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Mapping a buried Quaternary valley and pre-Quaternary faults through seismic methods in Copenhagen, Denmark.

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Limited knowledge of the subsurface geology motivates the use of geophysical techniques before large engineering projects are conducted. These applications are normally restricted to satisfy the project aims, like mapping the near surface sediments, unconsolidated rocks and/or geological structures that may affect the construction locally. However, the applications can also contribute to the general knowledge of the regional geology around the location of interest. This report highlights the mapping of a buried Quaternary valley and identification of regional faults by a reflection and refraction seismic survey performed in Copenhagen.

A 13.9 Km seismic survey was carried out at Copenhagen city along six crooked lines in order to determine the velocity fields in the near subsurface segment of a planned metro line and reflection patterns in deeper levels. The aim of the survey was to collect information needed for designing the underground metro. In particular it was sought to map the interface between Quaternary sedimentary layers of clay, till and sand, and the underlying layers of Palaeogene limestone found between 7 and 40 m below the ground surface.

The data acquisition was carried out using a 192 channels array, receiver groups with 5 m spacing and a Vibroseis as a source at 5 m spacing following a roll along technique to complete the survey spreads. The urban environment demanded extensive survey planning including traffic control, notifications to residents and a fluent coordination with municipal authorities in order to minimize disturbances and ensure data acquisition. The reflection data was processed under a conventional scheme and the refraction data was interpreted using a non-linear traveltime tomography algorithm.

The reflection results indicate the presence of faults oriented NW-SE to NNW-SSE affecting the limestone sequences. The faults may be associated to the Sorgenfrei–Tornquist Zone at the transition between the Danish Basin and the Baltic Shield. The refraction interpretation allowed the mapping of the velocity distribution in the upper sediments and their interface with the underlying limestone sequences. In this work two sections along the northern part of the survey are presented and discussed. The cases show the ability of the seismic results to image the presence of a buried valley that has been previously reported but was geophysically mapped for the first time under these investigations. The results delineate the sediments-limestone interface as the depth to the limestone increases. These results are validated through borehole data from locations along the surveyed lines. Other minor lateral variations are also observed and compared to a geological model. The location of the buried valley corresponds to a fault zone observed in the reflection seismic investigation. Accordingly, the location of the valley may in part have been controlled by the faults.

The overall results of the seismic investigations are currently being used as part of the design basis for the construction of the metro line and may be useful for future engineering projects in the area. In general, the investigation results demonstrated that in addition to meet specific project objectives near surface geophysics has the potential to provide insights to the general understanding of geological processes.

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