GENERAL GEOLOGICAL FRAMEWORK

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In order to understand the variation in thickness, lithology, fauna, and present extent of the Cretaceous in southern Sweden it is necessary to consider its position in relation to the border of the Fennoscandian part of the Fennosarmatian Shield. The border line is known as the Tornquist Line, although this particular term has not been much used in recent years. Actually, Tornquist's presentation (1908) of the border as a line from the Black Sea to Scania appears to be basically correct in its outline. The border structures are comparatively well known in Poland, and knowledge has also accumulated through research in Denmark and Sweden. From Kattegat, the extended Tornquist Line reaches Scania approximately at Helsingborg. Towards the south-east the south-west margin of the Romeleåsen uplift forms one major tectonic line and the Fyledalen fault and flexure line forms another major structure. If the former line is chosen to represent the Tornquist Line, the Ystad-Vomb area (or Rödmölla area) belongs to Fennoscandia, whereas if the latter structure is chosen the Ystad-Vomb area lies west of the Fennoscandian border. A third alternative, which was suggested by the late Dr. F. Brotzen, is that the Tornquist Line cuts off the southern part of the Ystad-Vomb area from the Fennoscandian Shield. Here for convenience the first alternative is chosen.

The margin of the Fennoscandian Shield is markedly disturbed by tectonic events. Part of this margin is distinguished as the Fennoscandian Border Zone by Danish geologists. It seems reasonable to include the whole of the southeast-northwest Scanian mosaic of uplifts and troughs in this border zone, which is therefore extended towards the north-east. An uplift at the northern and north-eastern margin of the Kristianstad area is characterised by a comparatively mature morphology and is probably much older than the uplifts within the border zone.

West of the Fennoscandian border or Tornquist Line, the Danish Embayment forms a basin which was a particularly important regional feature in Mesozoic times.

The geological structure of the area under discussion has been elucidated through work by Brotzen, Bölau, Mohrén, Sorgenfrei, and Voigt. The author is indebted to Walter Kegel Christensen, Erik Norling, and Niels Schröder of Aarhus for discussion and information on the delimitation and geology of the different areas.

The Danish Embayment

Whereas the Cretaceous sediments on the north-eastern side of the Tornquist Line vary considerably in their lithological characters and commonly have a modest thickness, corresponding rocks in the Danish Embayment are lithologically more uniform and commonly form a comparatively thicker sequence. In particular the terrigenic influence is markedly less than in the Fennoscandian Border Zone. The Santonian beds appear to be thickest close to the Tornquist Line in the Ystad-Vomb area.

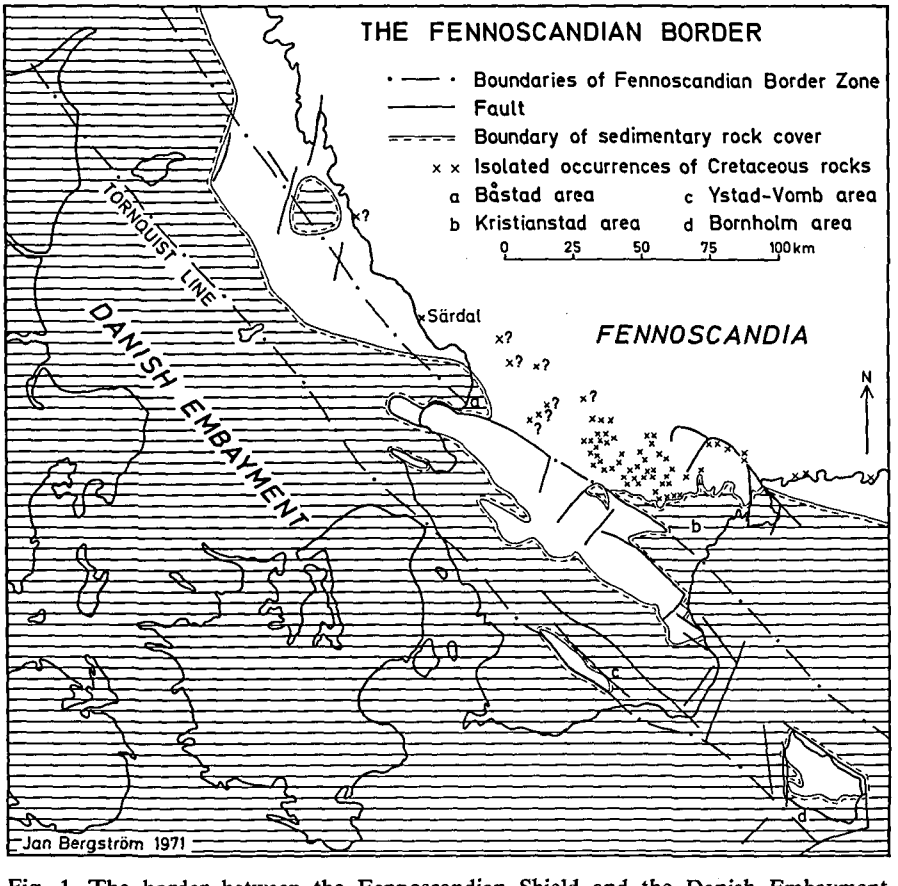

Fig. 1. The border between the Fennoscandian Shield and the Danish Embayment. The map is based largely on published geological, bathymetric, and reflectory data. The isolated area with presumed sedimentary rocks some 50 km NW of Särdal is based mainly on information from Karna Lidmar-Bergström regarding the distribution of Cretaceous rock fragments. The isolated questioned occurrences E of the Båstad area are based on information from Karna Lidmar-Bergström and Christer Johansson. The various boundary lines are not reliable in detail.

When sedimentation conditions throughout the Mesozoic (cf. Larsen, 1966) are taken into consideration, it is obvious that the Tornquist Line (or the whole of the Fennoscandian Border Zone) acted as a dividing line between two regimes with a profoundly different geological evolution—the mainly subsiding Danish Embayment and the essentially stable Fennoscandian Shield. In detail the geological evolution is very complicated because of small and large-scale tectonic movements.

The Fennoscandian margin in southern Sweden and Bornholm

On the north-eastern side of the Tornquist Line, as tentatively drawn in fig. 1, extensive areas with a cover of Cretaceous rocks are known as the Båstad, Kristianstad, Ystad-Vomb (or Rödmölla), and Bornholm areas. The Ystad-Vomb and Bornholm areas have been united into a Vomb-Bornholm area by Brotzen in 1945, but the validity of this unit is questionable. Apart from these occurrences, Cretaceous rocks are known from a large number of small outliers in a belt from the Båstad area, through and north of the Kristianstad area, and into Blekinge from its western boundary to Utklipporna in the south-eastern corner (Moberg, 1886; Troedsson, 1921, 1930 etc.; Lundegren, 1934; Björnsson, 1942; Weimarck, 1942; Eklund in Brotzen, 1948, p. 6; Eklund, 1957; Ringberg, 1971). Additional outliers in the same belt are indicated by a number of local concentrations of erratic material in glaciofluvial deposits and above the Late Glacial marine limit (Lidmar-Bergström & Johansson, 1971). No doubt this indicates occasional extensions of the Cretaceous sea into this belt, possibly in the form of a recurrent strait between the highland of Småland and uplifts in Scania. The majority of the localities reflect a Campanian-Maastrichtian transgressive period. The spatial extent of marine sediments from earlier Cretaceous transgressions is not well known, apparently because the transgressions occurred mainly in areas where the Campanian-Maastrichtian sediments are well preserved and cap the older rocks.

Inside Fennoscandia it is characteristic for Cretaceous rocks to form a comparatively thin cover with varying lithology and commonly include a fair amount of terrigenous material. The Ystad-Vomb area has an exceptional position, as noted above, and the thickness of Cretaceous rocks is also exceptional for an area on the Fennoscandian side of the Tornquist Line. However, the rocks include a noticeable amount of terrigenic material, and the lithologies are unlike those of the central part of the Danish Embayment. The absence of Danian rocks may be due to subsequent denudation (Brotzen, 1938).

On the Fennoscandian side of the Tornquist Line Cenomanian rocks are

known from the Båstad area, Åhus in the Kristianstad area, and south-west Bornholm. In the Båstad area the thickness is unknown but is at least a few metres. The thickness may be 14 m at Åhus (Christensen, 1970 a), while it is considerably thicker on Bornholm, in the order of 100 m. In all three areas greensand forms an essential part of the sequence. At Tormarp in the Båstad area the base consists of a sedimentary breccia (the Tormarp Conglomerate) with gneiss and amphibolite rock pieces cemented by limestone matrix. The limestone is fine grained, light grey, and contains small glauconite grains. Lithologically this limestone is similar to the Cenomanian (?) derived rock fragments at Särdal. It is worth noting that the Cenomanian and also to some extent the preceding Albian was characterised by extensive transgressions in northern Denmark, southern Sweden, northern Germany, Poland, and the Russian Platform (cf. Christensen, 1970 a, p. 75).

A stratigraphical revision is necessary before the Santonian sedimentary picture can be made out because several of the supposed Santonian occurrences in Scania appear to be incorrectly dated (Christensen, personal communication). The only previously known occurrence on the Swedish west coast is the Gräsryd boulders in the Båstad area. These boulders consist of a calcarenitic rock; there can be no serious doubt that they are of local origin. In the Kristianstad area Santonian rocks include calcarenites known from an outcrop at Ringeleslätt and 25 m of glauconitic sand at Åhus (Christensen, personal communication). On Bornholm, the Bavnodde Greensand is of Santonian age. As far as can be judged from the scanty evidence, the various Santonian sediments generally form a fairly thin cover, with an observed maximum thickness of about 180 m (Bavnodde Greensand), except in the Ystad-Vomb area, where the thickness is about 370 m at Köpingsberg and 480 m at Kullemölla (Norling, personal communication). However, as discussed above, it is not certain that the Ystad-Vomb area belongs to the Fennoscandian Border Zone. Evidently the Santonian transgression was preceded by a middle or late Cenomanian transgression in the same areas (Christensen, 1970 a, b) and by a succeeding Turonian-Coniacian regression (the Turonian or Coniacian Arnager Limestone on Bornholm may indicate a minor transgression).

With regard to both sediments and extension, the Santonian transgression in southern Sweden may have been fairly similar to the Campanian-Maastrichtian transgression as outlined on the map by Grönwall in 1912.

The bottom of Kattegat

The Tornquist Line may be traced fairly accurately from the south-east into Scania, where it is associated with large-scale faults and flexures. Its

north-eastern side, the Fennoscandian Border Zone, is characterised by the development of uplifted ridges and intervening grabens trending either NW-SE or NE-SW. To the north-west, in Kattegat, the existence of this border zone is indicated by several shoals, such as Stora Middelgrund and Lilla Middelgrund, Korallgrundet, and Groves Flak. These shoals appear to contain Precambrian rocks close to the surface (cf. Mörner, 1969, pp. 29–33 and maps) and therefore may represent uplifts. The sharp boundary between Fennoscandia and the Danish Embayment fades towards the north-west, and at Skagen and in Skagerak the surface of the Precambrian basement slopes fairly gently towards the south-west (Flodén, 1970). In Skagerak the border of the sedimentary cover towards the east is a very distinct cuesta or escarpment. East of this escarpment there is evidently no continuous sedimentary cover, although there may be small patches not visible in the reflection diagrams (Flodén, 1970). West of the escarpment the sedimentary cover increases regularly in thickness and reaches several hundred metres not far from the border.

Southwards the escarpment may be traced into the northern part of Kattegat, where the pattern is complicated by probable uplifts represented by various shoals. As a result of the complicated tectonic pattern, the boundary between a western area with sedimentary cover and an eastern area with Precambrian rocks in the surface is anything but a straight line. Instead, it appears that the rock surface in the Fennoscandian Border Zone is a mosaic somewhat similar to that found within the border zone in Scania. The arrangement is not well known in detail, although some fault blocks may be recognized morphologically; some of them are delimited by NNE-SSW fault lines.

North-east of the mosaic of the Fennoscandian Border Zone there may still be a cover of sedimentary rocks, at least locally, as indicated by the existence of autochthonous Cretaceous rocks both at Särdal and in the Båstad area. There is reason to suppose that the extent of Cretaceous rocks is much larger than the area of these occurrences. It should be stressed that the sequence might be expected to be more condensed than in the Danish Embayment because of the general difference between this area and Fennoscandia with regard to the geologic evolution in the Mesozoic. Therefore the cover of Upper Cretaceous rocks may have been comparatively thin from the beginning even if several or all of the stages were represented. This means that much of the Upper Cretaceous sequence may be represented even in small patches of rocks.