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Fault-valve action in real time: carbon dioxide release due to ML 3.5 earthquake in West Bohemia

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The West Bohemia/Vogtland region is specific for its collocation of earthquake swarm activity and degassing of CO_2 of mantle origin. In 2014 three mainshock-aftershock sequences occurred; the first ML 3.5 mainshock was followed four days later by fast increase of CO_2 flow rate in the Hartoušov mofette, 9 km apart from the epicentres. During the subsequent 150 days the flow reached the sixfold of the original level, then a slow decay followed, which suggests that the seismic activity could have been driven by the fluid-valve mechanism.
The detailed analysis of the spatiotemporal characteristics of the aftershock sequences and their ETAS modeling shows that an additional aseismic source with an exponentially decaying strength was needed to trigger a large fraction of the aftershocks. Corresponding pore pressure simulations with an exponentially decreasing flow rate show a good agreement with the observed spatial migration front of the aftershocks. To explain the observed gas flow rate anomaly in the mofette we simulated gas flow in a two dimensional model of Earth crust composed of a sealing layer located in the hypocentre depth, which is penetrated with earthquake fault and releases fluid flow from a relatively low permeable lower crust. The excellent fit of the simulated flow to the data shows that even this simple model is capable of explaining the observations including the short travel time of the flow pulse from 8 km depth to the surface. Based on the observations of aftershock migration and of surface gas flow confirmed by numerical simulations we derive scenario that the mainshock opened fluid pathways into the fault plane, which triggered significant part of aftershocks and was observed 4 days later on the surface as a rapid CO_2 flow rate increase. The present decrease of CO_2 flow rate indicates that the fault valve scenario is in action in the form of sealing the fault due to mineral precipitation.