

## WP 23: Induced seismicity

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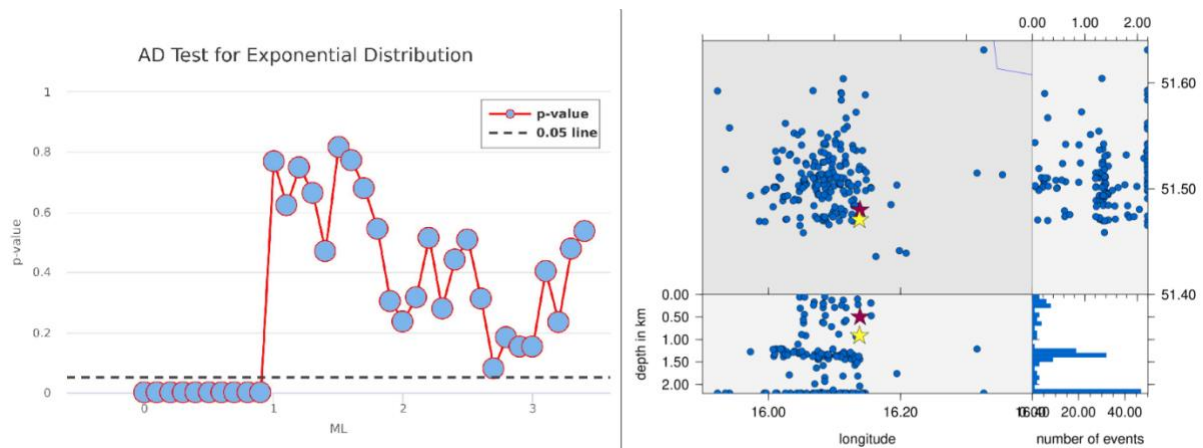
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### Keywords

Statistical toolboxes, induced seismicity in mines, enhanced seismic data set, Rudna and Garpenberg mines

### Figures



Figures: (*Left frame*) Example from Toolbox 1 (Magnitude Distributions). The graph shows the application of the Anderson-Darling test for magnitude distribution as applied to the data set from Song Tranh 2 water reservoir, Vietnam. (*Right frame*) Blue dots mark the spatial distribution of located events during half an hour after a large mine collapse on 15th of Sept., 2018 in Rudna mine. Stars give the locations of the main (red) and the first aftershock (yellow). The features lined out by the seismicity are the major production level (horizontal alignment), and probably shafts (vertical alignments).

### Main Results

IG-PAS contributed to JRA1 with the development and implementation of two Matlab software toolboxes for studying earthquake clustering and magnitude complexity, which are applicable to both natural and anthropogenic seismicity cases. Each software comprises two separate applications, developed in three individual versions: One interactive standalone version (V1), one function-like version (V2) and one online version (V3) integrated within the IS-EPOS platform. All programs together with auxiliary scripts, complete user guide documentation and sample data are freely available via GitHub. In addition to the aforementioned software, an application of the methodology connected with Toolbox 2 was performed and submitted for publication.

A second topic IG-PAS contributes to JRA1 is the investigation of induced seismicity through mining activities in the deep Rudna copper mine, Poland. The mine is known for the occurrence of intermediate magnitude events of up to M4, causing considerable damages and even fatalities. By applying the

automated detection and location algorithm of the BackTrackBB software (Poiata et al., 2016), in collaboration with CNRS, we could demonstrate that we are able to monitor induced seismicity and signals from mining activities with a surface network in a sufficient resolution to line out the major mine features. Several enhanced data sets could be achieved with a much larger amount of located events than in previous routine seismicity catalogues.

CNRS developed and applied a full-waveform-based automatic method for improved detection and location of microseismic events that makes use of continuous seismic records from an in-mine seismic network, and can be adjusted to a near-real-time monitoring scheme. The method consists of two steps:

1. event extraction and amplitude ratio-based preliminary location
2. event relocation by using a coherency-based back projection approach

The event extraction, based on multi-band signal characterization implemented in the first step, allows us to overcome the challenge of high sampling rate data (8 kHz), reducing the volume of transferred data and providing an energy-based signal classification scheme. This approach allows us to remove a significant number of machinery noise sources. The technique is developed and tested with the Institut National de l'Environnement Industriel et des Risques (INERIS) on the case study of the Garpenberg mine (Sweden) monitored by a local seismic network and maintained by INERIS. We demonstrated the improvement in event detection capacity by a factor of 50, compared with the standard triggered-based monitoring schemes. This increased number of detected microseismic events permits us to investigate the migration pattern of induced microseismicity that is generated in response to production blast.

## List of Publications

Palgunadi, K.H., Poiata, N., Kinscher, J., Bernard, P., De Santis, F. & Contrucci, I. (2019). Methodology for full waveform near real-time automatic detection and localization of microseismic events using high (8 kHz) sampling rate records in mines; application to the Garpenberg Mine (Sweden), *Seismol. Res. Lett.* 91 (1): 399-414.

Leptokaropoulos, K. (2020). Magnitude distribution complexity and variation at The Geysers geothermal field, submitted to *Geophys. J. Int.*, under revision.

## Access to Data and Services

- Access to Statistical Toolboxes (codes, sample data, documentation) can be found at: <https://git.plgrid.pl/projects/EA/repos/sera-applications/browse>
- The BackTrackBB full-waveform detection and location software used in the analysis is available from Git-Hub (<http://backtrackbb.github.io>) on open-source basis

### Liability claim

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