# 2. A new Tertiary Fauna from Spitsbergen.

By

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(With Pl. III—VI.)

## Introduction.

The material on which the present paper is chiefly based has been collected by Mr. ARTHUR S. LEWIN, mining engineer of Oslo, Norway, during the summers of 1923 and 1924. It was placed at my disposal in the most courteous way by the collector, and I therefore wish to express here to him my most sincere thanks.

In addition to the material first referred to also other material brought together by the late Mr. H. L. NORBERG of Tromsö, Norway, and by certain of the Swedish expeditions to Spitsbergen has been dealt with in the following pages.

## Description of the Material collected by Mr. A. S. Lewin.

### Geological Remarks.

The locality in which Mr. LEWIN collected his material is situated somewhat West of Coles Bay (on the South coast of the Ice Fjord) about half-way between Cape Eriksson[1] and the Lagoon. Mr. LEWIN says in a letter that the locality is situated about 150 m above the sea and about 300—400 m above the boundary between the Cretaceous and the Tertiary systems. The rock in which the fossils occur is an impure limestone rich in fossil wood. The chemical composition of the rock is as follows:

| | | |
|---|---|---|
| Not soluble in diluted hydrochloric acid | $H_2O$ given off at 105° | 0.3 |
| | $H_2O$ (firmer bound) + organic matter | 2.0 |
| | $SiO_2$ | 30.5 |
| | Metallic oxides | 6.2 |

[1] This Cape has been named so by DE GEER on his map published in 1912, whereas ISACHSEN, on the contrary, on his map published in 1915 called it Cape Laila.

| | | |
|---|---|---|
| Soluble in diluted hydrochloric acid | $Fe_2O_3$ | 0.9 |
| | FeO | 3.3 |
| | MnO | 0.2 |
| | MgO | 1.7 |
| | CaO | 28.4 |
| | $CO_2$ | 25.6 |
| | Other substances[1] (by difference) | 0.9 |
| | S:a | 100.0 % |

This analysis shows that the rock is composed of:

38.7 % substances not soluble in diluted hydrochloric acid
61.3 % » soluble » » » »

$SiO_2$ enters partly in free form as quartz in rather large grains, partly combined with the alkalies and the water to compounds of a composition not nearer made out. Organic matters with a faint smell of petroleum are present in but slight quantities.

The substances soluble in hydrochloric acid are represented chiefly by carbonates of Ca, $Fe^{II}$, Mg and Mn. If the RO-quantities found were bound exclusively to $CO_2$, the percentage of the different carbonates would be:

| | |
|---|---|
| $CaCO_3$ | 84.6 |
| $FeCO_3$ | 8.9 |
| $MgCO_3$ | 6.0 |
| $MnCO_3$ | 0.5 |
| S:a | 100.0 % |

These figures, however, only approximately correspond to the proportions between the carbonates present, because the $CO_2$-content of the sample should be 0.7 % higher to bind completely the total RO-quantities as carbonates.

The analysis is made by Dr. A. BYGDÉN, chemist at the Geological Survey of Sweden, to him and to his chief, Direktor GAVELIN, I therefore wish to express my sincere thanks.

The Tertiary of Spitsbergen was subdivided by NATHORST into six series, as follows:

| | | |
|---|---|---|
| 6) Upper sandstone series (with coal and fossil plants) | about | 313 m |
| 5) Flaky sandstone series | » | 193 m |
| 4) Upper series of black shales (with pebbles of Permo-Carbonic chert) | » | 230 m |
| 3) Series of green sandstone (with trails of worms) | » | 200 m |
| 2) Lower series of black shales | » | 75 m |

[1] Soluble $SiO_2$, alkalies etc.

1) Lowest series of bright sandstone (at the bottom with layers rich in fossil plants. Above the coal seams marine bivalves occur.) ..... » 150 m

The total thickness of the Tertiary thus amounts to ..... » 1161 m

The upper plant-bearing horizon (in series 6) differs from the lower one in the occurrence of *Sequoia Langsdorfi* and *Ulmus asperrima*. *Sequoia Langsdorfi* is replaced, in series 1, by *Sequoia Nordenskiöldi*.

In series 3 WIMAN and B. HÖGBOM found in 1908 a plant-bearing stratum in the »Bird Canyon» at Coles Bay, 290 m above the sea and at least 300 m above the basis of the Tertiary. The plants in that stratum resemble those from the lower plant-bearing horizon (in series 1).

As far as can be judged the material collected by Mr. LEWIN at Cape Erikson appears to belong to series 3. A remarkable fact is, however, that the rock consists of limestone, which otherwise is completely unknown in the Tertiary of Spitsbergen. The locality at Cape Erikson was previously unknown. The previously known locality with marine Tertiary fossils in the vicinity is Mount Vesuve at the western slope of which the Norwegian expedition in 1914 found both marine and fresh water bivalves, the former, according to RAVN, probably deriving from a stratum somewhat older than that in which the latter occur. Both these strata belong, according to RAVN's opinion, to series 3.

Marine bivalves are found in the Tertiary of Spitsbergen in series 1 by A. E. NORDENSKIÖLD, by NATHORST's and DE GEER's expeditions in 1882, by NATHORST's expedition in 1898, by HOLMSEN in 1909, by H. L. NORBERG in 1914 and by A. HOEL in 1919.

Fresh water bivalves from series 1 have been found only by NATHORST 1898 and by B. HÖGBOM in 1911. They have already been dealt with by RAVN in 1924.

The above data are according to statements given by NATHORST (1910) and RAVN (1922).

In 1910 NATHORST mentions that in 1898 some undeterminable gastropod remains had been found in series 1. The locality was not given, but from what he says it seems evident that it must be either the foot of Mt. Hedgehog or Fyrkanten. These statements evidently have regard to some remains of gastropods preserved in the Riksmuseum. They are imbedded in a large block of loose sandstone. This block was collected, according to the label, in Mt. Brongniart by NATHORST's expedition in 1898. The gastropods are not determinable. They are the only gastropods hitherto mentioned from the Tertiary of Spitsbergen.

In 1868 NORDENSKIÖLD discovered in series 1 remains of insects and fragments of decapod crustaceans and fishes, all land or freshwater animals, associated with plants in a freshwater deposit.

I series 2 no fossils seem to have been found hitherto.

From series 3 fossils were mentioned only as late as in 1924 by

RAVN. These fossils were collected by HOLMSEN in 1909, by B. HÖGBOM in 1911 and by HOEL in 1914. They consist of bivalves, both freshwater and marine ones, the former, however, predominant. These freshwater bivalves were collected by HOEL. According to RAVN the marine bivalves occur both in layers somewhat older and somewhat younger than that in which the freshwater bivalves have been found.

From series 4 only a single fragment of a bivalve is known (NATHORST 1910).

In series 5 bivalves have been found by NATHORST's and De GEER's expedition in 1882, by G. NORDENSKIÖLD in 1890, by NATHORST in 1898, and by B. HÖGBOM in 1909. Among the determinable species four are marine forms and three freshwater forms.

From series 6 no fossil animals at all have been known as yet. This is the layer most abundant with plant remains.

According to RAVN two species of bivalves are common to the series 1, 3 and 5, two species to series 1 and 3, and two species to series 3 and 5. Six species are found only in series 1, three only in series 3 and four[1] only in series 5.

It is noteworthy that four of the species from series 5 are found only in blocks, among these the two *(Cyrena, Solenocurtus)* which are common to series 1, 3 and 5, and two *(Cyrena, Cyprina)* of the four found only in series 5.

Concerning one of the species common to series 1, 3 and 5 it is, however, not impossible that it must be subdivided into two distinct species (cf p. 51 and fig. 26).

Thus, as seen, both marine and freshwater bivalves have been found in series 1, 3 and 5.

In series 3 the freshwater bivalves played a more important part than the marine bivalves.

According to RAVN the series 1—3 of the Spitsbergen Tertiary are Paleocene and the remaining series (4—6) only slightly younger.

The fauna of the Tertiary of Spitsbergen has been dealt with by HEER in 1870 (only freshwater and terrestrial animals), by FUCHS in 1883 and in 1910 (in NATHORST's Beiträge etc.), and in detail by RAVN in 1922 (marine and freshwater bivalves).

In the Arctic region marine Tertiary fossils have further been found in the following countries: North eastern part of Greenland (Cape Dalton), the north coast of Iceland, east of Ural, the north western part of Kamchatka, the north and west coasts of the Sea of Okhotsk, in Saghalien, on the north and western coast of Alaska, on St. Paul, Pribiloff Islands, and on the north coast of Canada (Mackenzie Territorium).

Somewhat south of the Arctic region Tertiary with marine fossils is

[1] Among these four is included as a distinct species also the specimen of *Solenocurtus* that was mentioned by RAVN on p. 26 together with *S. spitsbergensis*. That specimen is dealt with by me on p. 51 cf. also fig. 27 in the present work.

known from the Aleutian Islands, Alaska Peninsula, Shumagin Islands and Kadiak.

The Tertiary at Cape Dalton (Eastern Greenland) is said by RAVN in 1903 to be lower Eocene. On that account it is remarkable that there is no species in common with Spitsbergen, despite the fact that the deposits in question both contain marine species and forms of *Cyrena*.

The fauna of the Tertiary situated east of the Ural mountains is still almost undescribed. The oldest part of this Tertiary is considered to be Eocene and the youngest Oligocene. One species, *Solenocurtus* n. sp. RAVN is said by RAVN in 1922 to occur also in the Tertiary of Spitsbergen (in series 1 and 3).

From the Alaska Peninsula DALL mentioned in 1904 marine fossils of a middle Eocene age. Among these fossils is *Venericardia planicosta,* one of the fossils most characteristic of Eocene time, known for instance from Alabama and the Paris basin. As a proof of the importance attributed to this species as an indexfossil, I will quote to following words by C. A. WHITE (1882): »There is probably no species among all the known fossil mollusca concerning the geological age of which paleontologists are more in accord than *Cardita planicosta* LAMARCK. It is a wellknown form in the European Eocene, and it is quite as characteristic of the Eocene of our Atlantic and Gulf borders as of the Eocene of Europe. The European and the American specimens differ so little from each other that no one now pretends to question their specific identity. Both the European and the American strata furnish specimens of this species in abundance and great perfection, so that all the characteristics of the shell are well known. Its range of variation is not great.» In Europe, at least, the Eocene epoch was warmer than the Paleocene and thus the warmest time of the Tertiary period. It is probable, according to current views, that these marine deposits of the Alaska Peninsula are superimposed by the so-called Kenai formation, which contains coal and plants and which is said to be of a lower Oligocene age. DALL is of the opinion that the Oligocene time in these regions was much warmer than the Miocene time. The tertiary deposits on the north coast of Canada have been recently discovered; they are situated at Brock River (Mackenzie Territorium) near the mouth of the river in the Arctic Ocean. Their fauna is composed of marine and lacustrine bivalves as well as lacustrine gastropods. The lacustrine elements are by far predominating; together with them there occur plant fossils, too. The strata in question are considered by DALL (1924) to belong to the upper Eocene or the Oligocene.

Marine Miocene occurs on the Aleutian Islands, on the Alaska Peninsula, on Shumagin Islands, Kadiak, and the north coast of the Sea of Okhotsk. On the Aleutian Island, Alaska Peninsula, Shumagin Islands and Kadiak the Miocene follows immediately above the Kenai series and has several species in common with the Miocene at Astoria in Oregon; like this it is considered to belong to the horizon which is called the

Astoria group. Its fauna is considered by DALL to indicate that a cool climate prevailed at that time from Oregon as far as to Alaska. This cool climate might have been prevailing during the older and middle Miocene, whereas, during the upper Miocene, the climate was becoming warmer.

As was already pointed out by me (1924, p. 461), it is of much interest that the deposits of the Astoria group on the Aleutian Islands and Alaska Peninsula contain recent arctic marine bivalves which have not been found within the Atlantic region (neither in Europe nor in America) in strata of Miocene age. The recent fauna of marine arctic bivalves thus appears much earlier in the Pacific Ocean than in the north Atlantic.

According to DALL (1884) the Tertiary deposits on the north coast of the Sea of Okhotsk are also Miocene. Their fauna indicates, however, a warmer climate than the actual one. To me it appears, on the contrary, that this Tertiary formation is Pliocene.

Pliocene is said by DALL (1904) to occur on St. Paul and is found also on the north coast of Alaska (upper part of the Colville series) and on the Seward Peninsula (elevated beaches of Nome). DALL (1920) has shown that the Pliocene fauna from the latter two places indicates a climate which was warmer than in both the Miocene and the recent time.

The marine tertiary deposits at Tigil, N. W. Kamchatka, at Taui on the west coast of the Sea of Okhotsk and on Saghalien are said to be of Pliocene age. F. SCHMIDT states (1902) that at Taui Miocene with plants is superimposed by marine Pliocene. In 1868 SCHMIDT held the opinion that the marine Tertiary of Kamchatka and Saghalien is younger than the plant bearing lignite that he considers as Miocene.

According to the later investigations the lignite deposits, both in Kamchatka (after oral communication by Dr. R. FLORIN) and in Saghalien (after KRYSHTOFOVICH) are said to be partly of Paleogene, partly of Neogene age. KRYSTOFOVICH says that the paleogene lignite is superimposed by marine Tertiary.

Of pliocene age are, finally, the Tertiary deposits on the N. coast of Iceland. According to SCHLESCH these are closely related to the English Crag but contain a greater number of arctic Mollusca. There occur, however, together with those also southern forms which, in present time do not range so far towards the North as Iceland. The Pliocene of Iceland contains two species which are found nowadays in the Bering Sea, and many species living on the east coast of North America but lacking on the European side of the Atlantic.

Tertiary freshwater mussels are found in Spitsbergen and Greenland, as mentioned above, and besides in West Greenland. The West Greenland species belong to other genera than the Spitsbergen and East Greenland ones. From the latter countries we know only species of *Cyrena*. From West Greenland, on the contrary, a *Unio* and a *Cyclas* have been recorded, which, according to HEER, are similar to *Unio undatus* HUMB.

and *Cyclas rivularis*. The single species of *Cyrena* described from East Greenland is not identical with any of the Cyrenas found in Spitsbergen. From the Arctic region of Canada lacustrine bivalves have recently been reported, viz. representatives of the genera *Anodonta, Unio, Sphaerium* and *Cymatocyclas,* as well as lacustrine gastropods of the genera *Limnaea, Aplexa, Vivipara, Amnicola* and *Goniobasis*. No species are in common with Greenland, but one species *(Anodonta athlios)* is known from a plant-bearing deposit of the same age from the south coast of Alaska. The genus *Goniobasis* has a southern distribution and does not range nowadays north of Oregon (TRYON).

Arctic marine Crustacea are found in East Greenland only. They are Decapods of the genera *Hoploparia* and *Coeloma* (RAVN 1903).

## Description of the Species.

1. ?*Gibbula* spec. Pl. III, figs. 1 a, 1 b.

One fragmentary specimen.

2. *Natica* spec. 1. Pl. III, figs. 2, 2 a.

One specimen, height 21 mm.

3. *Natica* spec. 2. Pl. III, fig. 3.

7 specimens, the largest (fig. 3) 16 mm in height.

4. *Natica* spec. 3. Pl. III, fig. 4.

One specimen, 10 mm in height.

5. *Nassa* spec. Pl. III, figs. 5, 5 a.

One specimen, 17 mm in height.

6. *Nuculana* spec. 1. Pl. III, figs. 6, 6 a, 7.

14 specimens. The largest specimen (the original of figs. 6 and 6 a) is 6.5 mm in length, 4 mm in breadth and 3 mm in crassitude.

7. *Nuculana* spec. 2. Pl. III, figs. 8, 8 a 8 b.

3 specimens. The largest one (reproduced in Pl. 1) measures 6 mm in length, 5 mm in breadth and 3.5 mm in crassitude.

8. *Astarte* spec. Pl. III, fig. 9.

One specimen. Length 27 mm, breadth 22 mm, crassitude 12.5 mm.

9. *Lucina* spec. Pl. III, figs. 10, 10 a, 11.

The shell has no teeth, as was made evident from a section ground by me. There are 33 specimens, the largest attaining a length of 16.5 mm and a breadth of 15 mm.

10. *Thyasira bisecta* CONRAD. Pl. IV, figs. 14, 14 a, 15, 16, Pl. V, figs. 18, 19, 19 a, 20, 20 a.

1850. *Venus bisecta* CONRAD: U. S. Explor. Exp. 10 Geology. New York, p. 724, pl. 17, fig. 10.
1864. *Thyatira? bisecta* MEEK: Checklist Invertebr. foss. N. Amer. Miocene. Smithson. misc. coll. 183. Washington, p. 8, 29.
1865. *Cyprina bisecta* CONRAD: Amer. Journ. Conch. 1, 1865, Philadelphia p. 153.
1866. *Cyprina bisecta* CONRAD: Check list Invertebr. foss. N. Amer. Eocene and Oligocene. Smithson. misc. coll. 200, vol. 7. Washington, p. 6.
1869. *Conchocele disjuncta* GABB: Pal. Calif. 2, p. 27, pl. 7, fig. 48.
1875. » » SCHMIDT: Z. deutsch. geol. Ges. 27, Berlin, p. 713.
1891. *Cryptodon bisectus* DALL: Proc. U. S. Nat. Mus. 14, Washington, p. 189.
1895. *Cryptodon bisectus* » Proc. U. S. Nat. Mus. 17, Washington, p. 713, pl. 26, figs. 2, 5.
1901. *Thyasira bisecta* DALL: Proc. U. S. Nat. Mus. 23, Washington, p. 789, 817.
1902. *Conchocele disjuncta* SCHMIDT: Geogr. Journ. 19, London, p. 754.
1903. *Thyasira bisecta* DALL: Trans. Wagner Free Inst. of Sci., Philadephia, vol. 3, pt. 1903, p. 1340.
1909. *Thyasira bisecta* DALL: U. S. Geol. Survey, Prof. Papers no. 59, Washington, p. 118.
1921. *Thyasira bisecta* DALL: Bull. 112 U. S. Nat. Mus. Washington, p. 33.

Mr. LEWIN's material contains no less than 84 specimens and 10 single valves of this species. The largest specimen has a length of 85 mm.

This is the largest species of the genus. DALL (1901) gives its length to be about 80 mm (fossil specimens). Specimens from the miocene at Astoria, Oregon, are stated by CONRAD (1850) to be »two inches» in length. Living specimens attain, according to DALL, a length of 77 mm, in Pudget Sound, and 50 mm, S. of Alaska Peninsula. They are, consequently, larger in warm districts than in cold ones. The considerable size of specimens from the Spitsbergen Tertiary thus would possibly be interpreted as implying that a warmer climate than that of Pudget

Sound (Washington) nowadays were prevailing in Spitsbergen when this species existed there. A comparison between the average air temperatures at Seattle, situated near Pudget Sound and at Ice Fjord on the west coast of Spitsbergen gives the following table (HANN 1911):

| | Seattle | Ice Fjord |
|---|---|---|
| Coldest month | + 4.3° C. | — 18.5° C. |
| Warmest » | + 17.7° C. | + 4.6° C. |
| Average pr annum | + 10.6° C. | — 6.2° C. |

The difference between the average temperatures of year in the vicinity of Pudget Sound and in Spitsbergen is, consequently, 16.8° C. As, in the Tertiary, the species was larger in Spitsbergen than it is now in Pudget Sound, we may draw the conclusion that the average annual temperature in Spitsbergen would have been more than 16.8 degrees higher than now, when the species existed there. HEER held the opinion that the Tertiary flora in Spitsbergen indicated an annual average temperature in that country of + 9° C. As high an average temperature pr annum as above 10.6° C. can hardly have been prevailing in Spitsbergen during another period of the Tertiary than its warmest epoch, the Eocene; certainly it did not prevail in the Neogene.

Of the present species there are preserved in the Riksmuseum 2 specimens from the Tertiary of Saghalien. They are determined by FR. SCHMIDT as *Conchocele disjuncta* GABB. The largest of them is 83 mm in length. The smaller one has been reproduced by me for comparison (Pl. V, figs. 20, 20 a).

In preparing the specimens from the Spitsbergen Tertiary I have made out that their hinge is without teeth.

According to DALL the species occurs living partly S. of Alaska Peninsula, 69 fathoms (= 124 m) at a temperature of 44° F. (= 7° C.), partly in Pudget Sound, 133 fathoms (= 239 m). It is found fossil in the Miocene at Astoria, Oregon, and in the upper Miocene at Seattle, Washington. In the Pliocene it has been found at S. Pedro (California), in Japan, Saghalien and at Taui on the west coast of the Sea of Okhotsk, the three last-mentioned statements according to SCHMIDT 1875 and 1902. Thus it has been found neither living nor fossil without the Northern Pacific.

Akin species are living on the Californian coast, in the Gulf of California, on the Patagonian West coast and in the Straits of Magellan. During the Cretaceous period a closely related species, *Th. Townsendi* WHITE, lived in the Straits of Magellan and on the west coast of Graham Land (WILCKENS). The division of the genus *Thyasira* to which *Th. bisecta* belongs thus has had a distribution from Graham Land to Spitsbergen via the west coast of America. Nowadays it has disappeared from the uttermost outposts, Graham Land and Spitsbergen, that is from

the coldest districts of its former range. The division is now entirely lacking in the Antarctic and the Arctic Regions. The coldest tracts where it lives now, are the Straits of Magellan and S. E. of Alaska Peninsula. In this connection it may be of interest to recollect the fact that *Pleuroleura Walteri* KRAUSE, a marine gastropod which lives nowadays on Spitsbergen and N. E. Greenland (from where it was brought back by the KOLTHOFF-Expedition; HÄGG 1905), belongs to a genus which is, for the remaining species, known only from the Indopacific.

11. *?Kellia* spec. Pl. III, figs. 12, 12 a, 12 b.

One specimen, 3.5 mm in length.

12. *Xylophaga* spec. Pl. III, figs. 13, 13 a, 13 b, 13 c.

Two specimens. The length of the largest is 21.5 mm.

13. *Lamellibranchiate* 1. Pl. V, figs. 21, 21 a.

One specimen, 12 mm in length.

14. *Lamellibranchiate* 2. Pl. V, figs. 22, 22 a.

One specimen, 10 mm in length. It belongs probably to the same genus as the preceding species.

15. *Galathea* spec. Pl. VI, figs. 28, 28 a.

One fragment.

## Description of the Material collected by Mr. H. L. Norberg and by certain Swedish Expeditions.

In this connection I find it opportune to record a lot of Lamellibranchia from the Tertiary of Spitsbergen, which, since long, have been stored in the Riksmuseum. Except four specimens these have not been mentioned by RAVN nor any other author. Most of them are collected by Mr. H. L. NORBERG in 1913 in three localities S. of the Ice Fjord.

One of these localities, according to NORBERG's labelling, is situated »about 15 m above the uppermost coal layer, arctic coal comp. layer C». Judging from a map-sketch drawn by Mr. NORBERG this locality seems to be the same as RAVN's loc. 1. This is named by RAVN Flower Valley in spite of the fact that another valley, in Sassen Bay, has got the same name previously (CONWAY, DUBOIS). The rock is a sandstone belonging to series 1.

The second locality is labelled by NORBERG as »solid alp at the strand within Coles Bay, layer B.» Probably it is the locality 5 of RAVN.

The rock is a sandstone. From this place NORBERG also collected a slab of a conglomerate that Dr. T. HAGERMAN considers to belong possibly to the upper part of series 1.

The third locality is designed on NORBERG's label as »Fossil Fjeld». By this name evidently Mt. Fossil is meant. From that locality no animal fossils nor marin Tertiary remains have been recorded. In the Riksmuseum collections, further, there is kept a slab labelled »Spitsbergen, the summit of Mount Fossil, Green Harbour, by H. NORBERG 1912». In this slab there are remains of indeterminable mussels. The summit of Mt. Fossil lies 825 m above the sea level. In the Riksmuseum there are present, too, some plant fossils from Mt. Fossil, likewise collected by NORBERG. From the fact that no fossil plants have been found in series 5, and on account of the level above the sea it seems probable that the mussels in question come from series 6. As yet there are no reports at all on finds of animals or marine fossils from that series.

NORBERG's mussels from Mt. Fossil, beside the species of *Cyprina*, dealt with by me further on, form remains of 3 further species of Lamellibranchia. These are, unfortunately, undeterminable. One of them reminds one of a *Cyrena*. The rock is a sandstone with chert balls and pieces of coal. The chert balls recall the Permo-carbonic chert in series 4. The rock from the summit of Mt. Fossil is of a similar nature.

In this paper I have also mentioned a specimen of *Cyprina* taken during NATHORST's and DE GEER's expedition in 1882, which specimen is not included in the work of RAVN or else reported.

Finally, I have recorded 4 specimens belonging to as many species of mussels mentioned by RAVN. These are: *Cyprina* sp. 1, *Solenocurtus (Novaculina?)* sp., *Solenocurtus (Macha)* sp., and *Solenocurtus (Tagalus?)* sp.

## Description of the Species.

### 1. *Cyprina* spec. 1. Pl. VI, fig. 23.

1922. *Cyprina* sp. RAVN: Moll. Tert. Spitsb. p. 20.

Two valves of a single specimen. Locality: Mt. Brongniart. Block of sandstone. A. G. NATHORST 1898. The specimen which has been described by RAVN but not reproduced, is supposed by him to come from NATHORST's series 5? FUCHS has not reported this specimen in his publication, though he has put a label with the name *Cytherea* to the original. The find is not mentioned by NATHORST 1910.

### 2. *Cyprina* spec. 2. Pl. VI, fig. 24.

One cast, entirely without shell remains. Its length is 56 mm, and its height 41.5 mm. Locality: E. of Coles Bay. NATHORST's and DE GEER's expedition 1882. Sandstone.

The specimen was not mentioned by RAVN nor by any other author. It derives from NATHORST's series 1. FUCHS has neither mentioned nor labelled this specimen.

### 3. *Cyprina* spec. 3. Pl. IV, fig. 17.

One cast with fragments of the shell. Its length is 31 mm, and its height 21.6 mm. Locality: Mt. Fossil. H. L. NORBERG 1913.

Concerning rock, age etc. see p. 49.

### 4. *Meretrix (Callista) Nathorsti* RAVN.

1922. *Meretrix (Callista) Nathorsti* RAVN: Moll. Tert. Spitsb. p. 22, pl. 2, fig. 7.

Locality 1: Western side of Advent Bay, about 15 m above the uppermost coal seam, layer c. H. L. NORBERG 1913. Concerning rock, age etc. see p. 48.

8 casts without shells. The largest one has a length of 85 mm and a height of 43 mm.

Also RAVN mentions the species from this same locality.

Locality 2: on the shore inside Coles Bay, in place.

4 casts without shells. The largest has a length of 92 mm and a height of 52 mm. The largest specimen reported by RAVN has a length of only 65 mm. Concerning rock, age etc. see p. 48.

Also RAVN mentions the species from this same locality.

### 5. *Meretrix (Dosiniopsis) orbicularis* EDWARDS.

1852. *Cytherea orbicularis* EDWARDS; MORRIS: Fossil shells, p. 265, pl. 16, fig. 5.
1904. *Dosiniopsis orbicularis* EDWARDS; COSSMAN & PISSARO, Iconogr. eocène. Paris, fasc. 1, pl. 12, figs. 52, 53.
1922. *Meretrix (Dosiniopsis) orbicularis* EDW. sp?; RAVN: Moll. Tert. Spitsb., p. 20, pl. 1, fig. 10.

Two casts totally without any traces of shells. The largest specimen is 43.5 mm in length and 35.5 mm in height.

Locality: On the shore inside Coles Bay, in place, layer b. H. L. NORBERG 1913. Concerning rock, age etc. see p. 48.

The species is not reported by RAVN from this locality, but is new to it.

### 6. *Meretrix pyriformis* RAVN.

1883. *Terebratula* sp? FUCHS: Tertiärconch. Spitsb. p. 21, pl. 2, fig. 3.
1922. *Meretrix pyriformis* RAVN: Moll. Tert. Spitsb. p. 21, pl. 2, fig. 3.

Locality 1: Western side of Advent Bay, about 15 m above the uppermost coal seam, layer c. H. L. NORBERG 1913.

One cast without any trace of shell. Its length is 56 mm and its height 38 mm.

Considering rock, age etc. see p. 48.

RAVN reports the species from this same locality.

Locality 2: at the shore inside Coles Bay in solid rock, H. L. NORBERG 1913.

Two casts without all traces of shell. The largest has a length of 82 mm and a height of 64 mm. It is larger than RAVN's biggest specimen, which has a length of 75 mm.

Considering rock, age etc. see p. 48.

RAVN reports the species from this locality.

### 7. *Solenocurtus (Macha)* spec. Pl. VI, fig. 26.

1910. *Psammosolen* FUCHS in NATHORST: Beitr. Geol. Spitzb. p. 378. (partim).
1922. *Solenocurtus* n. sp. RAVN: Moll. Tert. Spitsb. p. 25 (partim).

Two casts without shell belonging to one single specimen.

Locality: Mt. Brongniart in a block. A. G. NATHORST 1898.

RAVN has written about the present specimen but not figured it. He considers that it may perhaps belong to a species distinct from his »*Solenocurtus* n. sp.» The rock which is a sandstone, is held by RAVN to belong to NATHORST's series 5?

### 8. *Solenocurtus? (Novaculina?)* spec. Pl. VI, fig. 27.

1883? *Psammobia* sp. FUCHS: Tertiärconch. Spitzb. p. 7.
1922. *Solenocurtus (Novaculina?) spitsbergensis* RAVN: Moll. Tert. Spitsb. p. 26 (partim).

Two casts without shell belonging to one single specimen. Its length is 33.5 mm and its height 14.5 mm. The specimen was previously mentioned but not figured by RAVN, who is of the opinion that it possibly belongs to *Solenocurtus (Novaculina) spitsbergensis* RAVN.

Locality: Mt. Hierta. A. G. NATHORST 1882. The rock is a sandstone and belongs to NATHORST's series 5.

### 9. *Solenocurtus (Tagalus?)* spec. Pl. VI, fig. 25.

1883. *Pharella* spec. FUCHS: Tertiärconch. Spitzb. p. 7.
1922. *Solenocurtus (Tagalus?)* sp. RAVN: Moll. Tert. Spitsb. p. 26.

Locality 1: East of Coles bay. A. G. NATHORST 1882.

Two casts without traces of corresponding valves belonging to one single specimen. Its length is 56 mm and its height 18 mm. It has been

mentioned by RAVN but not reproduced. The rock which is a sandstone, belongs to NATHORST's series 1.

Locality 2: At the shore inside Coles Bay, in solid rock. H. L. NORBERG 1913. Two casts belonging to one single specimen. Every trace of shell is absent. The length of the specimen is 38 and the height 12 mm. Considering rock, age etc. see p. 48.

## Conclusions.

A comparison between the fossils of Mr. LEWIN's material on the one hand and, on the other, all remaining marine material known from the Tertiary of Spitsbergen, makes evident that both have no species and only one genus *(Lucina)* in common. Nevertheless Mr. LEWIN's material counts 15 distinct species allotted to 11 genera, and the remaining marine material is formed by 16 species (including 2 not previously mentioned and 2 not discriminated by RAVN as distinct species) belonging to 6 genera. Also in another respect a great difference is to be observed. Mr. LEWIN's material comprises 5 species of gastropods, 9 species of lamellibranchs and 1 decapod crustacean. The remaining material is represented exclusively by mussels (leaving out of consideration the inconspicuous and indeterminable fragments of gastropods belonging to the Riksmuseum collections and only mentioned by NATHORST). Mr. LEWIN's collection contains only one species, *Thyasira bisecta*, found elsewhere, viz. from Miocene to recent time within the northern Pacific. The remaining material contains 4 species known from Paleogene deposits of England, France, Belgium and Ural Mountains.

RAVN has shown that the fauna from the tertiary deposits mentioned above which has not been brought back by LEWIN indicates the end of the Paleocene and the time nearest after.

The occurrence of *Thyasira bisecta* in LEWIN's collections refers them to the Neogene. As mentioned on p. 47 the species is larger in the Tertiary of Spitsbergen than as alive. As the species is, in recent time, larger in southern than in northern parts of its area, the inference might be drawn that the climate of Spitsbergen was warmer during the Tertiary period than it is now at the southern boundary of that area of distribution. From my argumentation on p. 47 it followed that the average annual temperature in Spitsbergen during the time when *Thyasira bisecta* lived there, would be higher than 10.6 C. = above 16.8 C. higher than in recent time. I also pointed out the probability that so high a temperature cannot have prevailed during another time than the Eocene, the warmest tertiary period, and certainly not during Neogene. Of course, conclusions drawn about the climate on account of comparisons of the mere size of a single species will be rather hypothetical, the more so, if we consider the considerable remoteness of the periods here in question. But the scant

material does not allow of any more positive statements. That the age of the new material belonging to Mr. LEWIN's collections must be estimated higher than the Neogene is corroborated also by the mass of the new species yielded. It is remarkable that Mr. LEWIN's material, which according to all facts available, seems to belong to NATHORST's series 3, does not contain any lacustrine mussels, which are, indeed, rather characteristic of that series (5 species of *Cyrena* against only 2 marine lamellibranchs). It is to be observed, further, that the fossils in question lie in a limestone, a rock which is totally absent in the remaining Tertiary of Spitsbergen. Conclusively, this material, both in faunistical and petrographical characters, differs from all previously known tertiary remains from Spitsbergen, and its exact relations implie a problem solvable only by further research.

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# Explanation of the Plates.

## Plate III.

Fig. 1, 1 a, 1 b. *?Gibbula*, 1 nat. size, 1 a × 3, 1 b × 3.
Fig. 2, 2 a. *Natica* spec. 1, nat. size.
Fig. 3. *Natica* spec. 2, nat. size.
Fig. 4. *Natica* spec. 3, nat. size.
Fig. 5, 5 a. *Nassa* spec., 5 nat. size, 5 a × 2.
Fig. 6, 6 a. *Nuculana* spec. 1, 6 nat. size, 6 a about × 3.
Fig. 7. *Nuculana* spec. 1, about × 3. The bright in the hinge margin is a remnant of the shell (the teeth), the dark zigzag line is rock filling between the teeth.
Fig. 8, 8 a, 8 b. *Nuculana* spec. 2, nat. size and × 3.
Fig. 9. *Astarte* spec., nat. size.
Fig. 10, 10 a, 11. *Lucina* spec., nat. size (10, 11) and × 2 (10 a).
Fig. 12, 12 a, 12 b. *?Kellia* spec., nat. size and × 3.
Fig. 13, 13 a, 13 b, 13 c. *Xylophaga* spec., nat. size and × 2.

## Plate IV.

Fig. 14, 14 a, 15, 16. *Thyasira bisecta* Conrad, nat size; fig. 15 a specimen with the left valve exceeding above.
Fig. 17. *Cyprina* spec. 3. nat. size. Riksmuseum, Stockholm.

## Plate V.

Fig. 18, 19, 19 a. *Thyasira bisecta* Conrad, from Spitsbergen, nat. size.
Fig. 20, 20 a. The same, from Saghalien, nat. size. Riksmuseum, Stockholm.
Fig. 21, 21 a. Lamellibranchiate 1, nat. size and × 2.
Fig. 22, 22 a. Lamellibranchiate 2, nat. size and × 2.

## Plate VI.

Fig. 23. *Cyprina* spec. 1, nat. size. Riksmuseum, Stockholm.
Fig. 24. *Cyprina* spec. 2, nat. size. Riksmuseum.
Fig. 25. *Solenocurtus (Tagalus?)*, nat. size. Riksmuseum.
Fig. 26. *Solenocurtus (Macha)* spec., nat. size. Riksmuseum.
Fig. 27. *Solenocurtus? (Novaculina?)* spec., nat. size. Riksmuseum.
Fig. 28, 28 a. *Galathea* spec., nat. size and × 3.

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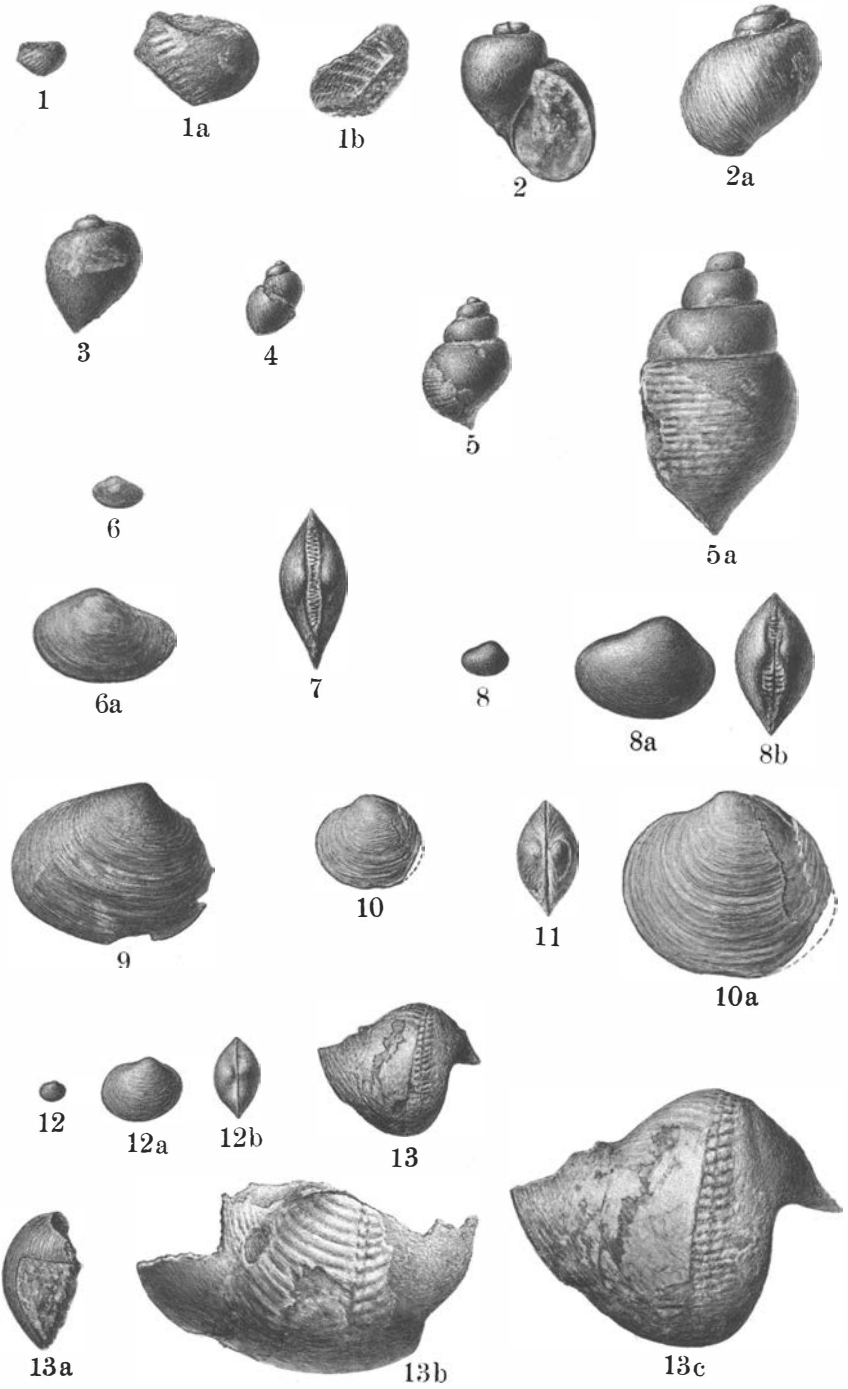


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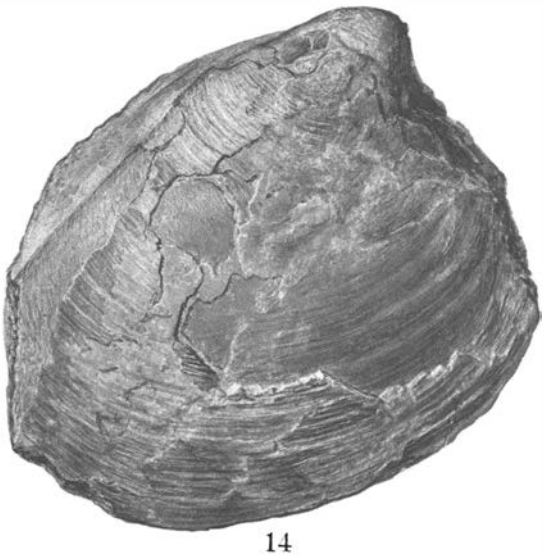

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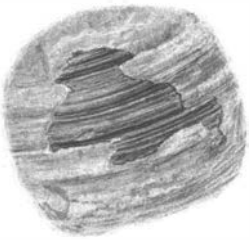

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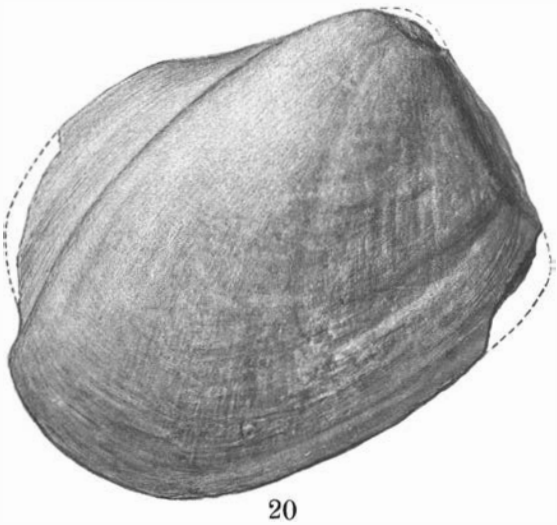

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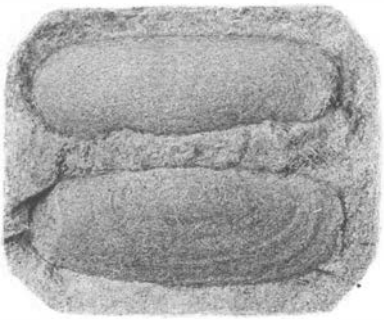

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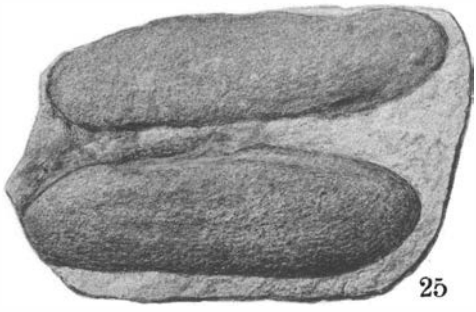

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