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Biostratigraphy of the uppermost part of the Smithian Stage (Lower Triassic) at the Botneheia, W-Spitsbergen.

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with Plates 10—14 and 3 Text Figures

Contents

Summary

The upper part of the Smithian (Lower Triassic) section at the Botneheia was measured and its fossil contents of ammonoids, conodonts, and pelecypods described and stratigraphically analysed. The section belongs to the *Wasatchites tardus* zone, probably to its upper part, for its conodonts all indicate the *Neogondolella milleri* zone. Contrary to the suppositions of FREBOLD (1930) and SPATH (1934), the lower part of the section is characterized by *Arctoceras*, the upper one by Prionitids such as *Arctoprionites* and *Wasatchites*. This is the first time that conodonts from the Smithian age are described from Spitsbergen. The fauna is in very good agreement with that described from British Columbia and Arctic Canada.

Zusammenfassung

Im altbekannten Küstenprofil an der Botneheia wurden die untersten aufgeschlossenen 35 m vermessen und auf Ammonoideen, Lamellibranchier und schließlich Conodonten untersucht. Der bearbeitete Abschnitt gehört zur *Wasatchites tardus*-Zone, wahrscheinlich zu ihrem oberen Teil, der Smithian-Stufe, denn die zugehörigen Conodonten entstammen der *Neogondolella milleri*-Zone. Im Gegensatz zu Vermutungen von FREBOLD (1930) und SPATH (1934) wird der untere Teil des Profils durch

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Arctoceras gekennzeichnet, der obere durch Prionitidae der Gattungen *Arctoprionites* und *Wasatchites*.

Conodonten des Smithian werden hier erstmals von Spitzbergen beschrieben. Die Fauna stimmt gut mit denen von Britisch-Columbien und dem arktischen Kanada überein.

I. Introduction

In July and August of 1972 the authors, together with Dr. Friedhelm Thiedig and Hans-Jürgen Lierl, visited Spitsbergen in search of mammals and ammonites for biostratigraphical and paleobiological investigations. We spent one day for the close inspection of a part of the Lower Triassic coast profile in the eastern part of the Botneheia. The section was measured and representative samples of the sediment, especially of the concretions, taken, these being the only source for well preserved ammonites in the profile. After dissolution, some of the concretions were found to contain considerable numbers of well preserved conodonts. The occurrence of both ammonites and conodonts in an exactly measured section enabled us to solve an old stratigraphical problem: the relative position of the ammonoid faunas within the "Fish-Niveau" of Wiman (1928). Similar detailed measurements together with in situ collections of fossils are desirable and intended by the authors for the whole Triassic sequence of Spitsbergen.

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We thank also Dr. A. Dürkoop (Geol.-Paläont. Inst., University of Bochum) for interesting discussions concerning the conodonts.

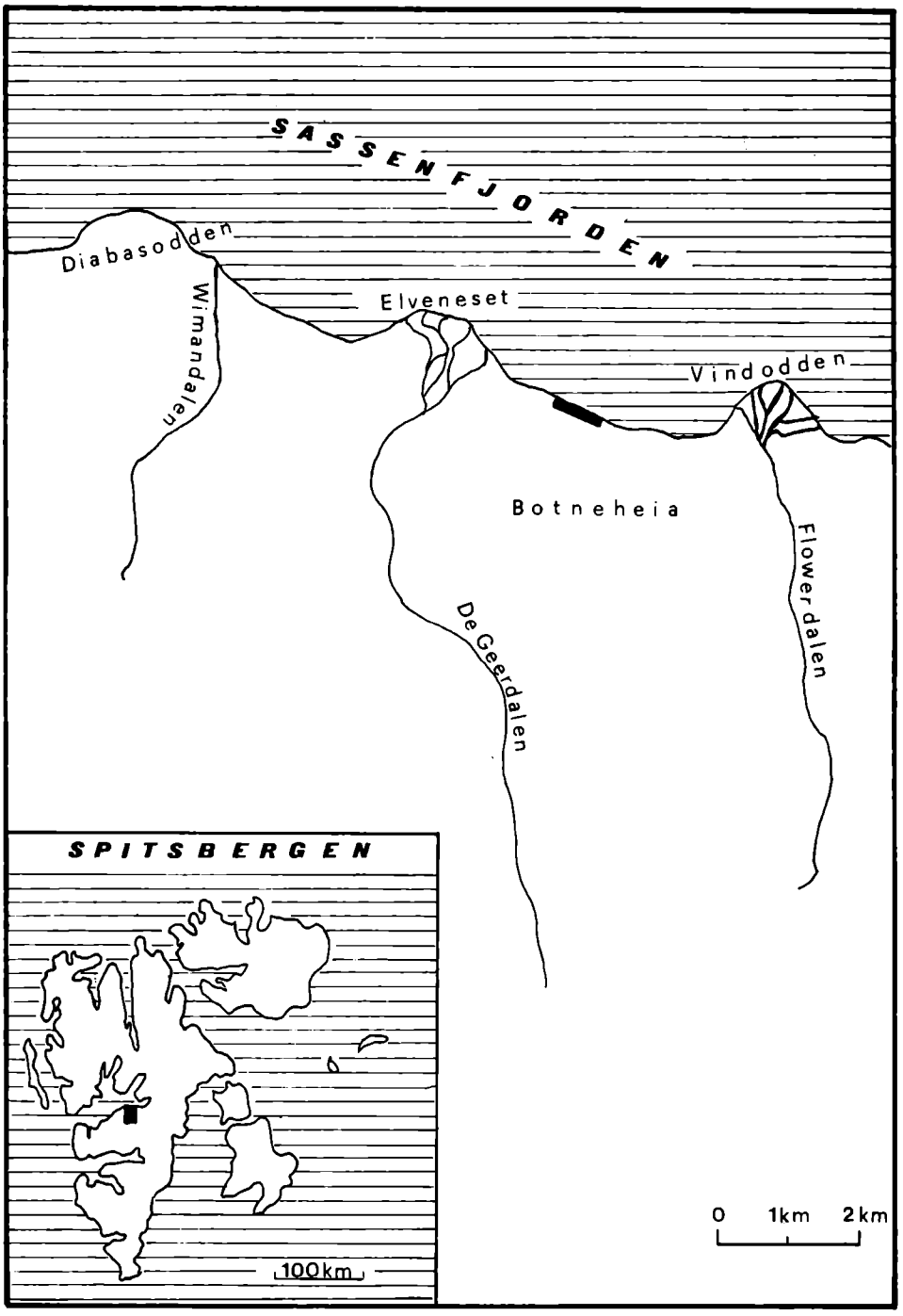
II. Stratigraphy

1. Previous work

The part of the coast section of the Botneheia which is studied here belongs to the so-called "Fish-Niveau" of Wiman (1928) and to the "Posidonomyen-Schichten" of Frebold (1930).

Frebold (1930) and Spath (1934) worked with the ammonites of the "Fish-Niveau" and concluded that there exist two distinct ammonite faunas which make it possible to distinguish two faunal zones. The lower one was considered to be characterized by Prionitids like *Wasatchites* and *Arctoprionites*, the upper one mainly by *Arctoceras* and *Prosphingites*. Frebold dated the lower fauna as Flemingitan, while Spath placed it in the upper Owenitan (both in the classification of the Lower Triassic after Spath 1934). The fauna of the upper zone was placed by both authors in the Olenikitan near the top of the Lower Triassic. (Text fig. 3.) As both authors worked with material which had been gathered more or less loose by several Spitsbergen expeditions, they could not prove their stratigraphical suppositions by detailed sections.

B. Kummel (1961) worked with Arctoceratids from Spitsbergen. Discussing the age of the *Arctoceras* fauna, he pointed out the strong similarities between the *Arctoceras* and *Wasatchites* beds of Spitsbergen and the *Meekoceras* and *Anasibirites* beds of the Western United States and Northern Canada. He doubted that the faunal sequence of the *"Posidonomya* beds" of Spitsbergen



Text Fig. 1: Geographical situation of the investigated area.

has been interpreted correctly and placed the *Arctoceras* fauna in the Owenitan Stage. Tozer (1961, 1963, 1965) described detailed sections of the Lower Triassic of Arctic Canada. In his nearly complete sequences he distinguished 9 ammonite

SERIES	STAGES		Ammonoid Zones	Conodont Zones	Spitsbergen
	SPATH (1934)	TOZER (1967)	SILBERLING & TOZER (1968)	SWEET et al. (1971)	BUCHAN et al. (1965)
LOWER TRIASSIC	Prohungaritan	Spathian	Keyserlingites subrobustus	13 Neospathodus timorensis 12 Neogondolella jubata	Sticky Keep Formation
	Columbitan		Kazakhstanites pilaticus	11 10 Platyvillosus	
	Owenitan	Smithian	Wasatchites tardus Euflemingites romunderi	9 Neogondolella milleri 8 Neospathodus conservativs 7 Parachirognathus/Furnishius	
	Flemingitan	Dienerian	Vavilovites sverdrupi	6 Neospathodus pakistanensis 5 Neospathodus cristigalli	Vardebukta Formation
	Gyronitan		Proptychites candidus	4 Neospathodus dieneri 3 Neospathodus kummeli	
		Griesbachian	Pachyproptychites strigatus	2 Neogondolella carinata	
	Otoceratan		Ophiceras commune Otoceras boreale Otoceras concavum	1 Anchignathus typicalis	

Text Fig. 2: Ammonoid and Conodont Zones of the Lower Triassic (Scythian) after SILBERLING & TOZER (1968) and SWEET et al. (1971)

zones and proposed 4 new stages for the subdivision of the Lower Triassic with type sections on Axel Heiberg and Ellesmere Islands (Arctic Canada). This subdivision has now been generally accepted. (Text fig. 2.)

BUCHAN et al. (1965) described detailed lithostratigraphical sections of the Triassic of Spitsbergen. They included both the "Fish Niveau" of WIMAN and the "Posidonomyen-Schichten" of FREBOLD in the lower part of the Sticky Keep Formation. The Sticky Keep Formation includes the Smithian and Spathian Stages of the subdivision of TOZER.

TOZER & PARKER (1968) correlated the lithostratigraphical sequences of BUCHAN et al. biostratigraphically with the type localities of Arctic Canada and described the ammonite zones stage by stage. As in the Canadian Arctic they distinguished two faunal zones within the Smithian Stage. The lower one is the *romunderi* zone (after *Euflemingites romunderi*); it contains *Euflemingites* and *Posidonia mimer*, while the upper one or *tardus* zone (after *Wasatchites tardus*) is characterized by Prionitids, *Xenoceltites* and *Pseudomonotis occidentalis*. They pointed out that there are still no sections known which show the relative position of both zones in Spitsbergen. According to TOZER & PARKER, *Arctoceras* occurs in both zones.

After all these publications, the relative position of the *Arctoceras-Prosphingites* fauna and the *Wasatchites-Arctoprionites-Xenoceltites* fauna was still not definitely known.

2. Description of the section

The section starts at sea level and measures 35 m. It consists of dark grey silty shales with layers of calcareous nodules and silty limestones. The nodule horizons and the limestones in which the ammonites are well preserved are numbered from the bottom to the top of the sequence.

1.	0,2 m	light weathering silty limestone with *Arctoceras blomstrandi*
	0,8 m	dark silty shales
2.	0,2 m	light weathering silty limestone with *Arctoceras blomstrandi*
	0,7 m	dark silty shales
3.	0,2 m	light weathering silty limestone with *Arctoceras blomstrandi*
	3,5 m	dark silty shales
4.	0,2 m	small round calcareous nodules
	4,0 m	dark silty shales
5.	0,3 m	light weathering silty limestone with *Arctoceras blomstrandi*, *Neogondolella milleri, N. nevadensis, N. planata*, *Neospathodus waageni*
	2,0 m	dark silty shales
6.	0,2 m	grey silty limestone
	4,0 m	dark silty shales
7.	0,2 m	silty limestone
	0,7 m	dark silty shales

7. 0,2 m silty limestone
0,7 m dark silty shales

8. 0,2 m grey weathering nodules with septarian structure
0,7 m dark silty shales

9. 0,1 m light weathering silty limestone with *Arctoceras blomstrandi*
0,2 m dark silty shales

10. 0,1 m small round calcareous nodules
0,2 m dark silty shales

11. 0,2 m light weathering silty limestone
2,4 m dark silty shales

12. 0,2 m silty limestone partly thickened by nodules
1,4 m dark silty shales

13. 0,2 m light weathering silty limestone
2,5 m dark silty shales

14. 0,2 m oval calcareous nodules with *Arctoceras blomstrandi*, *Neogondolella milleri*, *N. nevadensis*, *N. planata*, *Neospathodus waageni*
0,9 m dark silty shales

15. 0,2 m oval calcareous nodules with *Artoceras blomstrandi*
0,2 m dark silty shales

16. 0,2 m small round calcareous nodules with *Arctoceras blomstrandi*
1,1 m dark silty shales

17. 0,2 m oval calcareous nodules
0,7 m dark silty shales

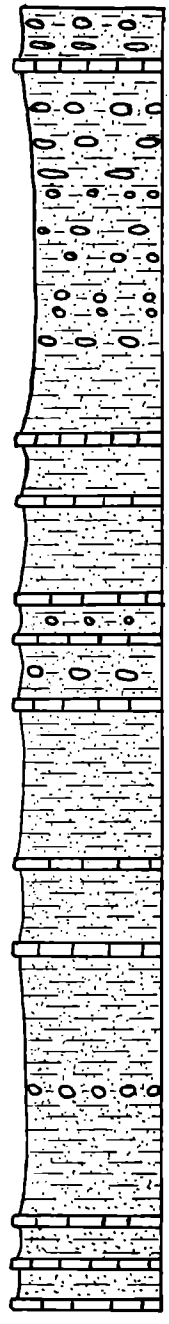
18. 0,2 m oval calcareous nodules
0,9 m dark silty shales

19. 0,2 m light weathering silty limestone
0,1 m dark silty shales

20. 0,2 m small oval calcareous nodules
0,4 m dark silty shales

21. 0,2 m long, oval calcareous nodules
0,8 m dark silty shales

22. 0,3 m large oval calcareous nodules with *Xenoceltites* sp. (rare)
1,2 m dark silty shales



Text Fig. 3: Stratigraphic section Botneheia coast, Vestspitsbergen.

23. 0,3 m yellow weathering silty limestone with septarian structure and *Arctoprionites nodosus* (large specimens, or body chambers containing small specimens)
0,4 m dark silty shales

24. 0,1 m flat calcareous nodules with *Xenoceltites spitsbergensis*, *X. subevolutus* (abundant), *Arctoprio-*

nites nodosus (only small specimens), *Wasatchites tridentinus, Peudosageceras multilobatum, Neogondolella milleri, N. jubata, N. nevadensis, N. planata,*
Neospathodus waageni, Posidonia mimer, Pseudomonotis occidentalis, "Orthoceras" sp.

0,2 m dark silty shales

25. 0,3 m large round silty limestone concretions (30 × 20 × 15 cm) nearly each with entire skeletons or skulls of fishes; between them smaller flat nodules with *Xenoceltites spitsbergensis, X. subevolutus, Wasatchites tridentinus, Arctoprionites nodosus, Pseudosageceras multilobatum, Pseudomonotis occidentalis, Neogondolella milleri, N. nevadensis, N. planata, N. jubata, Neospathodus waageni.*

3. Index fossils

a) Ammonoids

Two distinct ammonoid faunas characterize the measured section. While the lower part (nodule layers 1—16) contained only *Arctoceras blomstrandi*, the upper part (especially nodule layers 23—25) yielded a rich and well preserved fauna. Its most abundant genus is *Xenoceltites*, whereas the typical Prionitids like *Wasatchites* and *Arctoprionites* are relatively rare. A few specimens of *Pseudosageceras multilobatum* were also found in these nodules.

Although lacking the index species (*Wasatchites tardus*), the upper fauna contains the typical ammonoids of the *tardus* zone of the Smithian Stage and can well be correlated with that of the type locality (Toad Formation, British Columbia). In British Columbia, in contrast to our section, this zone is marked by an abundance of *Wasatchites* and rare *Xenoceltites*.

In Canada, *Xenoceltites* characterizes the upper part of the *tardus* zone (Tozer, 1967), whereas *Arctoceras blomstrandi* (in Kummel's broad interpretation 1961) occurs throughout the Smithian Stage. The exact stratigraphic position of the lower part of our section can therefore not be determined: at any rate it does not range below the base of the Smithian. The main level of *A. blomstrandi* seems to be the *romunderi* zone, but at one locality on Ellesmere Island (Arctic Canada) it is associated with *Wasatchites*.

Since we did not find typical ammonoids of the *romunderi* zone, it seems that in Spitsbergen also *A. blomstrandi* ranges up to the tardus zone, and that our section is restricted to the *tardus* zone.

b) Conodonts

As shown by Sweet et al. (1971) and Mosher (1973), Lower Triassic conodonts in some stages may possess relatively more biostratigraphical value than the ammonoids which form the standard scheme. For the Lower Triassic, 13 conodont faunal assemblages characterize zones which are distinguished by distinctive species of *Neogondolella, Neospathodus, Furnishius, Platyvillosus*, and *Parachirognathus*.

The four samples of our section which contained conodonts were obtained from nodule layers in which ammonites are common, thus rendering possible direct correlations between both groups. Throughout the whole sequence the following species occur: *Neogondolella milleri, Neogondolella nevadensis, Neogondolella planata,* and *Neospathodus waageni. N. milleri* is by far the most abundant species.

Neogondolella jubata is restricted to the top of the section (layers 24 and 25).

The whole assemblage clearly indicates the conodont zone 9 (zone of *Neogondolella milleri)* of SWEET et al. The range of *N. jubata,* described by SWEET from the Salt Range and Trans Indus ... "between the approximate top of the *milleri* zone and the base of the *Neospathodus timorensis* zone ..." places the upper part of our section near the top of the milleri zone.

Our conodont assemblage is nearly identical with that described by C. MOSHER (1973) from the *Wasatchites* beds of the Toad Formation (British Columbia) and from *Wasatchites* beds of the Blind Formation on Ellesmere Island. Only differences in the range of *Neogondolella planata* exist, which is restricted to the *romunderi* zone in Canada but ranges up to the *tardus* zone in Spitsbergen.

c) Pelecypods

TOZER (1961, 1967, 1968) described pelecypod species which seem to have some stratigraphical value for the Lower Triassic. He stated that the main level for *Posidonia mimer* ÖBERG is the *romunderi* zone and for *Pseudomonotis occidentalis* (WHITEAVES) the *tardus* zone of the Smithian.

In our section abundant specimens of *Pseudomonotis occidentalis* occur in the nodule layers 23—25, associated with *Xenoceltites, Wasatchites,* and *Arctoprionites.* In the same horizon we found a small number of specimens of *Posidonia mimer.*

The stratigraphical value of both pelecypod species seems to be more or less accidental. In reality, they are facies fossils. Using them unreservedly as index fossils, may lead to serious errors.

There are no pelecypods associated with *Arctoceras* in our section.

III. Systematic Paleontology

1. Ammonoidea

Family Prionitidae HYATT 1900

This family includes 4 more or less contemporary genera of Upper Scythian (Smithian) age which occur in the so-called *Anasibirites* or *Wasatchites* beds in Spitsbergen, Arctic Canada, British Columbia, Utah, the Salt Range, Japan, Himalaya, and Timor. They are *Prionites* WAAGEN, *Arctoprionites* SPATH, *Wasatchites* MATHEWS, and *Anasibirites* MCLEARN. All are ribbed and tuberculated forms which are characterized by a broadly tabulate venter. The suture line is ceratitic, with two lateral lobes and serrated auxiliary series.

The taxonomy of this group is difficult because all members of this family are remarkably variable — especially the immature forms. For exact determination, it is necessary to get well preserved material of all growth stages.

Genus *Arctoprionites* SPATH, 1934

Type species: *Goniodiscus nodosus* FREBOLD, 1930, "unterer Teil des Fischhorizonts", Sassental, Spitsbergen, p. 8, pl. 1, fig. 7 (1—6).

Diagnosis: More or less involute, discoidal Prionitidae, with tabulate venters, tending to develop crenulation of the latero-peripheral edges and costation or tuberculation on the whorl sides (SPATH 1934, p. 340).

Range and occurrence: Until now this genus has only been described from Spitsbergen.

The "Prionitid indet." figured by TOZER (1961, pl. 20, fig. 1—3) from the *Wasatchites* Beds of British Columbia and Arctic Canada may also belong to this genus.

Remarks: *Arctoprionites* is closely allied to *Wasatchites*, with which it occurs in the same nodule layer in Spitsbergen. Mature forms can only be distinguished by the position of the tubercles, which are more ventral in *Arctoprionites*.

Immature forms of both genera are more easily distinguished by the lack of sculpture and by the tabulate venter of *Arctoprionites*.

Arctoprionites nodosus (FREBOLD, 1930)

Plate 10, figures 1 a, b

Holotype: *Goniodiscus nodosus* FREBOLD, 1930, "unterer Teil des Fischhorizontes", Sassental, Spitsbergen, pl. 1, fig. 7.

Diagnosis: Phragmocon of mature forms with flat flanks, rounded umbilical slope and tabulate venter. With faint biconcave irregular striae. Body chamber with widening umbilicus, high umbilical slope and bullate spines in the middle of the whorl sides, which give rise to two or three ribs which cross the venter more or less straight.
Juvenile forms up to a diameter of 45 mm without any tuberculation and costation.

Material and occurrence: 25 specimens of all growth stages (diameters from 25 to 140 mm) from nodule layers 23—25. The main horizon is nodule layer 23 where large body chambers filled with juveniles occur.

Remarks: Our material shows the different ontogenetic stages which FREBOLD had already pointed out clearly.

Smaller specimens were described by SPATH (1934) as *Hemiprionites garwoodi*. The genera *Gurleyites* and *Hemiprionites* were considered synonyms of *Anasibirites* by TOZER (1971, p. 1024).

Genus *Wasatchites* MATHEWS, 1929

Type species: *W. perrini* MATHEWS, 1929, p. 40, pl. IX, fig. 1—3 (4—9)

Diagnosis: Prionitidae with trapezoidal whorl section, subtabulate venter and umbilical tubercles which give rise to lateral ribs that cross the venter.

Age and range: Upper Scythian (Smithian) of Timor, Arctic Canada, British Columbia, Utah, Spitsbergen, and Japan.

Wasatchites tridentinus SPATH, 1934

Plate 10, figures 3—5

Holotype: *W. tridentinus* SPATH, 1934, p. 352—353, pl. XVI, fig. 4, *Posidonomya* Beds, Trident, Sassendalen, Spitsbergen.

Diagnosis: *Wasatchites* with tabulate inner and more rounded outer whorls. With prominent tubercles appearing on the umbilical edge at diameters of about 25 mm. Tubercles give rise to two or three ribs which cross the venter straight. The ribs are more pronounced on the ventrolateral shoulder and less so across the periphery.

Material and occurrence: About 60 specimens from nodule layers 24 and 25.

Remarks: As TOZER (1961) pointed out, many of the Prionitidae seem to be remarkably variable. Especially the costation varies considerably in the different growth stages.

Some small juvenile specimens from Spitsbergen were described by SPATH (1934) as *Gurleyites* and *Hemiprionites*.

Family Xenodiscidae (FRECH, 1902)

Genus *Xenoceltites* SPATH, 1934

Type species: *Xenoceltites subevolutus* = *Xenodiscus* cf. *comptoni* (non DIENER) FREBOLD, 1930, pl. III, fig. 1 (lectotype) 2, 3, unterer Teil des Fischhorizontes, Sassental, Spitsbergen.

Diagnosis: Compressed, discoidal, serpenticone Xenodiscidae, with faint and distant bulges on the inner whorls and irregular costation, generally causing constrictions on the outer whorls. Suture line ceratitic with two faintly toothed lateral lobes. (SPATH, 1934, p. 127).

Range and occurrence: Upper Scythian (Smithian) of Spitsbergen, Siberia, Salt Range, Utah, and Arctic Canada.

Remarks: This genus is by far the most common in nodule layers 24 and 25. Our material consists of about 250 specimens from 10 up to 70 mm in diameter. Nearly all of them are juveniles. One specimen of about 70 mm — still septate — shows that mature forms could reach at least 100—110 mm in diameter.

SPATH (1934) distinguished three species: *X. spitsbergensis*, *X. subevolutus*, and *X. gregoryi*, which differ mainly in costation and umbilical width. In our material we can separate only two species: one relatively evolute, slightly ribbed form, which is much more numerous in nodule layer 25, and another, more compressed and nearly smooth form which is dominant in nodule layer 24.

The holotype of *X. spitsbergensis* is a characteristic specimen of the first group, and the type of *X. subevolutus*, although only 27 mm in diameter, represents the second group.

Xenoceltites spitsbergensis SPATH, 1934

Plate 11, figures 3 b, 4, 5

Holotype: *X. spitsbergensis*, SPATH, 1934, p. 128, pl. IX, fig. 2, from the Upper Eo-Trias of Trident, Sassendal, Spitsbergen.

Diagnosis: Evolute *Xenoceltites* with more or less distinct bulges in the inner whorls. Beginning at a diameter of about 10 mm with irregular ribs which at first are strongly projected and often constricted on and about the venter; later only less constricted ribs crossing the venter in a weakened condition without projections.

Material and occurrence: About 150 specimens from nodule layers 24 and 25.

Xenoceltites subevolutus SPATH, 1934

Plate 11, figures 1, 2, 3 a

Holotype: *Xenodiscus* cf. *comptoni* FREBOLD, 1930, pl. III, fig. 1, unterer Teil des Fischhorizontes, Sassental, Spitzbergen.

Diagnosis: *Xenoceltites* similar to *X. spitsbergensis* but more compressed and involute. Outer whorls only weakly ribbed or smooth.

Material and occurrence: About 100 specimens from nodule layers 24 and 25.

TOZER (1961) described this species from the upper part of the *tardus* zone on Axel Heiberg Island (Arctic Canada).

Family Sageceratidae HYATT, 1900

Genus *Pseudosageceras* DIENER, 1895

Type species: *P. multilobatum*, NOETLING, 1905 (ARKELL et al. 1957, p. 75).

Diagnosis: Like *Sageceras*, but with narrow angular or retuse venter and closed umbilicus (Treatise p. 75).

Range and occurrence: Lower Triassic of Timor, Madagaskar, North America, the Himalayas, Siberia, Arctic Canada, and Spitsbergen.

Pseudosageceras multilobatum NOETLING, 1905

Plate 10, figures 2 a, b

Holotype: *P. multilobatum* NOETLING, 1905, p. 181, pl. XIX, fig. 1, Lower Triassic, Salt Range.

Diagnosis: Compressed, discoidal *Pseudosageceras* with flattened sides and closed umbilicus. Venter narrow, tabulate or sulcate. Suture line complex ceratitic, with numerous lobes and saddles.

Material and occurrence: 4 specimens from nodule layer 25.

Remarks: *P. multilobatum* is one of the most widely distributed and characteristic ammonites of the Lower Triassic. It is a relatively long ranging species and has been recorded from the Dienerian and the Smithian Stages of the Salt Range, Siberia, Idaho, California, Timor, Madagaskar, Nevada, and Arctic Canada.

On Spitsbergen from where it is recorded for the first time here, *P. multilobatum* is very rare. Among some hundred ammonoids of nodule layers 24 and 25 we have found only 4 small immature specimens.

Family Meekoceratidae Waagen, 1895

Genus *Arctoceras* Hyatt, 1900

Type species: *Ceratites polaris* Mojsisowics, 1896, p. 31, pl. VII, fig. 1, *Posidonomya* limestone, Spitsbergen.

Diagnosis: Involute Meekoceratidae with narrowly arched venter and steepsided umbilical wall. Inner whorls more or less smooth, outer whorls with radial folds and small tubercles on the umbilical shoulder. Suture line ceratitic, with wide and low saddles.

Range and occurrence: Lower Triassic (Smithian) of Arctic Canada, Western United States, Timor, and Spitsbergen.

Remarks: B. Kummel (1961) showed that the seven described species of *Arctoceras* from the "*Posidonomya* beds" of Spitsbergen are immature forms or morphological variants of only one variable species.

Arctoceras blomstrandi (Lindström, 1865)

Plate 12, figures 1 a, b

Holotype: *Ceratites ? polaris*, Lindström, 1865, p. 4, pl. I, fig. 3, *Posidonomya* beds, Spitsbergen.

Diagnosis: (as of the genus)

Material and occurrence: About 25 specimens from nodule layers 1—16.

Remarks: Tozer (1968) described the range of *A. blomstrandi* from the *romunderi* zone ranging up to the *tardus* zone in Canada. In our section *A. blomstrandi* is not associated with *Wasatchites* and *Arctoprionites* but ranges also up to the *tardus* zone.

2. Conodonta

Genus *Neogondolella* Bender & Stoppel, 1965

Type species: *Gondolella mombergensis* Tatge, 1956.

Diagnosis (Sweet, 1970): *Neogondolella* includes conodont species in which the skeletal apparatus included elements of a single morphologic type. These elements, which are elongate, paired, and individually asymmetrical, have a terminal or subterminal posterior cusp; a median nodose or denticulate carina and finely to coarsely pitted, largely unornamented platformlike lateral extensions, which are joined posteriorly in most species by a more or less well developed brim that incloses the posterior end of the carina.

Range and occurrence: Permian and Triassic. Exact range not yet known. Worldwide.

Neogondolella milleri (MÜLLER, 1956)

Plate 13, figures 7—10

Holotype: *Gondolella milleri* n. sp. MÜLLER, 1956, p. 823, pl. 95, fig. 4—6, Lower Triassic, *Meekoceras* beds, Nevada.

Diagnosis: Unit subsymmetrical, elongate, platform bearing distinct crenulations on nearly upturned margins. Carina high, little bowed: 9—12 denticles, irregular in size and form, laterally compressed, relatively long; with 2—3 anterior denticles forming free blade; posterior cusp may be free of platform and strongly projects posteriorly. Basal keel broad and flat, may possess lateral grooves parallel to central groove.

Material and occurrence: Some hundred specimens from nodule layers 5, 14, 24, 25. Abundant in nodule layers 24, 25.

Remarks: *Neogondolella milleri* is the index species of the conodont zone 9 (SWEET et al., 1971). It is described from the *Meekoceras* or *Anasibirites* beds of North America (Nevada, Idaho), Canada (British Columbia, Axel Heiberg and Ellesmere Island), Afghanistan, Nepal, Japan, Timor, and Malaysia.

Our samples yield abundant well preserved specimens showing all ontogenetic stages.

Neogondolella planata (CLARK, 1959)

Plate 14, figures 1—5

Holotype: *Gondolella planata* CLARK, 1959, pl. 44, figs. 8—10; Lower Triassic, *Meekoceras* zone, Nevada.

Diagnosis: Unit quite short and broad; platform granular. Carina composed of 8—10 nodelike denticles; posterior cusp enlarged. Platform may surround terminal cusp with narrow brim. Wide furrow on aboral surface, loop does not extend to posterior portion of platform. Keel formed anteriorly, extends to anterior margin.

Material and occurrence: About 100 specimens from nodule layers 5, 14, 24, 25.

Remarks: SWEET (1970) included CLARK's species *N. nevadensis* and *N. planata* in *N. carinata*. As MOSHER (1973) has already pointed out, the three species are morphologically and stratigraphically distinguishable, and he separated the three forms. In Arctic Canada the main level for *N. carinata* is the *strigatus* zone (Griesbachian), for *N. planata* the *romunderi* zone (Lower Smithian), and for *N. nevadensis* the *tardus* zone.

In our samples, *N. planata* is associated with *N. nevadensis*.

Neogondolella nevadensis (CLARK, 1959)

Plate 14, figures 6—10

Holotype: *Gondolella nevadensis* CLARK, 1959, p. 391, pl. 47, figs. 28, 29; Pre-*Meekoceras* rocks, Nevada.

Diagnosis: Platform broad at posterior end, tapering abruptly towards anterior. Posterior part of the platform with abruptly curved margin. Platform

may be smooth or finely pitted and bowed upwards. Carina low, composed of 10 to 13 nodes or denticles; platform terminates in front of the enlarged cusp, leaving it free.

Material and occurrence: Some hundred specimens from nodule layers 5, 14, 24, 25.

Remarks: MOSHER (1973) described *N. nevadensis* as the dominant species of the *Wasatchites* beds in British Columbia and Arctic Canada. It occurs in the *romunderi* and *tardus* zone. In our samples this species is nearly as frequent as *Neogondolella milleri*. In contrast to the original description of CLARK most of our specimens have a finely pitted platform margin.

Neogondolella jubata SWEET, 1970

Plate 13, figures 1—6

Holotype: SWEET, 1970, p. 243—244, pl. 2, figs. 1—3; from the Lower Triassic, Pakistan.

Diagnosis (SWEET, 1970): A species of *Neogondolella* characterized by symmetrical and asymmetrical bladelike skeletal elements with a height to width to length ratio of about 1 : 1,5 : 5, a high even crested carina and a narrow, finely pitted platform that surrounds all but the anterior tenth of the unit.

Remarks: *N. jubata* is known from West Pakistan, Nevada, Idaho, Australia, British Columbia and Arctic Canada. The main level of this species is the Early-Middle Spathian conodont zones *Platyvillosus* (zone 10) through *N. jubata* (zone 12), but it also reaches down "to the approximate top of the *N. milleri* zone" (SWEET et al. 1970). MOSHER (1973) described *N. jubata* from British Columbia and Arctic Canada, where it ranges from the *tardus* to the *subrobustus* zone.
In our section, *N. jubata* occurs in some abundance. It is confined to the uppermost nodule layers. No specimens were found associated with *Arctoceras*.

Genus *Neospathodus* MOSHER, 1968

Type species: *Spathognathodus cristigalli* HUCKRIEDE, 1958, from the Lower Triassic, Pakistan.

Diagnosis (MOSHER, 1973): Bladelike conodonts with posteriorly terminal or subterminal pit and loop on basal surface. Denticles form series typically highest at a point approximately a third of distance from posterior inclination from front to back of unit. Longitudinal ribs present on modflanks of unit, which may develop into platform-like structure in some forms.

Range and occurrence: Late Permian through mid-Anisian, worldwide.

Neospathodus waageni SWEET, 1970

Plate 14, figures 11—12

Holotype: SWEET, 1970, p. 260—261, pl. 1, figs. 11—12, from the Middle Lower Triassic of the Salt Range.

Diagnosis (SWEET, 1970): A species of *Neospathodus* with bladelike skeletal elements in which the height to length is about 1 : 1 in all stages of growth,, but in which the ratio of width to lenght (or height) changes from 1 : 3 in early stages to 1 : 2 in late stages. Denticulate margin arcuate in lateral profile, with greatest height in posterior half of element. Basal margin straight anteriorly, but deflected conspicuously upward beneath posterior half of element.

Material and occurrence: About one hundred specimens from nodule layers 5, 14, 24, 25.

Remarks: *Neospathodus waageni* is represented throughout the Smithian (conodont zones 7—10).

It is described from Afghanistan, Timor, the Salt Range, Australia, and samples from the *Wasatchites tardus* zone of the Western United States, British Columbia and Arctic Canada.

In our samples, specimens of the genera *Neogondolella* and *Neospathodus* are dominant. The remainder of the collection, which are not described here represents elements of the multielement genus *Ellisonia* (like *Ellisonia gradata* SWEET, 1970 and *Ellisonia triassia* MÜLLER 1956, sensu SWEET, 1970) and of *Xaniognathus (X. expansus* MOSHER 1973).

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Plate 10

(All figures natural size unless otherwise stated)

Fig. 1 a, b: *Arctoprionites nodosus* (FREBOLD, 1930)

Nodule layer 23, Sticky Keep Formation, *tardus* zone (Lower Triassic); Botneheia coast, W. Spitsbergen
Type Cat. No. 2152

Fig. 2 a, b: *Pseusageceras multilobatum* NOETLING, 1905

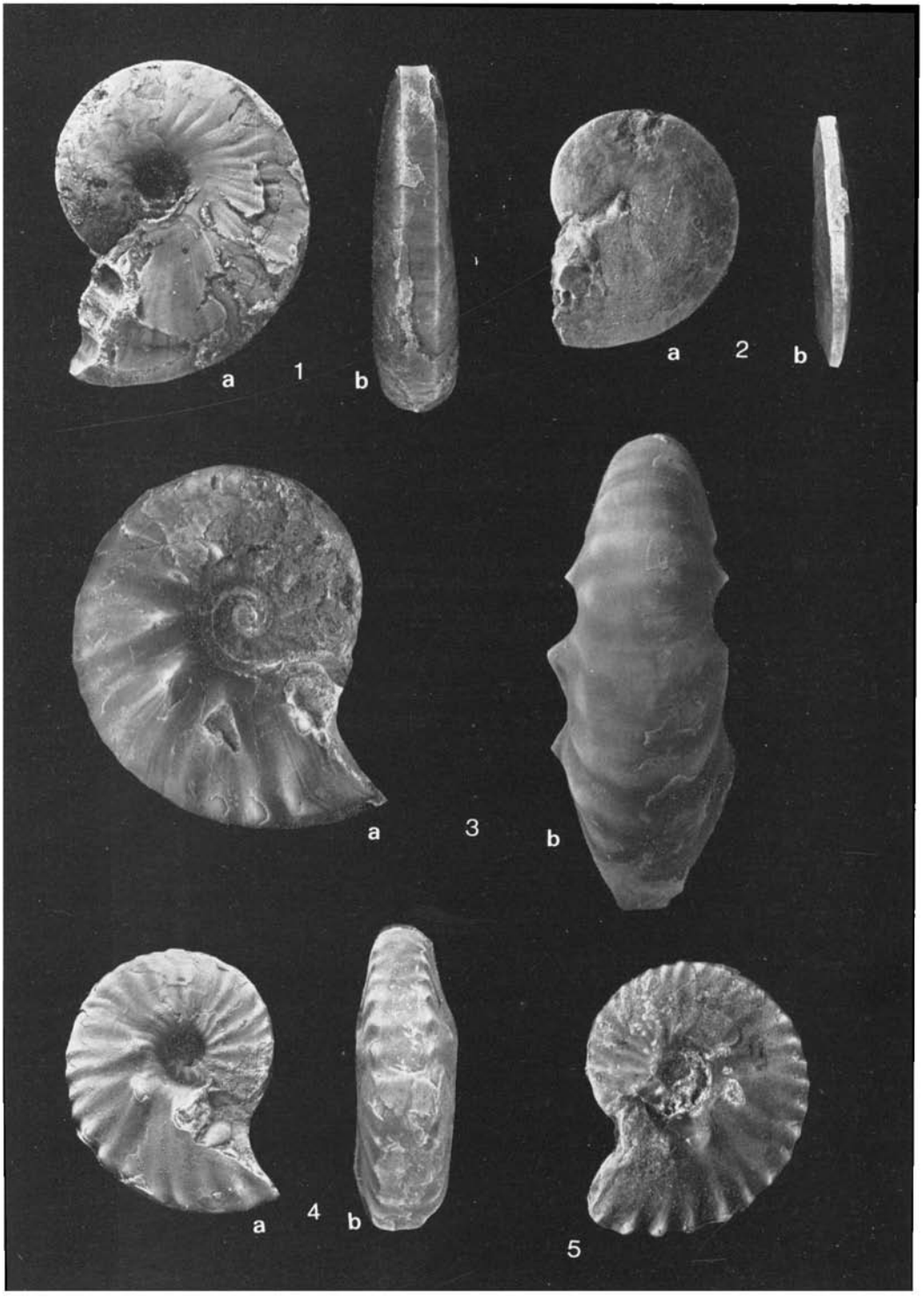
Nodule layer 24, Sticky Keep Formation, *tardus* zone (Lower Triassic); Botneheia coast, W. Spitsbergen
Type Cat. No. 2153

Figs. 3—5: *Wasatchites tridentinus* SPATH, 1934

Nodule layer 24, Sticky Keep Formation, *tardus* zone (Lower Triassic), Botneheia coast, W. Spitsbergen

3 a, b: nearly adult specimens, with rounded venter and well produced tubercles
Type Cat. No. 2154

4 a, b, 5: juvenile specimens, with tabulate venter and pronounced ribs.
Type Cat. No. 2155, 2156


a
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b
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Plate 11

Figs. 1—2: *Xenoceltites subevolutus* SPATH, 1934

Nodule layer 24, Sticky Keep Formation, *tardus* zone (Lower Triassic), Botneheia coast, W. Spitsbergen.
Type Cat. No. 2157
Type Cat. No. 2158

Figs. 3 a, b: *Xenoceltites subevolutus* SPATH, 1934 (3 a)
Xenoceltites spitsbergensis SPATH, 1934 (3 b)

Nodule layer 24, Sticky Keep Formation, *tardus* zone (Lower Triassic), Botneheia coast, W. Spitsbergen.
Type Cat. No. 2159

Figs. 4—5: *Xenoceltites spitsbergensis* SPATH, 1934

Nodule layer 25, Sticky Keep Formation, *tardus* zone (Lower Triassic), Botneheia coast, W. Spitsbergen.
Type Cat. No. 2160
Type Cat. No. 2161

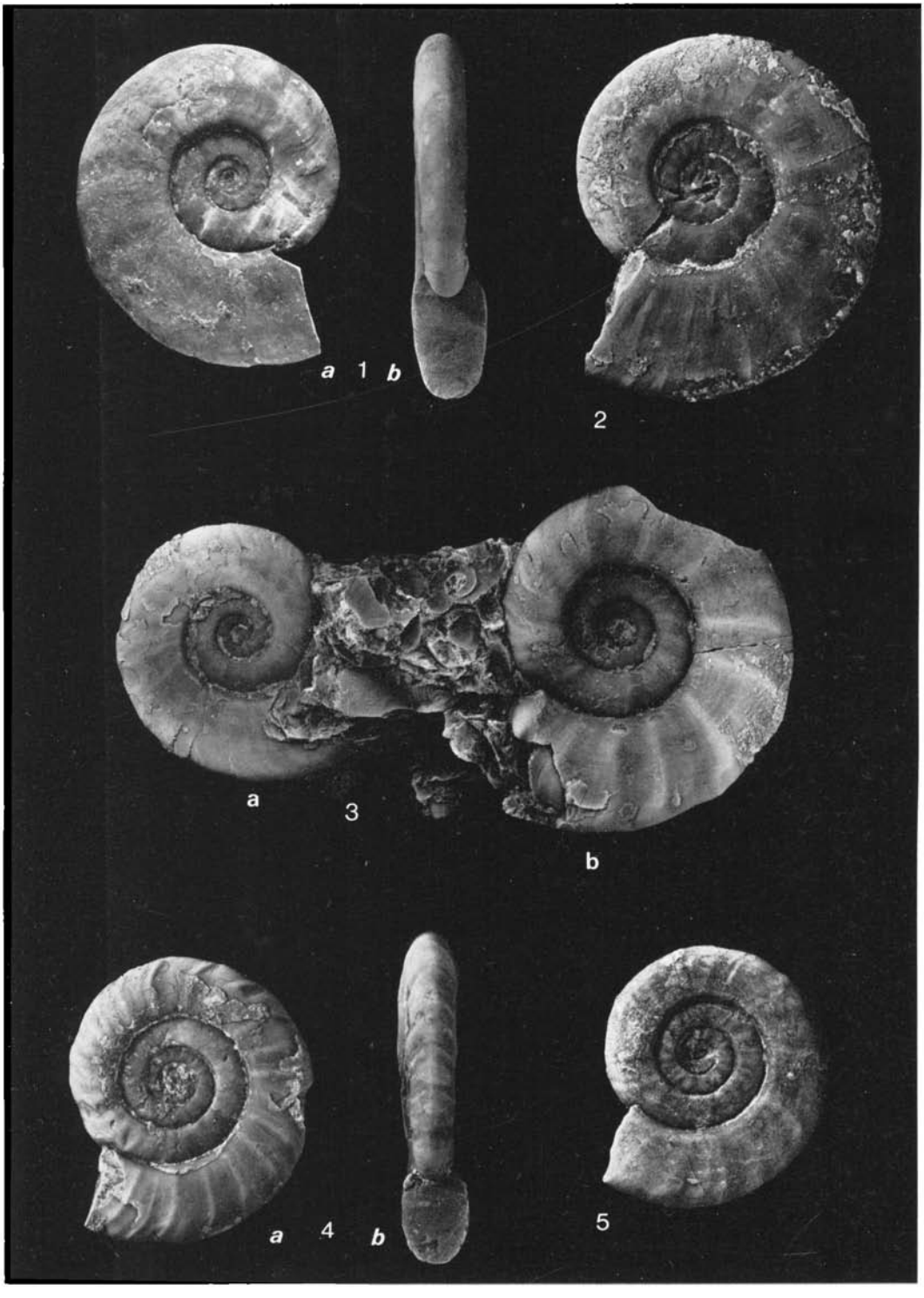
a 1 b
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Plate 12

Figs. 1 a, b: *Arctoceras blomstrandi* (LINDSTRÖM, 1865)

Nodule layer 5, Sticky Keep Formation, *tardus* zone, Botneheia coast, W. Spitsbergen
Type Cat. No. 2162

Fig. 2: *Pseudomonotis occidentalis* (WHITEAVES, 1889)

Nodule layer 24, Sticky Keep Formation, *tardus* zone (Lower Triassic), Botneheia coast, W. Spitsbergen
Type Cat. No. 2163

Fig. 3: *Posidonia mimer* OEBERG, 1877

Nodule layer 24, Sticky Keep Formation, *tardus* zone (Lower Triassic), Botneheia coast, W. Spitsbergen
Type Cat. No. 2164

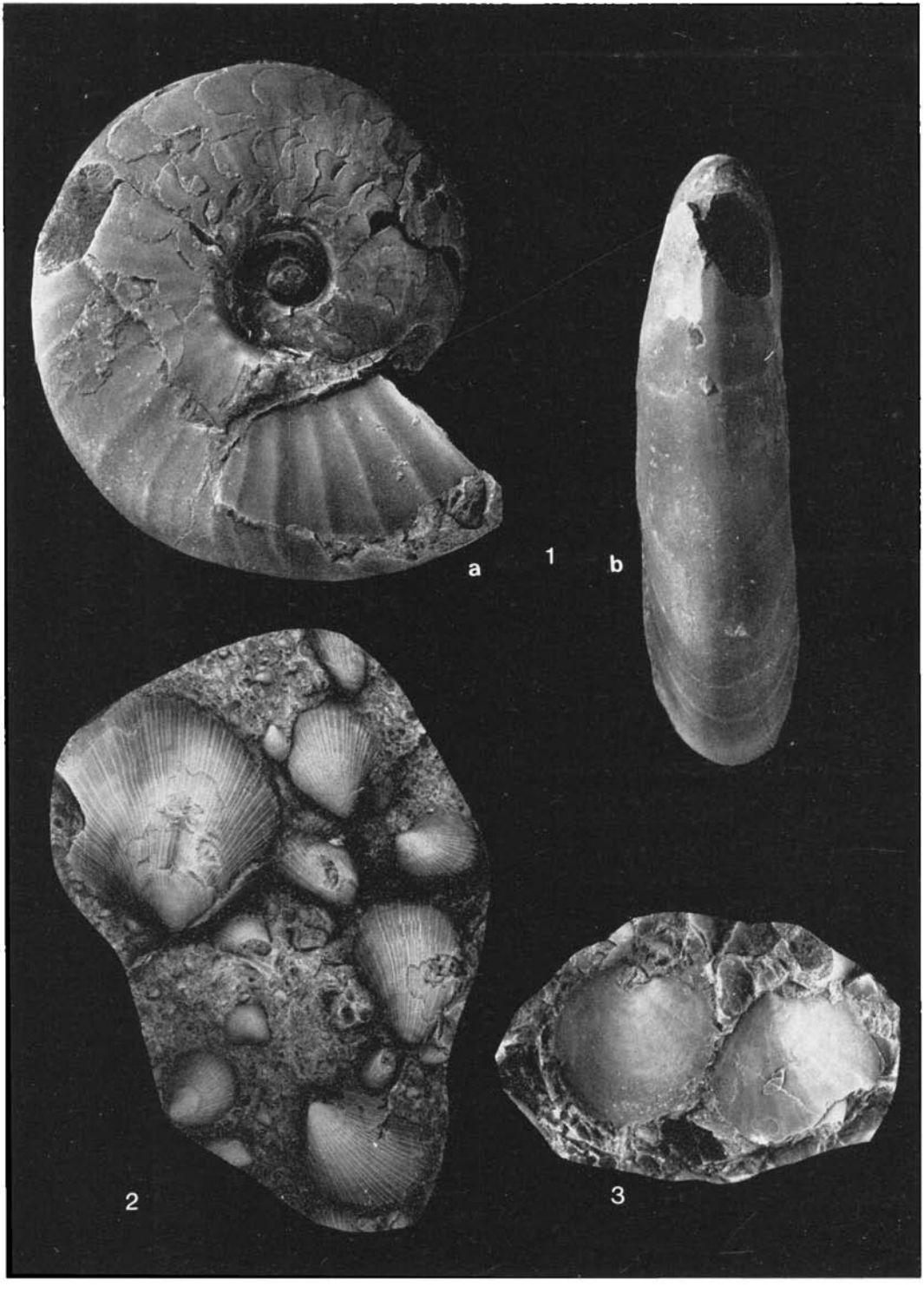
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Plate 13

(Scale: the white line in every figure corresponds to 100 μ (= 0,1 mm)

Figs. 1— 6: *Neogondolella jubata* SWEET, 1970

Nodule layer 24, Sticky Keep Formation, *tardus* zone (Lower Triassic), Botneheia coast, W. Spitsbergen

Fig. 1: oblique lateral view
Type Cat. No. 2165

Fig. 2: upper view
Type Cat. No. 2160

Fig. 3: upper view
Type Cat. No. 2166

Fig. 4: lateral view
Type Cat. No. 2167

Fig. 5: oblique lateral view
Type Cat. No. 2168

Fig. 6: lower view
Type Cat. No. 2169

Figs. 7—10: *Neogondolella milleri* (MÜLLER, 1956)

Nodule layer 24, Sticky Keep Formation, *tardus* zone (Lower Triassic), Botneheia coast, W. Spitsbergen

Fig. 7: lateral view
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Fig. 8: lateral view
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Fig. 9: upper view
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Fig. 10: lower view
Type Cat. No. 2171

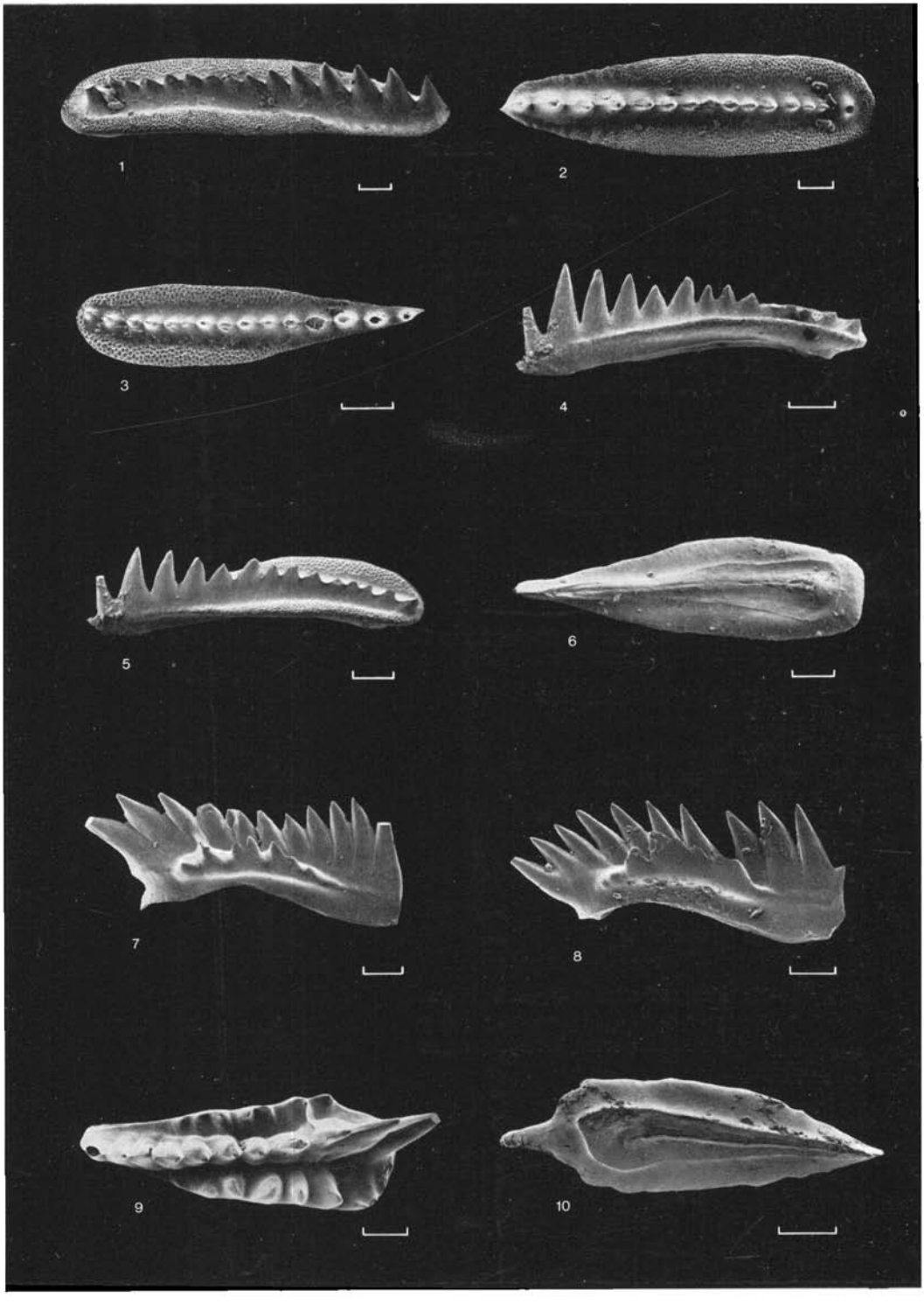
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Plate 14

(Scale: the white line in every figure corresponds to 100 μ = 0,1 mm)

Figs. 1— 5: *Neogondolella planata* (CLARK, 1959)

Nodule layer 24, Sticky Keep Formation, *tardus* zone (Lower Triassic), Botneheia coast, W. Spitsbergen

Fig. 1: oblique lateral view
Type Cat. No. 2172

Fig. 2: upper view
Type Cat. No. 2172

Fig. 3: lateral view
Type Cat. No. 2173

Fig. 4: upper view
Type Cat. No. 2174

Fig. 5: lower view
Type Cat. No. 2175

Figs. 6—10: *Neogondolella nevadensis* (CLARK, 1959)

Nodule layer 24, Sticky Keep Formation, *tardus* zone (Lower Triassic), Botneheia coast, W. Spitsbergen

Fig. 6: oblique lateral view
Type Cat. No. 2176

Fig. 7: lateral view
Type Cat. No. 2177

Fig. 8: oblique lateral view
Type Cat. No. 2178

Fig. 9: upper view
Type Cat. No. 2179

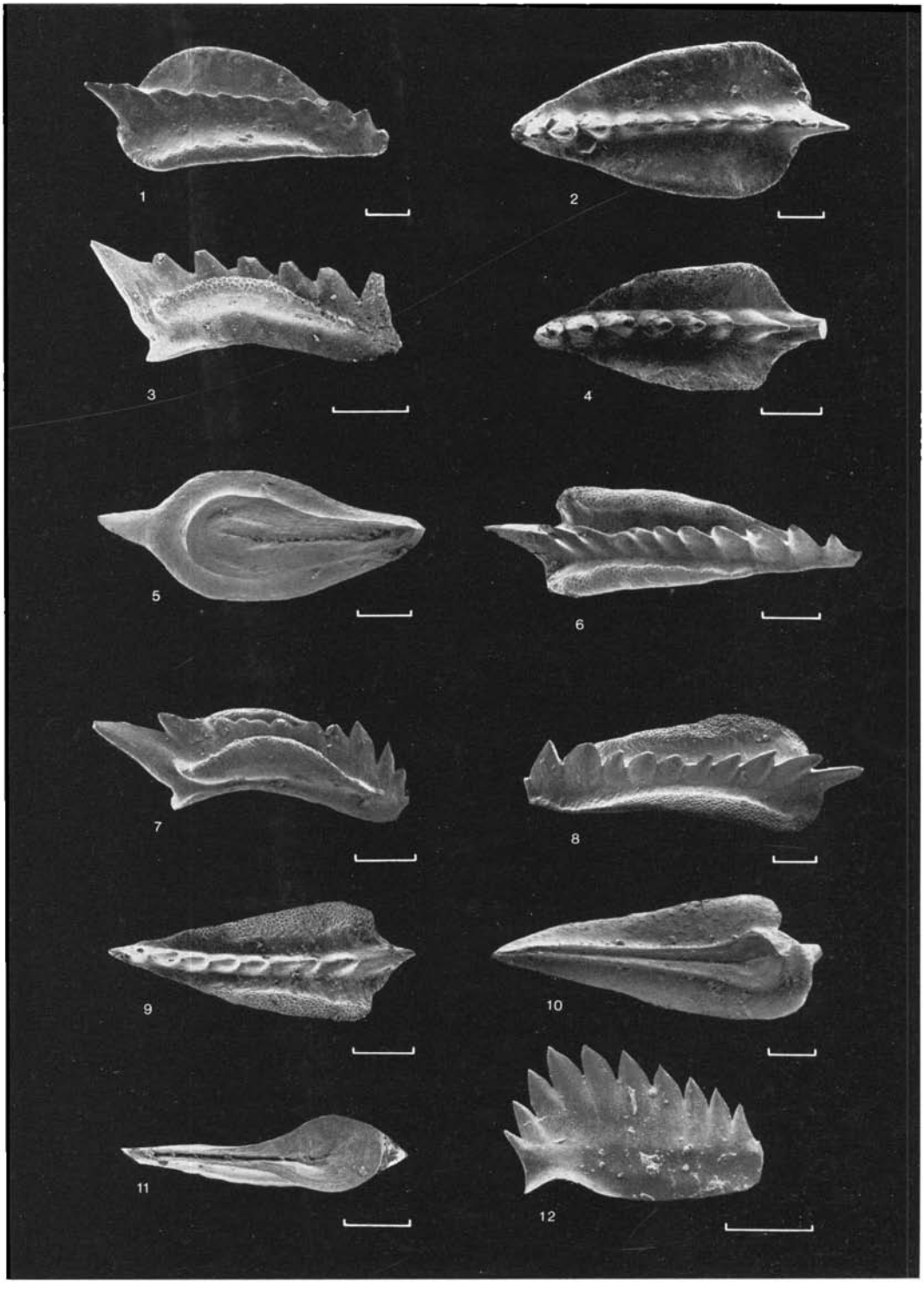
Fig. 10: lower view
Type Cat. No. 2180

Figs. 11—12: *Neospathodus waageni* SWEET, 1970

Nodule layer 24, Sticky Keep Formation, *tardus* zone (Lower Triassic), Botneheia coast, W. Spitsbergen

Fig. 11: lower view
Type Cat. No. 2181

Fig. 12: lateral view
Type Cat. No. 2182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