

# Permian–Triassic scolecodonts and conodonts from the Svalis Dome, central Barents Sea, Norway

HANS ARNE NAKREM, HUBERT SZANIAWSKI, and ATLE MØRK



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, 69–86.

Scolecodonts and conodonts are described 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. Correlation with adjacent conodont distribution indicates a shorter depositional gap in the late Permian than is evident on Svalbard. The conodont elements show little thermal alteration with CAI (colour alteration index) values between 1.0 and 1.5 indicating a maximum burial temperature of 50–90°C. The scolecodonts described herein have important evolutionary and distribution implications for polychaetes: the order Eunicida shows a richer diversification in the Permian than previously known; the family Paulinitidae survived at least until the Late Permian; the family Hartmaniellidae diversified already in the late Palaeozoic; some forms are considered as representatives of unknown species and genera; the order Phyllocladida originated already in the latest Palaeozoic.

**Key words:** Scolecodonts, Polychaeta, Conodonta, Permian, Triassic, Barents Shelf, Svalbard.

Hans Arne Nakrem [h.a.nakrem@toyen.uio.no], Palaeontological Museum, University of Oslo, Sars gt. 1, N-0562 Oslo, Norway;

Hubert Szaniawski [szaniaw@twarda.pan.pl], Instytut Paleobiologii, Polska Akademia Nauk, ul. Twarda 51/55, PL-00-818 Warszawa, Poland;

Atle Mørk [atle.mork@iku.sintef.no], SINTEF Petroleum Research, N-7465 Trondheim, Norway.

## Introduction

The Svalis Dome (Fig. 1) is located in the central southern part of the Barents Sea. The dome has a triangular shape (Bugge & Fanavoll 1995) and is formed by salt movements and later modified by tectonics. The central part of the dome consists of resistant Upper

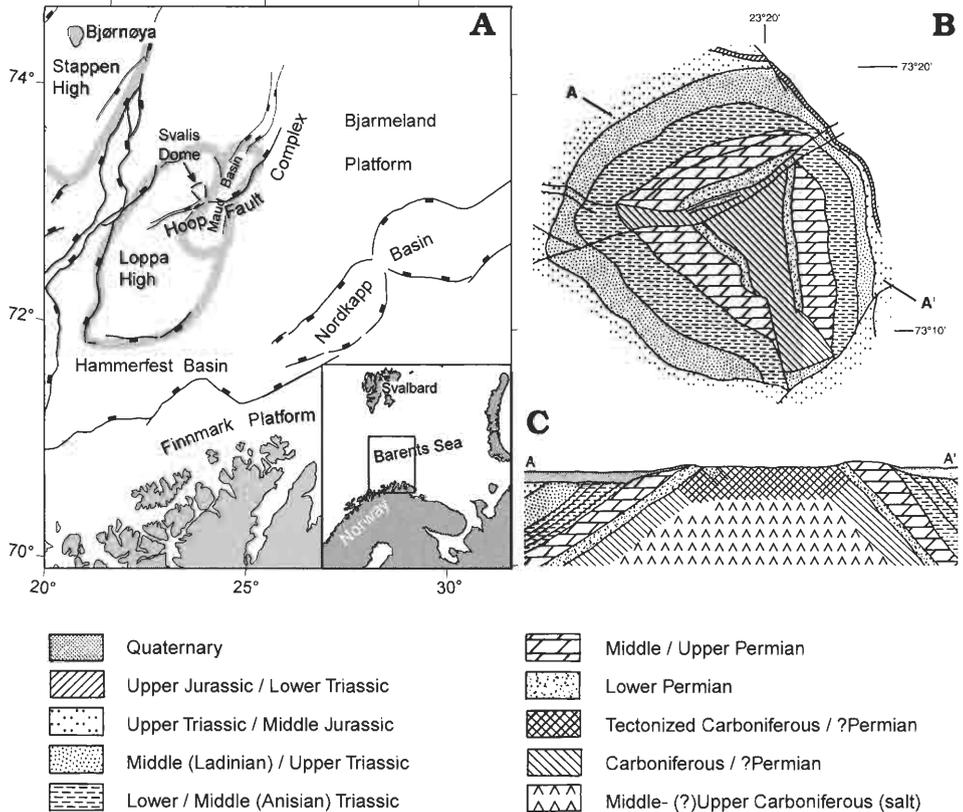


Fig. 1. Geological setting of the Svalis Dome. **A.** Location map with major structural elements and fault lines indicated. **B.** Geological map of the Svalis Dome. **C.** Schematic geological cross section of the Svalis Dome. Reproduced from Mørk & Elvebakk 1999, with permission of *Polar Research*.

Palaeozoic carbonates, cherts and fine-grained clastics (Nilsson *et al.* 1996) surrounded and overlain by Triassic sediments (Vigran *et al.* 1998; Mørk & Elvebakk 1999).

The Barents Sea covers a shelf that has been a major depositional area since the late Palaeozoic. Svalbard represents the uplifted north-western corner and the sedimentological pattern here continues southwards into the Barents Sea and also eastwards to Novaya Zemlya (Sobolev & Nakrem 1996) and further into the Timan Pechora Basin of northern Russia (Stemmerik & Worsley 1995; Heafford 1988). The Barents Shelf has depositional basins separated by highs (Gabrielsen *et al.* 1990) and is an active area of hydrocarbon exploration. Potential hydrocarbon reservoirs are Carboniferous–Permian limestones and Triassic–Jurassic sandstones while source rocks occur in the Permian, Triassic and Jurassic. These play models make detailed biostratigraphical understanding of the succession of great importance.

The sediments of the Svalis Dome can be easily correlated with those of Svalbard (Dallmann 1999). The oldest core Dia84-11 consists of palaeontologically diverse biosparites and is included in the Gipsdalen Group of late Asselian–early Sakmarian age (Nilsson *et al.* 1996; Fig. 2). Core Dia84-31 consists of cherty mudstones with

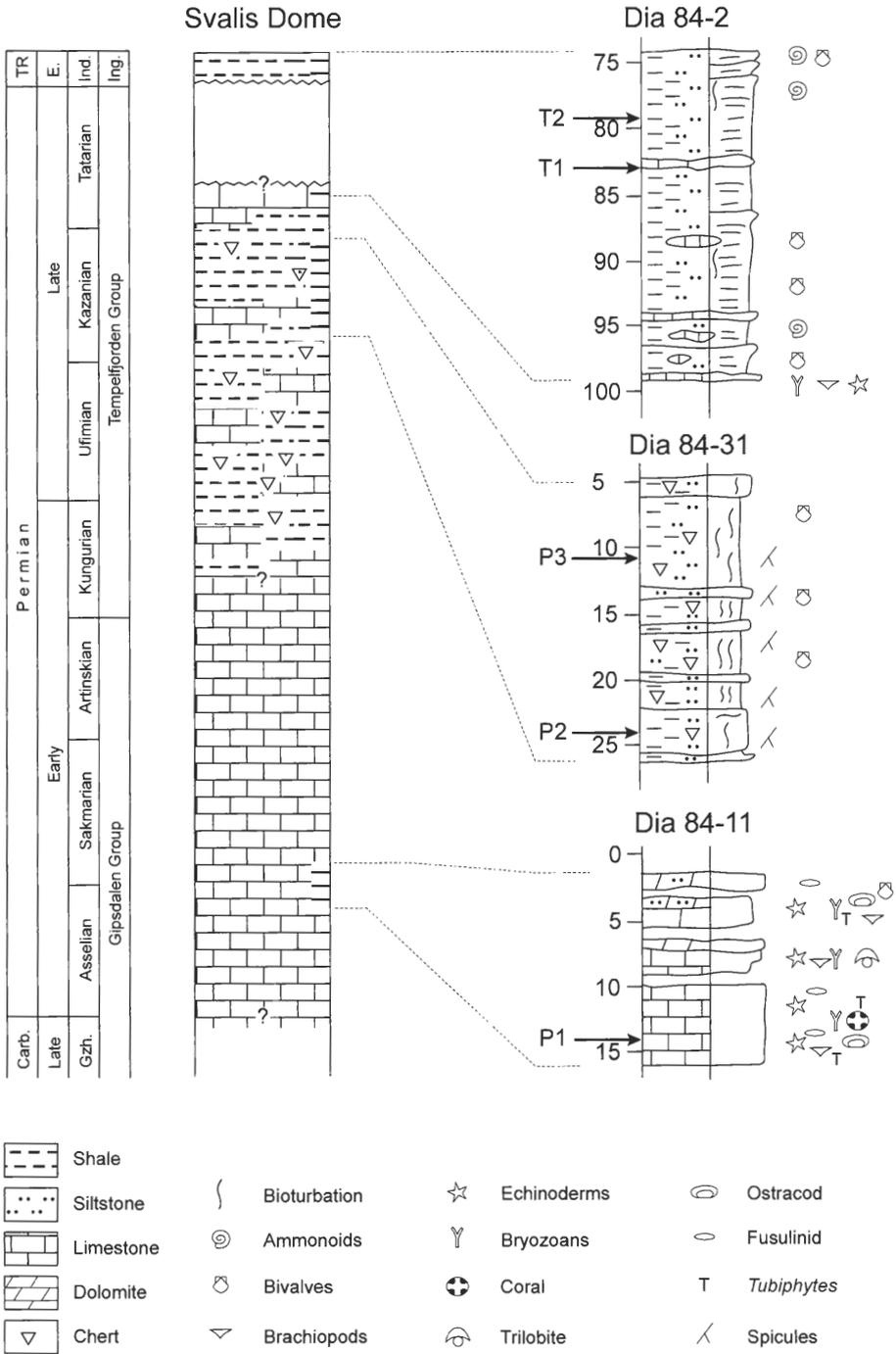


Fig. 2. Stratigraphy of the Svalis Dome section, composite section with indicated latest Permian break, and location of samples. Abbreviations: TR, Triassic; E., Early; Ind., Induan; Ing., Ingøydjupet Subgroup; Carb., Carboniferous; Gzh., Gzhelian.

*Zoophycos* trace fossils quite similar to the basinal development of the Kapp Starostin Formation of the Tempelfjorden Group and the core is given a Kazanian to possibly Tatarian age (Nilsson *et al.* 1996). The youngest core, Dia84-2, spans the Permian–Triassic boundary. The lowest 26 centimetre thick unit is a biosparitic limestone with brachiopods (including productids), echinoderms and bryozoans in a development quite similar to the Miseryfjellet Formation of Bjørnøya of undetermined latest Permian age (Nilsson *et al.* 1996; Vigran *et al.* 1998). This basal limestone is separated by a hiatus from the overlying 25 meter of shales and siltstones dated by ammonoids and palynomorphs to be Griesbachian in age (Vigran *et al.* 1998). Fossil debris and phosphorite fragments in the basal Triassic beds indicate reworking of the underlying bed and the succession represents a condensed sequence (Mørk & Elvebakk 1999). Thin carbonate beds occur in the finely laminated shaly Triassic succession yielding a few imprints of bivalves and ammonoids (Mørk & Elvebakk 1999).

The occurrence of scolecodonts was noticed by Nilsson *et al.* (1996) in several horizons of the Upper Permian drilling core Dia84-31, while conodonts are described herein for the first time from Barents Sea cores. Unfortunately Permian scolecodonts are still not well known and the collection described here, although taxonomically diversified and biologically interesting, adds little to our knowledge of the stratigraphy. Conodonts, on the other hand, are known to be useful in many biostratigraphical studies in adjacent areas, e.g. in Arctic Canada, Greenland and Arctic Russia (see below).

The present work describes the scolecodont and conodont faunas obtained from five samples taken from three investigated cores. The conodonts supplement previously published palynological dating of the samples, while the scolecodont faunas provide new information about polychaete evolution near the Palaeozoic–Mesozoic transition.

## Investigated material

Five samples (Fig. 2) were processed for conodonts and scolecodonts (Table 1):

T2 Dia84-2, 78.86–79.01 m (highest sample)

T1 Dia84-2, 82.62 m

P3 Dia84-31, 10.18–10.40 m

P2 Dia84-31, 24.22–24.49 m

P1 Dia84-11, 13.08–13.30 m (lowest sample)

The samples taken from carbonate rocks were first processed in acetic acid, and residues and clastic rock samples were processed in hydrofluoric acid. Except for P1 and P3 all samples produced small numbers of identifiable conodonts. Sample P3 (about 0.5 kg) yielded 53 identifiable and 33 strongly deformed or incomplete scolecodonts. In addition, the T1 sample produced numerous selachian dermal denticles and the P2 and P3 samples produced numerous sponge spicules. The oldest, P1 sample, did not yield any microfossils in the present study, but Sakmarian fusulinids were reported by Nilsson *et al.* (1996: fig. 12) from the same level.

**Sample P1 (Dia84–11, 13.08–13.30 m).** — Despite the rich occurrences of macrofossil fragments in this interval and the rich fusulinid fauna in this core below and above sample P1, no microfossils were extracted from this sample.

Table 1. Samples investigated, microfossil contents and stratigraphic implications.

Sample	Conodonts	Scolecodonts	Other fossils	Age
T2 Dia84-2, 78.86–79.01 m	<i>Neospathodus svalbardensis</i>		<i>Densoisporites nejburgii</i> , <i>Proprisporites pocockii</i> , <i>Maculatasporites</i> sp. (Vigran <i>et al.</i> 1998)	Conodonts: (Early) Dienerian  Palynomorphs: Late Griesbachian
T1 Dia84-2, 82.62 m	<i>Neospathodus svalbardensis</i>		<i>Densoisporites nejburgii</i> , <i>Proprisporites pocockii</i> , <i>Maculatasporites</i> sp. (Vigran <i>et al.</i> 1998)	Conodonts: (Early) Dienerian  Palynomorphs: Late Griesbachian
P3 Dia84-31, 10.18–10.40 m	Barren	All scolecodonts were extracted from this sample	<i>Scutasporites nanuki</i> , <i>Lueckisporites virkkiae</i> , <i>Vittatina</i> spp. (Nilsson <i>et al.</i> 1996)	Palynomorphs: Dzhulfian
P2 Dia84-31, 24.22–24.49 m	<i>Mesogondolella rosenkrantzi</i>		<i>Scutasporites nanuki</i> , <i>Lueckisporites virkkiae</i> , <i>Lueckisporites</i> sp. (Nilsson <i>et al.</i> 1996)	Conodonts and palynomorphs: Dzhulfian (late Wordian–early Capitanian)
P1 Dia84-11, 13.08–13.30 m	Barren		Fusulinds of the <i>Swagerina parva</i> zone (Nilsson <i>et al.</i> 1996)	Fusulinids: late Asselian–early Sakmarian

**Sample P2 (Dia84-31, 24.22–24.49 m).** — The conodont *Mesogondolella rosenkrantzi* (Bender & Stoppel, 1965), present in this sample was originally described from the Upper Permian Ravnefjeld Fm. in central East Greenland (Bender & Stoppel 1965) and was subsequently reported by Sweet (1976) and Rasmussen *et al.* (1990), and has also been published from North American and Arctic Canadian sections. Except for the occurrence in Arctic Canada (Beauchamp *et al.* 1989), these occurrences are debatable (see discussion in Rasmussen *et al.* 1990).

As correlated with these occurrences, the presence of *M. rosenkrantzi* indicates a Capitanian age, correlative with the Ravnefjeld Fm. of East Greenland, and the Trolld Fiord Fm. of Arctic Canada (Rasmussen *et al.* 1990; Beauchamp *et al.* 1989). This is equivalent to the early Dzhulfian of the standard conodont scheme in Kozur (1995). Palynomorphs from the same interval include *Scutasporites nanuki* Utting, 1994, *Lueckisporites virkkiae* Potonié & Klaus, 1954, and *Lueckisporites* sp. (Nilsson *et al.*, 1996). This flora is correlative to Kazanian–?Tatarian microfloras in Arctic Canada (Utting 1994) and in East Greenland (Balme 1980). This Permian core-interval is thus younger than any other Permian interval with conodont faunas so far investigated in the Svalbard-Barents Sea area (Szaniawski & Małkowski 1979; Nakrem 1991).

**Sample P3 (Dia84-31, 10.18–10.40 m).** — The sample was taken from the upper part of the core assigned to the Kazanian on the basis of palynological dates (Nilsson *et al.* 1996). The scolecodont assemblage retrieved supports this and indicates a Late Permian–Middle Triassic age, although reference material from other regions is sparse. Upper Permian scolecodonts were hitherto known only from the Zechstein basin (Seidel 1959; Kozur 1967; Szaniawski 1968). Lower Triassic scolecodonts are so far unknown, while Middle Triassic assemblages are known mainly from the Muschelkalk facies of Germany and Poland (Kozur 1967, 1972; Zawidzka 1971, 1975) and from the Anisian of the Northern Alps and Hungary (Kozur 1972).

*Kielanoprion magnidentatus*, present in this sample, was earlier known from both the Zechstein and Muschelkalk, while *K. mamillatus* was only known from the lower Muschelkalk. *Atraktoprion eudoxus* has been described from Zechstein sediments, but similar elements also occur in the Muschelkalk. Jaws very similar to *Leodicites* sp. are only known from the Muschelkalk. The stratigraphically youngest ?paulinitids were previously known from the Kungurian of Sicily (Corradini & Olivieri 1974; Catalano *et al.* 1991)<sup>1</sup> while the oldest representatives of *Palurites* and *Glycera* from the Muschelkalk of Germany and Poland (Kozur 1967, 1972; Zawidzka 1971, 1975). See also Szaniawski (1974) and Szaniawski & Imajima (1996) for taxonomic revisions of the discussed scolecodont faunas.

**Samples T1 (Dia84-2, 82.62 m) and T2 (Dia84-2, 78.86–79.01 m).** — The conodont species *Neospathodus svalbardensis* Trammer, 1975 occurs in these two samples. This species is not known from outside Spitsbergen, where it is associated with other age diagnostic conodonts and ammonites (see below), except for a possible Dienerian occurrence in Western Canada (Orchard & Tozer 1997a). The occurrence of *N. svalbardensis* in this interval thus indicates an early Dienerian (late Induan) age, which is slightly younger than the late Griesbachian (to early Dienerian) age suggested by palynomorph occurrences (*Densoisporites nejburgii* Schulz, 1964, *Proprisporites pocockii* Jansonius, 1962, and *Maculatasporites* sp.) and by the presence of *Ophiceras* sp. in a slightly higher sample (73.98–74.41 m) (Vigran *et al.* 1998).

## Discussion

**Biostratigraphy.** — Conodonts suggest a Dzhulfian (Capitanian) age for the Permian sample as compared with adjacent areas. The dating supports the palynological dating of the core samples. In central-western Spitsbergen, e.g. the Festningen section (Szaniawski & Małkowski 1979), there is a 100+ m shale/chert interval below the P/T boundary, which has not yielded conodonts. The age of this interval is uncertain, although palynomorphs suggest ‘a general Ufimian to Kazanian age’ (Mangerud & Konieczny 1993: p. 82).

<sup>1</sup> Corradini & Olivieri (1974) reconstructed an apparatus of isolated elements and determined it as *Langeites siciliensis* sp. n., family Paulinitidae. Catalano *et al.* (1991), examined new specimens of MI and on this basis transferred the species to *Delosites* Kozur, 1967, and thus a separate family. Judging, however, from illustrations it seems quite possible that the assemblage of scolecodonts from the Kungurian of Sicily includes two different taxa.

Conodonts suggest an early Dienerian age for the Triassic samples as compared with occurrences in Svalbard. The consistent late Griesbachian age based on ammonoids and palynomorphs (Vigran *et al.* 1998), however, contradicts this. This may be due to insufficient knowledge of the distribution of conodonts in the lowermost Triassic of Svalbard, and their correlation with strata in adjacent areas.

Conodonts are regarded as one of the better fossil groups for assigning biostratigraphical subdivision and ages around the Permian–Triassic boundary, although their value is questioned in some areas (especially the Arctic) and in some lithofacies (Yin *et al.* 1996; Baud 1996; Henderson 1997; Yin 1997; Orchard & Tozer 1997b; Nicora & Garzanti 1997). Conodonts are sparse in deep-water deposits in Svalbard (see also discussion in Mørk *et al.* 1999 for central Spitsbergen) thus limiting their use for interregional correlation and defining boundaries.

**Conodont colour alteration.** — The conodonts in the investigated material show a colour alteration index (CAI) of 1.0–1.5, indicating a burial temperature of 50–90°C. This is slightly lower than that obtained from Permian conodonts of Bjørnøya which have a CAI of 1.5–2.0, corresponding to a burial temperature of 50–140°C (Nakrem 1991). Palynomorphs in the same samples (Vigran *et al.* 1998) provide thermal alteration indexes (TAI) of 1+ to 2+, and vitrinite reflectance ( $R_o$ ) of 0.51–0.43%. TAI values are consistent with CAI values in the investigated core intervals, and thus suggest immature to low oil window maturity.

**Scolecodont evolution.** — So far scolecodonts add little to the biostratigraphy near the Palaeozoic–Mesozoic transition because the present knowledge of polychaete development during this time interval is insufficient. Based on the investigated scolecodont assemblage in the P3 sample, the age of this interval is vaguely Permian–Triassic. The scolecodonts can, however, be used as depositional environment indicators – numerous eunicemorph polychaetes like the ones described herein usually occur in shallow water mudstones and carbonates. Moreover the scolecodont occurrence recorded here sheds new light on the understanding of polychaete evolution (cf. Kielan-Jaworowska 1966; Kozur 1970; Szaniawski 1996). This is:

(1) Taxonomic diversification of Eunicida in the uppermost Palaeozoic was more pronounced than previously believed. Some still undescribed species and genera of eunicids existed in the late Permian.

(2) The family Paulinitidae, very common in the Silurian and Devonian survived at least until the Late Permian.

(3) The extant family Hartmaniellidae, very scarce in the present days seas (Orensanz 1990) but quite common in the Mesozoic (Szaniawski & Imajima 1996), was diversified already during the late Palaeozoic.

(4) The order Phyllodocida, represented today by diverse and numerous faunas, is now known to have been present in the Late Palaeozoic and thus did not originate in the Triassic (cf. Szaniawski 1996).<sup>2</sup>

<sup>2</sup> Kozur (1970) assigned *Palaeochaeta* Clarke, 1903 and *Palaeoscolex* Whittard, 1953, to Phyllodocida. Representatives of these genera are, however, only known from impressions of the whole body but lacking jaws. Their systematic position is not well known.

## Systematic palaeontology

All illustrated specimens are housed in the collection of the Palaeontological Museum, University of Oslo (abbreviation PMO) under the numbers 167.558–167.560.

**Conodonts** (by H.A.N.)

### Genus *Mesogondolella* Kozur, 1988

#### *Mesogondolella rosenkrantzi* (Bender & Stoppel, 1965)

Fig. 3C–K.

For synonymy, see Rasmussen *et al.* (1990).

**Material.** — 15 Pa-elements (+17 fragments), 3 Pb-elements, 3 M-elements, 2 Sa-elements, and 9 unidentified ramiform elements, all from sample P2.

**Remarks.** — The productive sample P2 yielded 15 diagnostic Pa-elements of this species. The collection of specimens comprises elements of different ontogenetic growth stages, and the anteriorly tapering of the Pa-element in mature specimens is the best diagnostic feature to distinguish this species from older forms, e.g. *Mesogondolella idahoensis* (Youngquist, Hawley, & Miller, 1951) which usually tapers in the anteriormost 1/3 or 1/4 part of the platform. For comparison, see illustrations of *Mesogondolella idahoensis* in e.g. Szaniawski & Malkowski (1979: pl. 4: 1, 3a, 6), Nakrem (1991: fig. 5e–g) and Nicoll & Metcalfe (1998: fig. 17e, h), and *Mesogondolella rosenkrantzi* in e.g. Sweet (1976) and Rasmussen *et al.* (1990).

**Stratigraphic significance.** — *Mesogondolella rosenkrantzi* occurs in the late Wordian–early Capitanian (Dzhulfian) Ravnefjeld Formation of East Greenland (Rasmussen *et al.* 1990) and in the late Wordian Trold Fiord Formation of Arctic Canada (Beauchamp *et al.* 1989).

### Genus *Neospathodus* Mosher, 1968

#### *Neospathodus svalbardensis* Trammer in Birkenmajer & Trammer, 1975

Fig. 3A, B.

1975 *Neospathodus svalbardensis* sp. n.; Trammer in Birkenmajer & Trammer, p. 306, pl. 1: 5–7; pl. 2: 1–7.

1984 *Neospathodus svalbardensis*; Hatleberg & Clark, pl. 1: 17, 20.

1989 *Neospathodus svalbardensis*; Dagens & Korchinskaya, p. 119–120, pl. 18: 1–6.

**Material.** — Three Pa-elements in sample T2, and one Pa-element in sample T1.

**Remarks.** — A total of four Pa-elements are assigned here and the species is characterised by possessing an upright main cusp, denticles of equal size (except for the smaller anteriormost 2–3 denticles), a prominent lateral rib, and straight basal margin.

*Neospathodus pakistanensis* Sweet, 1970 and *N. svalbardensis* have almost identical stratigraphical ranges in the Van Keulenfjorden section of western Spitsbergen, and both occur with *N. dieneri* Sweet, 1970 (Hatleberg & Clark 1984). The former two species are also morphologically quite similar, whereas *N. dieneri* is distinguished in possessing a larger cusp. *Neospathodus waageni* Sweet, 1970, of Smithian age, differs from the investigated specimens in having taller denticles of varying height.

**Stratigraphic significance.** — This species was originally described from southern Spitsbergen (Birkenmajer & Trammer 1975), from the ‘*Myalina*’ beds (Brevassfjellet *Myalina* Bed of Birkenmajer 1977), of early Dienerian age. It has subsequently been described from western Spitsbergen (Siksaken Mb. of the Vardebukta Fm.) together with *Vavilovites* sp. aff. *sverdrupi* (Tozer, 1963) (Hatleberg & Clark 1984), and from the Sassendalen area (Dagens & Korchinskaya 1989) together with e.g., *Proptychites rosenkrantzi* Spath, 1935, *P. cf. candidus* Tozer, 1961, and *P. cf. strigatus* Tozer, 1961. *N. cf. svalbardensis* is reported from the Deltadalen Mb. of the Vikinghøgda Fm. in central Spitsbergen (Mørk *et al.* 1999), and from the Vardebukta and Tvillingodden Fms. in cen-

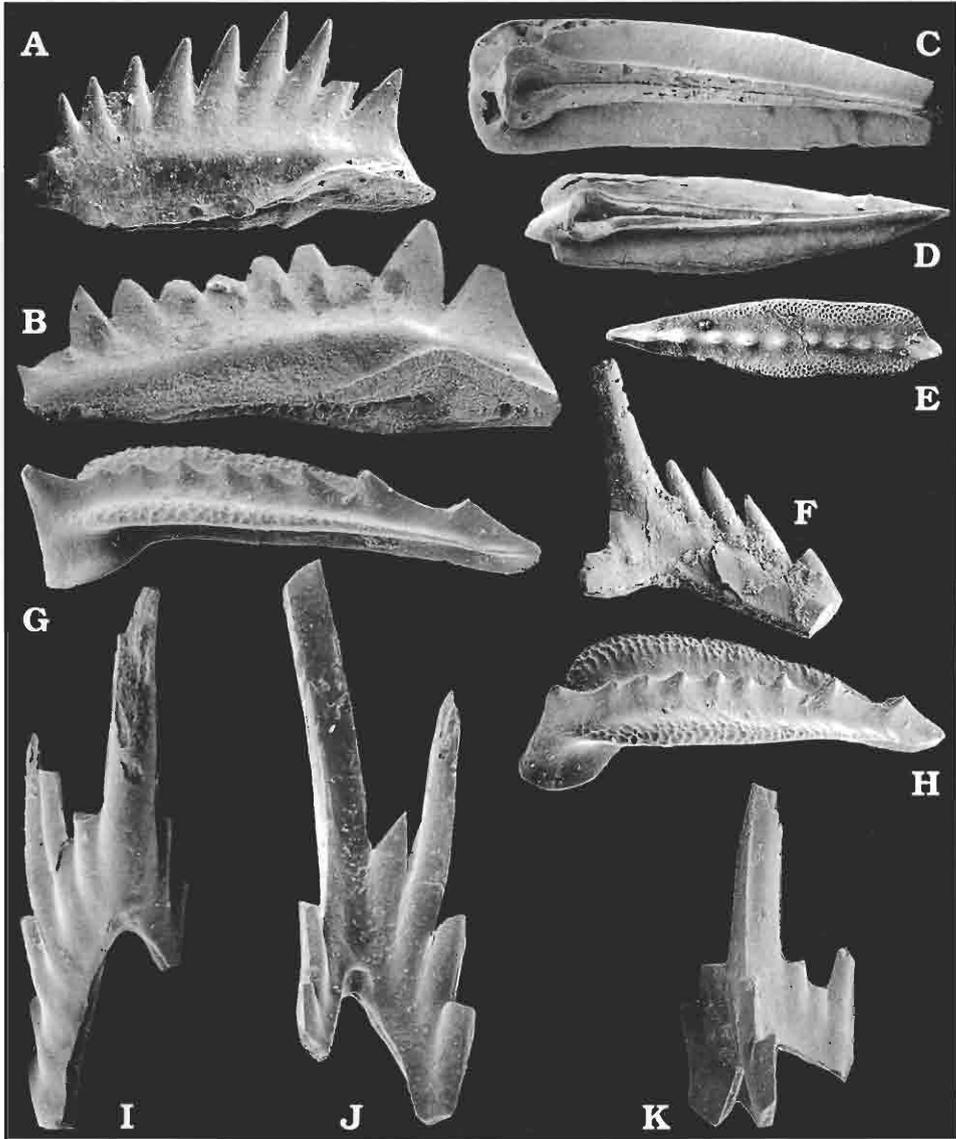


Fig. 3. Conodonts. **A, B.** *Neospathodus svalbardensis*. **A.** Lateral view of Pa-element, sample T2, PMO 167.558/12  $\times$  75. **B.** Lateral view of Pa-element, sample T2, PMO 167.559/6  $\times$  75. **C–K.** *Mesogondolella rosenkrantzi*. All from sample P2. **C.** Basal view of gerontic Pa-element, PMO 167.558/6  $\times$  75. **D.** Basal view of juvenile Pa-element, PMO 167.558/2  $\times$  75. **E.** Dorsal view of juvenile Pa-element, PMO 167.559/5  $\times$  75. **F.** Pb-element, PMO 167.559/3  $\times$  75. **G.** Oblique dorsal view of Pa-element, PMO 167.558/4  $\times$  150. **H.** Oblique dorsal view of Pa-element, PMO 167.558/4  $\times$  150. **I.** Sc?-element, PMO 167.559/5a  $\times$  150. **J.** Sc?-element, PMO 167.558/10  $\times$  150. **K.** Sa-element, PMO 167.559/2  $\times$  150.

tral-southern Spitsbergen (Nakrem & Mørk 1991). These occurrences are all of Dienerian (Induan) age. ?*N. svalbardensis* is reported from the *N. dieneri* Zone of the Dienerian Grayling Formation of Western Canada (Orchard & Tozer 1997b).

## Scolecodonts (by H. Sz.)

Abbreviations used in the descriptions: MI–MIV – maxillae of the first–fourth pair.

### Order Eunicida Dales, 1963

#### Family Dorvilleidae Chamberlin, 1919

##### ?*Dorvillea* sp. A

Fig. 4E.

**Material.** — Only the illustrated element, which is most probably right MI of an unknown apparatus.

**Remarks.** — Jaws of this type are comparatively rare. In the Palaeozoic somewhat similar elements occur in the apparatuses of the family Xanioprionidae Kielan-Jaworowska, 1966, known from the Ordovician, Silurian and Devonian but similar Late Palaeozoic jaws are not known. The element is most similar to the detached jaws described as *Dorvillea jansonii* Kozur, 1971, known from the Cretaceous of Germany (Kozur 1971). Similar elements may, however, occur in different apparatuses while the whole apparatuses of *Dorvillea* are known only from Recent forms. Therefore generic assignment of the discussed jaw is tentative.

##### ?*Dorvillea* sp. B

Fig. 4F.

**Material.** — Two jaws of an unknown apparatus.

**Remarks.** — The jaws have a characteristic arching, anterior projection, short but wide denticles and comparatively big size. They certainly represent an unknown species and possibly unknown genus.

### Family Paulinitidae Lange, 1947

#### *Paulinites* sp. A

Fig. 4D.

**Material.** — Three MI right.

**Remarks.** — Paulinitids are very common in the Silurian and Devonian. The only well known younger species, *Langeites siciliensis* has been described from the Kungurian of Sicily (Corradini & Olivieri, 1974, Catalano *et al.* 1991). The illustrated right MI is somewhat similar to the Devonian *Paulinites paranaensis* Lange, 1947 and Silurian *Paulinites gladius* Kielan-Jaworowska, 1966 but most probably represents an unknown species. Bergman (1989), without further explanation, assigned *P. gladius* to *Hindenites*.

#### *Paulinites* sp. B

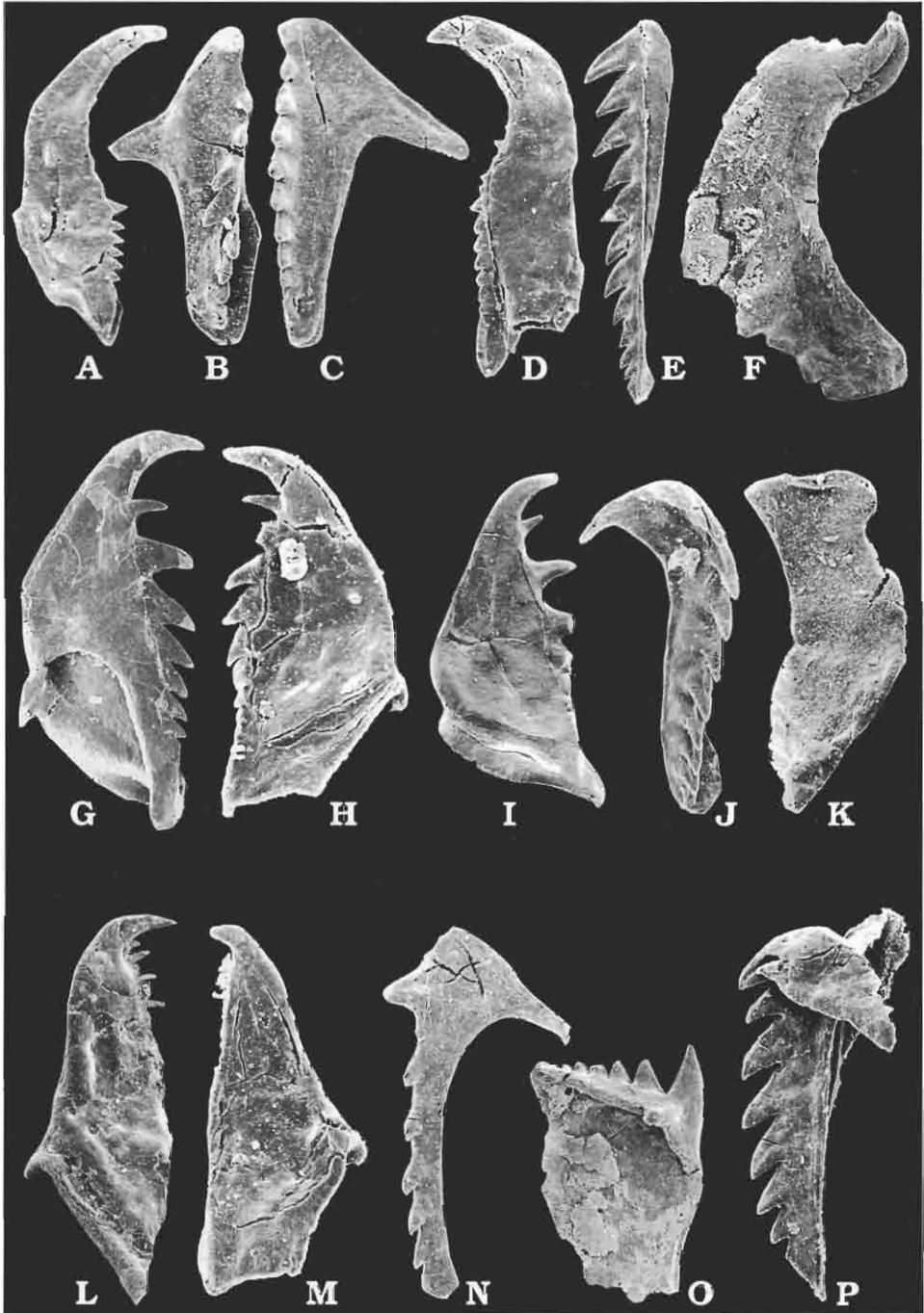
Fig. 4A.

**Material.** — Only the illustrated jaw.

**Remarks.** — The one available specimen represents left MI, probably of the same species as *Paulinites* sp. A. Among paulinitids the difference in structure between MI right and MI left can be considerable. Here the jaws are provisionally treated as separate species.

---

Fig. 4. Scolecodonts from sample P3. **A.** *Paulinites* sp. B, left MI in dorsal view, PMO 167.560/11,  $\times 120$ . **B.** *Paulinites* sp. D, left MII in dorsal view, PMO 167.560/25,  $\times 100$ . **C.** *Paulinites* sp. C, right MII in dorsal view, PMO 167.560/21,  $\times 100$ . **D.** *Paulinites* sp. A, right MI in dorsal view, PMO 167.560/10  $\times 120$ . **E.** ?*Dorvillea* sp. A, right MI? in right lateral view, PMO 167.560/30,  $\times 55$ . **F.** ?*Dorvillea* sp. B, MI? in lateral view, PMO 167.560/47  $\times 55$ . **G–K, O.** *Kielanoprion magnidentatus*. **G.** Right MI in ventral view, PMO 167.560/3,  $\times 55$ . **H.** Right MI in dorsal view, PMO 167.560/1,  $\times 100$ . **I.** Left MI in dorsal view, PMO 167.558/14,  $\times 55$ . **J.** Left MII in dorsal view, PMO 167.560/41,  $\times 160$ . **K.** Left carrier in ventral view, PMO 167.560/39,  $\times 120$ . **O.** Left MIV in ventral view PMO 167.560/45,  $\times 80$ . **L, M.** *Kielanoprion* cf. *mamilatus*. →



L. Left MI in dorsal view, PMO 167.558/15,  $\times 250$ . M. Right MI in dorsal view, PMO 167.560/8,  $\times 120$ . N. Gen. *et* sp. *indet.* right MII in dorsal view, PMO 167.560/24  $\times 80$ . P. *Leodicites* sp. right MII in right lateral view, PMO 167.560/19,  $\times 80$ .

***Paulinites* sp. C**

Fig. 4C.

**Material.** — Two MII right.**Remarks.** — This jaw probably represents the same species as *Paulinites* sp. A and *P.* sp. B. A very similar jaw has been found in the same core at the depth 9.18 m (Nilsson *et al.* 1996: fig. 10M).***Paulinites* sp. D**

Fig. 4B.

**Material.** — Three MII left.**Remarks.** — This jaw probably represents the same species as *Paulinites* sp. A, *P.* sp. B and *P.* sp. C.**Gen. et sp. indet. A**

Fig. 4N.

**Material.** — Only the illustrated jaw.**Remarks.** — Somewhat similar MII elements occur in the Silurian apparatuses of *Hindenites* Bergman, 1987, but they are wider and differ in denticulation. The jaw illustrated here probably represents an unknown species.**Family Kielanoprionidae Szaniawski, 1968*****Kielanoprion magnidentatus* (Seidel, 1959)<sup>3</sup>**

Fig. 4G–K, O.

1959 *Arabellites* ?*magnidentatus* n. sp.; Seidel, pp. 22–23, pl. 1: 16–18, pl. 2: 19, pl. 3: 16–18.cf. 1967 *Mülleriprion* cf. *magnidentatus* (Seidel); Kozur, pl. 2: 1.cf. 1967 *Mülleriprion* ? cf. *thuringensis* n. sp.; Kozur p. 847, pl. 2: 5.1971 'Arabellites' *magnidentatus* Seidel; Zawidzka, pp. 368–369, pl. 2: 5–7.**Material.** — Four MI right, one MI left, two MII left, ? one MIV right and ? two carriers.**Remarks.** — Specific determination of the elements assigned here is based on left and right MI. Other elements of this species were hitherto unknown. Their assignment to the species is based on comparison with corresponding elements in the similar apparatus of *Kielanoprion pomeranensis* Szaniawski, 1968.**Occurrence.** — Upper Permian (Zechstein) of Germany and Middle Triassic (Muschelkalk) of Poland.***Kielanoprion* cf. *mamilatus* (Zawidzka, 1971)**

Fig. 4L, M.

cf. 1971 'Arabellites' *mamilatus* sp. n.; Zawidzka, p. 368 pl. 3: 12.cf. 1975 *Elleriprion mamilatus* (Zawidzka); Zawidzka pl. 2: 2.**Material.** — One MI left and one MI right.

<sup>3</sup> Kozur (1970) believes that *Kielanoprion* is a junior synonym of *Eunicites* Ehlers, 1868. The type species, *E. avitus* Ehlers, is represented by a single impression of a whole body, and the jaw apparatus is too fragmentary to be identified. Kozur (1970, 1971, 1972) assigned *Eunicites* to the family Mülleriprionidae Kozur, 1967, but the family is not valid because *Mülleriprion* Kozur, 1967 (= *Eunicites*, Kozur 1970) is a *nomen dubium*. The type species, *M. jordani* Kozur, 1967 is based on a single, strongly deformed and unidentifiable jaw apparatus. Moreover, it is the only Permian specimen described in the paper and later the specimen became partly damaged (Kozur 1967). Provenance of the isolated left MI, schematically illustrated on fig. 1 d in Kozur (1967), is unknown. It is totally different from the left MI of the holotype illustrated on the same figure as 1c. (For more details see Szaniawski & Wrona 1973).

**Remarks.** — The two investigated specimens are slightly different, but both are very close to *K. mamillatus*. The jaw illustrated on Fig. 4M is very like that of the holotype of the species, but its denticulation is not sufficiently preserved for specific determination. The specimen illustrated in Fig. 4L deviates from the holotype by a somewhat different outline of the posterior part.

**Occurrence.** — Lower Muschelkalk of Poland.

## Family Hartmaniellidae Imajima, 1977

### *Palurites* cf. *raridentatus* (Kozur, 1967)

Fig. 5F–I.

cf. 1971 *Delosites raridentatus* Kozur; Zawidzka, pp. 365–367, pl. 1: 1–4 (includes synonymy to 1971).

cf. 1972 *Delosites raridentatus reiflingensis* subsp. n.; Kozur, pp. 765–767, figs. 5, 6.

cf. 1975 *Delosites raridentatus* Kozur; Zawidzka, p. 264, pl. 4: 1, 3, 4, 6, 7, 9–12.

cf. 1996 *Palurites raridentatus* (Kozur); Szaniawski & Imajima, fig. 4C–L.

**Material.** — Four MI right and five MI left.

**Remarks.** — The specimens of MI in the investigated material differ from the Triassic type material with somewhat bigger hook and slightly different course of the posterior margin. The specimen illustrated on 5:I is similar to the MI of the subspecies *Palurites raridentatus reiflingensis* known from the Anisian of Austria (Kozur 1972) but differs from it by having wider hook.

**Occurrence.** — Middle Triassic (Muschelkalk) of Germany and Poland, and Anisian of Austria (Tethys Province).

### *Palurites* sp. A

Fig. 5E.

**Material.** — Only the illustrated MI right.

**Remarks.** — This is evidently an unknown species of *Palurites* and differs in having a strong, posterior curvature of the hook and denticles of MI.

### ?*Palurites* sp.

Fig. 5J.

**Material.** — Two MII right and one MII left.

**Remarks.** — The figured jaws differ from all hitherto known MII of *Palurites* in having a longer lateral arm. They might belong to the same apparatus as the MI assigned above to *P. cf. raridentatus*.

## Family Atraktoprionidae Kielan-Jaworowska, 1966

### *Atraktoprion* cf. *eudoxus* Szaniawski, 1968

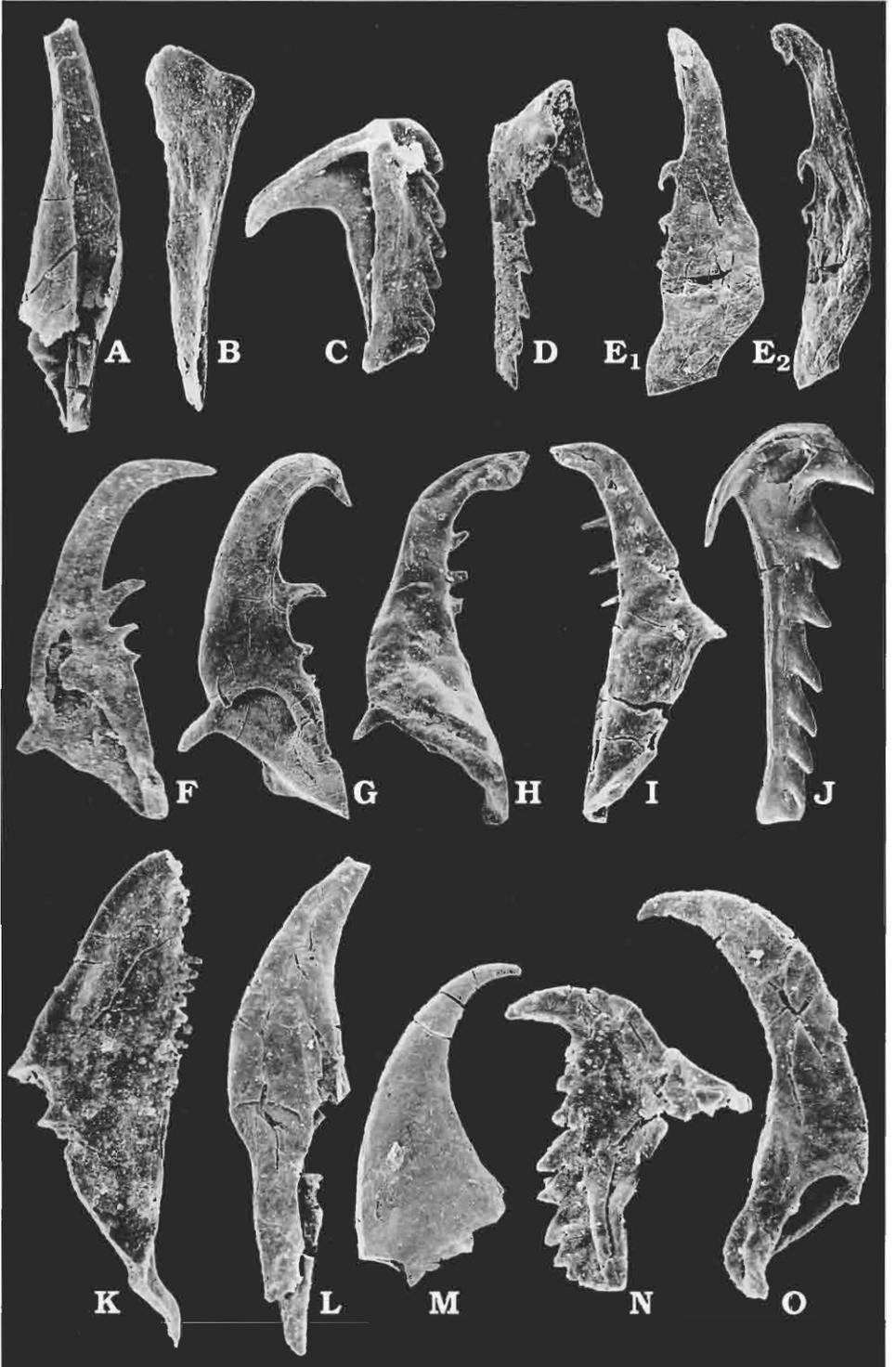
Fig. 5B, C.

cf. 1968 *Atraktoprion eudoxus* sp. n.; Szaniawski, pp. 274–278, fig. 4, pl. 7: 1–7.

**Material.** — One MII right, one MII left and one carrier.

**Remarks.** — The MII differs from corresponding jaws of the type material from the Zechstein of Poland by posterior curvature of the transverse branch and somewhat different development of the denticles. The carrier most probably belongs to the same species as the MII, although similar carriers may occur in different apparatuses of Atraktoprionidae.

**Occurrence.** — *A. eudoxus* is known only from the Zechstein of Poland but a very similar apparatus is known from the Muschelkalk of Germany and Poland (Kozur 1971; Zawidzka 1975) as *Atraktoprion anatinus* (Stauffer, 1939). However *A. anatinus* was originally described from the Devonian, and based only on right MI (Stauffer 1939). Occurrence of the same species in the Triassic is questionable. Most probably the Triassic specimens are closely related to *A. eudoxus* or even conspecific with it.



**Family unknown*****Leodicites* sp.**

Figs. 4P, 5D.

**Material.** — Three MII right and one MII left.**Remarks.** — The genus *Leodicites* is hitherto only known from MII elements. The investigated specimens are similar to the jaws described as '*Leodicites*' *angiformis* Eller, 1955, by Zawadzka (1971) from the Middle Triassic of Poland, but is comparatively shorter and has smaller number of denticles. *L. angiformis* is originally described from the Devonian and its conspecificity with the Triassic forms seems doubtful.**Gen. et sp. indet. B**

Fig. 5K.

**Material.** — Single left MI fused with carrier.**Remarks.** — The figured jaw is very characteristic because of its fusion with the carrier, and the unusual development of the latter. Denticles of the jaw are small and developed only along the anterior half of the inner margin. The hook is broken off but the cross section indicates that it was most probably relatively large. The jaw certainly represents an unknown species and genus.**Gen. et sp. indet. C**

Fig. 5N.

**Material.** — Single left MII.**Remarks.** — The figured jaw represents MII of an unknown apparatus possibly belonging to Paulinitidae. Somewhat similar jaws have been described by Tasch & Stude (1966) from the Lower Permian of Kansas and assigned to genus *Ildrantes* which is known from MII elements only.**Gen. et sp. indet. D**

Fig. 5O.

**Material.** — Two MI right and one MI left.**Remarks.** — Somewhat similar, undenticulated MI is known as *?Langeites lublinensis* Szaniawski & Wrona, 1973 from the Upper Devonian of Poland, as *Nereidavus orbiculoides* Tasch & Stude, 1966 from the Lower Permian of Kansas, USA and as *Praelumbrinerites zawadzkae* Kozur, 1967 from the Anisian of Austria (Kozur 1972) and the Muschelkalk of Poland (Zawadzka 1975). The investigated elements most probably represent an unknown species, possibly related to Paulinitidae and/or Lumbrineridae.

← Fig. 5. Scolecodonts from the sample P3. **A, L, M.** *Glycera* sp., three incomplete jaws, **A.** PMO 167.560/17 in 'ventral' view  $\times 220$ . **L.** PMO 167.560/15 in 'dorsal' view  $\times 120$ . **M.** PMO 167.560/16 in 'dorsal' view,  $\times 120$ . **B, C.** *Atraktoprion* cf. *eudoxus*, **B.** Left carrier in dorsal view, PMO 167.560/27,  $\times 160$ . **C.** Right MII in ventral view, PMO 167.560/35,  $\times 120$ . **D.** *Leodicites* sp., right MII in oblique dorsal view, PMO 167.560/36,  $\times 120$ . **E.** *Palurites* sp. A, **E1** in dorsal view, **E2** in oblique dorsal view, PMO 167.560/9,  $\times 80$ . **F-I.** *Palurites* cf. *raridentatus*, **F.** Right MI in ventral view, PMO 167.560/5,  $\times 80$ . **G.** Right MI in ventral view, PMO 167.560/4,  $\times 55$ . **H.** Left MI in dorsal view, PMO 167.558/16,  $\times 200$ . **I.** Right MI in dorsal view, PMO 167.560/7,  $\times 120$ . **J.** *?Palurites* sp., left MII in lateral view, PMO 167.558/17,  $\times 140$ . **K.** Gen. et sp. indet. B, left MI fused with the carrier, PMO 167.560/13,  $\times 120$ . **N.** Gen. et sp. indet. C, left MII in ventral view, PMO 167.560/32,  $\times 220$ . **O.** Gen. et sp. indet. D, left MI in ventral view, PMO 167.560/14,  $\times 160$ .

## Order Phyllococida Dales, 1963

### Family Glyceridae Grube, 1850

#### *Glycera* sp.

Fig. 5A, L, M.

**Material.** — Three incomplete jaws.

**Remarks.** — Glycerids do not possess such differentiated jaw apparatuses as do the eunicids. Their proboscis is armed with four identical jaws and their supports. Very similar jaws may occur in different species and their specific determination is difficult. The jaws from the current material are not well preserved, as often happens among glycerids. A specific determination is not possible, and it is not certain that all the three illustrated jaws belong to the same species.

**Occurrence.** — The stratigraphically oldest glycerids known until now have been described from the Middle Triassic (Kozur 1967; Zawidzka 1971, 1975) and originally assigned to *Paranereites*. Jaws of *Glycera* were quite common in the whole Mesozoic and Cenozoic (Szaniawski 1974, 1996) and are still common in the recent seas.

## Acknowledgements

The cores were drilled during the IKU (Continental Shelf Institute, Trondheim) Barents Sea Mapping Program, which was supported by many oil companies. The paper has benefited from comments and corrections made by Prof. David L. Bruton (Palaeontological Museum, Oslo) as well as referee remarks from Dr. Heintz Kozur (Budapest), Dr. Jerzy Trammer (University of Warsaw) and Dr. Bruce R. Wardlaw (U.S. Geological Survey, Reston).

## References

- Balme, B.E. 1980. Palynology of Permian–Triassic boundary beds at Kap Stosch, East Greenland. — *Meddelelser om Grønland* **200** (6), 1–37.
- Baud, A. 1996. The Permian–Triassic boundary: Recent developments, discussion and proposals. — *Albertiana* **18**, 6–9.
- Beauchamp, B., Harrison, J.C., & Henderson, C.M. 1989. Upper Paleozoic stratigraphy and basin analysis of the Sverdrup Basin, Canadian Arctic Archipelago: Part 1, time frame and tectonic evolution. — *Current Research, Part G, Geological Survey of Canada, Paper* **89-16**, 105–113.
- Bergman, C.F. 1989. Silurian paulinitid polychaetes from Gotland. — *Fossils and Strata* **25**, 1–128.
- Birkenmajer, K. 1977. Triassic sedimentary formations of the Hornsund area, Spitsbergen. — *Studia Geologica Polonica* **51**, 7–74.
- Birkenmajer, K. & Trammer, J. 1975. Lower Triassic conodonts from Hornsund, south Spitsbergen. — *Acta Geologica Polonica* **25**, 299–307.
- Bugge, T. & Fanavoll, S. 1995. The Svalis Dome, Barents Sea – a geological playground for shallow stratigraphic drilling. — *First Break* **13** (6), 237–251.
- Catalano, R., Di Stefano, P., & Kozur, H. 1991. Permian circum-pacific deep-water faunas from the western Tethys (Sicily, Italy) – new evidences for the position of the Permian Tethys. — *Palaeogeography, Palaeoclimatology, Palaeoecology* **87**, 75–108.
- Corradini, D. & Olivieri, R. 1974. *Langeites siciliensis* n. sp., a polychaete jaw apparatus from the Permian–Carboniferous of northwestern Sicily. — *Bolletino della Società Paleontologica Italiana* **13**, 156–163.
- Dagis, A.A. & Korchinskaya, M.V. (Korčinskaâ, M.V.) 1989. Triassic conodonts of Svalbard. In: A.S. Dagis & V.N. Dubatolov (eds.), Upper Paleozoic and Triassic of Siberia [in Russian]. — *Trudy Akademii Nauk SSSR, Sibirskoe otdelenie Instituta Geologii i Geofiziki* **732**, 109–121.
- Dallmann, W.K. (ed.) 1999. *Lithostratigraphic Lexicon of Svalbard. Upper Palaeozoic to Quaternary bedrock. Review and recommendations for nomenclature use*. 318 pp. Norsk Polarinstitut, Tromsø.
- Gabrielsen, R., Færseth, R.B., Jensen, L.N., Kalheim, J.E., & Riis, F. 1990. Structural elements of the Norwegian continental shelf. Part 1: The Barents Sea region. — *Norwegian Petroleum Directorate (NPD) Bulletin* **6**, 1–33.

- Hatleberg, E.W. & Clark, D.L. 1984. Lower Triassic conodonts and biofacies interpretations: Nepal and Svalbard. — *Geologica et Palaeontologica* **18**, 101–125.
- Heafford, A.P. 1988. Carboniferous through Triassic stratigraphy of the Barents Shelf. In: W.B. Harland & E.K. Dowdeswell (eds.), *Geological Evolution of the Barents Shelf Region*, 89–108. Graham & Trotman, Alden Press, Oxford.
- Henderson, C.M. 1997. Uppermost Permian conodonts and the Permian–Triassic boundary in the Western Canada Sedimentary Basin. — *Bulletin of Canadian Petroleum Geology* **45**, 693–707.
- Kielan-Jaworowska, Z. 1966. Polychaete jaw apparatuses from the Ordovician and Silurian of Poland and a comparison with modern forms. — *Acta Palaeontologica Polonica* **16**, 1–152.
- Kozur, H. 1967. Scolecodonten aus dem Muschelkalk des germanischen Binnenbeckens. — *Monatsberichte der Deutschen Akademie der Wissenschaften zu Berlin* **9**, 842–886.
- Kozur, H. 1970. Zur Klassifikation und phylogenetischen Entwicklung der fossilen Phyllocodica und Eunicida (Polychaeta). — *Freiberger Forschungshefte C* **260**, 35–81.
- Kozur, H. 1971. Die Eunicida und Phyllocodica des Mesozoikums. — *Freiberger Forschungshefte C* **260**, 35–81.
- Kozur, H. 1972. Die Bedeutung der triassischen Scolecodonten insbesondere für die Taxonomie und Phylogenie der fossilen Eunicida. Hat sich die Synthese vom 'orthotaxonomischen' und 'parataxonomischen' System in der Praxis bewährt. — *Mitteilungen der Gesellschaft der Geologie- und Bergbaustudenten* **21**, 745–776.
- Kozur, H. 1995. Permian conodont zonation and its importance for the Permian stratigraphic standard scale. — *Geologie und Paläontologie Mitteilungen Innsbruck* **20**, 165–205.
- Mangerud, G. & Konieczny, R.M. 1993. Palynology of the Permian succession of Spitsbergen, Svalbard. — *Polar Research* **12**, 65–93.
- Mørk, A., Dallmann, W., Dypvik, H., Johannessen, E.P., Larssen, G.B., Nagy, J., Nøttvedt, A., Olaussen, S., Pchelina, T.M., & Worsley, D. 1999. Mesozoic lithostratigraphy. In: W.K. Dallmann (ed.), *Lithostratigraphic Lexicon of Svalbard. Upper Palaeozoic to Quaternary Bedrock. Review and Recommendations for Nomenclature Use*, 127–214. Norsk Polarinstitut, Tromsø.
- Mørk, A. & Elvebakk, G. 1999. Lithological description of subcropping Lower and Middle Triassic rocks from the Svalis Dome, Barents Sea. — *Polar Research* **18**, 83–104.
- 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**, 51–82.
- Nakrem, H.A. 1991. Conodonts from the Permian succession of Bjørnøya (Svalbard). — *Norsk Geologisk Tidsskrift* **71**, 235–248.
- Nakrem, H.A. & Mørk, A. 1991. New Early Triassic Bryozoa (Trepotomata) from Spitsbergen, with some remarks on the stratigraphy of the investigated horizons. — *Geological Magazine* **128**, 129–140.
- Nicoll, R.S. & Metcalfe, I. 1998. Early and Middle Permian conodonts from the Canning and Southern Carnarvon Basins, Western Australia: their implications for regional biogeography and palaeoclimatology. — *Proceedings of the Royal Society of Victoria* **110**, 419–461.
- Nicora, A. & Garzanti E. 1997. The Permian/Triassic boundary in the Central Himalaya. — *Albertiana* **19**, 47–51.
- Nilsson, I., Mangerud, G., & Mørk, A. 1996. Permian stratigraphy of the Svalis Dome, south-western Barents Sea. — *Norsk Geologisk Tidsskrift* **76**, 127–146.
- Orchard, M.J. & Tozer, E.T. 1997a. Triassic conodont biochronology, its calibration with the ammonoid standard, and a biostratigraphic summary for the Western Canada Sedimentary Basin. — *Bulletin of Canadian Petroleum Geology* **45**, 675–692.
- Orchard, M.J. & Tozer, E.T. 1997b. Triassic conodont biochronology and intercalibration with the Canadian ammonoid sequence. — *Albertiana* **20**, 33–44.
- Orensanz, J.M. 1990. The eunicemorph polychaete annelids from Antarctic and Subantarctic seas. — *Biology of the Antarctic seas XXI, Antarctic Research Series* **52**, 1–183.
- Rasmussen, J.A., Piasecki, S., Stemmerik, L., & Stouge, S. 1990. Late Permian conodonts from central East Greenland. — *Neues Jahrbuch für Geologie und Paläontologie. Abhandlungen* **178**, 309–324.
- Seidel, S. 1959. Scolecodonten aus dem Zechstein Thüringens. — *Freiberger Forschungshefte C* **76**, 7–31.
- Stauffer, C.R. 1939. Middle Devonian Polychaeta from the lake Eire district. — *Journal of Paleontology* **13**, 500–511.

- Stemmerik, L. & Worsley, D. 1995. Permian history of the Barents Shelf area. *In*: P.A. Scholle, T. Peryt, & D.S. Ulmer-Scholle (eds.), *The Permian of Northern Pangea, 2, Sedimentary Basins and Economic Resources*, 81–97. Springer-Verlag, Berlin.
- Sweet, W.C. 1976. Conodonts from the Permian–Triassic boundary beds at Kap Stosch, East Greenland. — *Meddelelser om Grønland* **197**, 51–54.
- Szaniawski, H. 1968. Three new polychaete jaw apparatuses from the Upper Permian of Poland. — *Acta Palaeontologica Polonica* **13**, 255–281.
- Szaniawski, H. 1974. Some Mesozoic scolecodonts congeneric with recent forms. — *Acta Palaeontologica Polonica* **19**, 179–199.
- Szaniawski, H. 1996. Scolecodonts. *In*: J. Jansonius & D.C. McGregor (eds.), *Palynology: Principles and Applications*. — *American Association of Stratigraphic Palynologists Foundation* **1**, 337–354.
- Szaniawski, H. & Imajima M. 1996. Hartmaniellidae – living fossils among polychaetes. — *Acta Palaeontologica Polonica* **41**, 111–125.
- Szaniawski, H. & Malkowski, K. 1979. Conodonts from the Kapp Starostin Formation (Permian) of Spitsbergen. — *Acta Palaeontologica Polonica* **24**, 231–264.
- Szaniawski, H & Wrona, R. 1973. Polychaeta jaw apparatuses and scolecodonts from the Upper Devonian of Poland. — *Acta Palaeontologica Polonica* **18**, 223–267.
- Tasch, P. & Stude J.R. 1966. Permian scolecodonts from the Fort Riley limestone of Southeastern Kansas. — *Wichita State University Bulletin* **62**, 3.
- Utting, J. 1994. Palynostratigraphy of Permian and Lower Triassic rocks, Sverdrup Basin, Canadian Arctic Archipelago. — *Geological Survey of Canada Bulletin* **478**, 1–107.
- Vigran, J.O., Mangerud, G., Mørk, A., Bugge, T., & Weitschat, W. 1998. Biostratigraphy and sequence stratigraphy of the Lower and Middle Triassic deposits from the Svalis Dome, central Barents Sea, Norway. — *Palynology* **22**, 89–141.
- Yin, H. 1997. Permian–Triassic boundary: a discussion on *Hindeodus parvus* and the Meishan section. — *Albertiana* **20**, 19–24.
- Yin, H., Zhang, K., Wu, S., & Peng, Y. 1996. Global correlation and definition of the Permian–Triassic boundary. *In*: H. Yin (ed.), *The Paleozoic–Mesozoic Boundary*, 3–48. China University Geoscience Press, Wuhan.
- Zawadzka, K. 1971. A polychaete jaw apparatus and some scolecodonts from the Polish Middle Triassic. — *Acta Geologica Polonica* **21**, 361–377.
- Zawadzka, K. 1975. Polychaete remains and their stratigraphic distribution in the Muschelkalk of southern Poland. — *Acta Geologica Polonica* **25**, 257–274.

## Skolekodonty i konodonty z permu i triasu wysadu solnego Svalis na Morzu Barentsa

HANS ARNE NAKREM, HUBERT SZANIAWSKI i ATLE MØRK

### Streszczenie

Z rdzeni trzech wierceń wykonanych na wysadzie solnym Svalis na Morzu Barentsa opisano dobrze zachowane skolekodonty i konodonty. Konodonty *Mesogondolella rosenkrantzi* i *Neospathodus svalbardensis* potwierdzają późnopermski (dżulf) i wczesnotriasowy (diener) wiek badanych sekwencji. Porównanie z zasięgami występowania konodontów na Spitsbergenie pozwoliło stwierdzić, że przerwa sedymentacyjna na granicy P/T była w tym regionie krótsza. Stan zachowania konodontów wskazuje na bardzo niski stopień metamorfizacji termicznej tego regionu. Opisane skolekodonty wnoszą dużo nowych informacji do lepszego poznania ewolucji wieloszczetów: rząd Eunicida był w permie znacznie bardziej zróżnicowany taksonomicznie niż dotychczas sądzono (niektóre formy reprezentują nieznanne dotychczas gatunki i rodzaje); przedstawiciele rodziny Paulinitidae przetrwali co najmniej do późnego permu; rodzina Hartmanillidae oraz pierwsi przedstawiciele rzędu Phyllococida pojawili się nie w mezozoiku, jak dotychczas przypuszczano, lecz istnieli już w permie.