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

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Underground Gas Storages (UGSs) are important large-scale industrial facilities used to bridge the gap between the natural gas demand and supply. The UGS production can cause periodical changes of the subsurface stresses and probably change the seismicity pattern. The UGS operation related seismicity has important affects on the UGS, but is rarely reported. Hutubi UGS is the largest Underground Gas Storage in China and well equipped with seismic observations from the beginning of the UGS operation in Jun. 2013. The Hutubi UGS provides an unprecedented opportunity to study the seismicity related gas injection. The seismicity around the Hutubi UGS was detected and located by using matched filter and double difference relocation techniques. More than 7000 earthquakes were detected and located within 20 km of the UGS from Jan. 2011 to Dec. 2018 (i.e., 2 years before the operation and 6 injection-extraction cycles). The seismicity can be clustered into three groups South of, North of, and beneath the UGS. Two (South and North) of three groups occurred along two south-dipping planes with dipping angle ~40 degree, corresponding to local geological structures. While the underlaying group occurred along the direction conjugate to the other two groups, which was in accordance with the starting of the second injection stage and gradually migrated deeper. The northern cluster occurred mainly after the Murghob earthquake (M7.2) and the Hutubi earthquake (M6.2), which may be related to dynamic stress triggering from these two earthquakes. The seismicity in the southern cluster persists, but the rate shows seasonality, which is likely modulated by the gas operation and underground water exploitation. The seismicity in the Hutubi UGS area may have different origins. Understanding the mechanism of the impact of UGS operation on different clustering seismicity will help us to optimize the production parameters and reduce the risk of induced earthquake.