Pleistocene sedimentary record of the Falsterselv area, Jameson Land, East Greenland

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An exceptionally thick cover of Quaternary sediments on the west and south coastal areas of Jameson Land, East Greenland (Fig. 1), preserves a unique record of environmental changes, particularly from the Late Pleistocene (Funder *et al.*, 1994). The Falsterselv area on Jameson Land was briefly investigated in 1992 by Lyså *et al.* (1992) and Ingólfsson *et al.* (1994), and during field work in the summers of 1994 and 1995. This account is primarily based on field work in 1996, of which details are found in a preliminary unpublished report. These studies are part of the CATLINA project, the aims of which are to study interglacial-glacial and interstadial-stadial climatic transitions in Russia, Denmark, the Faeroe Islands and Greenland.

The main goals of the investigations in the Falsterelv area were: (1) to compile the stratigraphy of the area; (2) to interpret the depositional environments; (3) to discuss the implications and consequences of the new data for interpretations of the Pleistocene evolution of

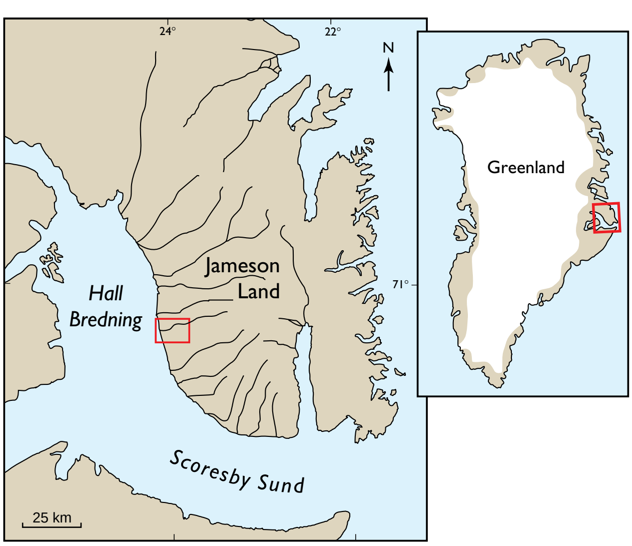

Fig. 1. Jameson Land, East Greenland, with the Falsterselv area shown in Fig. 3 marked by a rectangle.

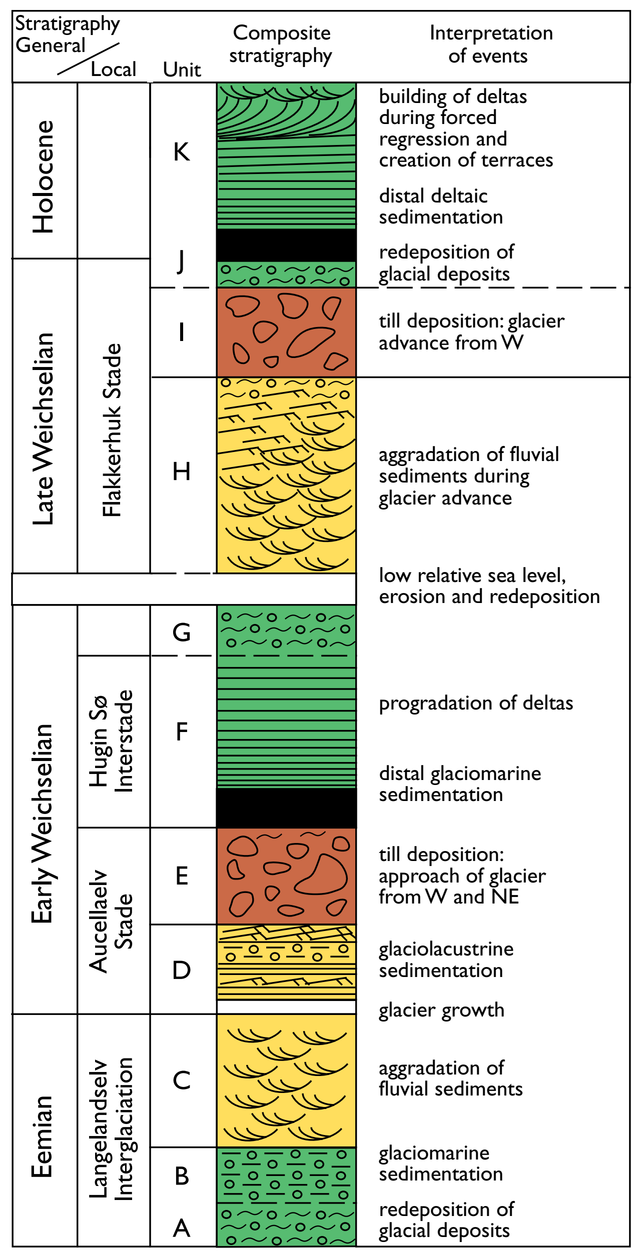

Fig. 2. Composite stratigraphy for the Falsterselv area. The local stratigraphy is after Funder *et al.* (1994).

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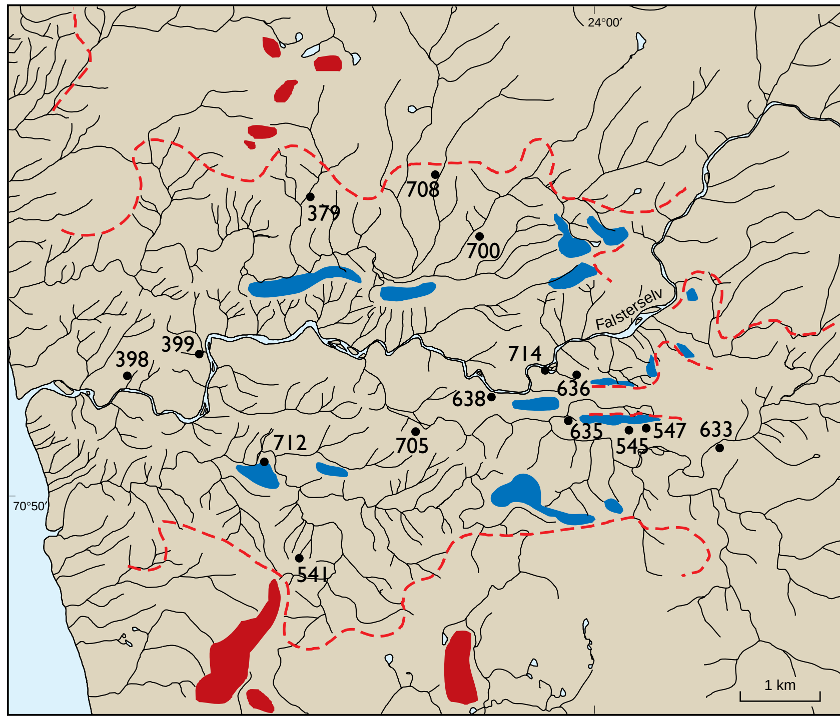

Fig. 3. The Falsterselv area of Jameson Land showing the location of the most important Quaternary deposits. The stippled red line separates the area into two categories: hummocky topography characteristic of glacial deposits with some pronounced hills (red areas); and areas characterised by fluvial erosion and terraces (marked in blue). Topography is modified from 1:50 000 Jameson Land map sheets produced in the Survey's photogrammetric laboratory.

Jameson Land; and (4) to use, for the first time, ground-penetrating radar (georadar) as a tool in the investigations. In general, the results are compatible with the Pleistocene stratigraphic scheme for Jameson Land presented by Funder *et al.* (1994; Fig. 2). Results of particular significance include:

1) Recognition of a new stratigraphic unit (unit D, Fig. 2) of white and grey glaciolacustrine sediments with a low content of clasts composed of local bedrock. These deposits have not previously been recorded from Jameson Land. The unit is tentatively assigned to the Early Weichselian.

2) Identification of at least one glacier advance from the interior of Jameson Land during the Weichselian. This area has previously been regarded as having been essentially ice free during this period (Funder *et al.*, 1994).

In addition to the studies reported here, investigations of Eemian and Early Weichselian deposits south of the Falsterselv area were carried out by Aslaug Geirsdóttir.

Methods

Field work mainly consisted of excavation of profiles, sedimentological logging and georadar profiling; the most important sites are shown on Figure 3. Logging involved detailed examination of facies, palaeocurrents, fabric and glaciotectonic structures. Mapping of the youngest stratigraphic units was also carried out, since they are readily recognised in terraces (Fig. 3) and from the micro-relief of the land surface. Correlation of the excavated sections is based on the occurrence of several marker beds: unit C which is a chronostratigraphic marker with a floral content typical of the last interglaciation on Jameson Land (Bennike & Böcher, 1994); unit D which is recognised by its distinctive lithology; and unit K , shown by ^{14}C dating to be Holocene in age, which is exposed in prominent terraces (Fig. 3). Diamictons at different stratigraphic levels, interpreted as tills, represent glacier advances. Correlation of other stratigraphic units is based on lithological and genetic relationships to accord with the simplest stratigraphic configuration. Proposed ages for the units are mainly based on correlation with similar units in the established stratigraphy for the area (Funder *et al.*, 1994). Samples for additional ^{14}C and luminescence dating were collected and organic remains were sampled for palaeoecological studies.

Fig. 4. The pulse EKKO IV georadar system in use at site 638 (see Fig. 3 for location). GPR is in reflection mode. The GPR consol, portable computer and power source are carried by the geologist and linked with fiber optic cables to two 50 MHz antennas.

Georadar (Ground Penetrating Radar: GPR) is a relatively new geophysical method compared to the more traditional refraction and reflection seismic and geoelectric methods; detailed descriptions are given by Davis & Annan (1989) and Bernabini *et al.* (1995). GPR profiles are comparable to seismic profiles, except that GPR systems use transient electromagnetic (EM) energy reflection. The field equipment comprised a portable pulse Ekko IV radar system (Fig. 4) in reflection mode with the option of 50, 100 and 200 MHz antennae frequencies and a 400 volt transmitter. At each site, all antennae frequencies were used, since low frequency data (50 MHz) gives maximum penetration (10–15 m) but low vertical resolution (2–2.5 m), while high frequency data (200 MHz) gives minimum penetration (2–2.5 m) and high vertical resolution (0.5 m). To optimise the horizontal resolution, data were sampled with a spacing of 0.5 m between radar profiles. Digital data were processed and plotted in the field, while acquisition and post-processing (i.e. scaling, topography, gain functions) were carried out later. All data handling was carried out using pulse EKKO software.

The georadar technique was adopted in order to provide subsurface profiles showing large scale sedimentary architecture and glaciotectonic structures. Profiles were selected so as to sample different geological settings: Eemian fluvial deposits (unit C), glacial deposits (units H, I, J) and deltaic terraces of mainly Holocene age (unit K). Lithological control was secured by sampling of profiles along cliff sections. Although sediments at depths greater than *c.* 1 m are affected by permafrost, this provided no obstacle for georadar profiling. In general, glaciotectonic structures and sandy sediments covered by till are mappable down to a depth of about 10 m (Fig. 5), provided that the clay content of the sediments is low. With respect to the deltaic terraces, the expected penetration was largely obtained in the coarse-grained sections, but only limited penetration was achieved in the fine-grained parts.

Results

The morphology of the investigated area generally falls into two categories (Fig. 3): elevated areas north and south of Falsterselv which display a hummocky topography that is probably primarily of glacial origin; and the area near Falsterselv itself which is characterised by the presence of terraces up to *c.* 80 m a.s.l., sloping gently toward the west. The terraces and older Pleistocene deposits are dissected by numerous streams and ravines, where most of the sedimentological investigations were carried out. Bedrock of Mesozoic sandstone and shale is exposed further east.

The Falsterselv area revealed a stratigraphic succession of eleven units (Fig. 2), ranging from Eemian to Holocene in age. Unit A consists of interbedded grey and brown diamictons with a mud matrix, numerous clasts and minor plant remains. This unit may represent redeposition of older glacial deposits. Unit B consists of a diamicton with a muddy matrix, several clasts and a diverse mollusc fauna. The unit is interpreted as glaciomarine. Units A and B are succeeded by a succession of fluvial sands and gravels, unit C, containing abundant plant remains that reflect a relatively warm subarctic climate. Unit C, and probably also A and B, correlate with the Langelandselv Interglaciation and the Eemian.

Unit D comprises white and grey muddy diamictons, massive to crudely bedded gravel and laminated mud. Proximal, mainly coarse-grained deposits are observed in the eastern part of the area while distal fine-grained sediments are observed in the western fjord region. The sediments have a very low content of shale clasts and mica from the local bed rock and may have been glacially transported to the area. The sediments are interpreted as having been deposited in a glaciolacustrine basin. This interpretation requires that glaciers were already present in the area and unit D may have been deposited during a phase of glacial stagnation. Unit D was probably deposited in the Early Weichselian although a correlation with the Saalian cannot be excluded.

Unit E consists of a muddy clast-rich diamicton interpreted as a till deposited by a glacier overriding the area. Fabric and glaciotectonic structures suggest that the glacier advance may have taken place both from the fjord in the west and from the north-east. The till of unit E was deposited after or contemporaneously with unit D in the Early Weichselian, probably the Aucellaelv Stade.

Unit F comprises laminated, probably marine fine sand and silt. The abrupt transition from glacial till to distal fine-grained deposits suggests that disintegration of the glacier took place by calving. Unit F is correlated with the Early Weichselian Hugin Sø Interstade. Unit G consists of a thin muddy diamicton with few clasts, interpreted as reflecting a phase of redeposition during subaerial exposure after a fall in relative sea level, an event which was also suggested by Lyså & Landvik (1994a, b). However, the succession of the units F, G and H is not considered to record a single cycle of relative sea level change, as suggested for comparable sedimentary successions by Lyså & Landvik (1994b). The genesis of unit H is here considered independent of relative sea level change, as argued below, and there may be a significant hiatus between units G and H as indicated on Figure 2.

Unit H is a succession of cross-bedded and ripple-laminated sands and silts that are interpreted as being of glaciofluvial and glaciolacustrine origin. Palaeocurrents change upwards from west to south and east. At some sites, the deposits grade into a compacted muddy diamicton with few clasts which is interpreted to represent proglacial flow tills. The succession of fluvial, lacustrine and diamict flows possibly reflects the drowning and damming of a fluvial system by glacier ice in the Scoresby Sund fjord. An approaching glacier from the fjord may have been responsible for the creation of accommodation space and for a large sediment supply. Some of these beds were previously interpreted to be marine (Ingólfsson *et al.*, 1994). Generally this also shows that aggradation of fluvial deposits on Jameson Land need not be a result of changes in relative sea level as suggested by Lyså & Landvik (1994a, b), but may in some instances be the result of glacier damming.

Unit I, which stratigraphically overlies unit H, is a fissile muddy diamicton with few clasts that is interpreted as a till. Deposition of unit H and I is inferred to have taken place during the last major glacier advance in the area during the Flakkerhuk stade (Late Weichselian); evidence of glacial thrusting from the west is revealed by georadar profiles (Fig. 5). Unit J may be either a loosely compacted diamicton formed by a mud flow or flow till, or a lag of pebbles and cobbles comprising redeposited glacial deposits. The highly irregular upper boundary of unit I is interpreted as partly a remnant of an irregular glacial surface left by the last glacier in the area, and partly a result of subsequent subaquatic erosion and redeposition. The transition from unit I to J and K reflects the disintegration of the glacier in a standing body of water.

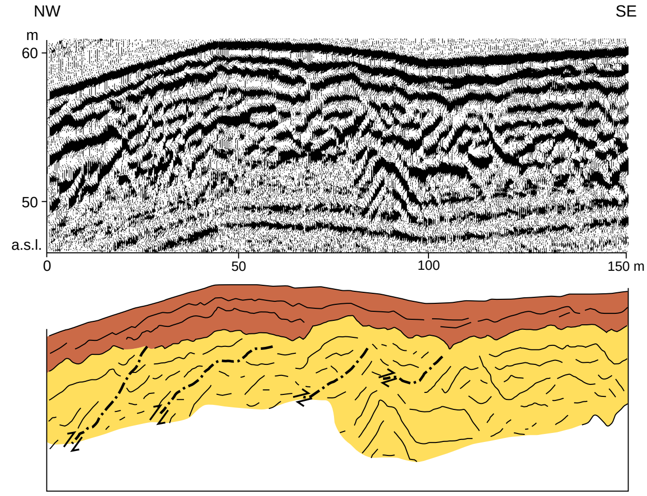

Fig. 5. Georadar profile at site 638 (see Fig. 3 for location) with interpretation below; a lower unit H (yellow) of glaciofluvial-lacustrine sediments shows evidence of glacial thrusting from the west, and is overlain by a *c.* 2 m thick bed of till (unit I, brown).

The overlying unit K is a generally upward coarsening succession of laminated clayey mud, muddy turbidites, inclined sandy beds and imbricated gravelly sediments, primarily interpreted as having been deposited in distal marine to delta front and delta top environments. The very sparse finds of periostraca of *Portlandia arctica* suggest deposition in a restricted fjord environment. Unit K makes up the body of westerly inclined terraces with the highest point at *c.* 80 m a.s.l. The delta front and top facies can be recognised at progressively lower levels towards the fjord, which reflects emergence during isostatic rebound, and sedimentation took place during a forced regression. It is suggested that internal erosional surfaces could be generated subaquatically due to an overall relative sea level fall and not subaerially succeeded by a rise in relative sea level as often suggested for comparable marine successions elsewhere on Jameson Land (Landvik *et al.*, 1994). The last glacier disintegration took place before 10 ka B.P based on ^{14}C dates on plant remains found in unit K.

The tentative chronostratigraphic relationships presented here will be adjusted in accordance with ^{14}C and luminescence dating of samples that were collected and sent for analysis in 1996. Environmental interpretations will also be modified according to results of microfossil studies.

Conclusions

The investigations in the Falsterselv area revealed a succession of eleven stratigraphic units deposited during times of changing relative sea level and changing climatic conditions from the Eemian to the Holocene. New significant finds include the white and grey glaciolacustrine deposits of unit D, interpreted as representing an Early Weichselian phase of glacier stagnation not earlier found on Jameson Land, and recognition of glacier advances during the Early Weichselian from the interior of Jameson Land (unit E), an area previously regarded as having been free of glacier ice during this period. Interpretations of the sedimentary environments in the Falsterselv area suggest that glacier damming and fall in relative sea level may at times have played a role in the genesis of sedimentary successions on Jameson Land. GPR profiling was successfully carried out in sediments with a low clay content down to *c.* 15 m below the land surface.

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