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USING CONTINUOUS MICROSEISMIC SURVEILLANCE FOR THE MANAGEMENT OF CAVERN FIELDS.

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Abstract

Large salt dome deposits were discovered in the Northeastern part of the Netherlands in the mid-20th century and are currently exploited for brine production and gas-storage facilities. Nouryon has developed around 30 salt caverns in the salt domes of Heiligerlee (Winschoten) and Zuidwending in the past decades.

On 17 November 2017, a series of four back-to-back events was recorded by the national seismic network run by the Royal Dutch Meteorological Institute (KNMI) in the vicinity of Heiligerlee salt dome. The largest event had an estimated moment magnitude of 1:28 ± 0:08 and approximate location above the western flank of the salt dome [Ruigrok et al., 2018]. A peak ground acceleration of 2.45mm/s^2 (0.0964 in/s^2) was recorded. This event was widely felt by locals, raising concern with the public and authorities about salt cavern safety.

The national seismic network is dedicated to monitor natural seismicity and it was densified in the north of the Netherlands to measure seismic activity induced by gas extraction [Van Thienen-Visser and Breunese, 2015]. The network has a large hypocentral distance in relation to Heiligerlee location, no vertical aperture and low frequency seismometers. Following a detailed review of the Heiligerlee event, it was decided the location accuracy of the national seismic network is insufficient to determine an accurate position for future events with respect to the salt dome flanks and individual cavern positions. Furthermore, the detection threshold is not low enough for ongoing monitoring of the field. Therefore, any cavern-induced earthquake hypothesis could not be ruled out or confirmed definitively for the Heiligerlee or any future event.

After this event, Nouryon in cooperation with Arup and Magnitude, developed and deployed a continuously recording subsurface microseismic network in order to monitor the structural integrity of its brine production site. Over the 23 months of monitoring, 60 microseismic events have been identified, with a maximum moment magnitude of 0.6. These are typical values for healthy and quasi-aseismic caverns in this geological and industrial context. This monitoring allowed Nouryon to grow a more detailed and accurate dataset for use in discussions with the authorities and the public.

Additionally, the seismic network has allowed distinguishing different types of seismicity in the salt dome: one related to the natural closure of the salt caverns, inducing shear and rockfall events of moderate energy; and one located in the cap rock inducing some of the strongest shear events.

All this information allowed Nouryon to collect data about the salt dome and overlying layers such as: heterogeneity in salt, faults in overburden, reasons for higher intensity of very small seismic events and relation with cavern operations. The high sensitivity network enables to observe the seismicity in its smaller scale, with a -0.7 completeness moment magnitude 500m (1640ft) away from all caverns, making a fine discrimination of source location between the various objects (caverns, salt edge) possible. Thus, microseismic monitoring can be used as a tool for integrity monitoring.

Moreover, we will discuss how microseismic data can be used for new caverns developments by describing an initial seismic context prior to drilling, which will be used to set a baseline level of seismicity. This baseline will enable the distinction between normal and mining-induced seismic activity. Finally, we will describe how microseismic surveillance can help through the complete life cycle of a cavern field including abandonment.

Key words: Microseismic, Cavern design, Cavern development, Abandonment, Mechanical integrity, Safety, Salt dome.