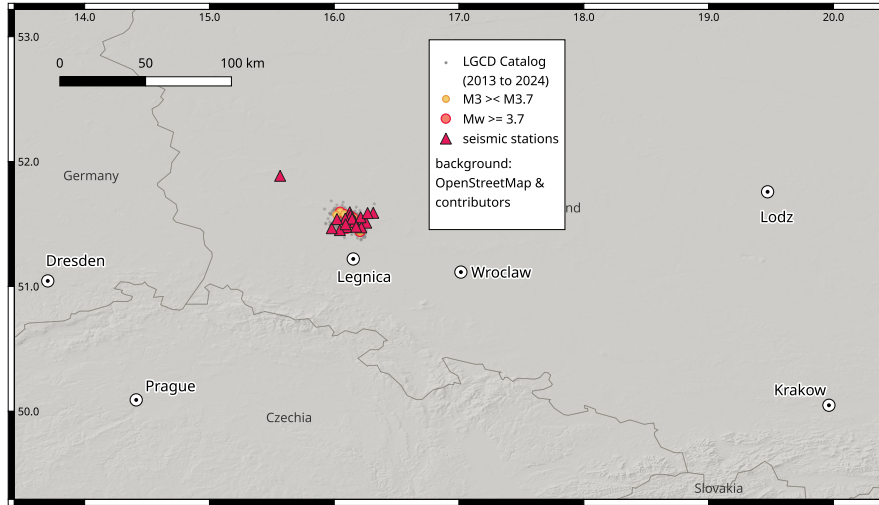


Investigating the source processes of underground-mining induced earthquakes based on geodetic and seismic observations

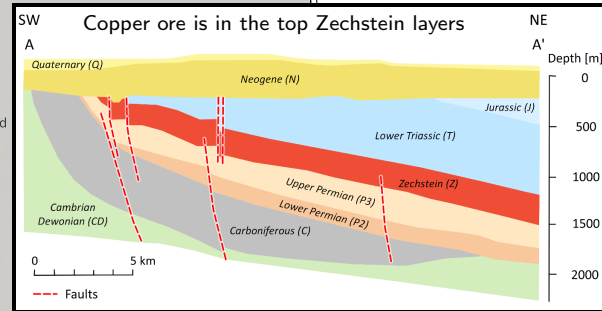
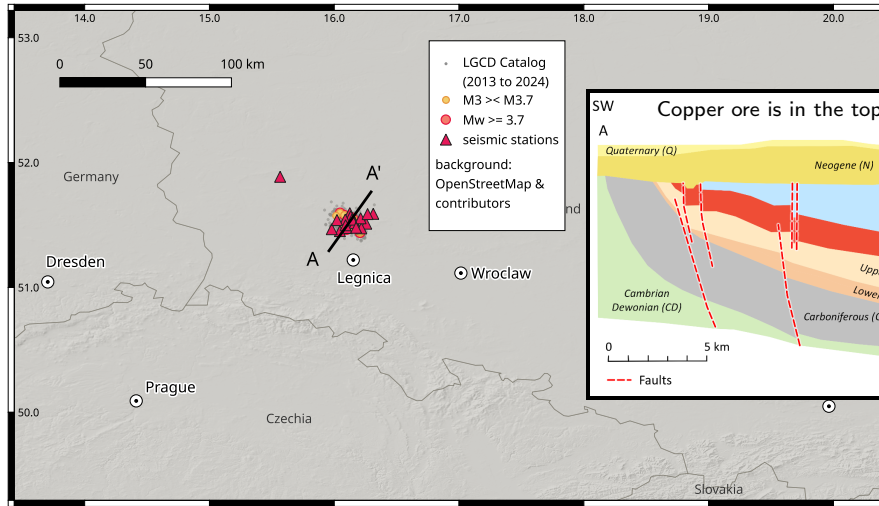
Henriette Sudhaus, Wojciech Witkowski, Katharina Jörg and Sarah Moser

henriette.sudhaus@kit.edu

Introduction to the Legnica Glogow Copper District

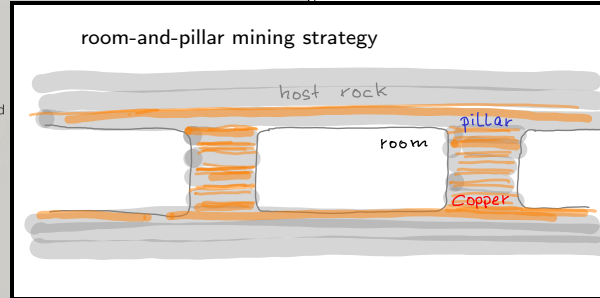
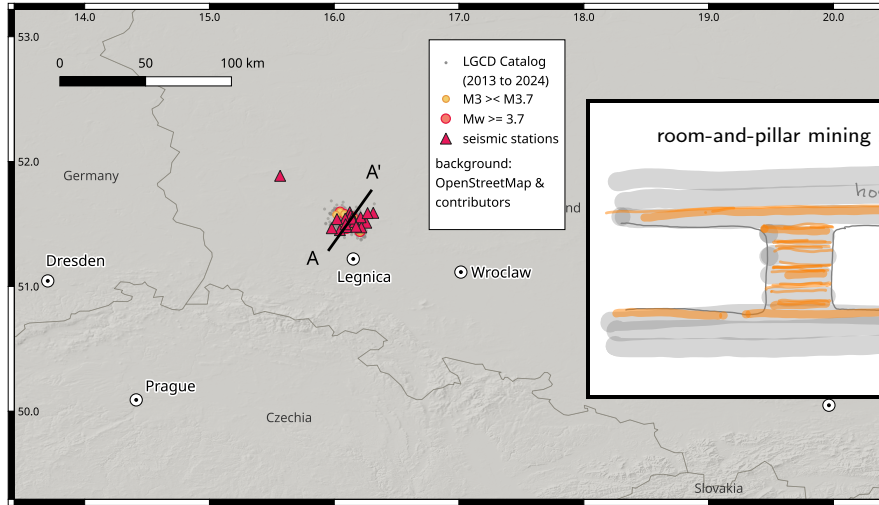


Introduction to the Legnica Glogow Copper District



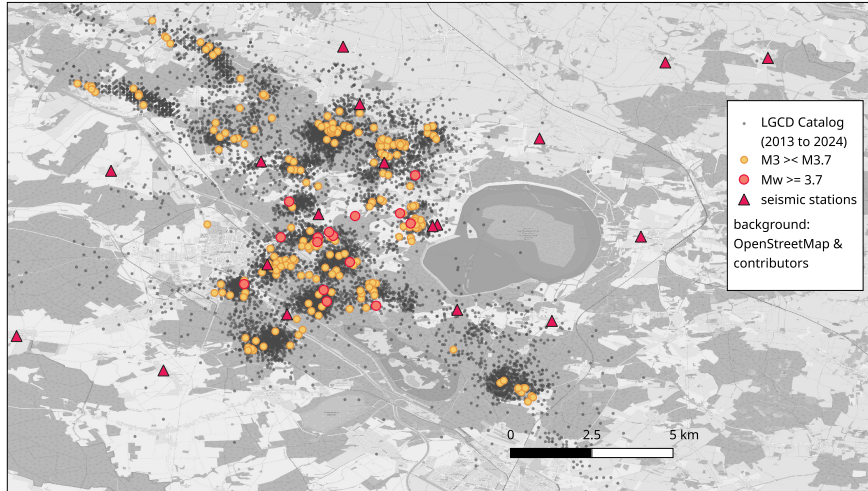
Witkowski et al. (2024)

Introduction to the Legnica Glogow Copper District



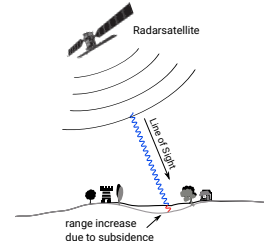
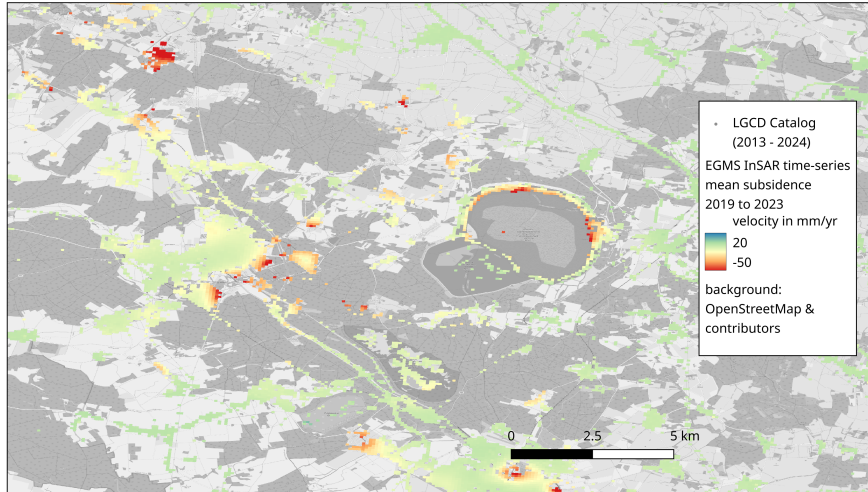
Seismic activity in the LGCD

Local network earthquake catalog from 2013 to 2024



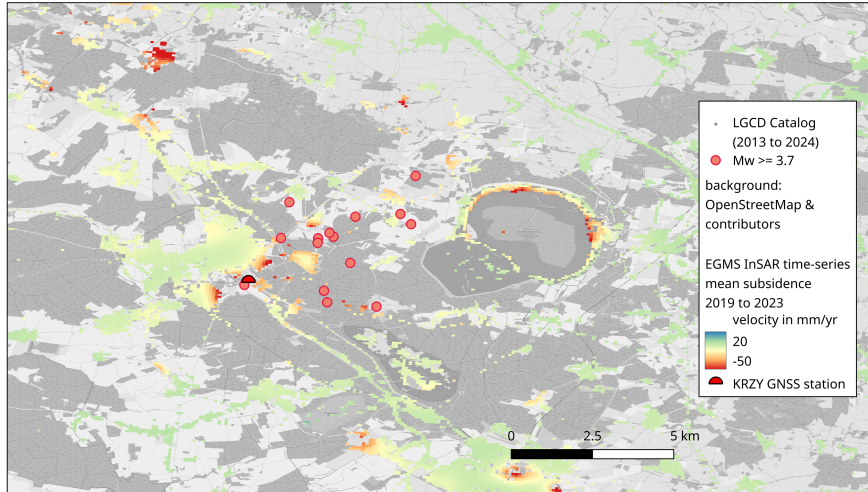
Ground motion in the LGCD

European InSAR ground motion data 2019-2023 (egms.land.copernicus.eu)



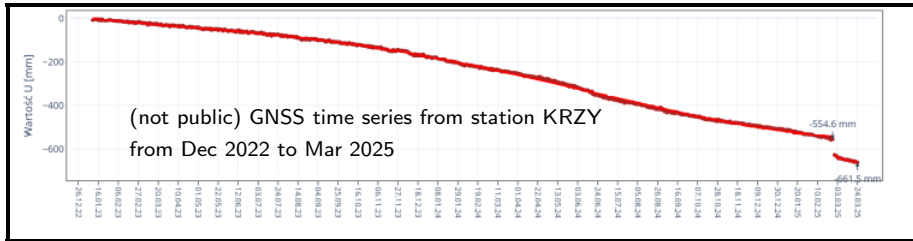
Ground motion in the LGCD

European InSAR ground motion data 2019-2023 (egms.land.copernicus.eu)



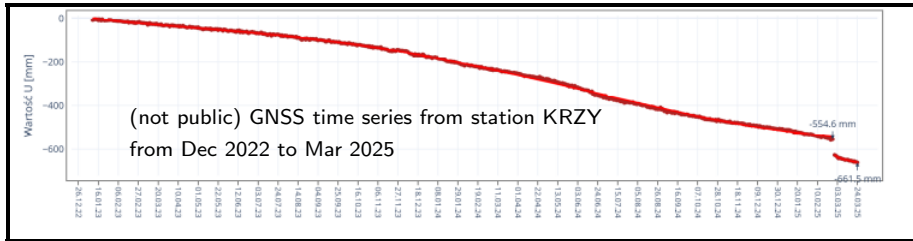
Ground motion in the LGCD

European InSAR ground motion data 2019-2023 (egms.land.copernicus.eu)



Ground motion in the LGCD

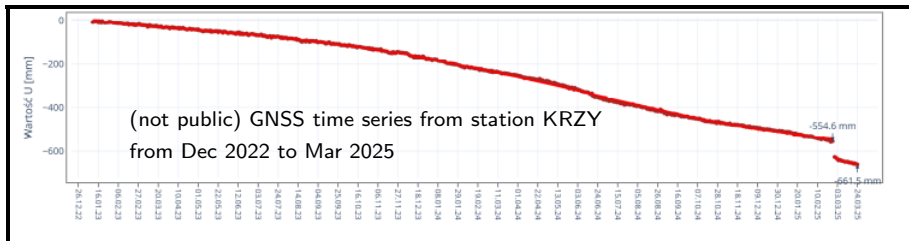
European InSAR ground motion data 2019-2023 (egms.land.copernicus.eu)



room-and-pillar mining scheme

Ground motion in the LGCD

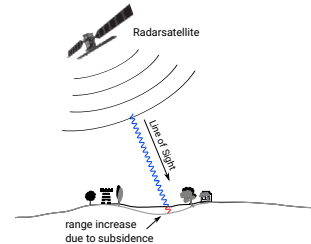
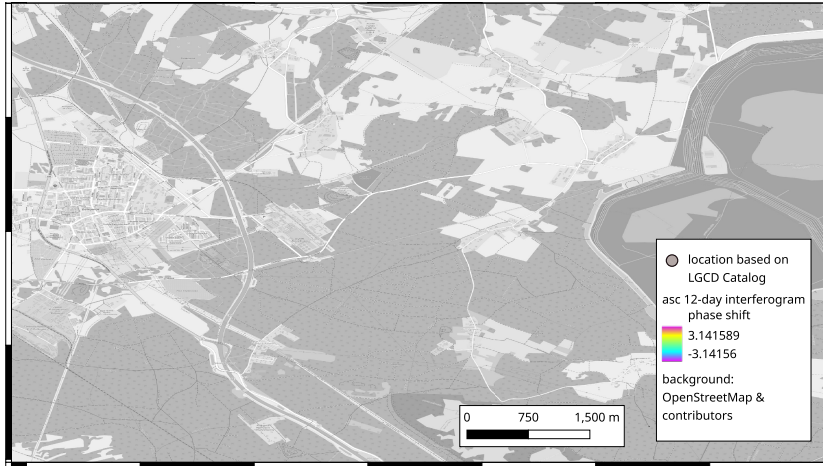
European InSAR ground motion data 2019-2023 (egms.land.copernicus.eu)



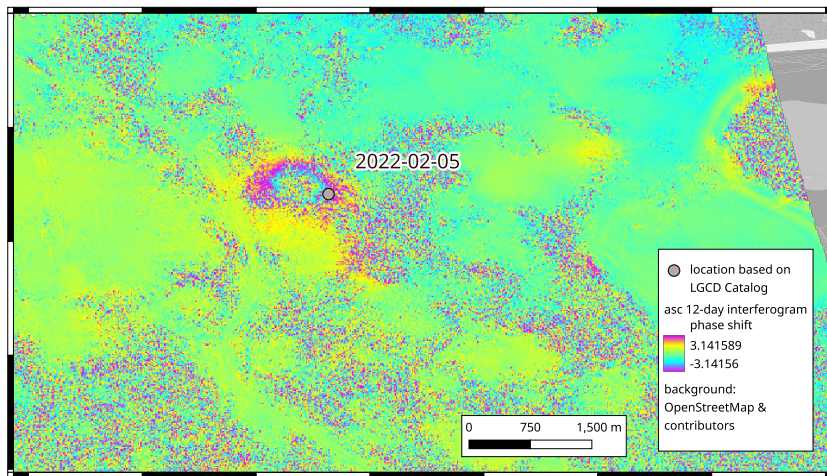
room-and-pillar mining scheme



Ground displaced by mining earthquakes

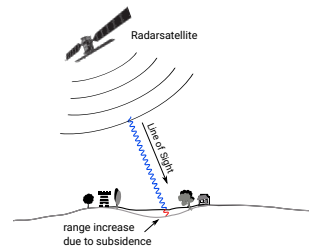


Ground displaced by mining earthquakes

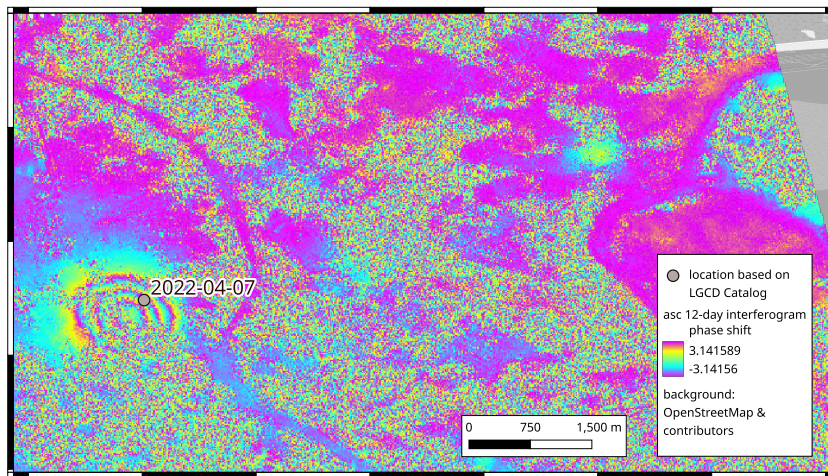


LGCD catalog:

Mw3.8, depth 700 m

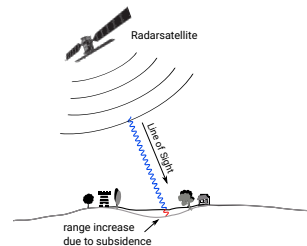


Ground displaced by mining earthquakes

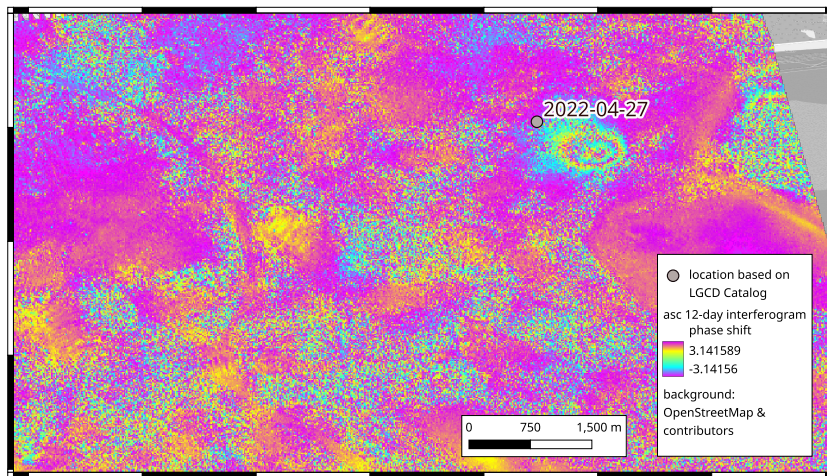


LGCD catalog:

Mw3.7, depth 700 m

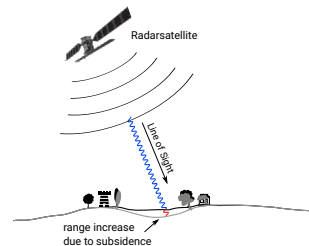


Ground displaced by mining earthquakes

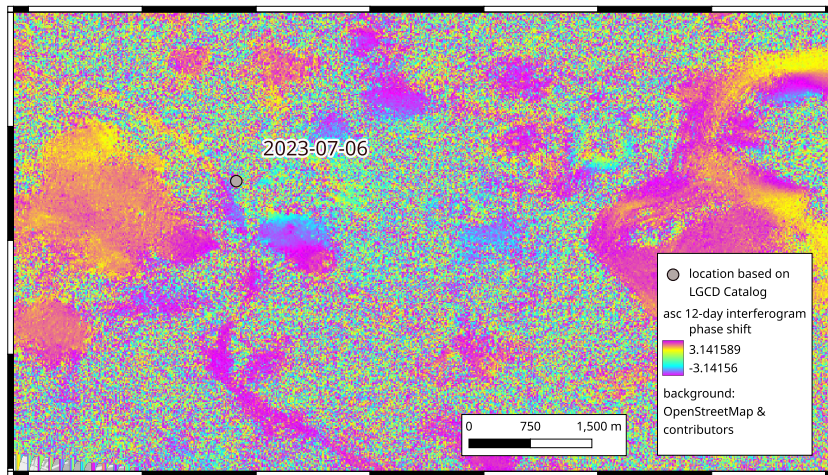


LGCD catalog:

Mw3.7, depth 800 m

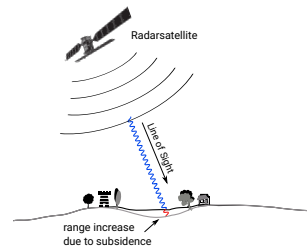


Ground displaced by mining earthquakes

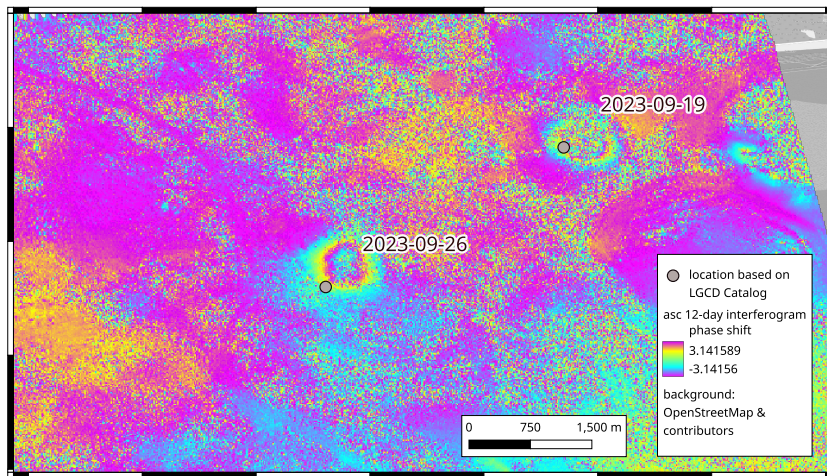


LGCD catalog:

Mw3.7, depth 980 m



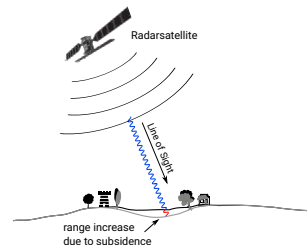
Ground displaced by mining earthquakes



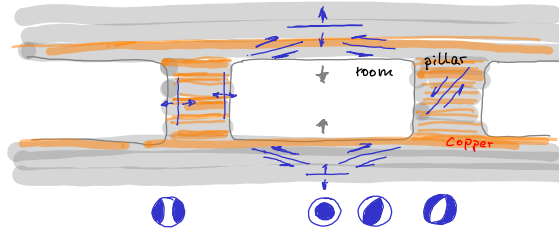
LGCD catalog:

Sep 19: Mw3.9, depth 800 m

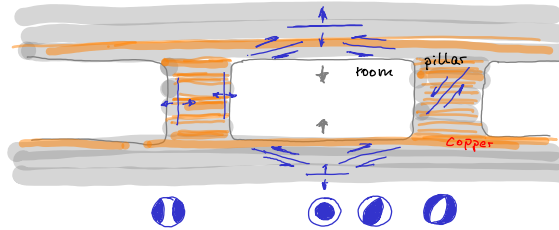
Sep 26: Mw3.5, depth 700 m



Expected Processes due to mining-induced stress changes



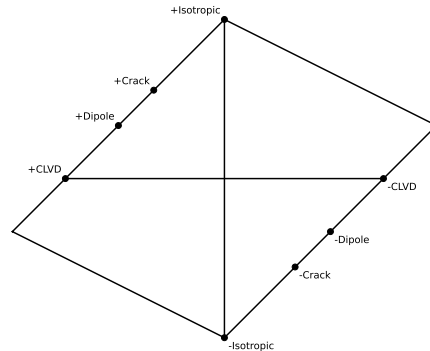
Expected Processes due to mining-induced stress changes



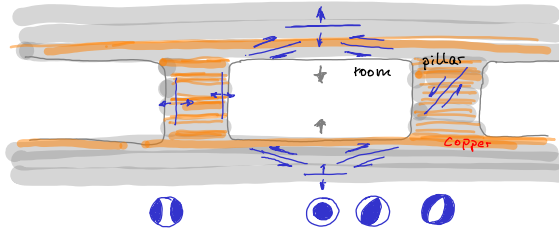
Hudson Plot:

shows the volume components of source mechanisms

CLVD: compensated linear vector dipole



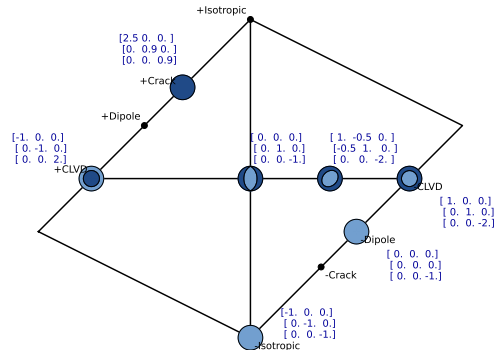
Expected Processes due to mining-induced stress changes



Hudson Plot:

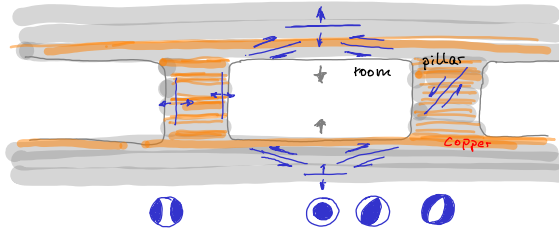
shows the volume components of source mechanisms

CLVD: compensated linear vector dipole



Expected Processes due to mining-induced stress changes

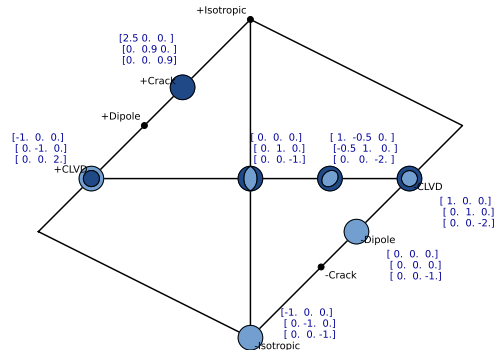
Few tens of meters source extensions: $M < 3$



Hudson Plot:

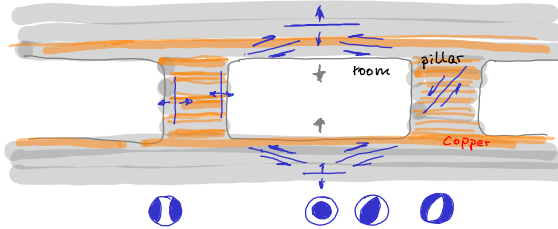
shows the volume components of source mechanisms

CLVD: compensated linear vector dipole

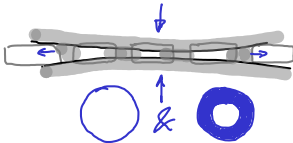


Expected Processes due to mining-induced stress changes

Few tens of meters source extensions: $M < 3$



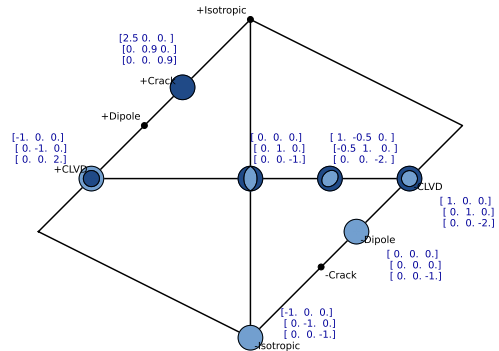
Larger earthquakes with $M > 3.5$ affect a larger area



Hudson Plot:

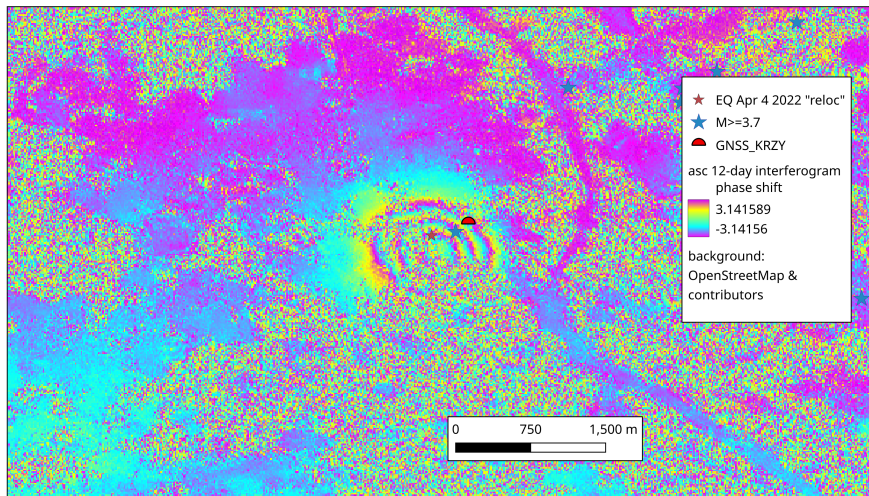
shows the volume components of source mechanisms

CLVD: compensated linear vector dipole



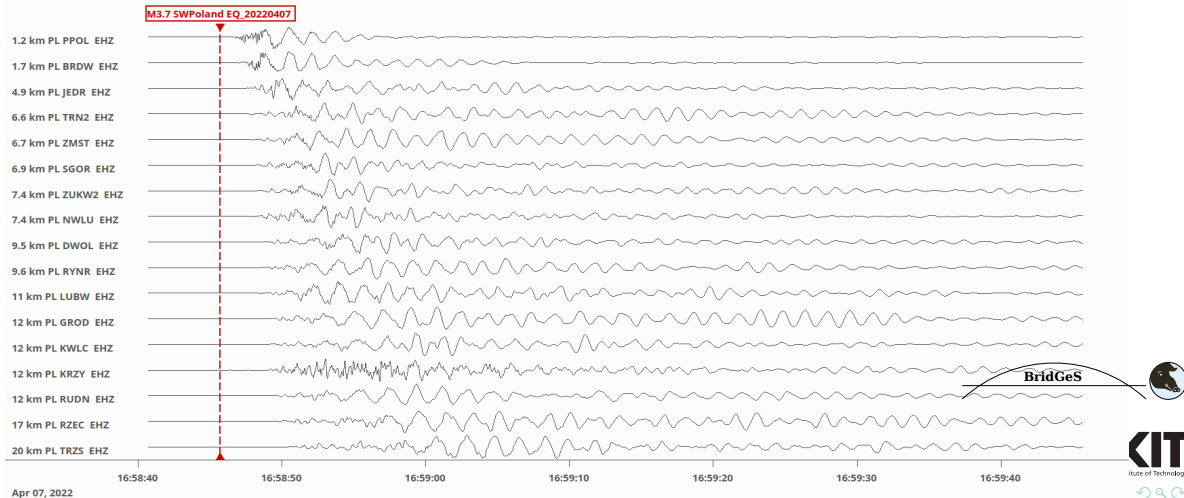
Analysing an event on April 7 in 2022

Sentinel-1 interferogram spanning the 7 April 2022 event

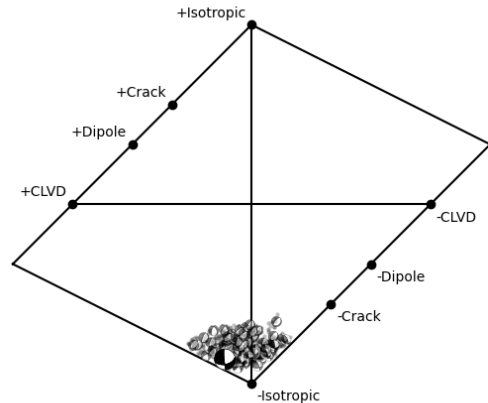
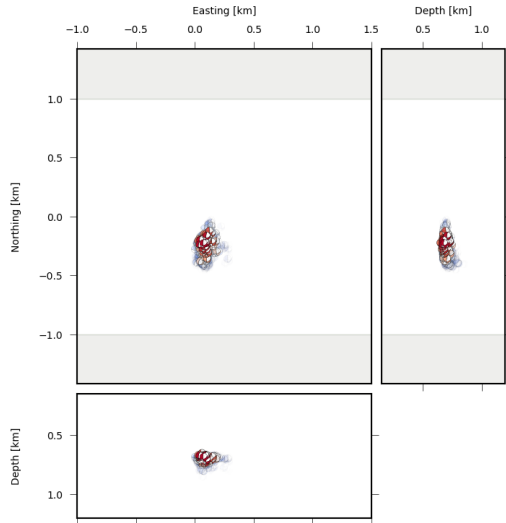


Analysing an event on April 7 in 2022

Public seismograms from the local network



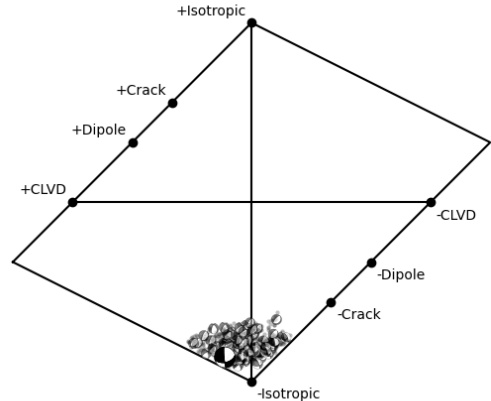
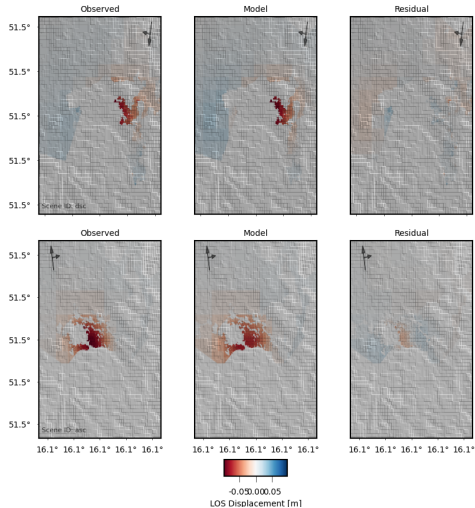
Source model results for the April 7 2022 earthquake



Mw4.2, depth 650 m

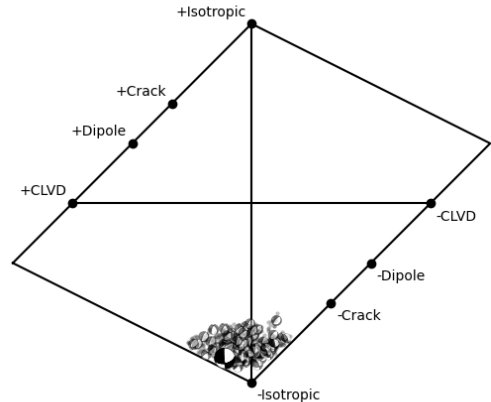
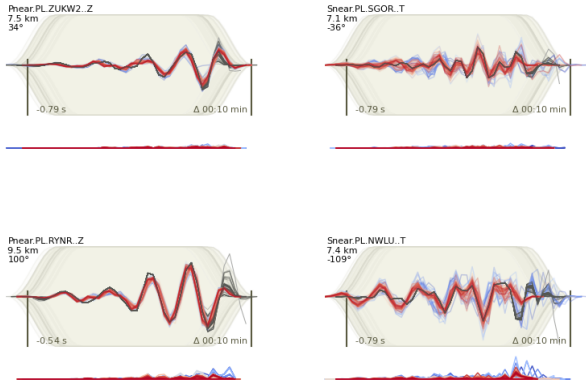
Source model results for the Apr 7 2022 earthquake

Optimization conducted with Pyrocko and Grond



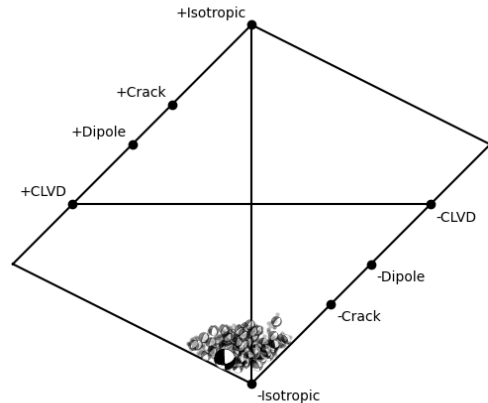
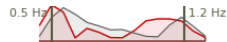
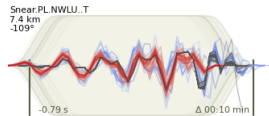
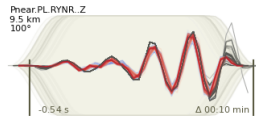
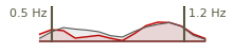
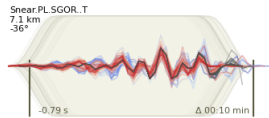
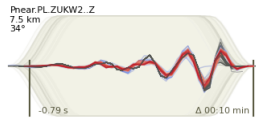
Source model results for the Apr 7 2022 earthquake

Optimization conducted with Pyrocko and Grond



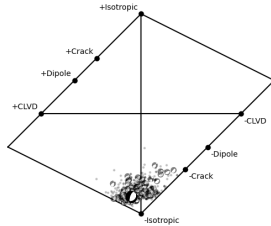
Source model results for the Apr 7 2022 earthquake

Optimization conducted with Pyrocko and Grond

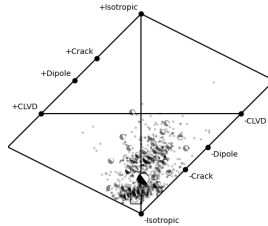


More results

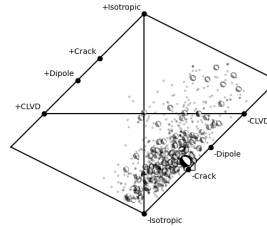
2022 Apr 7



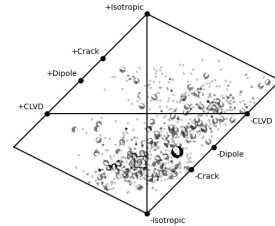
2023 Sep 26



2022 Feb 5

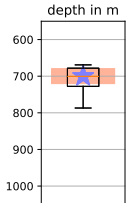
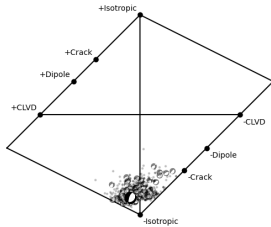


2023 Sep 19

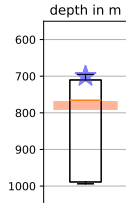
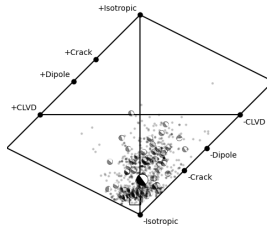


More results

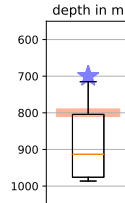
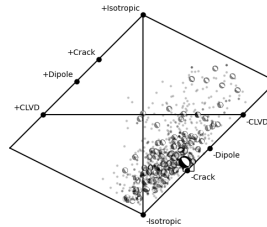
2022 Apr 7



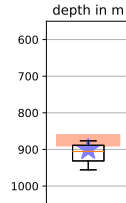
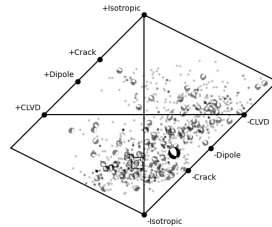
2023 Sep 26



2022 Feb 5



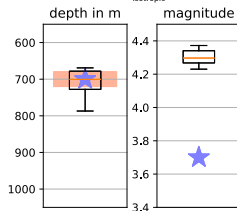
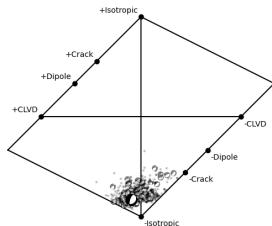
2023 Sep 19



★ LGCD catalog
■ top copper layer

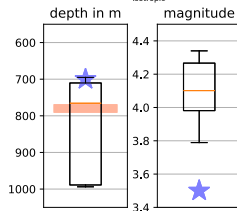
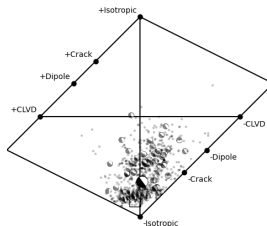
More results

2022 Apr 7

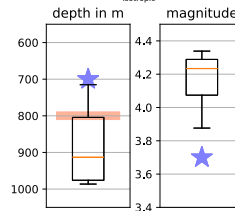
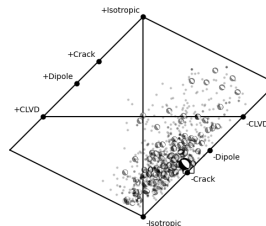


★ LGCD catalog
■ top copper layer

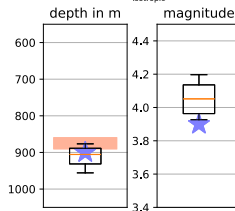
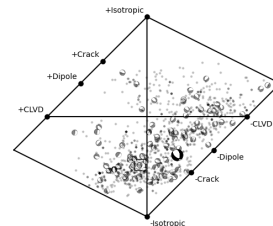
2023 Sep 26



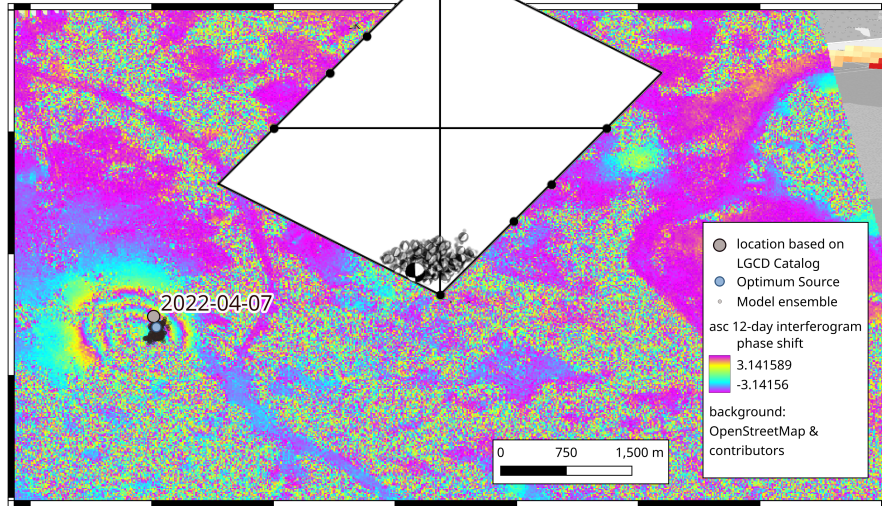
2022 Feb 5



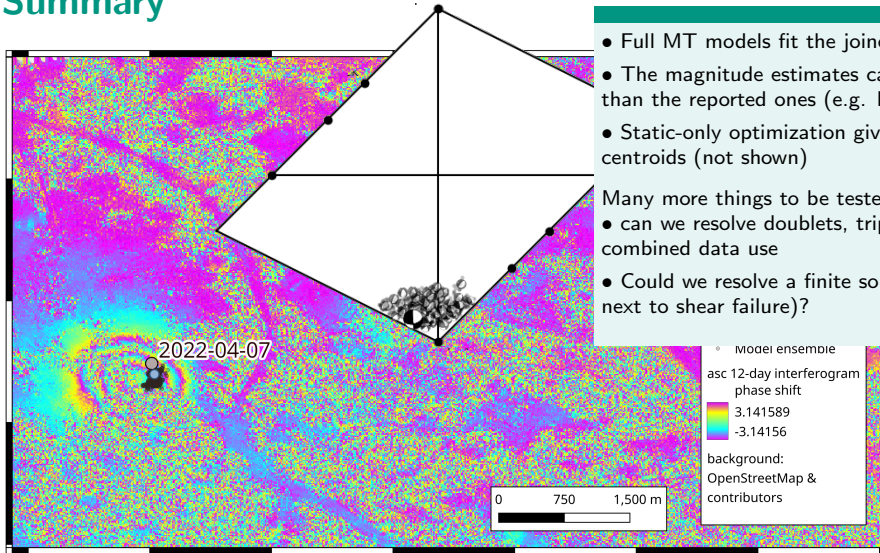
2023 Sep 19



Summary



Summary



- Full MT models fit the joined data very well
- The magnitude estimates can be significantly larger than the reported ones (e.g. Mw4.2 instead of Mw3.7)
- Static-only optimization give systematically shallower centroids (not shown)

Many more things to be tested/done:

- can we resolve doublets, triplets, etc. with the help of combined data use
- Could we resolve a finite source volume (roof collapse next to shear failure)?