The potential of detecting flaws in an experimental dam at Älvtarleby, Sweden, using P-wave traveltime tomography

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A large number of dams located in Sweden, built in the second half of 20th century, are earth embankment dams. Seepages and internal erosion represent safety issues, which are difficult to detect and predict. There are indirect methods to detect seepages, but these do not provide their location. The hydropower operator Vattenfall has initiated a research project to assess geophysical methods as a decision support and asset management tool for this type of structure. The project consists of detecting built-in flaws in the core of a 20 m long and 4 m high experimental dam using geophysical (seismic and resistivity) and temperature measurements taken at the top of and inside the dam structure for a period of approximately 18 months. The behaviour of the dam itself will be monitored by geotechnical instrumentation.

This work focuses on testing P-wave traveltime tomography for detecting defects and supporting the interpretation of P-wave reflection seismic data. Synthetic traveltime studies were performed using the dam structure, constant P-wave velocities for each material, and the seismic acquisition design. Five parallel lines of hydrophones were used, three at the top and two at the bottom of the dam. The central hydrophone line at the top of the dam coincides with the position of the seismic sources. In addition, four boreholes to 4 m depth are positioned on each side of the central hydrophone line in both edges of the dam. Within these boreholes shots and receivers were positioned at every 0.5 m depth. The initial velocity model of the dam considers that the dam is filled with water up to a height of 3.5 m. A series of defects (low velocity zones with varying size and position) were inserted. Other factors, like noise or error in the acquisition geometry, were also considered. The defects may be cavities or permeable/loose layers.

Preliminary results show, in general, that the defect position can be identified by tomography. The velocity and size of the defects, however, are not well recovered by the method. Recovery of the defects using traveltime tomography is greatly influenced by the defect position, as the seismic ray coverage is limited in some parts, such as the central lower part of the dam. In the case of a defect located closer to the top hydrophone lines or one of larger size, the anomalies are better identified. We note that the amplitudes of the anomalies are very small, which may complicate identifying defects using real data. The anomaly signatures depend on the shape of the defect, for example a cubic defect compared to a horizontal permeable layer, which could help to identify...
and characterize the defect. Although the primary focus lies on identifying the presence of defects, information about their dimension and type is also important.

Future work will be focused on processing repeated seismic fieldwork campaigns at the experimental dam, in order to investigate the dam integrity using time-lapse seismic measurements, including comparing the seismic data with other types of data.