

THE QUATERNARY STRATIGRAPHY AND DISLOCATIONS ON VEN

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Abstract. The author's investigations on the island of Ven in the Øresund strait show that the grey clay is a marine deposit and probably of late Eemian age. The grey clay and the overlying formation of stratified sand were dislocated by the movement from the east of the North-East Ice. Later the Young Baltic Ice partly eroded the dislocated formations and left a moraine discordant on the grey clay and the stratified sand.

Ven, with its exposed cliffs, provides good opportunities of studying the progress of geological events during the last part of the Quaternary Era (Fig. 1). The Quaternary stratigraphy of the area and the disturbances of the layers were described by Erdmann (1873, 1874, 1881 and 1883) and by Holmström (1874). Munthe (1896) described the grey fragmental clay with boulders and noted that it was overlain by at least one moraine. The deposit was interpreted as being a marine sediment, on account of the mollusc shells found in the clay. On the basis of the fossils found by Munthe, Ødum (1933) considered that the grey clay belonged to the Skærumhede Series, which he regarded as Eemian. Wennberg (1949) thought that the grey clay was the North-East Moraine. Johnsson (1956) supposed that the grey clay was overlain by the North-East Moraine observed on Ven as well as in claypits at Sundvik. Above the North-East Moraine, stratified sand is overlain by the Lower Baltic or Young Baltic Moraine. Markgren (1961) thought that the dislocations had arisen as a consequence of pressure from the south caused by the Young Baltic Ice on its way up through Øresund. Johnsson (1962) suggested that the grey clay had been deposited in a glacial lake between the melting North-East Ice to the north and the advancing Øresund glacier to the south. He also thought that the dislocations had been caused by the Øresund glacier.

The following account presents the results of the author's field work on Ven during the summers of 1970 and 1971. The author confirmed the Quaternary stratigraphy of Johnsson (1956). The Quaternary deposits

were observed to be undisturbed at the southernmost point and also on the northern coast of the island.

The grey clay, with a thickness exceeding 14 m, consists of relatively poorly sorted fine sand, silt and clay. Furthermore the deposit contains scattered, slightly rounded blocks and boulders, mainly of granite and gneiss. The grey clay contains a foraminifera fauna corresponding to the transition between the *Turritella terebra* Zone and the *Abra nitida* Zone in the Skærumhede Series and indicating boreo-arctic conditions (Anne-Lise Andersen, personal communication, 1972). The Skærumhede Series is considered to belong to the Eemian and Early Weichelian (Feyling-Hansen *et al.*, 1971).

On Ven, the grey clay and the overlying formation, consisting of more than 10 m of stratified silt, sand and gravel, are clearly dislocated in several exposures (Fig. 1).

In order to interpret the exact structure of the dislocations, it is necessary to observe the disturbances in the direction of the fold axes. On the southern coast of Ven, it is possible to make these observations. The dislocations are overturned folds traversed by thrust faults with nearly the same orientation as the axial planes of the folds; they are fold thrusts (Fig. 2). No moraine deposits have been observed in the dislocations.

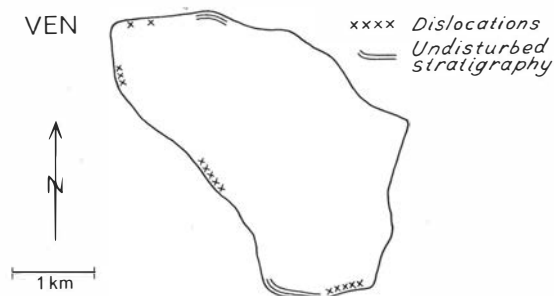


Fig. 1. The exposed cliffs on Ven.

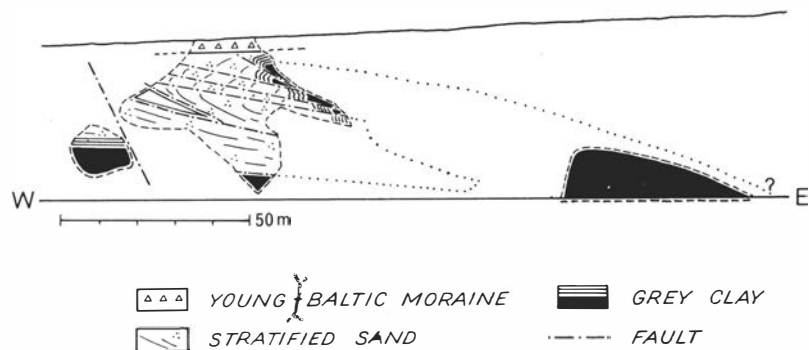


Fig. 2. Dislocations on the southern coast of Ven.

The directions of the fold axes and the orientations of the bedding planes, faults and thrust faults have been measured, and the measurements plotted in stereographic projections. This method of determining ice-movement directions has previously been used by Gry (1940).

The dislocations on the southwestern coast of Ven are presumed to have been caused by a glacier coming from the east-north-east (Fig. 3 upper). The dislocations on the southern coast are considered to have been caused by a glacier coming from the east (Fig. 3 lower).

On account of the preservation of the sedimentary structures, including periglacial features, in the dislocated formations, it is thought that the deposits were perma-frozen at the time of the glacial-tectonic disturbances. The grey clay probably acted as a lubricant for the dislocations, providing an analogy to the Eocene clay at Mols Hoved on Djursland, Jutland (Thamdrup, 1969).

In places where the stratigraphy is apparently undisturbed, for example, on the southernmost point of Ven, two moraine formations have been observed overlying the grey clay and the sand formations. The moraines are usually separated by a horizon of scattered blocks and boulders and locally by stratified sand. At the southernmost point of Ven, block-orientation analyses in the two moraines have been made. In the lower moraine the blocks have a north-east orientation, while the blocks in the upper moraine have a northerly orientation (Fig. 4). In agreement with Johnsson (1962), the lower moraine is regarded as the North-East Moraine and the upper moraine as the Young Baltic Moraine.

It is the author's opinion that the dislocations were formed as a consequence of an oscillation during the passage of the North-East Ice. Consequently the Young Baltic glacier left a moraine discordantly overlying the folded and faulted pre-North-East Ice sedi-

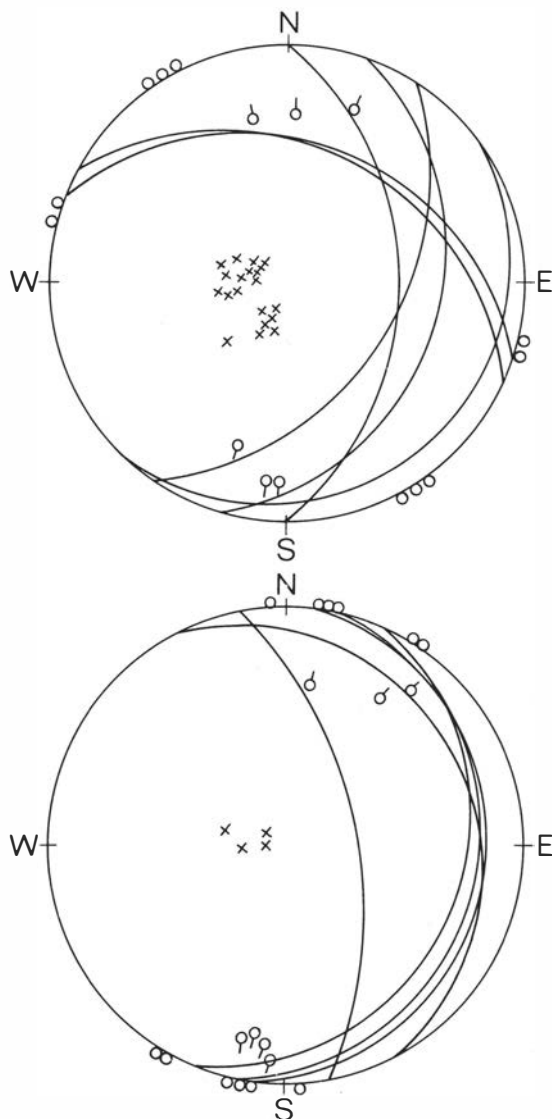


Fig. 3. Stereographic projections. Thrust faults plotted as large circles. Bedding planes plotted by their poles (X). Fold axes (o—). Above: The southwestern coast of Ven. Below: The southern coast of Ven.

ments. Thus coastal erosion has disclosed relict *Stauchmoränen* pushed up from the east; this is elsewhere under a cover of approximately 4 m of Young Baltic Moraine. This is in principle in accordance with Hannemann (1969).

The progress of geological events from the Eemian age until the last ice sheet melted away from the area can be described as follows. The grey clay was deposited in a sea into which a calving northern ice brought a considerable amount of material. Boulders and blocks were dropped from ice-floes in this marine clay deposit. Gradually, as the North-East Ice approached the area of Ven, the depth of the sedimentation basin decreased and the sea water became fresh. The marine foraminifera died out. In calm basins, laminated clay was deposited, which in several places characterizes the upper part of the grey clay. Over the clay there was deposited more than 10 m of stratified silt, sand and gravel coming from the meltwater streams draining the advancing North-East Ice. As a consequence of an oscillation during the passage of the North-East Ice over the area, the above-mentioned sediments were dislocated. After the retreat of the North-East glacier, Ven was covered by the Young Baltic Ice coming from the south. The glacier eroded the upper parts of the North-East Ice *Stauchmoränen* and left the Young Baltic Moraine as the highest deposit in the area.

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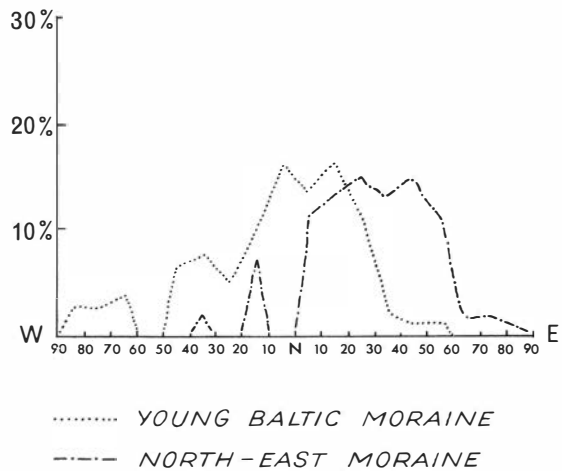


Fig. 4. Block-orientation analyses from the southernmost point of Ven.

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