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Induced seismicity at an underground gas storage facility in the Netherlands

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The Bergermeer field is a natural gas reservoir in the North-Western part of the Netherlands. The reservoir geometry is defined by a horst structure at 2km depth that consists of two major blocks (partly) separated by a large central scissor fault. The reservoir rock is a sandstone of Permian age from the Slochteren formation. The top and side seals consist of a series of evaporites from the Zechstein formation.

The field has been in production from 1970 to 2006. During the production two pairs of widely felt and slightly damaging earthquakes with local magnitudes between 3.0 and 3.5 have been induced. After the first pair of events in 1994 a local 3-station seismic network of shallow borehole sensors was installed. This network, with a local detection capability in in the order of magnitude 1, has not detected any local seismicity apart from the second pair of strong events in 2001. The hypocenters of all four events have been located close to the central fault, near the "hinge of the scissor".

Currently, the Bergermeer field is being prepared to be operated as an underground gas storage (UGS) facility. The preparation already involves the injection of cushion gas to limited pressure. Considering the historical events, a critical aspect of the UGS operation is the mitigation of induced seismicity. To investigate the relation between pressure/temperature changes on the one hand and induced seismicity on the other hand, both during preparatory and operational stages, the field has been subjected to both seismic monitoring and geomechanical modelling.

We present a case study for the Bergermeer field with some of the recent results in both downhole microseismic monitoring and 3-D geomechanical modelling and an integrated interpretation.