Kinematic slip imaging of the Mw 3.3 earthquake in the St. Gallen 2013 geothermal reservoir, Switzerland, using an isochrone back projection approach

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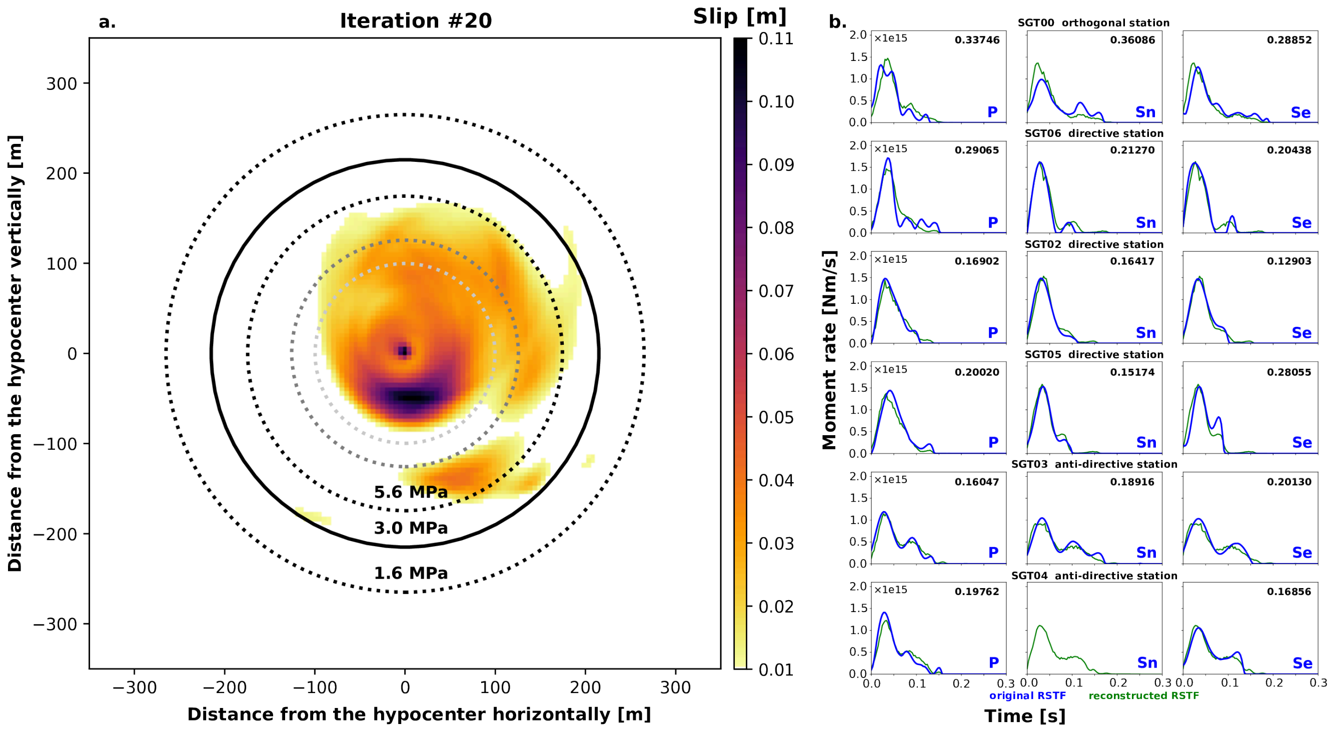
In most models and analyses, small earthquakes (i.e., M<4) are considered either point sources or "penny-shaped" solid surfaces with homogeneous or isotropic source properties. While these assumptions may be valid, details of individual earthquakes are more complex. Due to the insufficient resolution of most monitoring networks, micro-earthquakes (M<2) must be still approximated as dislocation on penny-shaped surfaces. But in case of larger events (M>3) recorded on well-distributed local seismic stations, detailed space-time slip pattern within the rupture area can be imaged.

Here, we analyze slip distribution and rupture kinematics of a moderate induced event (ML 3.5) occurred in the St. Gallen geothermal reservoir (NE Switzerland) in 2013. To image the slip of such a small magnitude earthquake, we carry out a two-step procedure: (1) we deconvolve the propagation effects from the seismograms using an empirical Green's function resulting in relative source time functions (RSTF) at all seismic stations; (2) the RSTFs are back-projected to the fault plane using the position of equal time delays, i.e., isochrones.

Results reveal that the mainshock rupture propagates towards NNE from the hypocenter with an average velocity of about 2000 m/s. Spatio-temporal organization of fore- and aftershocks suggests that the mainshock released a previously less active portion of the fault and that the sequence is mainly stress-driven.

Applying this method in an operational environment could enable to quickly map seismic slip allowing assessment of fault asperities and structures involved in the reservoir creation process.

Keywords: Earthquake Source, Earthquake Kinematics, Back Projection, Induced Seismicity


a.
Iteration #20
Slip [m]
Distance from the hypocenter vertically [m]
Distance from the hypocenter horizontally [m]
5.6 MPa
3.0 MPa
1.6 MPa
b.
SGT00 orthogonal station
SGT06 directive station
SGT02 directive station
SGT05 directive station
SGT03 anti-directive station
SGT04 anti-directive station
Moment rate [Nm/s]
Time [s]
original RSTF
reconstructed RSTF
P
Sn
Se