

Statistical analyses of microseismicity in salt cavern storages

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Abstract

Microseismic monitoring has become an essential tool for the management of cavern integrity in solution-mined storage facilities. Subsurface stress and strain changes from cavern mining or from daily operation of a facility commonly generate microseismicity, which is the phenomenological response of slip on pre-existing fractures. It is also not uncommon for blocks of insolubles (e.g. anhydrite) to fall from the roof or walls of salt caverns, and this too generates microseismic signals. Recording this microseismicity and understanding its mechanisms is thus essential to guarantee the integrity of a storage facility. Microseismic signals are very small (micro-earthquake magnitudes <1) and detecting and characterising them requires highly sensitive local seismic networks.

Classical analyses have focused on the detection of these signals, their classification into shear or rockfall events, and the precise determination of the position of their source (i.e. pinpoint where a microseismic event has occurred). These surveys provide very valuable information in the form of earthquake catalogues, which should then be analysed relative to site operation and mechanical considerations.

Hereafter we analyse microseismic catalogues using statistical spatial and time series analyses. The primary aim of our analysis is to track possible migration of microseismicity, detect changes in nucleation and/or moment release rates and assess the degree of event correlation. Further we suggest the advantages of inferring source characteristics. These analyses are performed alongside site operation data, taking into account mechanical constraints. We use case studies of multi-salt cavern storage facilities with excellent local seismic monitoring networks to illustrate the usefulness of these statistical tools. We suggest that close monitoring of changes in these statistical indicators can be used as warning thresholds for changes in the dynamics of the system.

Key words: microseismicity, gas storage, salt cavern integrity, rock mechanics