

# Thematic Core Service Anthropogenic Hazards

## Step-change in Tackling Grand Challenges of Hazards Associated with Exploitation of Geo-resources



**P. Salek**<sup>1</sup>, Beata Orlecka-Sikora<sup>1</sup>, S. Lasocki<sup>1</sup>, P. Bigarre<sup>2</sup>, A. Blanke<sup>3</sup>, K. Chodzińska<sup>1</sup>, S. Dineva<sup>4</sup>, A. Fremand<sup>5</sup>, A. Garcia<sup>6</sup>, J.R. Grasso<sup>7</sup>, G. Jones<sup>8</sup>, A. Karimov<sup>7</sup>, J. Kinscher<sup>2</sup>, J. Kocot<sup>9</sup>, E. Kozlovskaya<sup>10</sup>, G. Kwiatek<sup>3</sup>, K. Leptokaroupulos<sup>1</sup>, G. Lizurek<sup>1</sup>, J. Nevalainen<sup>10</sup>, D. Olszewska<sup>1</sup>, P. Roselli<sup>6</sup>, G. Saccorotti<sup>6</sup>, M. Schaming<sup>5</sup>, J. Schmittbuhl<sup>5</sup>, J. Sileny<sup>11</sup>, M. Sterzel<sup>9</sup>, T. Szeplieniec<sup>9</sup>, P. Urban<sup>1</sup>

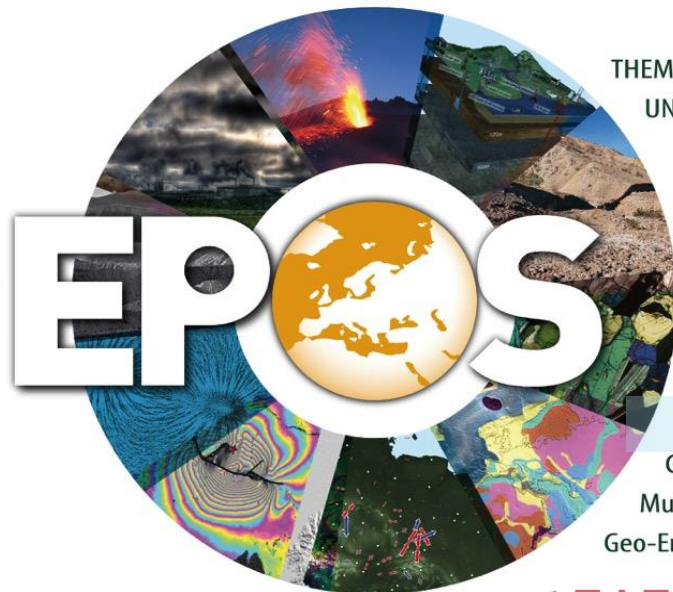
1 Institute of Geophysics, PAS, Warsaw, Poland (orlecka@igf.edu.pl); 2 INERIS, Nancy, France; 3 GFZ, Geomechanics and Rheology, Potsdam, Germany; 4 Luleå University of Technology, Sweden; 5 Université de Strasbourg, CNRS, IPGS-UMR7516, Strasbourg, France; 6 INGV, Italy; 7 Isterre, Grenoble Observatory, Grenoble, France; 8 Keele University, UK; 9 ACC Cyfronet, AGH, Poland; 10 Oulu Mining School and Sodankylä Geophysical Observatory, University of Oulu, Finland; 11 Institute of Geophysics, Academy of Sciences, CR

## Three Steps to better research into the Assessment and Mitigation of Anthropogenic Seismicity and other geophysical Hazards Induced by Exploitation of Georesources:

- ▶ **Cross-disciplinary approach** to the problem. Integration of research groups investigating the problem. Information exchange with other Earth sciences communities.
- ▶ Particular attention focused on studies of technology-nature couplings ↔ Deep synergy between **Science and Industry** based on mutual understanding of concerns and mutual respect of interests.
- ▶ **Integration of research infrastructures** both intra-disciplinary as well as interdisciplinary using the newest ICT.

# EPOS A long term plan for integration of research infrastructures for solid Earth Science

- > NERIES, NERA
- > MEDSUV, FUTUREVOLC, MARSITE
- > ORFEUS, EMSC, EUREF, EuroGeoSurvey, INTERMAGNET
- > OneGeology Europe
- > SHARE, SAFER, REAKT
- > GEM, ICDP, IODP
- > VERCE



## THEMATIC CORE SERVICES UNDER IMPLEMENTATION

Seismology  
Near-Fault Observatories  
GNSS Data & Products  
Volcano Observations  
Satellite Data  
Geomagnetic Observations  
Anthropogenic Hazards  
Geological Information and Modeling  
Multi-scale Laboratories  
Geo-Energy Test Beds for Low Carbon Energy



From the presentation of M. Cocco „EPOS IP Starts up”



EUROPEAN PLATE OBSERVING SYSTEM

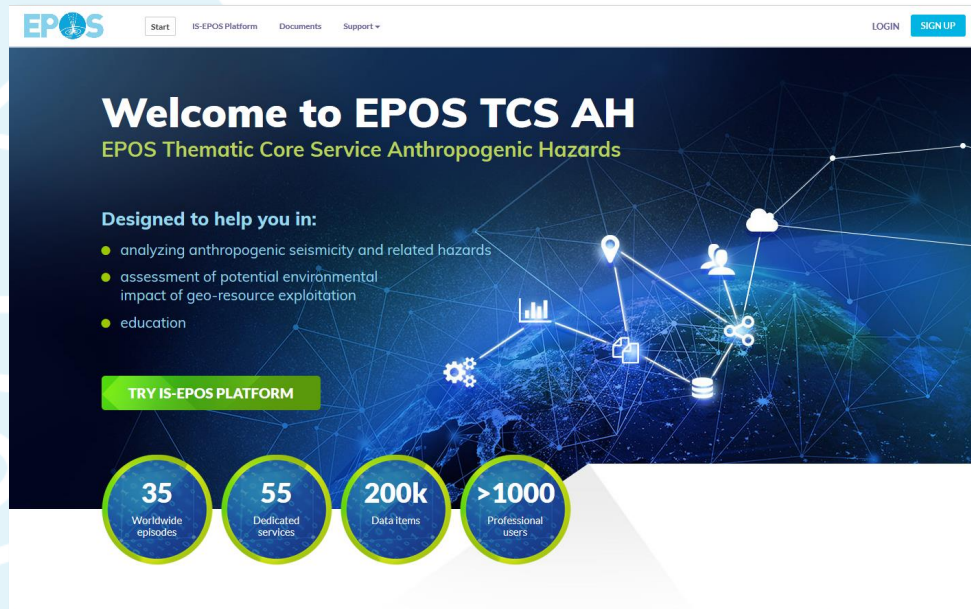
[www.epos-ip.org](http://www.epos-ip.org)

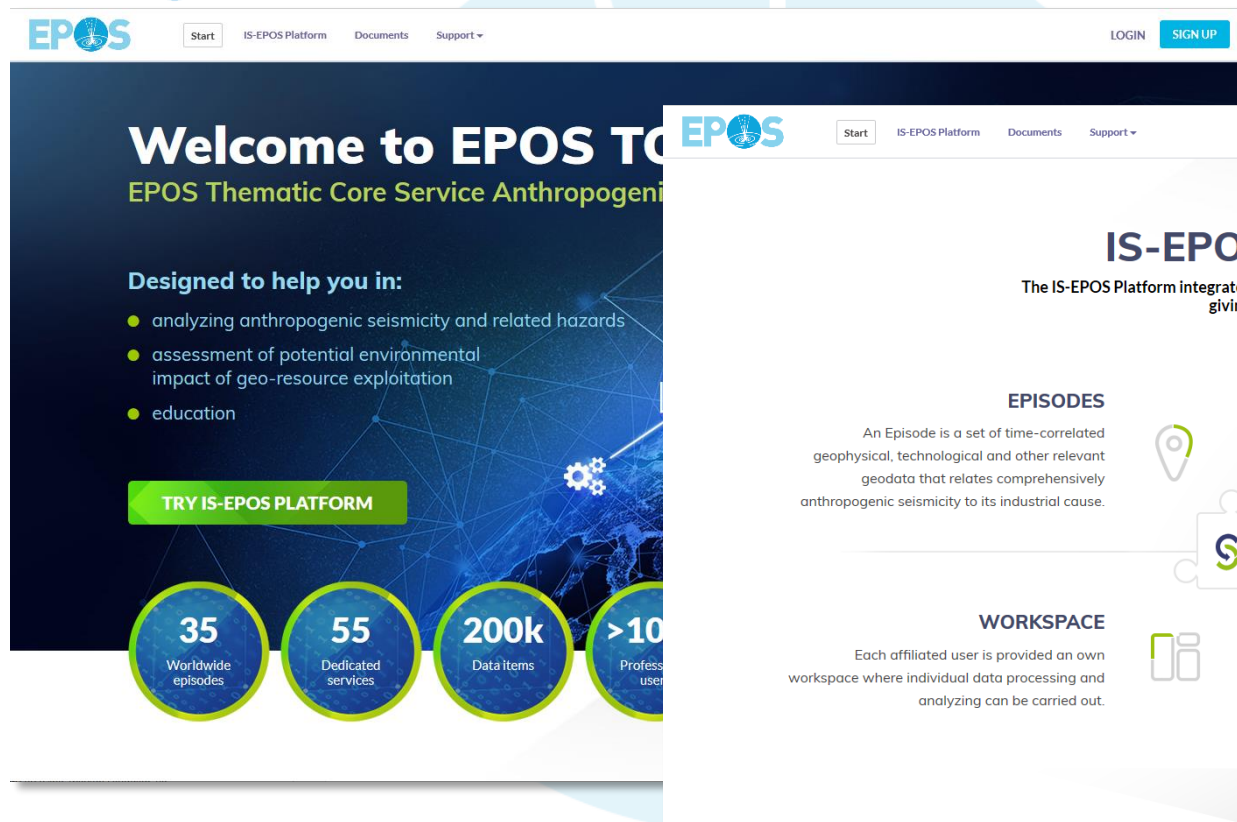
THIS PROJECT HAS RECEIVED FUNDING FROM THE EUROPEAN UNION'S HORIZON 2020 RESEARCH AND INNOVATION PROGRAMME UNDER GRANT AGREEMENT N° 676564  
Disclaimer: the content of this presentation reflects only the author's view and the Commission is not responsible for any use that may be made of the information it contains



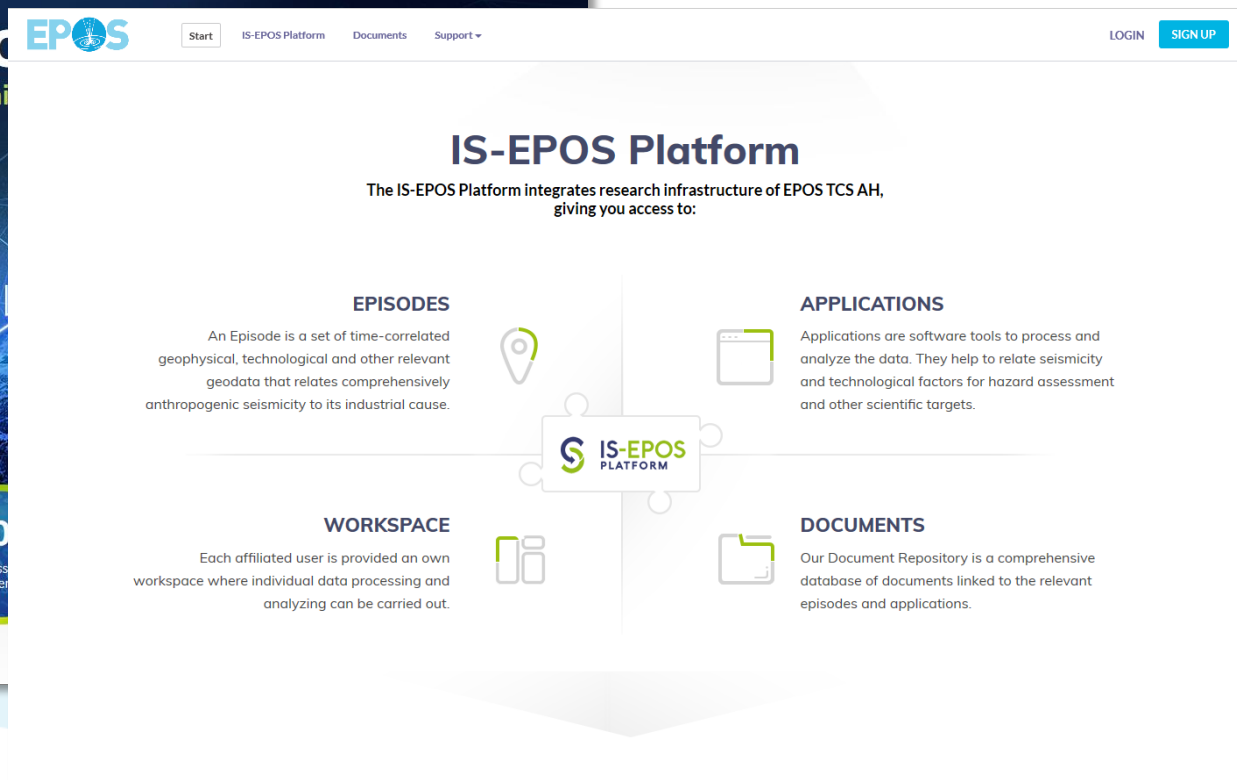
## TCS AH Consortium members:

- Institute of Geophysics Polish Academy of Sciences (IG PAS), Poland
- Instituto Nazionale di Geofisica e Vulcanologia (INGV), Italy
- Centre national de la recherche scientifique (CNRS), France
- Helmholtz Zentrum Potsdam Deutsches Geoforschungszentrum (GFZ), Germany
- L'Institut National de l'Environnement et des Risques (INERIS), France
- Geofyzikální Ústav AV ČR (IG ASCR), Czech Republic
- Oulun Yliopisto (OULU), Finland
- Lulea Tekniska Universitet (LTU), Sweden
- University of Keele (KU), UK
- University of Science and Technology – Academic Computer Centre Cyfronet (ACK UST), Poland
- Central Mining Institute (CMI), Poland
- Polish Mining Group (PMG), Poland





The screenshot shows the EPOS website homepage. The header includes the EPOS logo and navigation links: Start, IS-EPOS Platform, Documents, Support, LOGIN, and SIGN UP. The main content area features a large 'Welcome to EPOS' heading, followed by 'EPOS Thematic Core Service Anthropogenic Hazards'. Below this, a section titled 'Designed to help you in:' lists three bullet points: analyzing anthropogenic seismicity and related hazards, assessment of potential environmental impact of geo-resource exploitation, and education. A green button labeled 'TRY IS-EPOS PLATFORM' is prominently displayed. At the bottom, four circular statistics are shown: 35 Worldwide episodes, 55 Dedicated services, 200k Data items, and >10 Professional users.



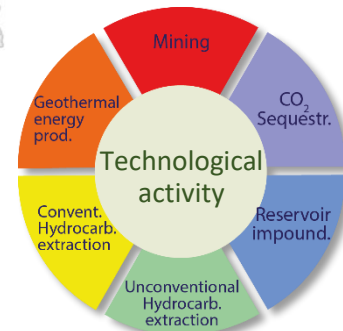
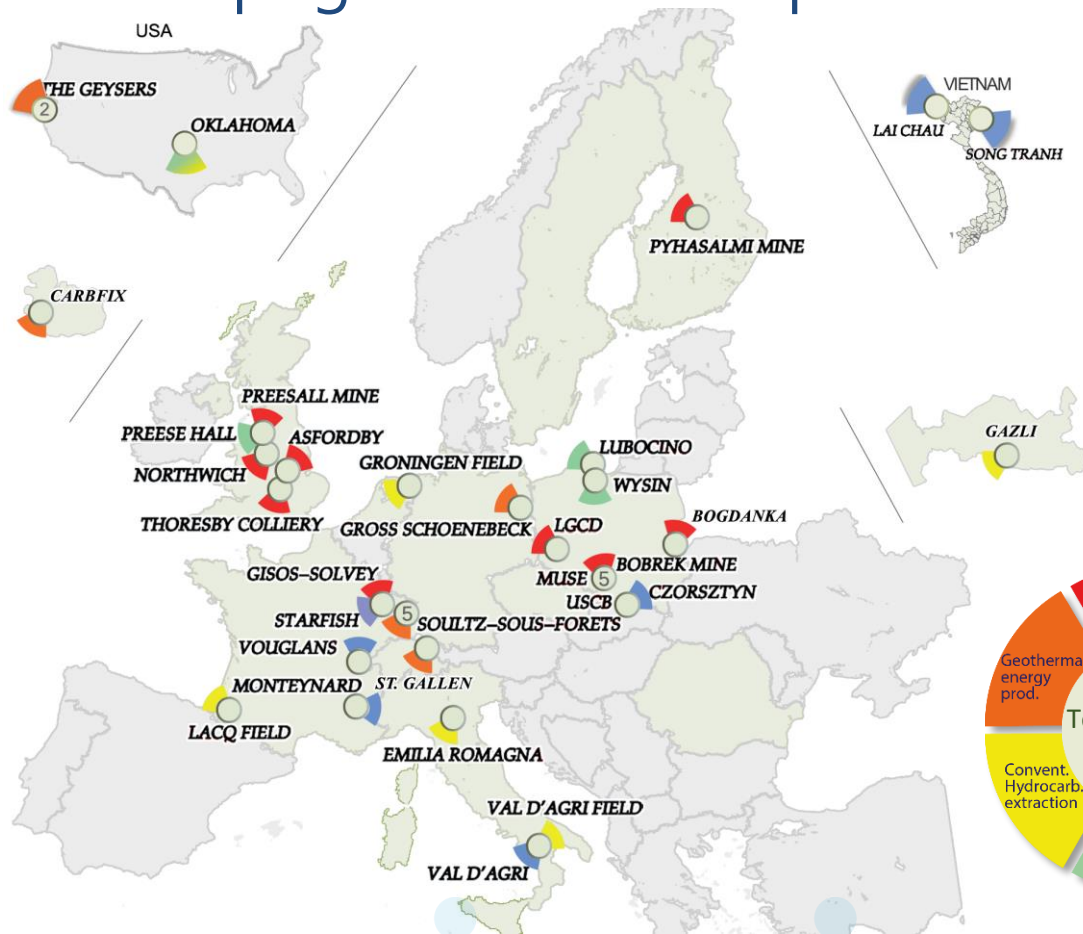
The screenshot displays the IS-EPOS Platform interface. The header is identical to the EPOS website. The main heading is 'IS-EPOS Platform', followed by the text: 'The IS-EPOS Platform integrates research infrastructure of EPOS TCS AH, giving you access to:'. The interface is divided into four quadrants around a central 'IS-EPOS PLATFORM' logo:

- EPISODES**: An Episode is a set of time-correlated geophysical, technological and other relevant geodata that relates comprehensively anthropogenic seismicity to its industrial cause. (Icon: location pin)
- APPLICATIONS**: Applications are software tools to process and analyze the data. They help to relate seismicity and technological factors for hazard assessment and other scientific targets. (Icon: document with checkmark)
- WORKSPACE**: Each affiliated user is provided an own workspace where individual data processing and analyzing can be carried out. (Icon: two server racks)
- DOCUMENTS**: Our Document Repository is a comprehensive database of documents linked to the relevant episodes and applications. (Icon: document)

tcs.ah-epos.eu



# Anthropogenic Hazards Episodes





# IS-EPOS platform – episodes overview



## SONG TRANH: deep water reservoir



Seismic activity linked to Song Tranh 2 hydropower plant and the reservoir containing backed up water of Tranh river in central Vietnam. The reservoir volume is 740 million cubic meters and the water level varies between 140 and 175 m. Seismic activity in the reservoir region, previously known as aseismic, began in 2011, soon after filling of the reservoir.



Reservoir impoundment



Vietnam, Quang Nam Province



IS-EPOS, EPOS-IP



## PREESE HALL: Shale Gas



An exploration well for shale gas was drilled into the Bowland Shale formation to a depth of 2.7 km. Hydrofracture stimulations were carried out at five depths. Felt earthquakes occurred during the stage 2 treatment.



Unconventional hydrocarbon extraction

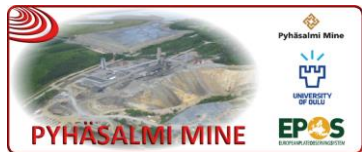


United Kingdom, Lancashire



EPOS-IP, SHEER

Episode integrated in the framework of:



## PYHASALMI MINE: in situ underground laboratory

RESTRICTED DATA ACCESS



Pyhasalmi mine, Central Finland, is an underground mine which produces copper, zinc and pyrite. A seismic network was installed underground in 2002 to monitor and locate frequently occurring microseismic scale events. Main target in Pyhasalmi episode is to: 1. Compare microseismic networks detected events with observations with national permanent seismic stations observations. 2. Correlate mining related microseismic events with the production data of the Pyhasalmi mine. 3. Analyze regions, where events concentrate and compare the locations with known geology.



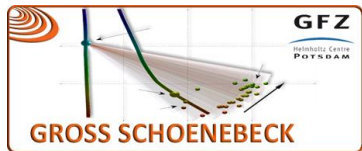
Underground mining



Finland, Pyhajarvi



EPOS-IP



## GROSS SCHOENEBECK: geothermal energy production experiment



A deep injection well and a doublet of production wells were established in this area reaching the reservoir rocks like red bed sandstone and andesitic volcanic rock at the 4200m depth. Injection performed from 9th to 14th August 2007 was used for repeated stimulation treatments to investigate scenarios of enhancing productivity of thermal fluid recovery from the underground. A total amount of 13.000 m<sup>3</sup> of water was injected. The maximum injection well-head pressure reached 58.6 MPa.



Geothermal energy production



Germany, Gross Schoenebeck



IS-EPOS, EPOS-IP, SHEER



## VAL D'AGRI FIELD: conventional hydrocarbon extraction



Seismic monitoring of the initial stage of wastewater injection into a disposal well of the Val d'Agri oil field. The monitoring unraveled a low magnitude swarm induced by disposal operations that initiated just a few hours after the beginning of injection. Main objective is to provide seismic data to be analyzed with advanced techniques for a better understanding of the mechanisms of injection-linked seismicity and of



Conventional hydrocarbon extraction, Wastewater injection



Italy, southern Apennines



EPOS-IP

### Description

Seismic monitoring of the initial stage of wastewater injection into a disposal well of the Val d'Agri oil field. The monitoring unraveled a low magnitude swarm induced by disposal operations that initiated just a few hours after the beginning of injection. Main objective is to provide seismic data to be analyzed with advanced techniques for a better understanding of the mechanisms of injection-linked seismicity and of physical properties of the reservoir.

Episode integrated in the framework of:

- EPOS IP project, European Plate Observing System Implementation Phase. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 676564

How to cite:

IS EPOS (2017), Episode: VDF, <https://tcs.ah-epos.eu/#episode:VDF>, doi:10.25171/InstGeoph\_PAS\_ISEPOS-2017-017

### Data

The data from this episode is embargoed till 2019/09/30

### DATA RELEVANT FOR THE CONSIDERED HAZARDS

#### SEISMIC

- [Catalog](#) 69 events from 02/06/2006 to 11/06/2006, magnitude ML range: 0.0 to 1.8
- [Seismic Stations](#) Locations and parameters of seismic stations at Val d'Agri oil field

#### INDUSTRIAL

- [Injection Volume](#) Injection volume in well at Val d'Agri oil field
- [Wellhead Pressure](#) Wellhead pressure in well at Val d'Agri oil field

#### GEODATA

- [Velocity Model](#) Seismic velocity model of Val d'Agri oil field

ALL DATA RELATED TO THIS EPISODE

AVAILABLE VISUALIZATIONS

See more information in Document Repository

### Status details

Episode status:

Closed

Impacting factor:

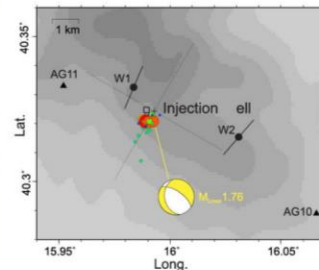
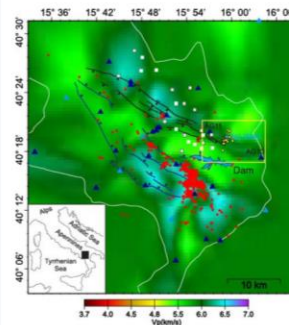
Conventional hydrocarbon extraction, Wastewater injection

Region:

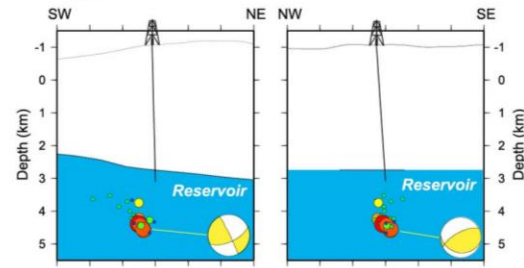
Italy, southern Apennines

Project association:

EPOS-IP



modified by Improta et al. (2015)





# IS-EPOS platform – applications

## Stationary Hazard: Maximum Credible Magnitude

This application uses the magnitude distribution and activity rate from calculated a seismic catalog to estimate the Maximum Credible Magnitude (MCM). The MCM for the time period of length T is the magnitude value whose mean return period is T. The MCM values are calculated for a series of periods of length values. Note: "Source size distribution functions/Stationary Hazard" application must be run before.

☰ Probabilistic Seismic Hazard Analysis  
⌚ Last updated: 2017 Jul 03

## Time dependent hazard in mining front surroundings

To estimate time-dependent values of seismic hazard parameters: the activity rate, the Gutenberg-Richter b-value, the return period and the exceedance probability for a space window surrounding an advancing mining front. The parameter values for the time moment t are estimated optionally either from events that occurred in dt time units preceding t, where dt is kept constant, or from n last events before t, where n is kept constant, or from a time period during which the front

☰ Probabilistic Seismic Hazard Analysis  
⌚ Last updated: 2017 Jul 03

## FOCI

This application makes use the P-wave first arrivals from the waveforms recorded by the seismic stations and resolves seismic moment tensors using various decomposition schemes. Three moment tensors are calculated: unconstrained (full) moment tensor solution, deviatoric moment tensor solution (no volumetric change in the source), and double-couple moment tensor solution (no volumetric change in the source, no linear dipole). In addition to the moment tensor

☰ Source Parameter Estimation  
⌚ Last updated: 2016 Jul 05

## Stress inversion

This application evaluates stress axis orientation ( $\sigma_1$ ,  $\sigma_2$ ,  $\sigma_3$  axis orientation as well as P and T axes orientation) and relative stress magnitude (R value) by inverting earthquake focal mechanisms. Stress state can be defined for a point (0D case), profile or time change (1D case), map (2D). The framework of calculating the deviatoric stress tensor together with its uncertainties using bootstrap resampling method is also provided along with a variety of plots.

☰ Stress Field Modeling  
⌚ Last updated: 2018 Jul 23

## MERGER: Dynamic risk analysis using a bow-tie approach

MERGER, a simulator for multi-hazard risk assessment in ExploRation/exploitation of GeoResources, is a tool for performing dynamic risk analyses using a bow-tie approach. The tool has been designed for solving fault trees (FT) and event trees (ET) linked in a bow-tie structure and using a Monte Carlo approach.

☰ Probabilistic Seismic Hazard Analysis  
⌚ Last updated: 2019 Aug 08

# IS-EPOS platform – user workspace

## Workspace tree

BOBREG\_catalog.mat

BOBREG

BOBREG\_catalog.mat

TDSHTimeVaryingGeom (2)

CatalogFilter

Signal download

seismic\_event

KW\_20091216020635\_2009121602065

SpectralAnalysis

TRG\_100I-g\_20150417\_221613.seed

TDSHTimeVaryingGeom

TDSHTimeVaryingGeom (1)

NSD\_BOBREG\_mining\_front\_advance\_EPSG4

USCB

Project

CZORSZTYN\_catalog.mat

CatalogFilter (5)

MagnitudeConversion (1)

MagnitudeConversion

MagMagColumnExtractor

CatalogFilter (3)

CatalogFilter

NSD\_CZORSZTYN\_ray\_tracing\_table.mat

CZORSZTYN\_catalog.mat (1)

CZORSZTYN MT

## Spectral Analysis ACTIONS

### File

SpectralAnalysis

### Description

P and S waves spectral levels and corner frequencies using Snok

### INPUTS

Using Seed Waveform

BOBREG/Signal download/KW\_20091216020635\_20091216020651.seed

CHANGE INPUT

Using Velocity Model

test BOB/NSD\_BOBREG\_1D\_velocity\_model.mat

CHANGE INPUT

Using Seismic event

BOBREG/Signal download/seismic\_event

CHANGE INPUT



### Show channels:

☒ Z ☒ N ☒ E

Pick points and phases:

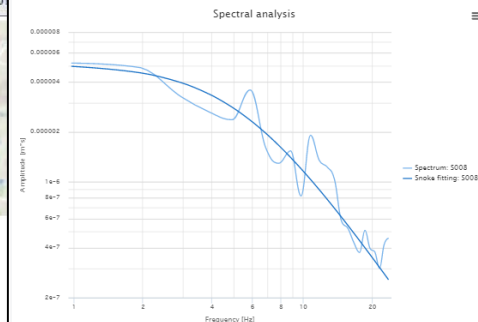


### OUTPUTS


#### P Wave Parameters:

|                      |             |                      |  |                       |  |
|----------------------|-------------|----------------------|--|-----------------------|--|
| Source radius [m]    | 120         | Spectral Level [m/s] |  | Corner frequency [Hz] |  |
| Seismic moment [Nm]  | 1.31E13     |                      |  |                       |  |
| Seismic energy [J]   | 4.0E6       |                      |  |                       |  |
| Stress drop [Pa]     | 3.297E6     |                      |  |                       |  |
| Apparent stress [Pa] | 8.34E3      |                      |  |                       |  |
| Sle [m]              | 1.07E-2     |                      |  |                       |  |
| Moment magnitude     | 2.7         |                      |  |                       |  |
| Station              | KW.S008.DHE |                      |  |                       |  |
|                      |             | 5.141E-6             |  | 5.4                   |  |

### Plot



# IS-EPOS platform – RI in the scientific works

- ❑ > 25 publications of JCR;
- ❑ Special Issue of Acta Geophysica: SHEER "Environmental footprints induced by geo-energy exploitation: the shale gas case,,;
- ❑ 4 papers in the peer-review proceedings; 
- ❑ Newsletters of SHEER, SERA and S4CE;
- ❑ Publications in the national journals;
- ❑ PhD theses, habilitations

MENU ▾

SCIENTIFIC REPORTS

Article | OPEN | Published: 05 June 2018

## Induced seismicity response to fluid injection: results of a multi-scale monitoring at the Wysin site

J. A. López-Comino , S. Cesca, J. Jaroslowski, N. Montcouquiol, S. Heimann, T. Dahm, S. Lasocki, A. Gunning, P. Capuano & W. L. Ellsworth

Scientific Reports 8, Article number: 8653 (2018) | Download Citation ▾

### Geophysical Journal International

Issues ▾ Subject ▾ Advance articles Submit ▾ Purchase About ▾



Volume 215, Issue 1  
October 2018






### Modelling fluid-induced seismicity associated with fluid injection related to fracture stimulation of geothermal areas

Alexander Garcia-Aristizabal 

Geophysical Journal International, Volume 215, Issue 1, pp 1–28, <https://doi.org/10.1093/gji/ggy284>



## Temporal static stress drop variations due to injection activity at The Geysers geothermal field, California

M. Staszek , B. Orlecka-Sikora , K. Leptokaropoulos , G. Kwiatek , and P. Martínez-Garzón 

Pure and Applied Geophysics  
pp 1–28 | [Cite as](#)

Relocation of Seismic Events and Validation of Moment Tensor Inversion for SENTINELS Local Seismic Network


Acta Geophysica

February 2019, Volume 67, Issue 1, pp 385–410 | [Cite as](#)

A probabilistic tool for multi-hazard risk analysis using a bow-tie approach: application to environmental risk assessments for geo-resource development projects

Authors

Authors and affiliations

Alexander Garcia-Aristizabal , Joanna Kocot, Raffaella Russo, Paolo Gasparini

THIS PROJECT HAS RECEIVED FUNDING FROM THE EUROPEAN UNION'S HORIZON 2020 RESEARCH AND INNOVATION PROGRAMME UNDER GRANT AGREEMENT N° 070394  
Disclaimer: the content of this presentation reflects only the author's view and the Commission is not responsible for any use that may be made of the information it contains



# IS-EPOS platform – easy and effective teaching tool

University of Oulu Finland, Luleå University of Technology Sweden, IGF PAS Poland, Master geo-risk, UGA, Grenoble France, GFZ Potsdam Germany, INERIS France, INGV Bolonia Italy, Keel University UK, Workshops of teachers of UE in the frameworks of ERIS and SCIENTIX (STEM Discovery week, March/April 2018), Summer School of S4CE in Salerno 09/2019.

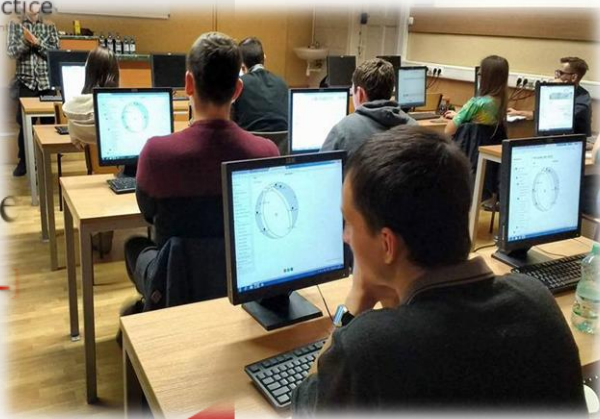


Exploitation of Research results In School practice

The project has been funded with support from the European Commission within ERASMUS+ Programme (grant agreement)

## Physics of earthquake

### "Picking the seismograms on IS-



Instytut Geofizyki  
Polskiej Akademii Nauk



UNIVERSITATEA  
DIN BUCUREȘTI  
— VIRTUTE ET SAPIENTIA —



EUROPEAN PLATE OBSERVING SYSTEM

[www.epos-ip.org](http://www.epos-ip.org)

THIS PROJECT HAS RECEIVED FUNDING FROM THE EUROPEAN UNION'S HORIZON 2020 RESEARCH AND INNOVATION PROGRAMME UNDER GRANT AGREEMENT N° 676564  
Disclaimer: the content of this presentation reflects only the author's view and the Commission is not responsible for any use that may be made of the information it contains

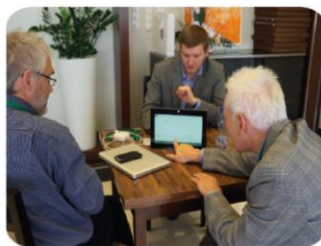




# TCS Anthropogenic Hazards



DIGITAL  
RESEARCH  
SPACE  
OF  
INDUCED  
SEISMICITY  
FOR  
EPOS  
PURPOSES



THEMATIC NODE  
FOR THE INDUCED SEISMICITY

INTER-SECTORAL  
KNOW-HOW  
TRANSFER

CONSOLIDATION  
OF  
SCIENTIFIC  
COMMUNITY



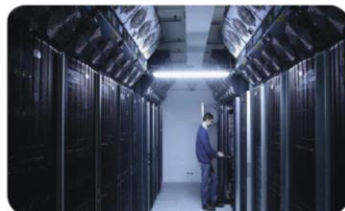
SYNERGY OF SCIENCE  
AND INDUSTRY

INTEGRATION  
OF  
DISPERSED  
RESEARCH INFRASTRUCTURE

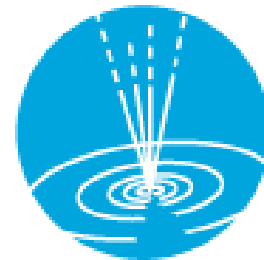
CLOUD COMPUTING

ADVANCED  
IT  
INFRASTRUCTURE

[www.is-epos.eu](http://www.is-epos.eu)



ANTHROPOGENIC  
HAZARDS



35 Worldwide Episodes

55 Dedicated Services

200k Data Items 1000+ Professional Users



@TCS\_AH



[tiny.cc/qr456y](https://tiny.cc/qr456y)



Search: Anthropogenic Hazards



Subscribe to the EPOS-AH Newsletter: [eepurl.com/dx-HAD](https://eepurl.com/dx-HAD)



EUROPEAN PLATE OBSERVING SYSTEM

[www.epos-ip.org](http://www.epos-ip.org)

THIS PROJECT HAS RECEIVED FUNDING FROM THE EUROPEAN UNION'S HORIZON 2020 RESEARCH AND INNOVATION PROGRAMME UNDER GRANT AGREEMENT N° 676564  
Disclaimer: the content of this presentation reflects only the author's view and the Commission is not responsible for any use that may be made of the information it contains



DIGITAL  
RESEARCH  
SPACE  
OF  
INDUCED  
SEISMICITY  
FOR  
EPOS  
PURPOSES

INTER-SECTORAL  
KNOW-HOW  
TRANSFER

CONSOLIDATION  
OF  
SCIENTIFIC  
COMMUNITY



THEMATIC NODE  
FOR THE INDUCED SEISMICITY



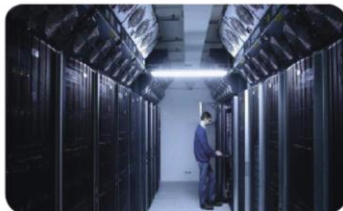
SYNERGY OF SCIENCE  
AND INDUSTRY

INTEGRATION  
OF  
DISPERSED  
RESEARCH INFRASTRUCTURE

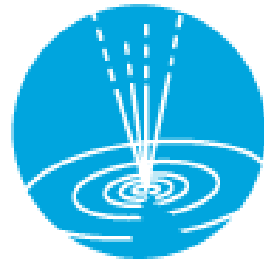
CLOUD COMPUTING

ADVANCED  
IT  
INFRASTRUCTURE

[www.is-epos.eu](http://www.is-epos.eu)



ANTHROPOGENIC  
HAZARDS



35 Worldwide Episodes

55 Dedicated Services

200k Data Items 1000+ Professional Users



@TCS\_AH



[tiny.cc/qr456y](https://tiny.cc/qr456y)



Search: Anthropogenic Hazards



Subscribe to the EPOS-AH Newsletter: [eepurl.com/dx-HAD](https://eepurl.com/dx-HAD)

Thank you!



 Institute of Geophysics  
Polish Academy of Sciences



EUROPEAN PLATE OBSERVING SYSTEM

[www.epos-ip.org](http://www.epos-ip.org)

THIS PROJECT HAS RECEIVED FUNDING FROM THE EUROPEAN UNION'S HORIZON 2020 RESEARCH AND INNOVATION PROGRAMME UNDER GRANT AGREEMENT N° 676564  
Disclaimer: the content of this presentation reflects only the author's view and the Commission is not responsible for any use that may be made of the information it contains

