Application of 2D and 3D mUHRS surveys on Mjösa lake, Norway. A first-of-its-kind 3D survey on a lake

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A bridge crossing Norway's largest lake, the Mjösa lake, is being constructed, and therefore offshore geophysical site investigations was needed as a part of the pre-investigations. The survey area consists of two bridge layouts, a northern and a southern, where a final position will be determined based on the findings of the pre-investigation.
The lake lies in a deep incision into the Pre-Cambrian bedrock, with steep sloping rock walls at the sides of the lake, creating difficulties for seismically mapping of the bedrock and subsurface units, due to the possibility of extensive side reflections. To reduce the effects of side reflections a combination of 2D and 3D mUHRS (Multi-channel Ultra High Resolution Seismic) was applied, making it possible to acquire high resolution data with a penetration depth of more than 60 m below lakebed. Normally a large vessel setup would be needed to conduct these types of offshore investigations, however, this was not an option due to the many tunnels on the highway leading to the lake and the small port facilities. Therefore, a first-of-its-kind catamaran barge was built that could support the heavy equipment and at the same time easily manoeuvre in the lake.
The acquired UHRS data showed to be almost free from side reflections and revealed a deep bedrock incision infilled with various glacial formations and recent lakebed deposits. It was possible to identify 10 different units deposited on top of the bedrock. The oldest unit was interpreted as a moraine formation deposited during the latest glacial advance, Weichsel. The moraine was found across the survey area, but was notably seen in the shape of a large mount in the central part of the lake in the southern area, stretching N-S. The remaining units consisted of glacial and late glacial meltwater deposits and marine to lacustrine deposits of sand and clay. Along with the geological interpretation a large-scale boulder-investigation was conducted in a 30m radius around the potential pillar positions. The investigation yielded 47 boulders picked in the sizes ranging from 0.8-7.8 m horizontally and 0.5-1.8 m vertically.
The interpretation yielded a geological history of an incised glacial valley that was infilled first with moraine and later with meltwater sand and silt from the retreating Weichsel ice sheet. An example of a delta deposit was recognized in the meltwater units and was proposed to come from the Moelv river in the southern part of the area. In the postglacial period, during the Holocene transgression, the setting became marine where sand and silt was deposited. During the rise of the land resulting from the previous pressure from the ice, the area was lifted to its current setting as a freshwater lake, and lacustrine deposits of clay and organic materials were deposited. Two propositions for the N-S running moraine mount were given: either it could be an Esker deposited in the middle of the large glacial incision or else it could be a medial moraine formed due to a large bedrock mount found just to the north of the moraine feature. The boulders identified in the units were located using both migrated and unmigrated data, and the approximate sizes of them could be assessed in the 3D dataset.
The study showed that 2D mUHRS and 3D mUHRS investigations can be applied and are highly suitable for offshore lake investigations in remote areas. A detailed 3D model was created including the interpreted units along with the 47 boulders and the well logs. This highly visually intuitive way of displaying data provided a basis for better collaboration between the different disciplines involved in this large construction project.

References

COWI, 2023, Fagrapport 3D UHRS Geofysikk på vann for E6 Moelv-Roterud