

## On some vertebrate fossils from Gotland with some comments on the stratigraphy

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With 1 plate and 2 figures in the text

During his field work in Gotland the last two summers (1948—1949), the author also found some remains of vertebrates in two new localities (Fig. 1). In one of these localities, Lau Backar, a large number of samples were taken from layers which might be expected to contain vertebrates. The samples were treated with diluted acetic acid in order to dissolve the carbonates. The insoluble rest of several kg. of rock contained some 20 scales, some indeterminable remains of vertebrate hard tissues, and also a large number of phosphatic pieces of invertebrates, chiefly Brachiopods, Bryozoans, Conodonts, and Phyllocarids.

The other new locality is a small grinding-stone quarry in the Burgsvik sandstone, approximately 1.5 km. south of Grötlingbo railway station, at Sallmunds in the parish of Grötlingbo (Fig. 2). The vertebrate fossils found in this quarry are relatively large fragments of Cephalaspids and other lower vertebrates. All the vertebrate fossils occur in one layer of sandstone which is rich in clay pellets. The bedding is quite irregular and the layer has possibly been exposed to prediagenetic movements (subaqueous slides). This rock is unsuitable as a grinding-stone, and is consequently discarded in the quarry. *Homalonotus knighti* and *Dolerorthis rustica* are the only invertebrates met with in the vertebrate-yielding layer.

### Description of fossils

#### Indeterminable Cephalaspid

(Pl. I, figs. 8—9)

The largest specimen found at Grötlingbo is a fragmentary ventral rim of a Cephalaspid, indeterminable as to species, genus and family. The cephalic shield to which the rim belonged must have been about 6 cm. broad, and is consequently the largest one so far met with in the Baltic area. Some minor fragments found show an ornamentation similar to that of the ventral rim.

#### Acanthodian scales

(Pl. I, figs. 6—7)

The vertebrate material from Lau Backar comprises about 10 Acanthodian scales belonging to the *Nostolepis* type and the *Gomphodus* type (GROSS 1947).

The first type is represented by a single, small scale. The scales of the *Gomphodus* type vary a good deal with regard to the height in an apico-basal direction. The constriction between the base and the crown may be more or less pronounced. All the *Gomphodus* scales discussed here have a smooth crown.

### **Coelolepid scales**

(Pl. I, figs. 1-5)

The material available contains at least 11 Coelolepid scales, 10 of which are from Lau Backar, while one comes from Grötlingbo. They are of different types, some of them resembling the *Lanarkia* type (Pl. I, Fig. 4). The single scale from Grötlingbo is suggestive of the one shown in Pl. I, Fig. 2, but has well-marked grooves and ridges on the constriction between the base and the crown.

### **The invertebrate fauna**

The invertebrate fauna associated with the vertebrates has not been studied in detail as yet. As the few invertebrates found at Grötlingbo have already been mentioned, the following description refers only to the fauna at Lau Backar. Only those of the fauna elements which have phosphatic, silicified or chitinous skeletons are dealt with here. The other faunal elements which have a calcareous skeleton have not been studied. They are chiefly Bryozoans and Brachiopods.

#### **Foraminifera**

Agglutinating foraminifera were observed. Most of the fragile specimens have been damaged, but some are well preserved. They belong to several different types, some of them resembling *Thurammina* and *Sorosphaera*. They may, however, possibly not belong to the genera mentioned, and the lack of well-preserved specimens excludes a closer determination.

#### **Polychaete jaws**

Only some few Scolecodonts have been found. They belong to the genus *Lumbriconereites* HINDE.

#### **Inarticulate Brachiopods**

Several fragmentary valves of inarticulate Brachiopods occur in the material. Some of them belong to the genus *Lingula*, others are thick-valved, with coarse, semi-concentric ridges.

#### **Bryozoans**

The material from Lau Backar contains numerous small, more or less spherical bodies, which are globules of bryozoans (see OAKLEY 1934). Such globules occur commonly in many members of the *Ceramoporidae*. In this case it is of

course impossible to determine from which species the globules come. Two species of globule-bearing Ceramoporids are met with in the vertebrate-yielding layer, *Favositella* sp, and *Spatiopora irregularis* HENNIG, but it is probable that the free globules were deposited secondarily.

The larger globules are of an order of size similar that of the Acanthodian scales (0.25–0.50 mm), and often resemble rounded Acanthodian scales as regards their colour and shape. The chemical composition of the globules is the same as that of bone (Carbonate apatite, OAKLEY 1934). Probably because of this, they stain in the same manner as does the vertebrate hard tissue (with methylene blue, picro-fuchsine, and malachite green), and they may therefore be mistaken for corroded fish-scales. Generally, it is very easy to distinguish between globules and scales in thin sections. In some cases, however, the preservation of the internal structures of the scales is poor. Many of the globules have been attacked by algae and "thread moulds" and therefore show canals and small spaces which resemble dentine tubes, bone-cells, etc. These globules and other phosphatic parts of the Bryozoans will be subjected to further study by the author.

### Conodonts

Conodonts occur abundantly. They belong to several "genera": *Ozarkodina*, *Prioniodus*, *Drepanodus*, and others. This fairly rich material will be subjected to a further study.

### Phyllocarids

Some tooth-like bodies, too, were found in the material. Similar bodies have been described by HARLEY (1861) as *Astacodermata* from the Ludlow Bone-bed. HARLEY (l.c.) seems to regard them as Conodonts. In fact, the "genus" *Astacodermata* appears to comprise both Phyllocarids and Conodonts for *A. serratum* and *A. spinosum* are Conodonts, while the other species most likely comprise material of Phyllocarids. In the material from Lau Backar there is also a large *Ceratiocaris*-spine.

### Other fossils

Besides the fossils already mentioned, the author has also found some indeterminate moulds of Ostracods, Lamellibranchs and Gastropods, and a small fragment of a *Pterygotus*.

## Earlier records of vertebrates from the Silurian of Gotland

Up to now, the records of vertebrate remains from the Silurian of Gotland have been very meagre. A Cyathaspid (*Cyathaspis schmidtii* LINDSTRÖM 1896, non GEINITZ 1884 = *Archegonaspis lindströmi* KIAER & HEINTZ 1932<sup>1</sup>) and Coelolepid scales (SÄVE-SÖDERBERGH 1941, p. 237, footnote 2) have been mentioned. The only reference to Acanthodians is by ROHON (1893), who reported *Gomphodus*

<sup>1</sup> The statement of KIAER & HEINTZ (1932) that *Archegonaspis lindströmi* comes from the upper Silurian of Scania, is erroneous. Their figured specimen is the holotype of LINDSTRÖM's description and is from Lau Kanal, Gotland, from layers belonging to the Hemse Group.

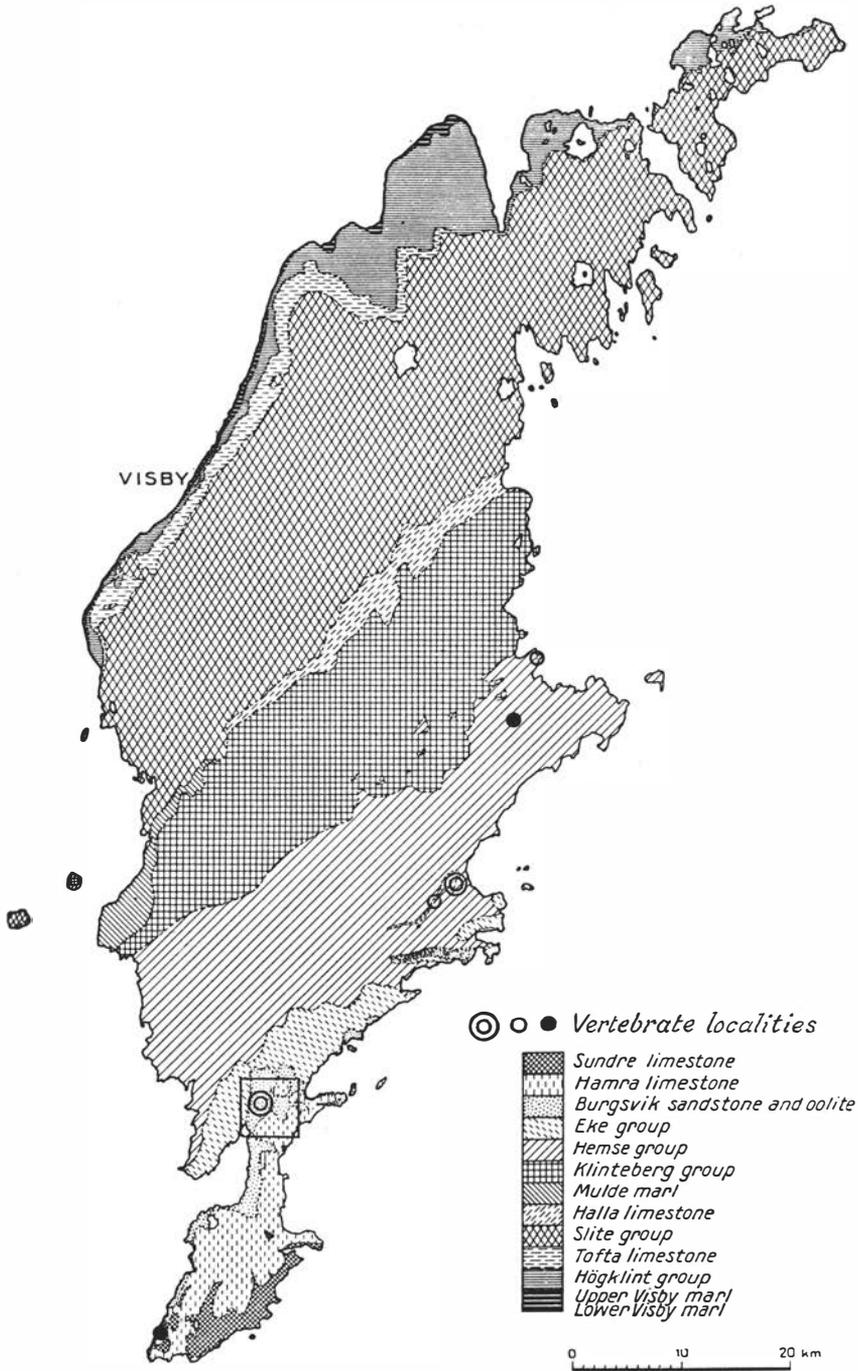


Fig. 1. Geological map of Gotland, showing the distribution of the vertebrate localities. Filled circles indicate uncertain localities, unfilled indicate older, certain ones, and double circles indicate the new localities. The small rectangular area is that shown in fig. 2. The map is from HEDE (1942, fig. 1).

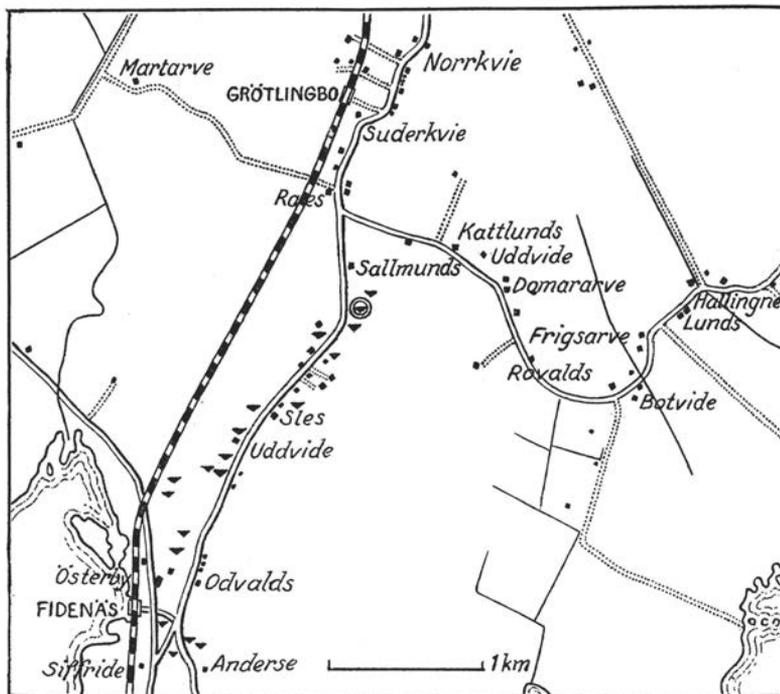


Fig. 2. Map of the new vertebrate locality in Grötlingbo. The quarry is indicated by a double circle. Scale: 1: 50 000. The map is a copy of the geological map "Burgsvik jämte Hoburgen och Ytterholmen", S. G. U. (Swedish Geol. Survey), ser. Aa., nr. 152.

*volborthi* ROHON and a doubtful fin-spine from Hammarudd in the parish of Kräklingbo. The material referred to by SÄVE-SÖDERBERGH (l.c.) from this locality as *Coelolepids*, has been studied histologically by T. ØRVIG, who has informed me that three of the five scales labelled "*Thelolepis glaber*" are from Acanthodians, whereas two are from *Coelolepids*. At least one of the Acanthodian scales belongs to the histological type of *Gomphodus* (*in sensu* GROSS 1947).

The exact stratigraphical position of the vertebrate-yielding layer at Hammarudd in Kräklingbo is unknown, but according to the geological maps (HEDE *et al.* 1929) this layer probably belongs to the middle or lower part of the Hemse Group (Lower Ludlowian).

Besides the records in the literature, the author has found an unpublished note by LINDSTRÖM. In an interleaved specimen of his "List of the Fossil Faunas of Sweden II, Upper Silurian" (1888) he has made some additions including some vertebrates from Gotland:

*Thelolepis glaber*, and *T. parvidens*, Torsburgen and Hammarudd in Kräklingbo (Hemse Group),

*Thelolepis glaber*, Lau Kanal (Hemse or Eke Group),

*Thyestes* sp. Hoburgen d. (Upper, oolitic part of the Burgsvik Group).

Except for the scales from Hammarudd, mentioned above, these fossils have not been reported later on, and are unknown in Swedish museums.

Dr. G. WÄNGSJÖ has informed me that a fragment of a *Dartmouthia* has been brought back from Gotland by an excursion with students from the University of Uppsala. It is preserved in the collections of the Palaeontological Institute of the University of Uppsala; both locality and horizon are unknown.

### Stratigraphical remarks

In the Grötlingbo locality, the geological features are quite simple. The vertebrate-yielding sandstone-layer is approximately one meter below the oolitic limestone, which usually forms the upper part of the Burgsvik Group.

In the Lau District, the geology and stratigraphy are more complicated. This area has been described by MUNTHE (1902) and HEDE (1925). The vertebrate-yielding layer is also found in the well-known profile of Lau Kanal, some 2 km. south-west of Lau Backar. Here, however, the author did not succeed in finding any doubtless vertebrate remains. Stratigraphically, the layers in question, at Lau Backar and Lau Kanal, belong to the lowermost part of the Eke Group, situated just above the Hemse Group. The boundary between these two groups appears, at least in the Lau District, as a discontinuity. This discontinuity is marked by a thin even layer of phosphorite with glauconite. The sediments above and below this phosphorite layer are quite different. The Hemse Group is made up of a soft, grey marl with lenses and thin bands of limestone. Its uppermost part is finely sandy and frequently full of impressions of shells of a brachiopod, "*Strophomena*" *impressa*. The lower part of the Eke Group consists of a brownish-yellow, coarsely crystalline limestone, more or less well stratified. This limestone is composed chiefly of the calcareous parts of fossil invertebrates and algae. The colour seems to be due to small flakes of "limonite" (Goetite), which are abundant. The basal part of the limestone is a coarse conglomerate with pebbles up to 25 mm. in diameter. The pebbles are generally water-worn fossils, chiefly corals and calcareous algae, but some of them consist of more or less marly limestone with fragments of fossils. Thus, it is possible that some of the fossils mentioned earlier are from these pebbles, and consequently are older than the conglomerate. Real terrigenous material (insoluble in acetic acid) is practically absent in the coarser fractions ( $>0.02$  mm); only some few grains of quartz were met with.

This type of rock is very common in the border-zones of the reef-limestones of Gotland, indicating a deposition in shallow water, where the action of the waves was strong, perhaps in the littoral zone of a coral-reef, the upper part of which was above or at least near the surface of the sea.

The age of the Eke Group is probably Middle Ludlowian. Unfortunately, our present knowledge of the fauna of the Eke Group does not permit of a direct and reliable determination of its relative age. It can only be placed between the well determined groups lying above and below it. Of these, the underlying Hemse Group is especially well determined, because of its relatively rich fauna of graptolites (HEDE 1942). It belongs to the Lower Ludlowian and corresponds to the zone of *Monograptus nilsoni* and, perhaps, also to the lower part of the zone of *M. scanicus*. One single specimen of *M. scanicus* has been found 12 m. below the top of the group (HEDE 1919).

## Correlation table

Ösel	Gotland (chiefly Lau District)	Great Britain (type profile)	Scania
K 4 ?	Sundre Limestones Hamra	Downtonian Ludlow Bone-bed	Öved-Ramsåsa Group
	Burgsvik Group	Upper Ludlowian	
	Eke Group ? — — — ? — — —	Middle Ludlowian	
K 3	<b>Break</b> in the Lau District — — — ? — — —	zone of: <i>Monograptus tumescens</i>	Colonus
K 2	Hemse Group	zone of: <i>M. scanicus</i>	
		zone of: <i>M. nilsoni</i>	
K 1	Klinteberg Limestone	zone of: <i>M. vulgaris</i>	Shale
	Mulde Marl	Wenlock	

The Burgsvik Group, directly superimposed on the Eke Group, is certainly of Upper Ludlowian age and contemporaneous with the upper Whitcliffe Flags (HEDE 1921; SÄVE-SÖDERBERGH 1941). The comparatively thin Eke Group thus represents a very great space of time (the whole Middle Ludlowian, and parts of Upper and Lower Ludlowian). As the sediments of the Eke Group do not indicate a slower rate of sedimentation than the Hemse and Burgsvik Groups, one may expect one or more breaks in the stratigraphical sequence here. This opinion is also supported by the occurrence of a well-marked surface of discontinuity, and a conglomerate between the Hemse and Eke Groups. This break is observed not only at Lau Backar and in Lau Kanal, but also at Nyudden, Males in När, and at some other localities (MUNTHE 1902).

Since some members of the Upper Ludlowian fauna (*inter alia Homalonotus knighti* and *Retzia bayley*) also occur in the Eke Group, it is likely that this group belongs to the upper part of the Middle Ludlowian, or even to the lower part of the Upper Ludlowian. Therefore the break may be expected chiefly to lie below the Eke Group, represented by the surface of discontinuity between the Eke and Hemse Groups.

If this suggestion is true, it means that the break here referred to, includes not only the zone of *Monograptus tumescens*, but also the greater part of the Middle Ludlowian, and perhaps even the upper part of the zone of *Monograptus*

*scanicus*. Quite a number of local differences occur, however, and a detailed survey of the faunal and sediment-petrographical variations is necessary to solve this problem.

Of course, it is not the author's opinion that this break is common to the whole of Gotland; probably it is only a local phenomenon in the Lau District.

Another thing worth mentioning is that the layers above the Burgsvik Group, the Hamra and Sunde Groups, possibly belong to the basal Devonian (Downtonian). Now, most authors draw the boundary between the Silurian and the Devonian below the Ludlow Bone-bed, and then the uppermost layers of the Silurian will be the Upper Whitcliffe Flags, which are contemporaneous with the Burgsvik Group. Consequently the layers above the Burgsvik Group must belong to the Devonian.

The above stratigraphical table shows the suggested place of the break between the Hemse and Eke Groups. Most of the data are from HEDE (1921, 1942) and SÄVE-SÖDERBERGH (1941).

LIST OF REFERENCES. **Geinitz** 1884. Ueber ein graptolitenführendes Geschiebe mit Cyathaspis von Rostock. Z. d. Deutsch. Geol. Gesellsch., Bd. 36. Berlin 1884. — **Gross** 1947. Die Agnathen und Acanthodier des obersilurischen Beyrichia-kalkes. Palaeontographica. Bd. 96. Abt. A, Liefer. 5—6. Stuttgart 1947. — **Harley** 1861. On the Ludlow Bone-bed and its Crustacean Remains. Quart. Journ. Geol. Soc., vol. 17. London 1861. — **Hede** 1919. Djupborrningen vid Burgsvik på Gottland. Sveriges Geol. Unders., ser. C, nr. 298. Stockholm 1919. — — 1921. Gotlands Silurstratigrafi. Ibid. ser. C, nr. 305. Stockholm. — — et al. 1925. Beskrivning till kartbladet Ronehamn. Ibid., ser. Aa. nr. 156. Stockholm 1925. — — 1929. Beskrivning till kartbladet Katthammarsvik. Ibid., ser. Aa. nr. 170. Stockholm. — **Hede** 1942. On the correlation of the Silurian of Gotland. Medd. från Lunds Geol.-min. Inst., nr. 101. Lund. — **Kiaer & Heintz** 1932. On the Devonian and Downtonian Vertebrates of Spitsbergen. IV. Suborder Cyathaspida. Skrifter om Svalbard og Ishavet. nr. 52. Oslo. — **Lindström** 1895. On Remains of a Cyathaspis from the Silurian Strata of Gotland. Kungl. Svenska Vet.-Akad. Handl. Bihang. Bd. 21. avd. VI, no. 3. Stockholm. — **Munthe** 1902. Stratigrafiska studier över Gotlands Silurlager. S. G. U. ser. C. nr. 192. Stockholm. — **Oakley** 1934. Phosphatic Calculi in Silurian Polyzoa. Proc. Roy Soc., Ser. B. vol. 116. London. — **Rohon** 1893. Die obersilurische Fische von Oesel. Theil 2. Mem. Acad. Imp. Sci. St. Petersburg. St. Petersburg 1893. — **Säve-Söderbergh** 1941. Remarks on Downtonian and Related Vertebrate Faunas. Geol. Fören. Förhandl., Bd. 63. h. 3. Stockholm.

### Explanation of Plate I

Figs. 1–5. Coelolepid scales from Lau Backar. Middle (?) Ludlowian.

Fig. 1. Scale No. C. 1343. a) seen from above, b) seen from below. 50 x.

Fig. 2. Scale No. C. 1344. a) seen from below, b) seen from the side. 50 x.

Fig. 3. Scale No. C. 1345. a) seen from above, b) seen from below. 50 x.

Fig. 4. Scale No. C. 1346. a) seen from the side, b) seen from above. 50 x.

Fig. 5. Scale No. C. 1347. a) seen from below, b) seen from the side. 50 x.

Figs. 6–7. Acanthodian scales from Lau Backar. Middle (?) Ludlowian.

Fig. 6. Scale No. P. 4383. *Nostolepis*-type. a) seen from above, b) seen from below. 50 x.

Fig. 7. Scale No. P. 4384. *Gomphodus*-type. a) seen from the side, b) seen from below. 50 x.

Figs. 8–9. Indeterminable Cephalaspid from Grötlingbo. Upper Ludlowian.

Fig. 8. Specimen No. C. 1348. Whole specimen. Natural size.

Fig. 9. Same specimen. Frontal part of ventral rim. 4 x.

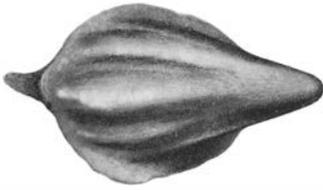
All specimens belong to the Swedish Museum of Natural History, Stockholm.

All specimens photographed by the author, and the photographs retouched by Mr. S. EKBLOM.

Tryckt den 23 oktober 1950

Uppsala 1950. Almqvist & Wiksells Boktryckeri AB

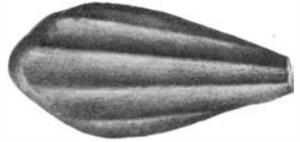
1a



2a



3a



1b



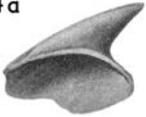
2b



3b



4a



4b



5a



5b



6a



6b



8



7a



7b



9

