"A CHARACTERIZATION OF THE DISTAL PART OF TRANDUM DELTA, SOUTHERN NORWAY, BY GROUND PENETRATING RADAR" BY NUHA ELZEIN MOHAMMAD AND TOR SIMON PEDERSEN.

The report is part of the Gardermoen Project focussing on the geometry and the depositional history of the Trandum delta, 40 km north of Oslo, the largest unconfined Quaternary aquifer in Norway and a part of the Gardermoen ice contact delta. The Gardermoen Project was initiated as a part of scientific effort taken when constructing the new National Airport of Norway. The aim of the project has been to establish knowledge of the hydrogeology of this aquifer.

The depositional mechanisms that built up the ice-contact Gardermoen delta earlier referred to the Hauerseter delta in the literature are quite diverse and make the delta system complex. The characterisation of the distal part of the Trandum delta is based on the interpretation of the ground penetrating radar data, according to the following procedure: 1) collecting the GPR data by the Pulse Ekko acquisition system, 2) processing the data by the Gradix processing and interpretation software, 3) reformatting the GPR data to the standard SEGY format and conversion into the seismic Charisma interpretation system, and 4) interpreting the GPR data as a 2D-survey using Charisma.

The GPR technique is based on the time domain (transient) electromagnetic method (TEM). The velocity and the attenuation are the factors that describe the propagation of the GPR waves in the ground. These factors depend on the dielectric and conductivity properties of the materials. In particular, the GPR data shows how the presence of water in a soil formation increases the dielectric constant, electrical conductivity, and attenuate the radar waves.

A 2D survey of 69 GPR profiles of all together some six kilometers have been collected using a 50 MHz antenna frequency. 17 of these profiles were re-collected by a 25 MHz antenna frequency in order to try reach bedrock. The GPR data were recorded as a single-fold, fixed-offset reflection profiles, expect for three common depth point (CDP) gathers recorded for velocity analysis. Both the 50 and 25 MHz data have been processed by the Gradix software mainly for attenuation removal, filtering to remove unwanted frequencies, gain enhancement and velocity analysis. Furthermore, migration and fk-filtering have been tested in some profiles. The velocity analysis above and below the groundwater table resulted in velocities of 0.12 m/ns and 0.07 m/ns, respectively. The processed 50 MHz records have a maximum depth of 26 m. In spite of the processing, the 25 MHz data did not image the bedrock and the maximum penetration depth was less than 30 m.

This result is ascribed to the existence of clay-rich sediments at depth, and to a low signal-to-noise ratio.

Interpretation in the Charisma system is based on profiles in a grid pattern. A considerable effort was made to convert the data into Charisma format. The conversion includes the following steps 1) reformatting the basic format of the Pulse Ekko data file into a SEGY format file, 2) loading the navigation data for each GPR profile including the x, y coordinates in the UTM system as well as the elevation information, 3) utilizing the GPR SEGY scale to find suitable scaling parameters for the Charisma display, 4) utilizing the SEGY scan to obtain information about the contents of the GPR SEGY formatted files, and 5) utilizing SEGY-2D load to store the GPR data on the Charisma workstation.

The Charisma workstation interpretation of the GPR data is tied to the sedimentary log of well G21 located 120 m east of the study area. Three main reflectors were identified and interpreted as the soil surface, groundwater table, and the base of a prominent foreset unit. The interpretation was carried by Track/Auto Track and Draw modes. Charisma plots the interpreted reflectors in a grid environment, allowing generation of a time-structure map for each reflector. In addition, to isopach maps in time of the unsaturated and the saturated zones. The maps reveal an anticlinal structure, which is interpreted as a mouth bar structure. The overall interpretation may be summarized as follows:

1. The surveyed Moreppen field lies about 4 km from the glacier terminus. In this area the delta rest on the basement rocks with fine clay sediments as the bottomset unit. Coarse sandy sediments make up the inclined foreset unit that is clearly imaged in the GPR data. The topset unit that constitutes of nearly horizontal layers was deposited during a high discharge period.
2. The basement rocks, and the clay-rich sediments of the bottomset unit is supposed to be thickening distally. However, they have not been observed

directly in the GPR data except for the boundary between the bottomset and foreset units at about 18 to 20 meter depth. This observation demonstrates that the GPR data are strongly attenuated by the clays decreasing the imaging potential of the GPR method in this geological setting.

3. A sandy foreset unit shows well-developed progradation geometry of river mouth lobes. GPR profiles parallel to the delta front show that the foreset layers incline gently. The tie to well G21 shows that these sediments vary in their composition from pebbly to fine sand. An unconformity between the foreset unit and the overlying topset unit is interpreted due to fluvial erosion. The thin topset unit comprises of sub-horizontal reflectors which consists of pebble sandy layers. These layers were aggraded during a regional marine regression.
4. The GPR profiles also imaged sedimentary structures such as gravel bars with less than 3 m width in the topset unit, small shallow channels in the foreset unit, and onlap sequences of coarser sand and pebbles. There is also evidence of small-scale faults.
5. The mouth bar structures indicate rapid changes in feeder directions. The rapid outbuilding of the huge Trandum delta during 70 years suggests an extreme supply of sediments.
6. The vertical thickness of the unsaturated zone vary between 2 and 7 m increasing westwards. The limited GPR penetration has only allowed thickness calculation of the saturated zone in the eastern part of the study area where it is about 25 m.