Geophysical Research Abstracts
Vol. 20, EGU2018-7211, 2018
EGU General Assembly 2018

Rupture Processes and Magnitude Statistics of the 2014 M5.5 Earthquake Sequence Below a Gold Mine in Orkney, South Africa

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Despite our general understanding of earthquake processes, it is still not fully understood how earthquake ruptures nucleate and propagate and why they stop. Furthermore, the controlling factors of the frequency and the size of earthquakes are subject of ongoing research. We address these questions with a comprehensive study of seismicity from deep South African gold mines. Here, we find the unique situation that the seismicity consists of both mining-induced earthquakes and aftershocks triggered by the M5.5 Orkney earthquake in August 2014. We hypothesize that the finiteness and geometry of the volume of stress perturbation, either by mining activities or by a main shock, controls the nucleation and propagation of ruptures and influences the frequency-magnitude distribution. To test our hypothesis, we apply novel approaches to the seismcity from the deep mines which involve both waveform-based and probabilistic methods. These methods were recently elaborated and successfully applied to fluid injection induced earthquakes and include rupture propagation imaging (Folesky et al., 2015), rupture directivity analysis (Folesky et al., 2016, 2017), and studies of the scaling of the earthquakes magnitude statistics (Shapiro et al., 2013, Dinske et al., 2016). We test the applicability of these approaches to the seismicity in deep South African mines which also occurs in finite volume where the in-situ stress is perturbed. It contributes to a better understanding of seismogenic processes and, in particular, to an improved assessment and mitigation of seismic hazard in mining environment. First results indicate a unilateral rupture of the M5.5 main shock, which is in agreement with previous results (Imanishi et al., 2016, Ogasawara et al., 2017), and we find a clear spatial separation of aftershock hypocenters and the induced seismicity in the different mining horizons.