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The seismogenic potential of withdrawal-reinjection cycles: numerical modelling and implication on induced seismicity

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Induced seismicity can be associated to the activity of fluid withdrawal and injection from/into the shallow crust (fracking, wastewater disposal into the deep crust, EGS technology, fluid extraction in oil fields and geothermal power plants). Long-term injection of large volumes of fluids is normally associated with induced seismicity, but the effect of withdrawal-reinjection in the same reservoir is largely unknown. However, it is common experience worldwide that small geothermal plants with withdrawal and re-injection of fluids in the same reservoir are not associated to any significant seismicity. This paper aims at understanding how to discriminate the seismogenic potential of withdrawal-reinjection operation with respect to injection only. With this aim, we analyzed the induced pressure changes, the perturbed volumes of rocks and the potential for induced seismicity due to the above activities. A set of simulations of injection/reinjection cycles into the same reservoirs, by using the numerical code TOUGH2®, is applied to simple models of geothermal reservoirs, with varying permeability and lateral confinement. For each permeability model, we then compare the time growth of perturbed volumes obtained with withdrawal-reinjection cycles to those obtained during simple withdrawal or injection, using the same flow rates. Our results clearly show that, for all models, withdrawal-reinjection is by far less critical than simple injection or withdrawal, because the perturbed volumes are remarkably smaller and remain constant over the simulated time, so minimizing the likelihood of interference with seismogenic faults. Our results have significant implications for geothermal projects, and in the assessment of the potential hazard related to fluid stimulation and induced seismicity.