Microseismic and Induced Seismicity Monitoring and Tomography of the Changning-Zhaotong shale gas play in China using dense nodal arrays

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With the development of shale gas in the Changning-Zhaotong play in the southern Sichuan basin of China, which is the largest shale gas prospect in China, the frequency and magnitude of earthquakes in this region have increased significantly in recent years. For example, a M5.7 earthquake occurred on December 16, 2018, and a M5.3 earthquake on January 6, 2019 in addition to many M4.0+ earthquakes in this area. Some studies argue the large magnitude earthquakes are triggered by hydraulic fracturing in for the local shale gas development, which commenced in 2011. The frequency of the earthquake occurrence has been on steady increase in the past few years that local residents often reported felt quakes. To further understand the correlation between the shale gas development and local seismic activity, we conducted a two-phase dense array seismic monitoring with about 200 Zland 3C and SmartSolo 3C 5 Hz seismic nodes, from late February to early May, 2019 for a period of 70 days. The survey consists of roughly 340 deployments at 240 sites, with an average interstation distance of 1.5 km, covering 500 km2 in total. We have processed seismic records from late February to early April, 2019 (phase I), and picked some 600,000 P- and S-wave arrival times from 4385 detected local earthquakes. The earthquake hypocenters and the subsurface velocity structure of the Changning-Zhaotong area are inverted for using the double-difference tomography method. The relocation results show that the majority of hypocenters were located at depths ranging from 1.0km to 4.0km, in the proximity of the horizontal hydraulic fracturing wells. The tomographic results (< 3 km) correlate well with the known surface geological units, and most earthquakes occurred along the velocity discontinuities, likely characterizing a large hidden fault which, interestingly, is where the January 2019 M5.3 occurred. Our study is very important for understanding the seismic potentials in this
area, and should provide useful information for the shale gas development in this region and other areas in China with similar geological, tectonic and stress conditions.