paper. Correspondence with Theo van Kempen, Ulrich von Hacht and Freek Rhebergen on the topic of erratic sponge material in the Pleistocene of western Europe has also brought to light a fascinating aspect of Ordovician sponge re-distribution hitherto unknown to me.

References

Bergström, S. 1979: Whiterockian (Ordovician) conodonts from the Hølonda Limestone of the Trondheim Region, Norwegian Caledonides. *Norsk Geologisk Tidsskrift 59*, 295-307.

Bergström, S. 1997: Conodonts of Laurentian faunal affinities from the Middle Ordovician Svartsætra limestone in the Trondheim Region, Central Norwegian Caledonides. *Norges geologiske undersøkelse Bulletin 432*, 59-69.

Berry, W.B.N. 1968: Age of Bogo shale and western Ireland graptolite faunas and their bearing on dating early Ordovician deformation and metamorphism in Norway and Britain. *Norsk Geologisk Tidsskrift 48*, 217-230.

Brenchley, P.J. & Newall, G. 1975: The stratigraphy of the Upper Ordovician Stage 5 in the Oslo-Asker District, Norway. *Norsk Geologisk Tidsskrift 55*, 243-275.

Bruton, D.L. & Bockelie, J.F. 1979: The Ordovician sedimentary sequence on Smøla, west central Norway. *Norges geologiske undersøkelse 348*, 21-31.

Bruton, D.L. & Bockelie, J.F. 1982: The Løkken-Hølonda-Støren areas. *Paleontological Contributions, University of Oslo 279*, 77-86.

Carstens, H. 1956: Geological map. In *Fosdalens Bergverks Jubileumsbok*, Trondheim.

Carstens, H. 1960: Stratigraphy and volcanism of the Trondheim area, Norway. *Norges geologiske undersøkelse 212a*, 27-39.

Cocks, L.R.M. & Modzalevskaya, T.L. 1997: Late Ordovician brachiopods from Taaimyr, Arctic Russia, and their palaeogeographical significance. *Palaeontology 40*, 1061-1093.

Hacht, U. von & Rhebergen, F. 1997: Ordovizische Geschiebespongien Europas. *Berliner Beitrage zur Geschiebeforschung*, 51-63.

Hall, L.M. & Roberts, D. 1988: Timing of Ordovician deformation in the Caledonian-Appalachian orogen. In Harris, A.L. & Fettes, D.J. (eds.) The Caledonian-Appalachian Orogen. *Geological Society of London Special Publication 38*, 291-309.

Harper, D.A.T. 1981: The brachiopod Stenocamara from the Ordovician of Smøla, Norway. *Norsk Geologisk Tidsskrift 61*, 149-152.

Kempen, T.M.G. van 1978: Anthaspidellid sponges from the Early Paleozoic of Europe and Australia. *Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen 156*, 305-337.

Kempen, T.M.G. van 1981: Anthaspidelliden (sponzen) uit het Oostzeegebeid. *Grondboor & Hamer 6*, 156-174.

Laubenfels, M.W.de 1955: Porifera. *In* Moore, R.C. (ed.) Treatise on Invertibrate Paleontology. Part E, Archaeocyatha and Porifera. *Geological Society of America and University of Kansas Press*, 21-112.

Moore, R.C. 1960: Treatise on Invertebrate Paleontology. Part I, Mollusca. *Geological Society of America and University of Kansas Press*.

Neuman, R.B., Bruton, D.L. & Pojeta, J. Jr. 1997: Fossils from the Ordovician 'Upper Hovin Group' (Caradoc-Ashgill), Trondheim Region, Norway. *Norges geologiske undersøkelse Bulletin 432*, 25-58.

Owen, A.W., Bruton, D.L., Bockelie, J.F. & Bockelie, T.G. 1990: The Ordovician successions of the Oslo Region, Norway. *Norges geologiske undersøkelse Special Publication 4*, 3-54.

Rhebergen, F. & von Hacht, U. 1996: De ordovicische sponzenfauna uit Nedeland en het Duitse grensgebied. *Grondboor & Hamer 50 (4)*, 83-94.

Rigby, J.K. & Webby, B.D. 1988: Late Ordovician sponges from the Malongulli Formation of central New South Wales, Australia. *Palæontographica Americana 56*, .

Roberts, D. 1967: Geological observations in the Snåsa-Lurudal area, Nord-Trøndelag. *Norges geologiske undersøkelse 247*, 18-38.

Roberts, D. 1980: En ny fossil lokalitet i Snåsakalken, Nord-Trøndelag. *Norges geologiske undersøkelse Rapport (unnumbered)*, 5 pp.

Roberts, D. 1988: The terrane concept and the Scandinavian Caledonides. *Norges geologiske undersøkelse Bulletin 413*, 93-99.

Ryan, P.D., Skevington, D. & Williams, D.M. 1980: A revised interpretation of the Ordovician stratigraphy of Sør-Trøndelag and its implications for the evolution of the Scandinavian Caledonides. *Proceedings, IGCP Caledonide Orogen Symposium, Virginia Polytechnic Institute Memoir2*, 99-103.

Spjeldnæs, N. 1985: Biostratigraphy of the Scandinavian Caledonides. In Gee, D.G. & Sturt, B.A. (eds.) *The Caledonide Orogen – Scandinavia and related areas*. John Wiley & Sons, Chichester, 317-329.

Tietzsch-Tyler, D. 1983: *The Caledonian geology of the southwestern part of the Snåsa synform in the Central Norwegian Caledonides and its regional significance*. Unpublished Ph.D. thesis, University of Wales, Cardiff, xxx pp.

Torsvik, T.H. 1998: Palaeozoic palaeogeography: a North Atlantic viewpoint. *Geologiska Föreningens i Stockholm Förhandlingar 120*, 109-118.

Torsvik, T.H., Tait, J., Moralev, V.M., McKerrow, W.S., Sturt, B.A. & Roberts, D. 1995: Ordovician palaeogeography of Siberia and adjacent continents. *Journal of the Geological Society of London 152*, 279-287.

Wolff, F.C. 1979: Beskrivelse til de berggrunnsgeologiske kartbladene Trondheim og Østersund 1:250 000 (with English summary). *Norges geologiske undersøkelse 353*, 77 pp.

Yochelson, E.L. 1963: Gastropods from the Otta Conglomerate. *Norsk Geologisk Tidsskrift 43*, 75-81.

Manuscript received February 1998; revised manuscript accepted May 1998.