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The static behaviour of induced seismicity: From geometric to risk analysis

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The standard paradigm to describe seismicity induced by fluid injection is to apply non-linear diffusion dynamics in a poroelastic medium. I show that the spatio-temporal behaviour and rate evolution of induced seismicity can, instead, be expressed by geometric operations on a static stress field produced by volume change at depth. I obtain laws similar in form to the ones derived from poroelasticity while requiring a lower description length. Although fluid flow is known to occur in the ground, it is not pertinent to the geometrical description of the spatio-temporal patterns of induced seismicity. The proposed model is equivalent to the one for tectonic foreshocks developed in the Non-Critical Precursory Accelerating Seismicity Theory (N-C PAST). This study hence verifies the explanatory power of this theory outside of its original scope and provides an alternative physical approach to poroelasticity for the modelling of induced seismicity. The applicability of the proposed geometrical approach is illustrated for several EGS experiments, including problematic cases where the stress field may be spatially heterogeneous. The usability of the approach in time-dependent risk analysis (considering various injection profiles and mitigation strategies) is also discussed.