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Microseismicity induced within Hydrocarbon Storage in Salt Caverns, Manosque, France.

Hazard review and event re-location in a 3D velocity model.

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Abstract

The underground storage complex for liquid hydrocarbons in salt leached caverns at Geosel-Manosque (Southern French Alps) has a capacity of 7.5 million m3. It came on stream in 1969 and has currently 27 storage caverns, one brine production cavern, plus two caverns under leaching. Each salt-leached cavern, located at a depth of between 300 and 500 meters (top cavern), is the size of the Eiffel Tower (up to 400 meters height). These caverns are located in a saliferous diapiric structure, within a seismo-tectonic region.

In this context, the microseismicity is a good indicator of the physical properties of rocks and may be triggered by a number of causes including dynamic characteristics of leaching processes or/and external events associated to structural features and halokinetic phenomena.

Continuous digital microseismic monitoring has been performed since 1992. About 10,000 induced microseismic events with magnitude lower than 0.3 have been located within the storage perimeter. More than 90% of the events are associated to leaching process. Beside the induced seismicity, about 1000 events with magnitude up to 3.5 have been located around the diapiric structure and are related to the on-going halokinetic phenomena.

A new interpretation of the 3D geology has been performed in 2011/2012 by combining existing data along with new well logs and new geophysical profiles. The study allows a better understanding of the geological sequence. The structural map indicates the salt thickness distribution and has been used for locating new caverns. Consequently, a new 3D velocity model was built, with three different interfaces, and more precise seismic velocities.

Microseismic event location accuracy is fully driven by the seismic velocities and this new model should provide a better characterization of the microseismic activity induced by both storage operations and leaching process. Location accuracy is of prime importance to properly analyze the seismicity in order to understand event distribution and mitigate the risks associated to seismic hazards.

In order to test the improvement we can expect by using the new velocity model, we focused the re-location study on seismicity clearly induced by the leaching of the new caverns. As expected, the new 3D model allows improving the location accuracy and the resulting 3D distribution of events is more consistent with both geological and leaching contexts.

This event re-location study was also an opportunity to revisit the microseismic database in order to better define the seismicity which can be considered as an inherent part of leaching process and storage operation. The next step would consist in the complete re-location of the microseismic dataset acquired since 1992 in this new 3D model. The spatio-temporal distribution should then be re-analyzed to draw lessons we can use to improve the risk mitigation procedures.

Key words: underground storage, saliferous unit, tectonic, leaching, seismic monitoring, risk assessment, micro-seismicity, magnitude, velocity model, location improvement.