RECONSTRUCTION OF EARLY HOLOCENE PALEOGEOGRAPHY OF GRAAL-MÜRITZ SOUTHERN BALTIC SEA, GERMANY

Salahuddin Husein*

ABSTRACT

This paper presents an example of shallow marine single channel seismic survey for coastal area. The working area was Graal-Müritz, located in southern Baltic Sea of Germany. This area was covered by extensive glacial deposits of late ice age of Late Pleistocene. Determined purpose is to extract a figure of paleogeography of Early Holocene based on hydroacoustic measurements (boomer). The knowledge of paleogeography is important in field of coastal dynamics, in order to predict future coastal changes in response to various natural factors. Another important value of the study of paleogeography in this area is its data as a basic to calculate amount of glacial deposits that has economical meaning, regarding such deposits are being today exploited, especially for sand and gravel.

INTRODUCTION

The entire Baltic Sea underwent multiple glaciations during the Pleistocene. The continental ice sheets had modified the topography by both erosion and deposition. Those glaciations left various forms of glacial deposits behind, which later became a local sediment source for near-shore dynamic processes. They have been eroded, transported and deposited in surrounding areas. The amount of the eroded sediment has also economical meaning, regarding such deposits are being today exploited, especially for sand and gravel.

The investigated area is located in the western part of the Mecklenburg Bay and is about 5 x 3 km large, which covers the extraction site "Graal-Müritz I" of about 4 x 2 km. The average depth is about 8 m and it gets deeper towards north-west, the offshore direction (see Fig. 1).

The investigated area is also a part of the well-known Darss Sill area, a shallow water area in south-western Baltic Sea. In geological terminology the Darss Sill is restricted to a 10-12 km wide zone extending from the Danish Isle of Falster to the German Fischland-Darss Peninsula (Lemke et al., 1994; after Kolp, 1965). The zone is characterised by the presence of submarine till outcrops, which were believed to belong to the Late Weichselian ice marginal zones (Lemke et al., 1994). Weichselian or Weichsel glaciation is the latest period of continental glaciation over Northern Europe of about 18.000 – 13.000 years before present (yr. BP). Tills are nonstratified bodies of material transported and deposited directly by glacier ice (Nilson, 1983). Typical tills are unsorted accumulations that contain a varying proportion of particles ranging from clay to boulders.

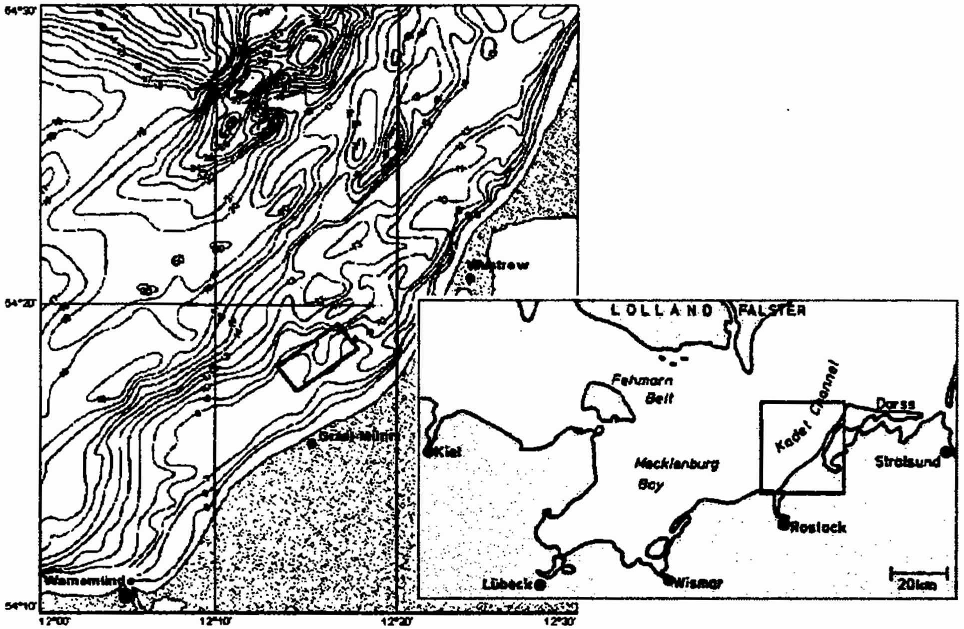

Figure 1. Location and bathymetry of the investigated area (shown by small rectangular box).

Little has been known of the Late Quaternary sub-bottom structure of this area. The geological information available about this area was primarily based on the results from vibrocoring (Kolp, 1965; in Lemke, 1998), which later combined with data from seismo-acoustical profiling that are mainly done by Lemke et al. (1994) and Lemke (1998). This paper then is particularly concerned to a part of sub-bottom structure, i.e. the paleogeography that is important in field of coastal dynamics, in order to predict future coastal changes in response to various natural factors. The subject of paleogeography itself deals with the distribution of land and water, etc., during earlier periods of the earth's history (Moore, W.G., 1978). It describes physiography of an area with its distinctive features.

METHODS

1. Data collection

The seismic surveys in the working area were carried out in August and December

consists of an EG&G Uniboom® (0.3 – 11 kHz) boomer system, which achieves a vertical resolution up to 0.3 m and a maximum penetration up to 40 m. This shallow seismic information was collected concurrently and the analog filtered echoes were printed on paper by graphic recorders (EPC). Positioning during the surveys was done by DGPS (Differential Global Positioning System) navigational system with a level of accuracy of < 10 m.

Altogether 84 profiles of boomer data were collected systematically (see Fig. 2). Within the working area 33 of the track lines were arranged, 30 of them are situated parallel to the coastline in northeast-southwest direction with a track spacing of 100 m. The other 3 track lines were oriented perpendicular to the coastline in northwest-southeast direction with a track spacing of around 1700 m, which are used for better interpolation among the track lines.

All seismic profiles are provided with thicknesses in meters for conceptual ease. Thicknesses were calculated using an assumed velocity of 1500 m/s, which is same as the velocity of sound in water.

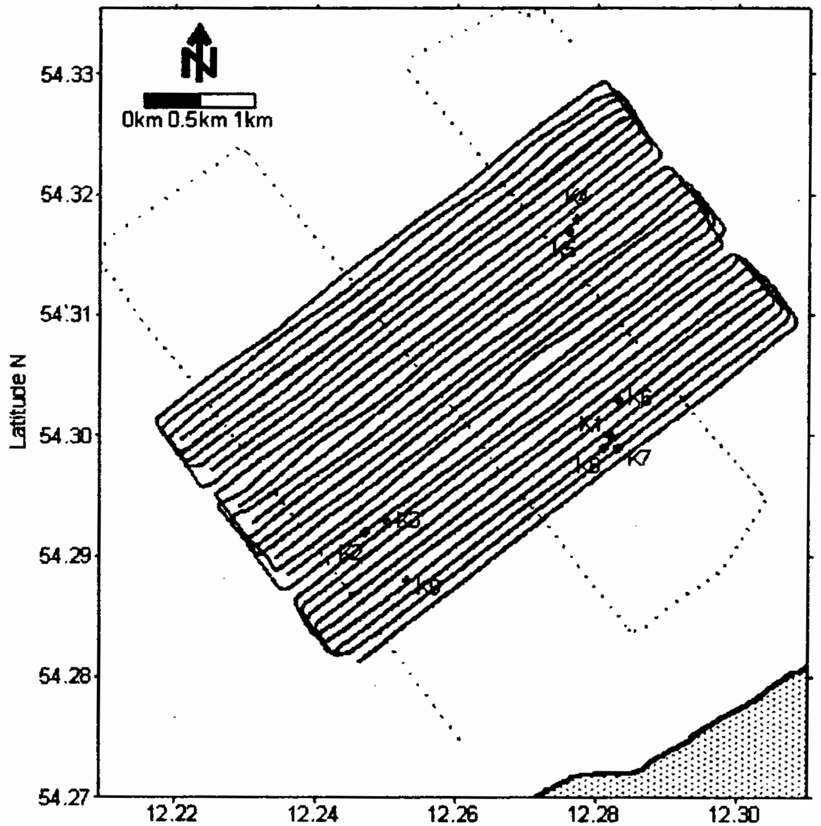

Figure 2. Seismic profiles (shown by continuous pathways) and locations of vibrocores (shown

2. Lithological information

Shallow marine seismic information are correlated and verified by sediment samples. In part the evaluation of the seismograms and the interpretation of stratigraphic sequences is based on information gathered from cores taken with a vibrocorer. During the survey of R.V. LITTORINA in August 1999 altogether 9 vibrocores were taken in the working area with a VK 300 vibro-hammer-coring device. The positions of the taken samples are shown in Figure 2.

3. Mapping procedure

Three kinds of maps are resulted from the data: the bathymetry map, the modified Pleistocene topography (depth of till surface) map and the sediment thickness map. Contouring was done with the computer software SURFER® (Golden Software, Inc.).

RESULTS

1. Seafloor topography

The bathymetry of the investigation area shows a rugged topography of the sea floor (see Fig. 3). It ranges from 5 to 11 m below the present sea level (b.s.l.) with an average depth of 8-m b.s.l. There are three notable features: a steep slope in the northern part (pointed by number 1), which strike in east-west direction; a channel-like structure in the south-western part (pointed by number 2) that straighten in northwest-southeast direction; and some deep hollows with different dimensions in the middle of the working area (pointed by number 3), which have reached the depth up to 11 m b.s.l. while the surrounding depth is around 8 m b.s.l.

From the map of modified Pleistocene topography (see Fig. 4), it seems that the main pattern of the present sea floor topography follows the modified Pleistocene topography. The first two notable features explained above also appear in the map of modified Pleistocene topography (pointed by the same numbers as well).

2. Modified Pleistocene topography

In the investigation area, all the late- and post-glacial deposits are reworked sediments. The source is the glacial landscape, developed in connection with the retreat of the Weichselian ice sheet. Therefore, it is not possible to re-establish the original glacial surface topography. However, by stripping off Late Pleistocene and Holocene stratified drift deposits, it is possible to reconstruct a modified topography of the surface left over by the melting Weichselian ice sheet. This map is the main object of this paper, since this map represents Early Holocene paleogeography of the area.

The resulting map (Fig. 4) shows the seismic depth to the base of the lowermost stratified units interpreted as sub-aqueous deposits of Late Pleistocene or Holocene age. This map shows that the underlying Pleistocene topography of the area basically consists of east-west oriented steep slope (pointed by number 1), northwest-southeast oriented channel structure (pointed by number 2) and hilly topography covered the area. The surface of the till in the working area is situated in a depth between 8 and 17 m

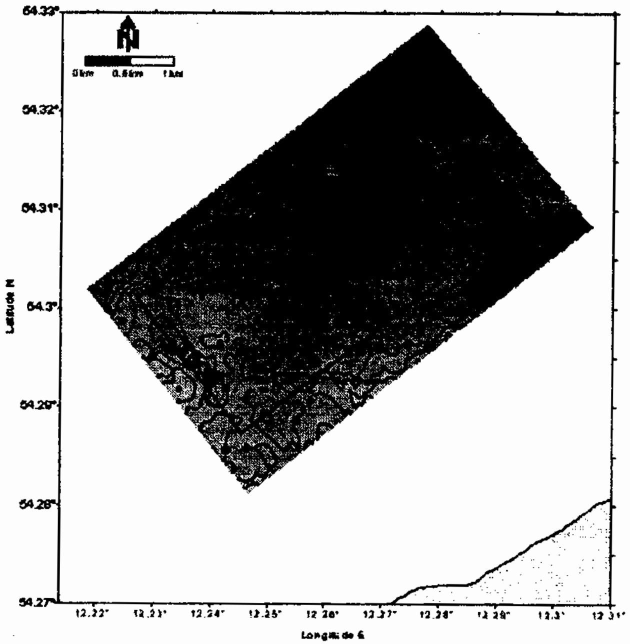

Figure 3. Recent bathymetric map, rectangular box indicates the working area. Numbers point specific features, see text for explanation.

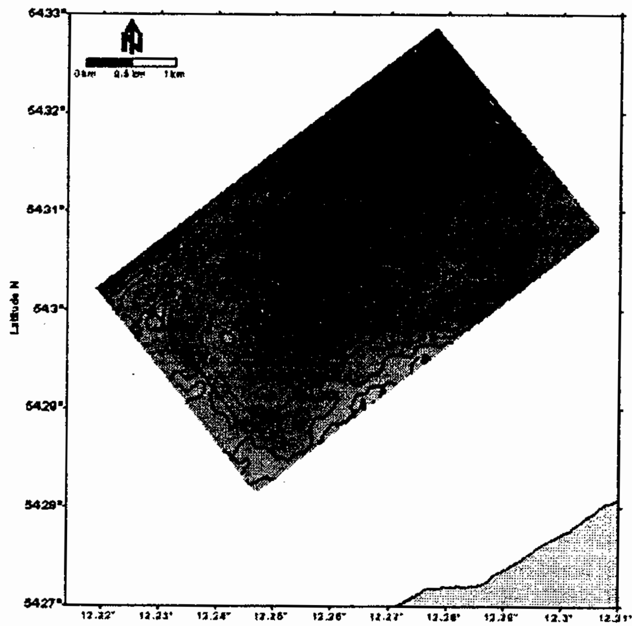

Figure 4. Modified Pleistocene topography (also called as Early Holocene paleogeography map), rectangular box indicates the working area. Numbers point specific features, see text for

DISCUSSION

The glacial deposits that built the Early Holocene paleogeography of working area up consist of till. At least two till units were able to distinguish in the boomer profiles, both of them are always paralel; one above another. The stratigraphic positions of the till units are not really understood (Lemke et al., 1998; after Steinich, 1992). The lower till was assigned to be from Pommerian Stadium of Weichsel glaciation (Lemke, 1998; after Rühberg et al., 1995), around 15.000 yr. BP. The upper till was assigned by Lemke (1998) to be from Mecklenburger Stadium of Weichsel glaciation, around 13,000 yr. BP.

A special attention is paid for presence of a northwest-southeast channel that found in western part of the working area (pointed by no. 2 in Fig. 3 & 4). This channel is suggested as part of a drainage system that developed around 12,800 yr. BP. The drainage system itself was a part of a river delta system that firstly proposed by Kolp (1957) and Schulz (1961) (in Lemke & Kuijpers, 1995), which is located in the area between Warnemünde and the Fischland-Darss peninsula, somewhere in the vicinity of the working area. The river delta system was one way for transporting water from inland to Baltic Ice Lake (the initial state of the Baltic Sea; formed as a fresh water lake that resulted from ice melts).

Directly over the Pleistocene sediments (the till) the working area is built up by Holocene marine sands. The average thickness is only around 1 m. Significant accumulation (>3 m) of Holocene marine deposits is only found in the immediate vicinity of Gedser Reef and in the deeper north-eastern part of the area north of the Kadet Channel (Lemke et al., 1994). Compare to that number, the sediment accumulation in the working area is relative small. The primary sediment source is not transported from the basin margin but rather from within the basin itself, which is indicated by the presence of lag deposits (Davis et al., 1996). Not all of the working area is covered by the Holocene marine sediments. Some area where the till units outcrop are covered by thin lag deposits, which reflect the difference in erosion regime. Lemke et al. (1994) reported that the thickness of the lag deposits layer generally was thinner than 30 cm.

CONCLUSIONS

Due to erosion and deposition processes that have been taking place after the late ice retreat (Weichselian period), it is not possible to re-establish the original glacial surface topography. However, by stripping off Late Pleistocene and Holocene channel and marine stratified deposits, it is possible to reconstruct a modified topography of the surface left over by the melting Weichselian ice sheet.

The resulting map of Early Holocene paleogeography shows shows that the underlying Pleistocene topography of the area basically consists of east-west oriented steep slope, northwest-southeast oriented channel structure and hilly topography covered the area. The surface of the Early Holocene paleogeography in the working

The average sediment thickness over the Early Holocene paleogeography surface in the working area is 1 m. The primary sediment source is not transported from the basin margin but rather from within the basin itself, which is indicated by the presence of lag deposits

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