

Report on the use of an International Association of Sedimentologists Postgraduate Grant Scheme 2005 Award

Recipient:

Mark Tarplee,  
Department of Geography,  
Queen Mary, University of London,  
Mile End Road,  
London.  
E1 4NS

Tel: 0044 (0)20 7882 5555 ext. 4769  
Fax: 0044 (0)20 8981 6276  
Mobile (Cell): 0044 (0)79 2975 5569  
E-mail: M.Tarplee@qmul.ac.uk

The grant was used to part-fund (travel and subsistence costs) attendance on course AG-321 - Arctic Terrestrial and Marine Quaternary Stratigraphy – Excursion, at the University of Norway in Svalbard (UNIS) ([www.unis.no](http://www.unis.no)). As the PhD research is addressing processes beneath polythermal ice-sheets with specific reference to the glacial erratic train associated with the late Weichselian glaciation over the Tynagh mineral deposit, southeast Co. Galway, Ireland, a visit to a modern glaciated environment was considered essential to enhance understanding of glacial dynamics.

The course was focused on an 8-day ship based field excursion to the key sites containing evidence of late Quaternary glaciation around western Spitsbergen, Svalbard. The extent of Weichselian Barents Sea ice sheets and their interaction with contemporaneous Svalbard ice sheets remains the subject of debate, terrestrial evidence often conflicting with an increasing body of marine data (Landvik *et al.*, 2005). The field course was designed to give a critical insight into the debate, the sources of evidence and the field/analytical methods applied in establishing a stratigraphy for each site. The following information provides one perspective on the debate, for a more detailed discussion the reader is referred in the first instance, to Mangerud *et al.*, 1998.

Site 1 – Poolepynten, east coast, Prins Karls Forland. Eemian/Early Weichselian (OIS 5) shallow marine deposits underlie an Early Weichselian till which is overlain by pre-Late Weichselian shallow marine sediments. At the top of the sequence are raised beach deposits up to 36m above m.s.l., an in-situ whale bone dating the sediments to 11 350 - 180 BP (Forman, 1990; Andersson *et al.*, 1999). Amino acid racemization ratios and biostratigraphic correlation together with morphological and sedimentological evidence indicate that this area experienced limited and localised glacial activity during the Late Weichselian (Andersson *et al.*, 1999).

Site 2 – Forlandsundet, off shore west coast, Spitsbergen. Swath bathymetry, seismic profiling and gravity coring within the strait was conducted over 2 days (while part of the group were onshore) to establish sea-bed morphology. The course final report submitted to UNIS (awarded Grade A) discussed the findings of this research but these cannot be divulged here as the data will be incorporated into future publications.

Site 3 – Brøggerhalvøya, west coast, Spitsbergen. Possible OIS 7 and 6 sediments are overlain by OIS 5e interglacial shallow marine deposits. The sedimentary sequence above indicates an Early Weichselian (late OIS 5) glacial-deglacial and marine transgression-regression cycle followed by an extended period of subaerial exposure. Late Weichselian glacially induced isostatic depression led to a marine transgression and deposition of Late Glacial-Early Holocene raised beach deposits (Miller *et al.*, 1989). The raised beaches at Hvadehuksletta were the main focus of the site visit.

Forman & Miller (1984) assessed elevation and geomorphological (including level of soil development) evidence and applied dating techniques to subdivide the raised beaches on Brøggerhalvøya into Saalian, Late Saalian-Early Weichselian and Late Weichselian-Holocene deposits. Test pits were dug into raised beaches within each of the age zones by the course group and an assessment made of the techniques used. There was general agreement with the findings of Forman & Miller (1984) but debate as to the mechanisms involved in soil development.

Site 4 – Kongsfjordrenna/Kongsfjorden/Krossfjorden. Swath bathymetry, seismic profiling and gravity coring of the trough/fjord area was conducted over 3 days to establish sea-bed morphology. The data obtained cannot be discussed here as it will be incorporated into future publications.

Site 5 – Linnédalen, west coast, Spitsbergen. Coastal sections expose Early-Middle Weichselian proglacial shallow glaciomarine and beach sediments overlain by a Late Weichselian till considered to be of local provenance. The proglacial deposits may be associated with an 87m marine limit terrace to the south (inland) dated 36000 BP and also overlain by till (Mangerud *et al.*, 1987; Mangerud *et al.*, 1992; Lønne & Mangerud, 1991). Postglacially Linnédalen became a marine inlet followed by isostatic recovery leading to emergence and isolation of the valley and development of Linnévatnet around 9500 BP (Snyder *et al.*, 2000). All the above locations were visited and discussed as well as a series of rock glaciers situated on the eastern slopes of Vardeborg.

Site 6 – Nordenskiöldbreen, north-east Billefjorden, central Spitsbergen. Neoglacial (Little Ice Age) landform/sediment assemblages have been exposed due to glacier retreat over the last 60 years (Landvik, *pers comm.* 2005). These landforms are particularly well exposed on the north-west edge of the snout of Nordenskiöldbreen. This location was visited and both the morphology and (where possible) internal sedimentology of the landforms were analysed. A solifluction lobe north of the glacier was also studied and two sediment samples acquired for micromorphological analysis(\*).

Site 7 – Kapp Ekholm, eastern shore of Billefjorden, central Spitsbergen. The key Quaternary stratigraphic site on the Svalbard archipelago has been logged in detail but is still not satisfactorily chronostratigraphically constrained (Mangerud *et al.*, 1998; Landvik, *pers comm.* 2005). Four sedimentary cycles are present each consisting of a till overlain by shallow (glacio) marine sediments indicative of glacier advance and related isostatic depression followed by retreat, a marine transgression, isostatic rebound and a consequent regression (Mangerud *et al.*, 1998). Using various dating techniques Mangerud *et al.* (1998) proposed (tentatively) that the lowest (A-B) (glacio) marine sediments were Eemian in age, the overlying (C-D) till/marine sediment cycle was Early Weichselian, the E-F cycle Middle Weichselian and the G-H cycle Late Weichselian-Holocene. Various parts of the sections were studied by the course group and five sediment samples were acquired for micromorphological analysis(\*).

Mangerud *et al.* (1998) made the significant observation that the sedimentary sequence at Kapp Ekholm indicates large scale isostatic depression and rebound through each glacial phase associated with advancement of a regional (Barents Sea) ice sheet over the area rather than local glacier expansion. The Poolepynten, Brøggerhalvøya and Linnédalen sites all contain evidence contradicting the regional ice sheet hypothesis as they retain well preserved pre-Late Weichselian landforms and tills consisting of locally derived material only. However, recent research on the continental shelf west of Prins Karls Forland has produced strong evidence in support of a Late Weichselian Svalbard/Barents Sea Ice Sheet extending to the shelf edge. The preservation of pre-Late Weichselian landforms seemingly undisturbed is explained by the presence of low activity (cold-based) ice over much of the coastal lowlands of western Spitsbergen, the majority of the ice volume being drained via cross-shelf troughs such as Isfjorden and Kongsfjorden (Landvik *et al.*, 2005; Ottesen *et al.*, 2005).

Visiting each of the sites proved invaluable in helping to conceptualise probable ice sheet dynamics and processes in the Spitsbergen region. Additionally, many other landforms and processes (glacial, proglacial, periglacial, glaciofluvial, slope, coastal and weathering) were observed and techniques (swath bathymetry, seismic and gravity coring) applied. The experience will undoubtedly enhance the outcomes of the PhD research

\*Undisturbed sediment thin sections will be produced from the samples obtained and analysed at the Centre for Micromorphology, Queen Mary/Royal Holloway, University of London, England. It is envisaged that 1-2 papers will be published from the evidence obtained.

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