Architecture of glaciotectonic complexes and glaciodynamic sequence stratigraphy

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The glaciotectonic complexes exposed along the Danish cliff coasts are probably the most instructive sites for studying the architecture of thin-skinned thrust-fault deformations (PEDERSEN 2005, 2014). Furthermore the glaciotectonic complexes provide the features for establishing the glaciodynamic sequence stratigraphy, which support the understanding of the development of the glacial geology during the Pleistocene (PEDERSEN 2012).

Although the cross sections through the glaciotectonic complexes are exposed, the basal parts of the complexes are never exposed, because they are situated about 50–100 m below the shore surface. For the study of the basal parts, where the décollement zones are situated, seismic sections from offshore areas in the North Sea have been consulted. These sections provide excellent opportunities for comparable studies of the glaciotectonic architecture. This presentation will demonstrate the principles of architecture of glacial deformation and the system of glaciodynamic sequence stratigraphy based on the comparable studies of onshore and offshore glaciotectonic complexes in Denmark.

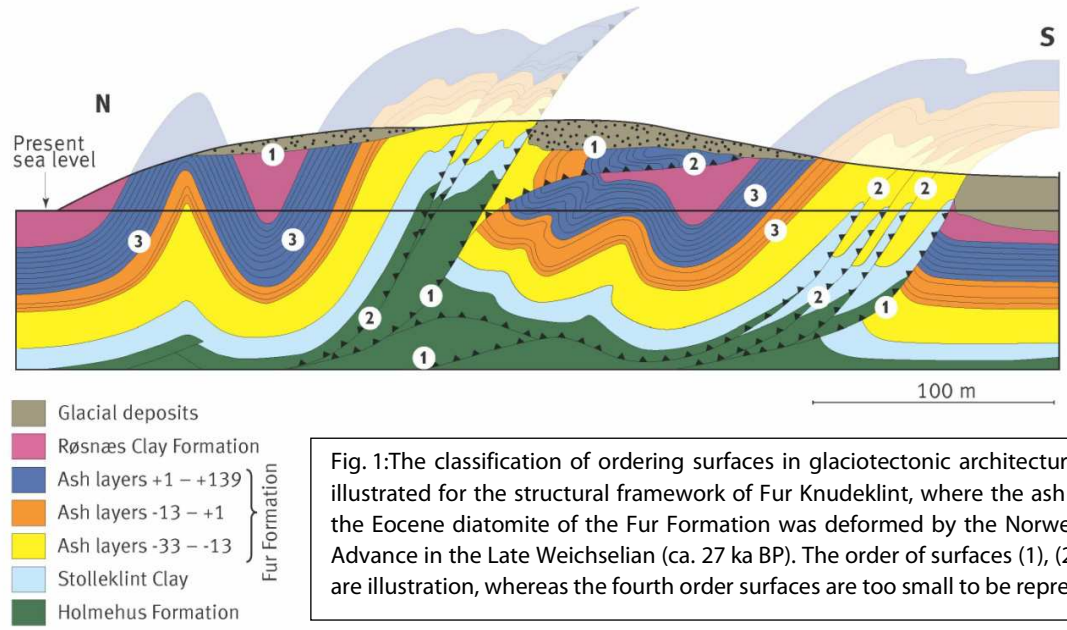

Fig. 1:The classification of ordering surfaces in glaciotectonic architecture is here illustrated for the structural framework of Fur Knudeklint, where the ash layers in the Eocene diatomite of the Fur Formation was deformed by the Norwegian. Ice Advance in the Late Weichselian (ca. 27 ka BP). The order of surfaces (1), (2) and (3) are illustration, whereas the fourth order surfaces are too small to be represented.

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Architecture of thrust-fault deformations in glaciotectonic complexes

Compared to fold belt ranges glaciotectonic complexes are relatively small and capable of being overviewed in a complete frame. For these structural complexes a classification of architecture has been defined, which is based on the description and ordering of surfaces and their relations to create constructions (PEDERSEN 2014). It is emphasized that the creation of constructions comprising surfaces is the basic element in architecture.

For the analysis of glacial architecture and construction of 3D geological models of glaciotectonic complexes the classification of a hierarchy of bounding surfaces comprises four orders of surfaces (PEDERSEN 2014). The décollement surface is regarded as the most important element in structural complexes, and it is therefore defined as a first-order surface (Fig. 1). One may say that the décollement surface is the "bottom" of the complex, and therefore the top of the complex has also to be defined as a first-order surface. This "second" first-order surface is the topographic top of the tectonic complex, or alternatively a truncating unconformity, above which post-deformational units occur.

The internal framework of a tectonic complex comprises thrust sheets. These are bounded by thrust faults, which are defined as the second-order surfaces (Fig. 1). The thrust faults are differentiated into ramps and flats, where a ramp is cross-cutting the bedding, whereas the flat is more or less parallel with bedding. When two or more thrust sheets are bounded by ramps and flats they form duplexes. These generally form imbricate complexes or may be stacked in a way that they create complex repetitions of the geological units (PEDERSEN 2005).

The folding of beds comprises third-order surfaces. These are differentiated into anticlines, synclines, recumbent folds and monoclinal bends. Folds may further be classified due to the orientation of the axial plane, the angle of their limbs and inclination of their fold axes.

The fourth-order of surfaces includes all small scale structures like faults with minor displacement, which are important for the prediction of dynamic development. Joints and anastomosing joints indicate early deformation impact, and the zone axis of conjugate faults indicates direction of compaction. The asymmetry of small and mesoscale folds and sense of displacement on faults indicated by groove marks can be used to reconstruct the kinematics of deformation.

Glaciodynamic sequence stratigraphy

In a glacitectonic complex the geological elements can be listed, from the base to top: 1) a tectonite at the base of the thrust sheets and duplexes related to brecciation and fracturing in the décollement zone, eventually including a hydrodynamic brecciation and mobilised mud diapirism, 2) an allochtonuos unit of pre-Quaternary and/ or pre-glacial sedimentary rocks, 3) syn-glacial deposition of glaciofluvial and glaciolacustrine sediments, 4) a glacitectonic unconformity including a glacitectonite, and finally 5) a lodgement till (PEDERSEN 2005).

The glaciodynamic sequence system is regarded as a lithostratigraphic concept of grouping and classifying glaciogeological successions, which represents the environmental development during a major glacial advance including glaciotectonic deformation. In an ideal situation the glaciodynamic sequence should be bound by a sequence stratigraphic frame. However, this is unlikely to be represented in reality, but a division into a glaciodynamic group, based on the depositional development related to a well-.defined ice-advance is regarded to be obtainable.

References:

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