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Induced seismicity response of hydraulic fracturing: results of a multidisciplinary monitoring at the Wysin site, Poland

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Shale oil and gas exploitation by hydraulic fracturing (HF) experienced a strong development worldwide over the last years, accompanied by a substantial increase of related induced seismicity. In Europe, the potential application of this technology has led to worries regarding the alleged magnitude of the environmental impact, and expectations about production of hydrocarbons. One of the last operated well at Wysin (Poland) was monitored independently in the framework of the SHEER (SHale gas Exploration and Exploitation induced Risks) EU project through a multidisciplinary system including seismic, groundwater and air quality monitoring. HF operations were carried out along two horizontal boreholes during 10 days each on 2016 June and July. Wellbores are located at about 4 km depth and oriented WNW-ESE, with approximate horizontal lengths of 1.7 km each. The hybrid seismic network combines surface mini-arrays, broadband and shallow borehole sensors. In this work, the seismic response of HF stimulations at Wysin is analysed and discussed over a 4-months period involving different stages before, during and after the ending of HF operations. Shallow artificial seismic noise sources are detected and located at the wellhead active during the fracturing stages for periods of 1.5-2 h. Variations of the seismic noise amplitude reduce temporally the signal-to-noise ratio of local shallow borehole installations, which are located much closer (< 1 km) to the wellhead. To account for the changed noise conditions, the magnitude of completeness is recalculated increasing from 0.55 to 0.80 around the HF area. Local microseismicity was also detected, located and characterised, culminating in two events of Mw 1.0 and 0.5, occurring days after the stimulation in the vicinity of the operational well, but at very shallow depths. Continuous seismic recording were processed using a recently developed automated full waveform detection and location algorithm based on waveform stacking and coherence analysis. Given the accurate assessment of the monitoring conditions, we can proof that the HF experiment at the Wysin site did not induce earthquakes with Mw > 1. Possible correlations between the production stages, observed microseismicity and changes in water and air parameters are also investigated. The air monitoring shows the occurrence of repeated anomalies of methane, lasting for one to several hours, exceeding the natural cycle of daily variation of these pollutants. A first anomaly is seen shortly after the end of the second stimulation. The methane concentration reached 3.5 ppm, almost double of the average level of ∼1.9 ppm. A series of sharp, outstanding methane peaks (maximum 7.4 ppm) of decreasing amplitude were recorded starting ∼19 h after the occurrence of the Mw 0.5 seismic event. No impact from HF activities was detected on the groundwater parameters at short- and medium-term scale.