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Spatial permeability variations of aquifers in North China Plain derived from large magnitude earthquake signals

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Permeability changes induced by earthquakes have been widely studied. The question remains of how multiple large earthquakes influence permeability at different depths in the far-field and permeability changes could possibly be employed for hydraulic characterization of the aquifers has not yet been investigated. We study the change in permeability in fractured aquifers of the North China Paraplatform based on 11 years of groundwater hydrographs of 7 wells and 62 earthquakes. From 2008 to 2018, the permeability changes varied from well to well, all aquifers showed a consistent and distinct magnitude of change in permeability (decrease, increase and no change) following each earthquake. From the perspective of a single well to multiple shocks, the permeability variation of the JN well is the most sensitive to seismic events. From the perspective of multiple wells to one single earthquake, there were no cases of simultaneous permeability changes in all 7 wells induced by a single earthquake. Permeabilities varying within a wide range at a given depth implies that it could be considered as a dynamically self-regulating value, while permeability changes indicate great differences at varying depths. We found that the correlations between permeability changes and seismic energy density or depth are weak, however, the azimuths of seismic waves could greatly impact the changes in permeability, i.e., from 25° to 295°, and the most significant span is 250° to 295°, and fault distribution around the monitoring wells may also contribute to this result. Employing a seismic waves-pressure amplitude model, the mobilization of colloids driven by the oscillation of pressure head as a possible mechanism of permeability change. Distant, large magnitude earthquakes can alter the permeability, also can accelerate or slow down the rate of permeability change of the aquifer material.