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Technical Conference Paper

Detailed microseismic monitoring improvement by a high- resolution field specific velocity model - Salt caverns of a Nobian site in the Netherlands

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Abstract

In 2018, Baker Hughes was commissioned to install and operate a seismic monitoring network on a salt cavern field to monitor cavern stability. This seismic network includes six shallow buried arrays. The seismic sensors are arranged around the cavern field to have optimized coverage. Each shallow buried array is composed of two levels of three-component geophones. Each cemented array is connected to a high gain digitizer located on surface and allowing a real time monitoring.

During six years of monitoring, the network recorded some microseismic events of which the location could be determined. The energy released by these detections is low with magnitudes below 0.5 on a Richter scale. The location was determined using a regional 3D velocity model based on velocity profiles from the NAM, and the 3D geological structure. With this velocity model the seismic events were located around caverns but also at the interface of top salt and overburden. However, a clear mechanism that could explain the spatial distribution of the events was lacking.

An improved geological model led to an update of the local velocity model along which the velocity profiles were better constraint, and the event database was re-evaluated for arrival time picking. With a more detailed velocity model it is possible to validate the determined event locations with the aim to improve the quality and reliability of the process to determine event locations. The improvement is done by building a site-specific 3D velocity model. As input publicly available sonic logs from around the caverns field were used to extract information on the acoustic velocities in the rock salt and overlying layers. Furthermore, acoustic velocities and v_p/v_s ratios were re-evaluated using values published in literature. These data were integrated along with the updated geological structure using JewelSuite™ Surface Modelling software.

Before relocation using this new 3D velocity model, a quality control of all the picking arrivals was done on the seismic signal, considering the experience acquired in five years of monitoring. The location of the events was then determined using the new velocity model. Our results show that the signal picking of the different wave arrivals has a relatively small impact on the location variation compared to that of a more reliable and detailed velocity model. Events were no longer located on the top salt interface, and spatially more concentrated to specific intra-salt interfaces near some caverns that crosscut the same contact. We hypothesize that the redistribution of stresses near the caverns leads to different amounts of strain across the contact, which eventually leads to microseismic slip events.

Key words: Seismic events, velocity model, field stress, Richter magnitude, leaching cavern, seismic network.