Spatial and temporal evolution of micro-earthquakes during Multi-cycle operation of the Hutubi underground gas storage, Xinjiang, China

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1. Introduction

Underground Gas Storages (UGSs) are important large-scale industrial facilities used to bridge the gap between the natural gas consumption and supply. The UGS production (periodical natural gas injection into and extraction from UGS) can cause changes of the subsurface stresses and probably the local seismicity pattern. The UGS related seismicity has important effects on the UGS safety and local seismic hazard, but is rarely reported, comparing to well-documented seismicity associated with liquid injection and extraction. As the largest Underground Gas Storage in China, the Hutubi UGS is well equipped with seismic observations from the beginning of the UGS operation, which provides an unprecedented to investigate the seismicity related to the periodical UGS operation.

2. Geologic settings & UGS Operation

Hutubi Underground Gas Storage is located in the uplifted Hutubi anticline near the North Tianshan. There are three near east-west reverse faults tend to southwest develop along the axis of Hutubi anticline and cut through the formation of Ziniqunzi formation.

3. Data processing & Detected result

To monitor the seismicity around the Hutubi UGS, we first detect micro-earthquakes from the continuous seismic records using the Matched and Filtered Technique (MFT, Meng & Peng, 2012). And then we relocate the detected events using double difference method (Waldhauser & Ellsworth, 2000).

4. Seismicity of three main clusters near the Hutubi UGS

Figure 5. Spatial-temporal distribution around Hutubi UGS. According to its spatial distribution, we divide the regional seismicity into three main clusters. The cluster A, B, and C are marked as blue, red, and green cycles, respectively. The seismicity in cluster A and B are shown in (b) and (c). The M=1 plot (black dots) and the seismic rate per month (grey histogram) indicated that the b-cluster event mainly occurs when the storage capacity gradually increases, while the a-cluster event mainly occurs after the end of the capacity increase.

5. Stress or Fluid Diffusion?

Figure 7. Coulomb stress perturbation induced by the operation of Hutubi UGS at the begin of second injection. (a) and (b) show Coulomb stress perturbation with different receiver faults the spatial distribution characteristics from different angles.

6. Conclusions

1. Seismicity related to the operation of gas storage in Hutubi area. Their physical mechanisms may be different. In the different periods of operation of the gas storage, the mechanism of induced earthquakes in the surrounding area is different.
2. Understanding the mechanism of seismicity around gas storage will help us to adjust the operation strategy of gas storage to reduce the seismic risk. Continuous high-precision seismic activity monitoring can effectively monitor the state of natural gas storage and reservoir trap, and improve the security of gas storage operation.