Late Pleistocene to Holocene Sediments from Southern Lake Vättern

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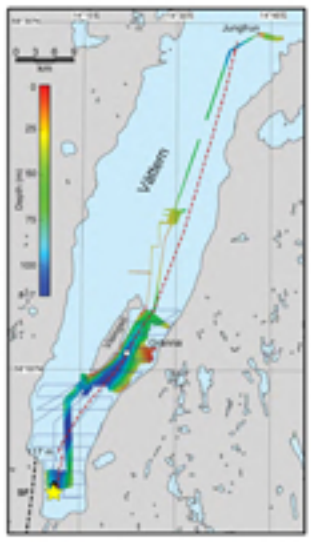
Introduction



Lake Vättern, formed by extensional faulting along the Protogine zone, is an astonishing feature among Swedish lakes. The half-graben structure provides a deep channel that runs along the eastern part of the lake with depths down to 130m south of Visingsö. (Fig. 1).

Seismic imaging of the Vättern basin reveals roughly 200 m of sediment in its deeper parts. These sediments are disturbed by neotectonic activity likely associated with glaciostatic rebound in combination with rapid drainage of the Baltic Ice Lake. In addition, several large subaqueous slope failures are found on the margins of Lake Vättern and may be linked to these earthquake events (Jakobsson et al., submitted).

In the Autumn of 2012, five closely spaced boreholes (A-E) were drilled using a portable drilling system from a barge anchored offshore from Tränghalla in southern Lake Vättern (Fig. 1, Fig. 2)). Using high resolution physical property measurements, core images and pore water data, we present the major lithological units of the late Pleistocene to Holocene sediments that are found in the upper 70 m below the lake floor (mblf). These units can tentatively be connected to the widely regocnised Baltic Sea stages. Strong indications of paleoseismic activity are found below ~10 mblf, and are more pronounced between 20-25 mblf. These sediments lie above the interval containing the most saline pore waters, indicating that large-scale seismic activity post-dated the retreat of the Scandinavian icesheet and the marine intrusion of Lake Vättern

Fig. 1. Map of southern Lake Vättern. Yellow star marks location of the drill site. Red dashed line the position of the deep central channel.

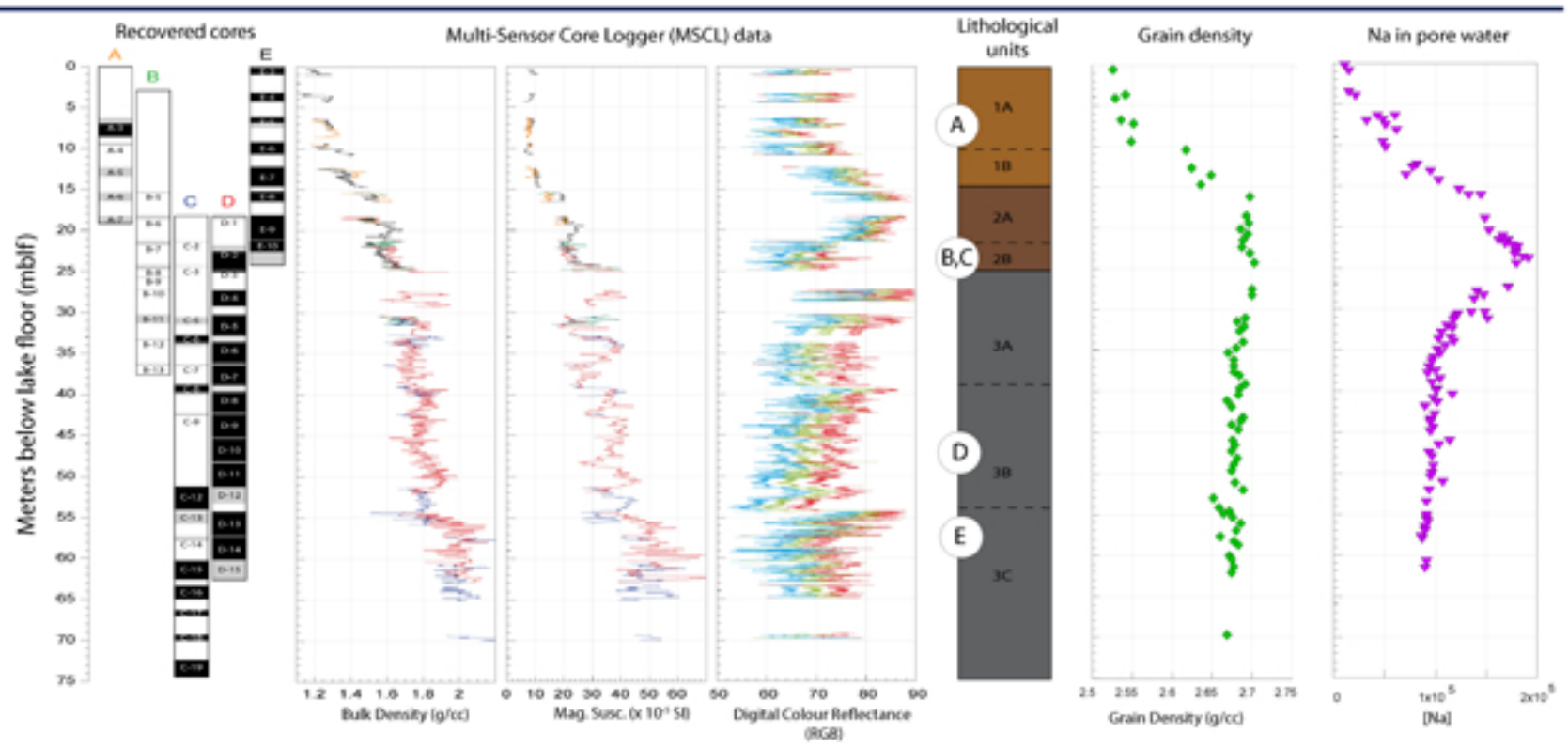
Fig. 2. The drilling barge at southern Lake Vättern

Fig. 3. Bore crown with core catcher inside

Fig. 4. Pore water sampling from the Lake Vättern sediment cores

Fig. 5. The recovery at the Dormand harbour

Results



Highlights from the sediment cores

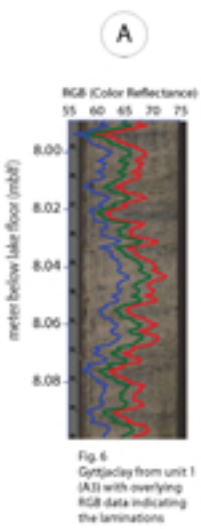


Fig. 6
Gyttjaclay from unit 1 (A3) with overlying RGB data indicating the laminations

Fig. 7
Very disturbed varved clay at the bottom of unit 2 (E10) showing signs of seismic acticity: micro faults

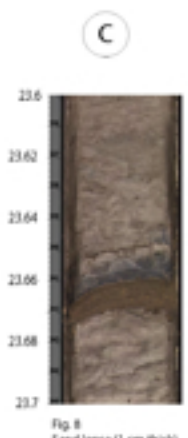


Fig. 8
Sand lense (1 cm thick) occuring at same depth as the saline peak in pore water.

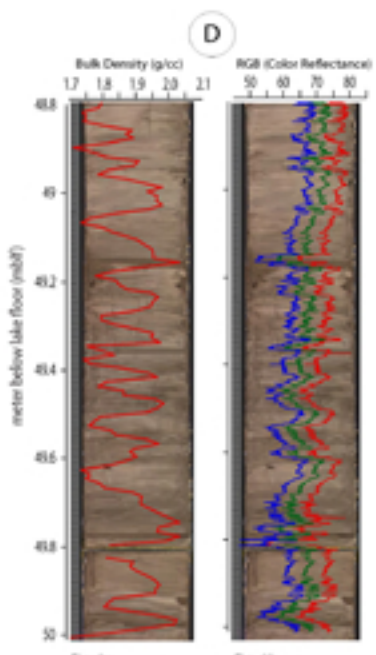


Fig. 9a
Bulk density data reflecting different grain size layers in unit 3 (D11)

Fig. 9b
Cyclic RGB data reflecting varved structure of the clay in unit 3 (D11)

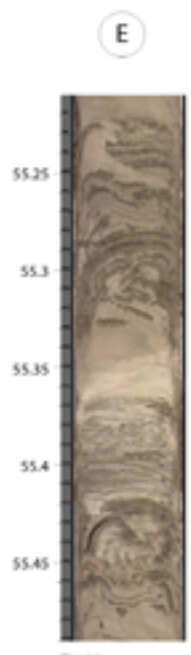


Fig. 10
Glaciotectonised sediment from the top of unit 3C (D13)

Summary

Three major lithologic units are identified in the 70 meters of penetrated sediments. The lowermost unit is a 45m interval of 'varved' glacial clays (Baltic Ice Lake deposits), followed by a transitional unit with marine intrusion (Yoldia Sea deposits) before leading into the uppermost unit with laminated gyttja clay (later lake deposits).

Throughout units 2 and 3, there is substantial evidence for post-depositional deformation of the sediments. In the deeper lying portions of unit 3, this deformation is associated with ice grounding. Above 55 mblf there is no evidence for grounded ice, but an ice tongue may have occupied Northern Lake vattern for much of the interval covered by Unit 3. This is partly supported by the thick, decimeter scale 'varved' sequences that occur up to a depth of ~30 mblf, and which are interspeered with large pebbles, possibly dropstones.

The most pronounced deformation associated with neotectonic activity is found in the deeper parts of unit 2, shortly after the marine intrusion into Lake Vattern. The deepest retrieved core which is completely undisturbed from seismic activity is from ~ 10 mblf. Between 10-20 mblf, more detailed analyses are required to pinpoint the end of neotectonic activity.

References

Jakobsson, M., Björck, S., O´Regan, M., Flodén, T., Greenwood, S. L., Swärd, H., . . . Skelton, A. (submitted)
Major earthquakes at the Pleistocene-Holocene transition in Lake Vättern, southern Sweden.

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