

species form monospecific assemblages. It shows that *A. subremotus* was particularly tolerant of environmental stress. The critical factor in this case was reduced salinity, as small-sized species of *Ammodiscus*, similar in shape to *A. subremotus*, are known from both modern and ancient low diversity assemblages of hyposaline environments: *Ammodiscus yonsnabensis*, a species closely related to *A. subremotus*, is highly dominant in Bajocian strata of the North Sea Basin, both in the Cloughton Formation of the Yorkshire Coast and in the Rannoch Formation of the Gullfaks Field. These occurrences are interpreted as indicating strongly delta-influenced hyposaline environments (Nagy et al. 1990). The small-sized modern species *Ammodiscus gullmarensis* is dominant in low salinity estuarine waters of the Drammensfjord (Alve 1995).

It is also well-known that species of *Trochammina* can tolerate low salinities, and small-sized forms are reported as abundant in modern low diversity brackish water faunas, e.g. in the Chezzetcook inlet of eastern Canada (Scott et al. 1980). Other genera of interest, reported as abundant in hyposaline environments are *Ammobaculites*, *Reophax* and *Verneulinoides*. In the Knorringfjellet Formation, these genera are represented by common to sporadic occurrence of the following species: *A. aff. bivarians*, *A. sp.*, *R. aff. metensis*, *R. sp.*, *V. subvitreus* and *V. aff. kirillae*.

The Knorringfjellet foraminiferal succession of the Festningen and Marhøgda sections reveal an essentially similar, low diversity agglutinated development of restricted nature. The most marked differences between the two sections appear when we compare the Teistberget member. At Festningen it shows a high dominance of *Ammodiscus* and a more reduced diversity than at Marhøgda where *Trochammina* is dominant; features suggesting that the Festningen area was more hyposaline than the Marhøgda region.

The similarity index which compares the faunal composition of successive samples through each of the two sections indicates only smaller faunal discontinuities, in spite of the condensed nature of the Knorringfjellet Formation and its content of supposed larger hiatuses. Several minor faunal discontinuities (smaller drops in similarity) are recognized, and one of these marks the Tverrbekken-Teistberget member boundary. The apparently gradual development and generally restricted nature of the faunal succession suggest that essentially the same type of hyposaline conditions prevailed in the gross region during deposition of the formation, recurring at the studied sites after each period of non-deposition or erosion.

#### References

Alve, E. 1995. Benthic foraminiferal distribution and recolonization of formerly anoxic environments in Drammensfjord, southern Norway. *Marine*

*Micropaleontology* 25, 169-186.

Mørk, A., Dallmann, W.K., Dypvik, H., Johannessen, E.P., Larsen, G.B., Nagy, J., Nøttvedt, A., Olaussen, S., Pchelina, T.M. & Worsley, D. 1999. Mesozoic lithostratigraphy. In *Lithostratigraphic Lexicon of Svalbard*. (ed. W.K. Dallmann) Norsk Polarinstitut, 127-214.

Nagy, J., Pilskog, B. & Wilhelmsen, R.M. 1990. Facies-controlled distribution of foraminifera in the Jurassic North Sea Basin. In *Paleoecology, Biostratigraphy, Paleoceanography and Taxonomy of Agglutinated Foraminifera*. (eds. C. Hemleben, M.A. Kaminski, W. Kuhnt & D.B. Scott) *Kluwer Academic Publishers*, The Netherlands, 621-657.

Scott, D.B., Schafer, C.T. & Medioli, F.S. 1980. Eastern Canadian Estuarine Foraminifera: a framework for comparison. *Journal of Foraminiferal Research* 10 (3), 205-234.

## Triassic conodonts from Svalbard and their Boreal correlations – A review.

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As based on recently processed samples, as well as published sources [but not all collections taxonomically revised], the distribution of conodonts through the Lower and Middle Triassic of Svalbard can be compiled as follows:

### Lower Triassic

#### Vikinghøgda Formation, Deltadalen Member

From the Lusitania River, southern side of Sassenfjorden, Dagis & Korchinskaya (1987) reported the presence of *Neogondolella carinata* associated with *Otoceras boreale*. This conodont species indicates a Late Griesbachian age for the lower part of the Vikinghøgda Formation (Deltadalen Member) at this locality.

From a possible higher level in the Deltadalen Member Dagis & Korchinskaya (1989) added new conodont species: *Neogondolella sweeti* and *Neospathodus svalbardensis*. This level may be identical to the *Myalina* beds (=Brevassfjellet Beds elsewhere), as Dagis & Korchinskaya refer to the conodonts coming from a sample with abundant *Promyalina degeeri*.

Mørk et al. (1999) reported presence of *Neogondolella carinata* from calcareous nodules 5.0 and 11.5 meters above the base of the formation. *N. meishanensis* is also probably present in this sample. These conodonts were found together with *Otoceras boreale*, *Claraia stachei*, *Bellerophon borealis* and

*Tompophiceras* cf. *gracile*. Higher up, from a sample 79.0 meters above the base of the formation, *Neospathodus* cf. *svalebardensis* was found.

Age of this unit: Early Griesbachian, or even latest Permian if identification of *Neogondolella meishanensis* is correct.

**Vikinghøgda Formation, Lusitaniadalen Member**

A single sample from the Lusitaniadalen Member yielded specimens of *Neospathodus waageni*, indicating a Smithian age for this unit.

**Vikinghøgda Formation, Vendomdalen Member**

Weitschat & Lehmann (1978) reported the presence of the following species in samples collected from the southern shore of Sassenfjorden, close to Botneheia, from the *Wasatchites tardus* ammonoid zone: *Scythogondolella milleri*, *Scythogondolella mosheri*, *Borinella buurensis* (originally described as *Neogondolella planata*, *Neogondolella nevadensis* and *Neogondolella jubata*) and *Neospathodus waageni*. The age of this fauna is Smithian. In the current study *Neogondolella* cf. *paragondolellaeformis* in addition to probably new species of *Neogondolella* have been extracted from the middle part (middle Spathian) of the Vendomdalen Member. This unit also contains occurrences of *Neogondolella transita?*, *Neogondolella inclinata?* and *Neogondolella ex gr. constricta?* (study in progress).

**Vardebukta Formation, Brevassfjellet Bed**

Conodonts have been reported from the basal Triassic beds of the Sørkapp-Hornsund area (the Brevassfjellet *Myalina* Bed of Birkenmajer, 1977) by Birkemajer & Trammer (1975), Nakrem & Mørk (1991) and Luppold (2001). An early - middle Dienerian age was proposed based on the presence of *Ellisonia triassica*, *Neospathodus dieneri*, *Neospathodus peculiaris*, and *Neospathodus svalbardensis*. *Neospathodus dieneri* ranges from early Dienerian to middle Smithian, and in part co-exists with *Neogondolella elongata* (Sweet *et al.*, 1971). *Neogondolella elongata* is a Spathian species, and the reported occurrences of this species in the Dienerian and Smithian of Svalbard probably represent a species of *Borinella*.

Conodonts mentioned in Sweet (1970b, p. 216), Sweet *et al.* (1971, p. 451) and Trammer (1978, p. 283) from Spitsbergen were supplied by G. Hamar, also from samples from the Brevassfjellet *Myalina* bed of this area.

**Vardebukta Formation, Siksaken Member**

Clark & Hatleberg (1983) and Hatleberg & Clark (1984) processed conodonts from Ahlstrandodden, Pitnerodden and Reinodden (southern side of Van Keulenfjorden), Siksaken Member. Conodonts indicating a Dienerian age were found: *Ellisonia triassica*, *Neospathodus dieneri*, *Neospathodus cristagalli*, *Neospathodus svalbardensis*,

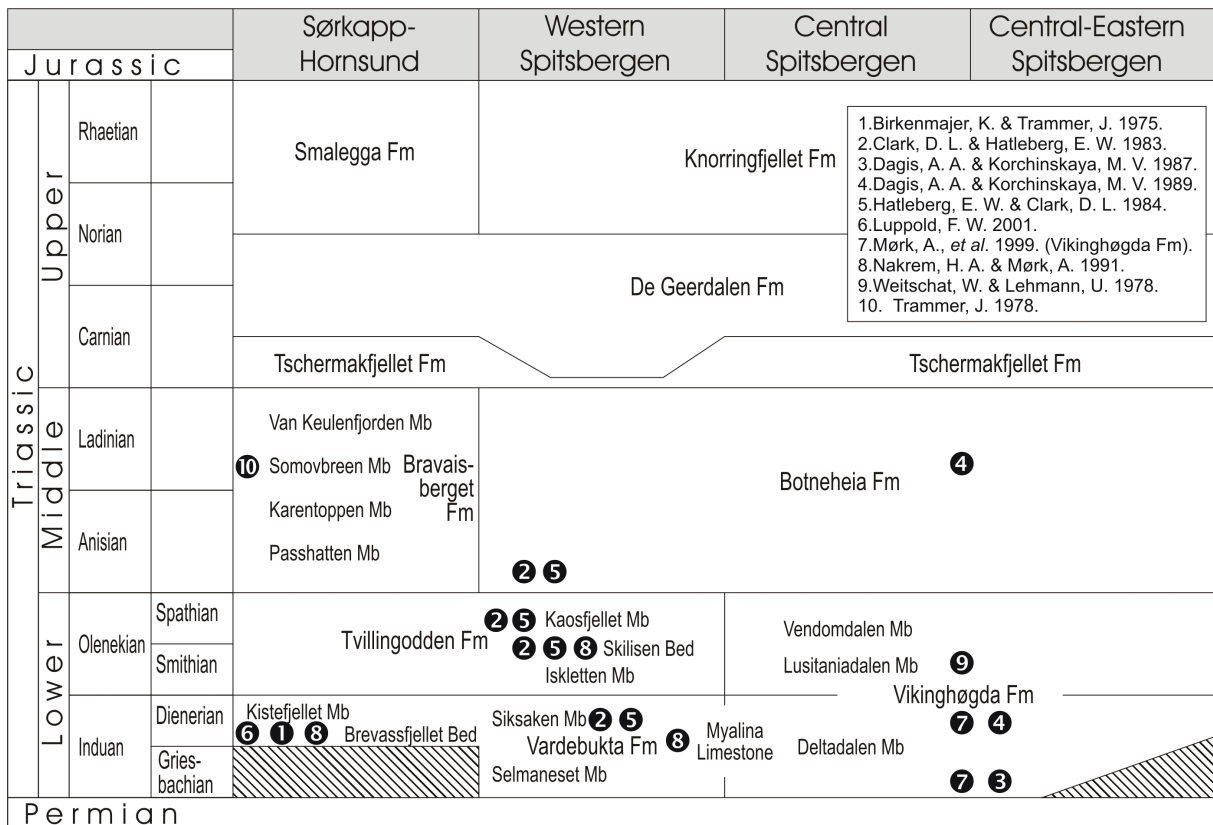


Figure 1. Triassic lithostratigraphy of Svalbard (ex Bjørnøya) and position of previously published conodont occurrences.

*Neospathodus pakistanensis*, *Neospathodus peculiaris*, *Neogondolella elongata*, and *Neogondolella* sp. aff. *mombergensis*. Ammonoid correlation: *Vavilovites*.

Conodonts were reported from the *Myalina* limestone beds of the Siksaken Member at Mariaholmen (Bellsund) by Nakrem & Mørk (1991). The conodont fauna from this unit comprises *Neogondolella elongata*, *Neospathodus* sp. cf. *svabardensis* and *Ellisonia triassica*. *Neogondolella elongata* has a fairly long range in the Early Triassic, but is an important species of the *Neogondolella milleri* conodont zone (Sweet *et al.*, 1971) and the *Neospathodus pakistanensis* conodont zone (Sweet, 1970b). These zones are of middle Dienerian and late Dienerian - early Smithian age respectively.

**Tvillingodden Formation, Iskletten Member**

Clark & Hatleberg (1983) and Hatleberg & Clark (1984) pro-cessed conodonts from the Iskletten Member at Pitnerodden and Reinodden. Conodonts indicating a Smithian age were found: *Ellisonia triassica*, *Neogondolella nevadensis* and *Xaniognathus* sp.

**Tvillingodden Formation, Kaosfjellet Member**

Clark & Hatleberg (1983) and Hatleberg & Clark (1984) pro-cessed conodonts from Pitnerodden,

Kaosfjellet Member. Conodonts indicating a Spathian age were found: *Ellisonia triassica*, *Neospathodus collinsoni*, *Neospathodus homeri*, *Neospathodus* cf. *triangularis*, *Neogondolella elongata* and *Neogondolella jubata*.

**Tvillingodden Formation, Skilisen Bed**

A sparse collection of conodonts from this unit has been published by Nakrem & Mørk (1991) yielding only *Neogondolella elongata* of rather indistinct Early Triassic age.

**Middle Triassic**

**Botneheia Formation**

Dagis & Korchinskaya (1989) reported the following conodonts from the Botneheia Formation of Sassenfjorden (Botneheia): *Neogondolella longa*, *Neogondolella transita*, *Neogondolella spitzbergensis*. They conclude with an early Ladinian age for this unit (associated with the ammonoids *Ptychites* cf. *euglyphus* and *Ussurites spitzbergensis*).

In the current study the following conodonts have been extracted from the Botneheia Formation at locality Milne Edwardsfjellet: *Neogondolella* ex gr. *regalis* and *Chiosella* cf. *timorensis* from the lowermost part (Early Anisian); *Neogondolella* ex gr. *constricta* from the middle part, and

| Jurassic |                              |           | Western Spitsbergen | Central Spitsbergen          | Conodonts  |  |
|----------|------------------------------|-----------|---------------------|------------------------------|--|--|
| Triassic | Upper                        | Rhaetian  | Knorringsfjellet Fm |                              |  |  |
|          |                              | Norian    | De Geerdalen Fm     |                              |  |  |
|          |                              | Carnian   | Tschermafjellet Fm  |                              |  |  |
|          | Middle                       | Ladinian  | Botneheia Fm        |                              | <i>Ng. inclinata</i><br><i>Ng. ex gr. constricta</i><br><i>Ng. ex gr. regalis</i> ,<br><i>Chiosella</i> cf. <i>timorensis</i>  |  |
|          |                              | Anisian   |                     |                              | <i>Scythogondolella milleri</i><br><i>Sc. mosheri</i> ,<br><i>Borinella buurensis</i><br><i>Ng. cf. paragondolellaformis</i><br><i>Ng. transita?</i> , <i>Ng. inclinata?</i> ,<br><i>Ng. ex gr. constricta?</i><br><i>Neospathodus waageni</i> |  |
|          | Lower                        | Olenekian | Spathian            | Kaosfjellet Mb               | Vendomdalen Mb   |  |
|          |                              |           | Smithian            | Skilisen Bed<br>Iskletten Mb | Lusitaniadalen Mb<br>Vikinghøgda Fm  |  |
|          |                              | Induan    | Dienerian           | Siksaken Mb<br>Vardebukta Fm | Myalina Limestone<br>Deltadalen Mb   |  |
|          |                              |           | Griesbachian        | Selmaneset Mb                |  |  |
|          | Permian (Kapp Starostin Fm.) |           |                     |                              |  | <i>Mesogondolella</i> cf. <i>idahoensis</i> - <i>bitteri</i> ? |

Figure 2. Occurrences of conodonts in the Triassic of Svalbard.

*Neogondolella inclinata* from the uppermost part (Late Anisian).

#### **Bravaisberget Formation, Somovbreen Member**

Clark & Hatleberg (1983) and Hatleberg & Clark (1984) published conodonts from the basal beds of the Botneheia Formation (now Bravaisberget Formation) at Reinodden: *Neogondolella mombergensis* and *Neogondolella regale*. The implied age is early Anisian, but the faunas reported by Clark & Hatleberg (1983) and Hatleberg & Clark (1984) need further revision.

Early Ladinian conodonts from Spitsbergen were also reported by Trammer (1978). They were extracted from samples collected at Treskelen, within the Somovbreen Member of the Bravaisberget Formation (Drevbreen Formation of Birkenmajer, 1977 and Trammer, 1978), and comprise "*Neogondolella mombergensis*" and *Neogondolella haslachensis trammeri*.

#### **Upper Triassic Tschermakfjellet Formation**

In the current study, conodonts reported by Hounslow *et al.* (2006) include the Carnian fauna comprising *Neogondolella inclinata* and *Metapolygnathus* ex gr. *polygnathiformis* collected from the lowermost part of the Tschermakfjellet Formation at Milne Edwardsfjellet.

#### **Triassic conodonts from the Barents shelf**

Nakrem, Szaniawski & Mørk (2001) published occurrences of Permian and Triassic conodonts (and scolecodonts) from five samples of three cores from the Svalis Dome, central Barents Sea. The conodont species *Mesogondolella rosenkrantzi* and *Neospathodus svalbardensis* confirm latest Permian (Dzulfian) and earliest Triassic (Dienerian) ages for the investigated intervals, which are within the Ørret and the Havert Formations respectively.

#### **References**

- Bender, H. 1970. Zur Gliederung der mediterranen Trias II. Die Conodontenchronologie der mediterranen Trias. *Extract Annales Géologiques des Pays Helléniques* (1) 19, 465-540, 9 fig., 5 plts.
- Birkenmajer, K. & Trammer, J. 1975. Lower Triassic conodonts from Hornsund, south Spitsbergen. *Acta Geologica Polonica* 25, 299-307.
- Clark, D. L. 1959. Conodonts from the Triassic of Nevada and Utah. *Journal of Paleontology* 33, 305-312.
- Clark, D. L. & Hatleberg, E. W. 1983. Paleoenvironmental factors and the distribution of conodonts in the Lower Triassic of Svalbard and Nepal. *Fos-sils and Strata* 15, 171-175.
- Dagis, A. A. & Korchinskaya, M. V. 1987. Pervye nakhodki konodontov v ototserasovykh sloyakh Sval'barda' [The first discoveries of conodonts in the *Otoceras* beds of Svalbard]. *Trudy Akademiy SSSR Sibirskoe otdelenie Instituta Geologii i Geofiziki* 689, 110-113.
- Dagis, A. A. & Korchinskaya, M. V. 1989. Triasovye konodonty Sval'barda [Triassic conodonts of Svalbard]. In Dagis, A. S. & Dubatolov, V. N. (Eds.) *Verkhni Paleozoi i Trias Sibiri* [Upper Paleozoic and Triassic of Siberia] *Trudy Akademiy Nauk SSSR Sibirskoe otdelenie Instituta Geologii i Geofiziki* 732, 109-121.
- Hatleberg, E. W. & Clark, D. L. 1984. Lower Triassic conodonts and biofacies interpretations: Nepal and Svalbard. *Geologica et Palaeontologica* 18, 101-125.
- Hounslow, M. W., Peters, C., Mørk, A., Weitschat, W. & Vigran, J. O. 2006. Magneto-biostratigraphy of the Vikinghøgda Fm, Central Svalbard and the geomagnetic polarity timescale for the Lower Triassic. In: Nakrem, H. A. & Mørk, A. (eds.) *Boreal Triassic 2006. NGF, Abstracts and Proceedings of the Geological Society of Norway*, 3, 2006, (this volume).
- Kozur, H. & Mostler, H. 1971. Probleme der Conodontenforschung in der Trias. *Geologisches-Paläontologisches Mitteilungen Innsbruck* 1 (4), 1-19.
- Luppold, F. W. 2001. New biostratigraphic data from west Spitsbergen based on conodonts. *Geologisches Jahrbuch B* 91, 603-633.
- Mørk, A., Elvebakk, G., Forsberg, A. W., Hounslow, M. W., Nakrem, H. A., Vigran, J. O., Weitschat, W. 1999. The type section of the Vikinghøgda Formation: a new Lower Triassic unit in central and eastern Svalbard. *Polar Research* 18(1), 51-82.
- Nakrem, H. A. & Mørk, A. 1991. New Early Triassic Bryozoa (Trepostomata) from Spitsbergen, with some remarks on the stratigraphy of the investigated horizons. *Geological Magazine* 128, 129-140.
- Nakrem, H. A., Szaniawski, H., & Mørk, A. 2001. Permian-Triassic scolecodonts and conodonts from the Svalis Dome, central Barents Sea, Norway – *Acta Palaeontologica Polonica* 46(1), 67-84.
- Sweet, W. C. 1970a. Permian and Triassic conodonts from Guryul Ravine, Vihi District, Kashmir. *The University of Kansas Paleontological Contribution Paper* 49, 10 pp.
- Sweet, W. C. 1970b. Uppermost Permian and Lower Triassic conodonts of the Salt Range and Trans-Indus Ranges, West Pakistan. In *Stratigraphic boundary problems - Permian and Triassic of West Pakistan* (eds. B. Kummel and C. Teichert, C.), pp. 207-275. Kansas: University of Kansas Press.
- Sweet, W. C., Mosher, L. C., Clark, D. L., Collinson, J. W. & Hasenmueller, W. A. 1971. Conodont biostratigraphy of the Triassic. In *Symposium on Conodont Biostratigraphy* (eds. W. C. Sweet and S. M. Bergström), *Geological Society of America Memoir* 127, 441-465.
- Tatge, U. 1956. Conodonten aus dem germanischen Muschelkalk. *Paläontologische Zeitschrift* 30, 108-127.
- Trammer, J. 1978. Middle Triassic (Ladinian) conodonts and cephalopod arm hooks from Hornsund, Spitsbergen. *Acta Geologica Polonica* 28, 283-287.
- Weitschat, W. & Lehmann, U. 1978. Biostratigraphy of the uppermost part of the Smithian Stage (Lower Triassic) at the Botneheia, W-Spitsbergen. *Mitteilungen aus dem Geologisch-Paläontologischen Institut der Universität Hamburg* 48, 85-100.