SHEER News
www.sheerproject.eu
Shale Gas Exploration and Exploitation Induced Risks
Issue 05, May 2017

Welcome to the fifth SHEER newsletter. The aim of this Horizon 2020 project is to develop best practices aimed at assessing the impacts and mitigating the environmental footprint of shale gas extraction and exploration.

First SHEER Conference set for a full house

This year the Second SHEER Annual Meeting taking place in Blackpool will be followed by a one day free conference for delegates and stakeholders. Interest in the conference has been extremely high and all tickets have been allocated. We are therefore anticipating a full house with 120 attendees including consultants, academics, regulators and approximately 30 members of the SHEER Consortia. We look forward to seeing you there!

In this Issue...

Latest Project Developments

- Environmental monitoring at Wysin has continued since the fracking.
- Three new peer-reviewed publications
- Work from the project has been presented at several conferences

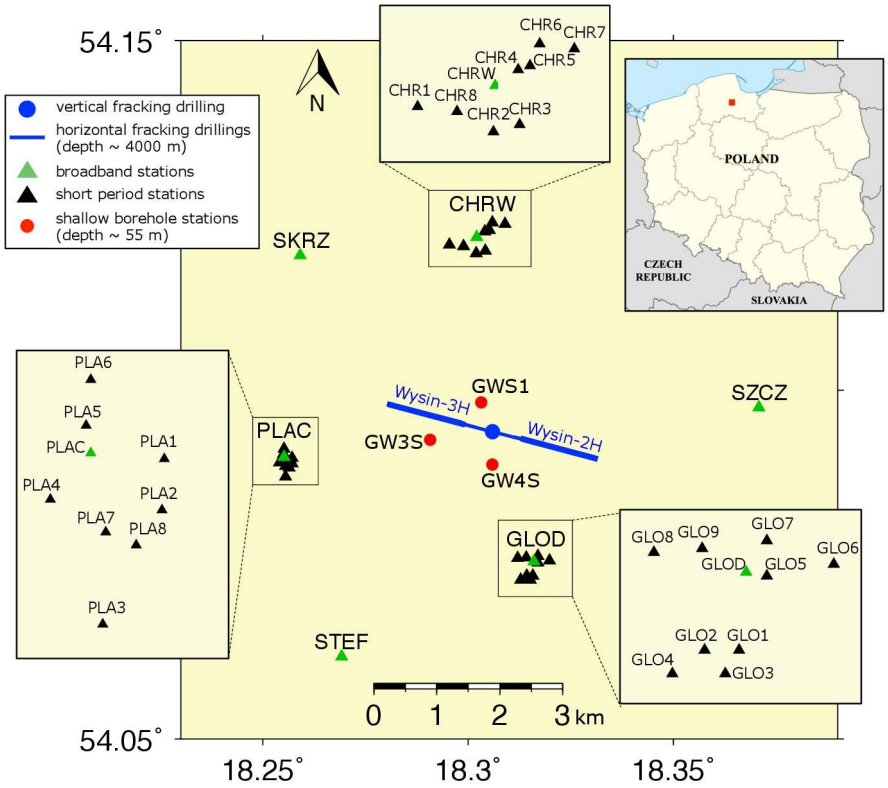
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 640896

Monitoring performance of hydraulic fracturing using a synthetic microseismic catalogue at the Wysin site (Poland)

By José Ángel López Comino and Simone Cesca (GFZ Potsdam)

It is important to monitor microseismicity in regions where industrial activities, such as hydraulic fracturing, are planned which can affect stress and permeability conditions in the shallow underground and potentially trigger or induce earthquakes. Seismicity induced by hydraulic fracturing is typically assumed to consist of local microseismicity, in the vicinity of the injection well. An accurate detection and location of these microseismic events is important to track the fracture migration and image the evolution of the system permeability. Triggered seismicity is initiated upon fluid injection, but controlled in its size by the background stress conditions; it may occur at larger distances from the well and trigger larger earthquakes. From a seismic monitoring point of view, two aspects are the most important prior to the starting of fracturing operations: the deployment of a proper monitoring network and the assessment of its performance.

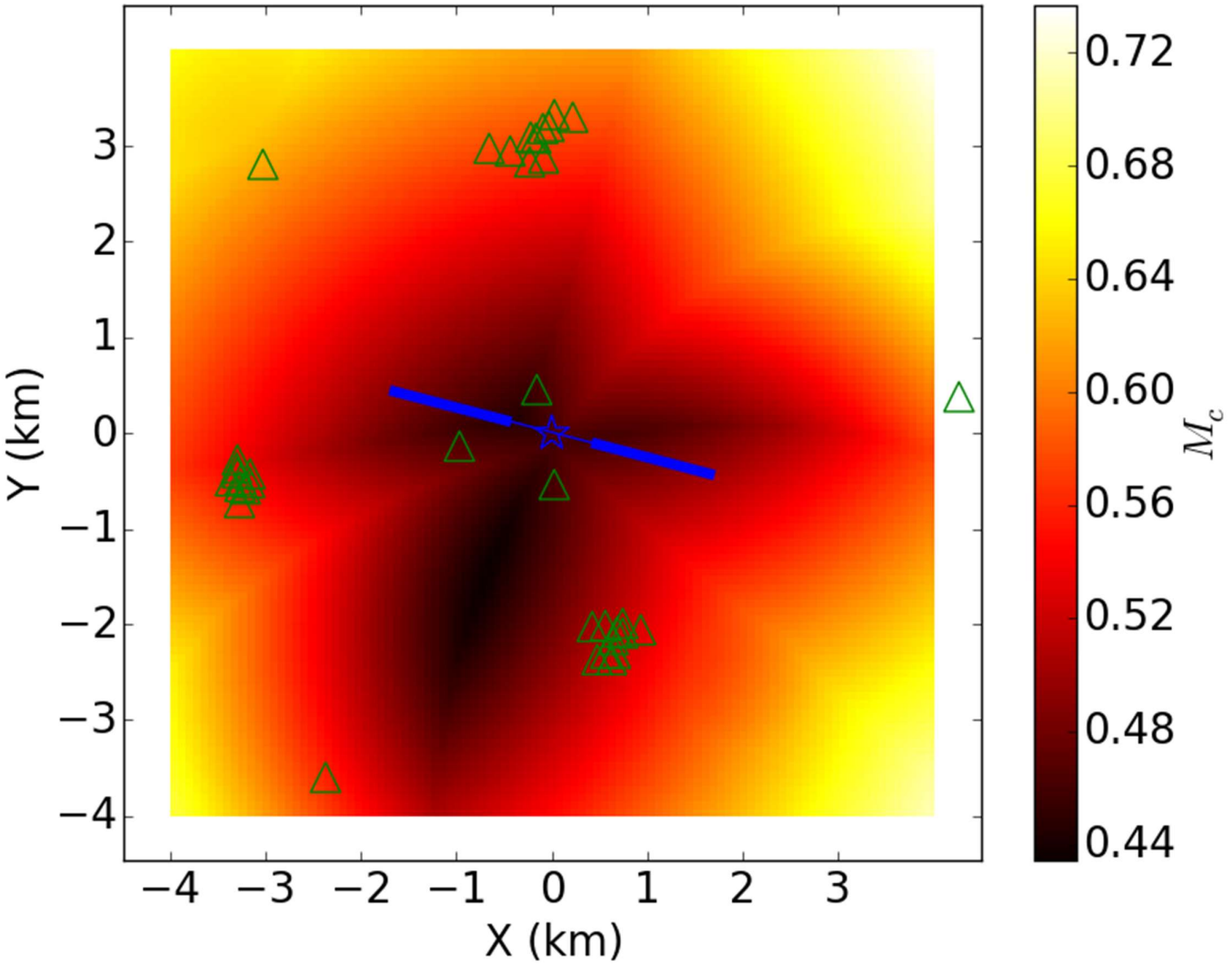
Within the SHEER project we operated a dedicated seismic network from November 2015 until January 2017 in Poland, monitoring a shale gas exploration/exploitation site close to the village of Wysin. To account for both triggered and induced seismicity, we planned a mixed seismic installation, including a distributed network of six broadband stations, three shallow borehole stations and three small-scale arrays (see figure below). The two horizontal fracking boreholes are located at ~4 km below the surface; they are designed for prospecting and exploration of oil and natural gas with an approximate horizontal length of 1.7 km each.



We have recently developed a new approach to realistically simulate induced seismicity and test the performance of detection and location routines, prior to the beginning of fracturing operations. We generate a catalogue of

synthetic earthquakes, which have realistic properties, such as their location, magnitude and rupture processes, both considering the creation of new fractures, their closure or the activation of faults, taking into account the background tectonic stress conditions. We can then simulate seismic signals generated by these sources, modelling the seismic wave propagation through a realistic shallow crust model, obtaining a catalogue of synthetic waveforms. However, real seismic data appear as the superposition of coherent signals generated from earthquake sources and seismic noise. Thereby, we create realistic full waveforms combining synthetic waveforms and real seismic noise samples recorded in the pre-operational phase. We use this realistic synthetic dataset to assess the monitoring performance: the ability of the network to detect weak microearthquakes as well as larger triggered events depends on the seismic instrumentation, station number, network geometry, seismic noise and installation conditions. To assess the network detection performance we make use of the concept of completeness magnitude (M_c), which is the lowest magnitude above which 100% of the earthquakes are detected. M_c may change in space, depending on the network geometry, and in time, depending on the temporal evolution of the seismic noise. We estimate a $M_c \sim 0.55$ around the fracking area, with an increase of 0.05 during noisy day hours; M_c can be lowered to ~ 0.45 by using different seismic array techniques. Our approach, recently published in *Geophysical Journal International,* can be easily adapted to other induced or natural seismicity environments.

Reference: López-Comino, J. A., S. Cesca, M. Kriegerowski, S. Heimann, T. Dahm, J. Mirek and S. Lasocki (2017). Monitoring performance using synthetic data for induced microseismicity by hydrofracking at the Wysin site (Poland), *Geophys. J. Int.* DOI: https://doi.org/10.1093/gji/ggx148



Monitoring at the Wysin site, Poland

By Grzegorz Lizurek - Institute of Geophysics Polish Academy of Sciences

The surface monitoring network in Poland has been operating since autumn 2015. Operations conducted by PGNiG on Wysin boreholes finished in winter 2016. Hydraulic fracturing operations conducted by site operator PGNiG finished in August 2016. Since the fracking is not planned to be continued, the seismic monitoring network was rearranged. Between 16-19 January 2017, all GFZ seismometers (6 Broadband and 9 short period sensors) were uninstalled. Broadband seismometers in CHRW, GLOD, PLAC were replaced by seismometers owned by IG PAS. Due to the winter conditions the operation was more adventurous than usual. The field work involved a lot of snow removal from the dirt roads to make them clear enough for the 4x4 vehicle. After that the "real" maintenance and installation works could be performed.

Fig. 1 Clearing the road to the monitoring site. Winter in Pomerania January 2017

Fig. 2 Winter in Pomerania during seismic network maintenance works. Seismic station near Wysin January 2017

Monitoring of the groundwater conditions that commenced in December 2015 is ongoing. Twelve field visits for sample collections have been undertaken and continuous monitoring is in place at the four boreholes. Samples of the frack fluid and flowback fluid were provided courtesy of PGNiG and were analyzed to identify key trigger species that might indicate escape of either into the ground water.

Air pollution monitoring is also ongoing as a continuous measurement of all planned air quality parameters. Monthly data sets are available for the period from October 2016 to February 2017. Available data covers over 90% of the total measurement time and a complete set of air quality parameters is available. Overall, measurements and station maintenance procedures are continuous.

Fig. 3 Winter in Pomerania road to seismic station near Wysin January 2017

EPOS ANTHROPOGENIC HAZARDS

THE EUROPEAN PLATE OBSERVING SYSTEM

EPOS aims at creating a pan-European infrastructure for solid Earth science to support a safe and sustainable society. EPOS will enable innovative multidisciplinary research for a better understanding of the Earth's physical and chemical processes that control earthquakes, volcanic eruptions, ground instability, tsunami, and all those processes driving tectonics and Earth's surface dynamics. Through the integration of research infrastructures and data, EPOS will allow scientists to make a step change in developing new geo-hazards and geo-resources concepts and Earth science applications to help address key societal challenges.

The Thematic Core Services (TCS) are the community-specific integration (e.g., seismology, volcanology, geodesy, experimental laboratories, etc). They represent transnational governance frameworks where data and services are provided to answer scientific questions and where each community discusses their specific implementation and best practices. The fact that ten TCS contributed to EPOS demonstrates the multidisciplinary breadth of the integration plan and the potential impact of the community building aspect of EPOS.

TCS Anthropogenic Hazards

The SHEER team are providing important data, services and information relating to the seismic and environmental hazards associated with shale gas exploitation.

The EPOS-IP AH platform provides "Episodes" (open access data sets of seismic event monitoring) and applications that researchers can use to investigate the impact of shale gas and hydrocarbon related exploitation.

GRONINGEN FIELD: conventional hydrocarbon production
Impacting factor: **Conventional hydrocarbon extraction**
Region: **Netherlands, Groningen**
Integrated within SHEER

GROSS SCHOENEBECK: geothermal energy production experiment
Impacting factor: **Geothermal energy production**
Region: **Germany, Gross Schoenebeck**
Integrated within IS-EPOS

LUBOCINO: Shale Gas
Impacting factor: **Unconventional hydrocarbon extraction**
Region: **Poland, Pomerania**
Integrated within SHEER

PREESE HALL: Shale Gas
Impacting factor: **Unconventional hydrocarbon extraction**
Region: **United Kingdom, Lancashire**
Integrated within EPOS-IP

WYSIN: Shale Gas
Impacting factor: **Unconventional hydrocarbon extraction**
Region: **Poland, Pomerania**
Integrated within SHEER

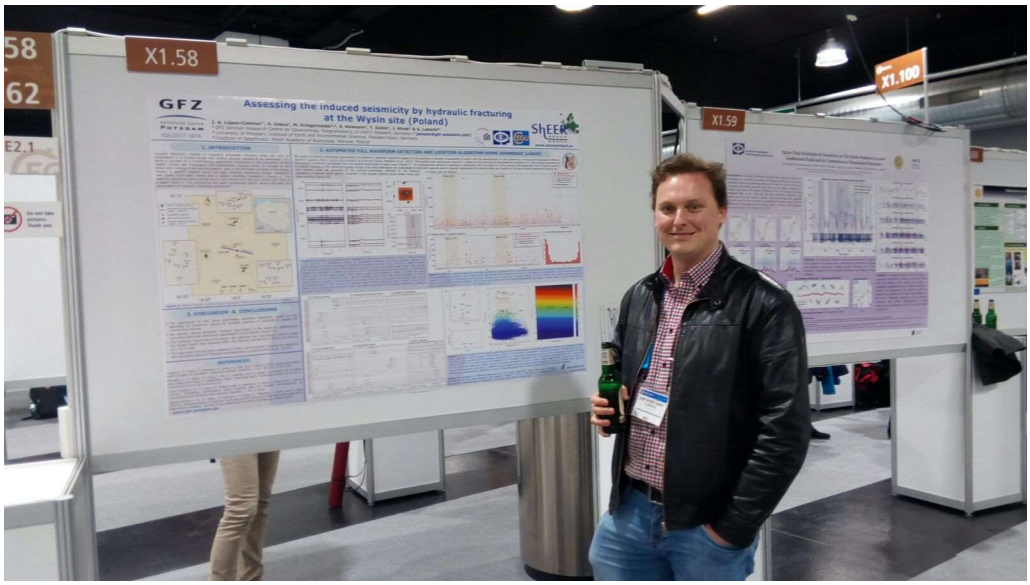
For more information see the EPOS website at
https://www.epos-ip.org
and the TCS AH website at
https://www.epos-ip.org/tcs/anthropogenic-hazards

EPOS
EUROPEANPLATEOBSERVINGSYSTEM

EGU 2017, Vienna, Austria

This year 14,496 scientists from 107 countries participated at the European Geosciences Union (EGU) General Assembly. The event in Vienna is one of a kind in providing a large scale opportunity for geoscientific research dissemination and networking. It is therefore great to report that the SHEER project was well represented here through both conference talks and posters.

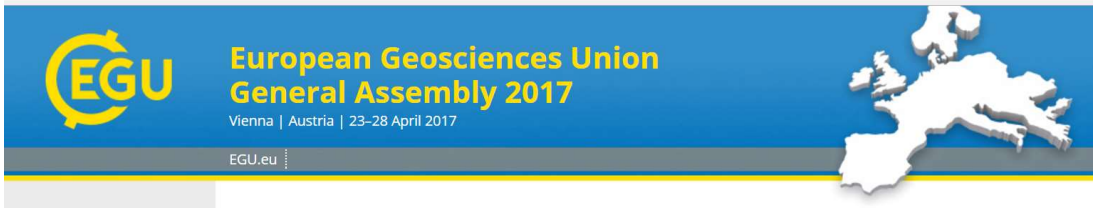
Thank you to Jose for providing the below photo and for doing a double act in presenting two posters and giving a talk, that beer in hand is well deserved!



Details of the EGU 2017 contributions including access links for the Geophysical Research Abstracts from Jose and colleagues are below;

Oral presentations

- Garcia-Aristizabal, A., Gasparini, P., Russo, R., and Capuano, P. Multi-hazard risk assessment applied to hydraulic fracturing operations. Vol. 19, EGU2017-9280, 2017, http://meetingorganizer.copernicus.org/EGU2017/EGU2017-9280.pdf
- López-Comino, J. A., Cesca, S., Kriegerowski, M., Heimann, S., Dahm, T., Mirek, J. and Lasocki, S. (2017). Monitoring performance for hydraulic fracturing using synthetic microseismic catalogue at the Wysin site (Poland). Geophysical Research Abstracts, Vol. 19, EGU2017-1873, 2017, http://meetingorganizer.copernicus.org/EGU2017/EGU2017-1873.pdf
- Marcak, H., Lasak, M., and Mirek, J. Using the velocity of seismic waves estimated from ambient seismic noise to assess the results of hydro-fracturing and the exploitation of shale-rock formations, Vol. 19, EGU2017-3238, 2017, http://meetingorganizer.copernicus.org/EGU2017/EGU2017-3238.pdf
- Montcoudiol, N., Isherwood, C., Gunning, A., Kelly, T. and Younger, P. Shale gas impacts on groundwater resources: insights from monitoring a fracking site in Poland, Vol. 19, EGU2017-7694, (2017), http://meetingorganizer.copernicus.org/EGU2017/EGU2017-7694.pdf
- Staszek, M., Orlecka-Sikora, B., Lasocki, S., Kwiatek, G., Leptokaropoulos, K., and Martinez-Garzon, P. Temporal changes of static stress drop as a proxy for poroelastic effects at The Geysers geothermal field, California. Vol. 19, EGU2017-2817, 2017, http://meetingorganizer.copernicus.org/EGU2017/EGU2017-2817.pdf



Poster presentations

- Capuano, P., Orlecka-Sikora, B., Lasocki, S., Cesca, S., Gunning, A., Jarosławski, J., Garcia-Aristizabal, A., Westwood, R. and Gasparini, P. (2017). Shale Gas Exploration and Exploitation Induced Risks - SHEER, Vol. 19, EGU2017-9659, 2017, http://meetingorganizer.copernicus.org/EGU2017/EGU2017-9659.pdf
- Jarosławski, J. and Guzikowski, J., Preliminary results of assessment of impact of the shale gas exploration and exploitation activities on the quality of ambient air - analysis of Wysin, Poland case study, 2015-2017, Vol. 19, EGU2017-4909, 2017, http://meetingorganizer.copernicus.org/EGU2017/EGU2017-4909.pdf
- Lasocki, S., Mirek, J., Bialon, W., Cielesta, S., Lasak, M., Cesca, S., Lopez Comino, J. A., Dahm, T., Scarpa, R., Gunning, A., Montcoudiol, N., Isherwood, C., Jarosławski, J. and Guzikowski J. Monitoring environmental effects of shale gas exploitation at Wysin in Poland, (2017). Vol. 19, EGU2017-8388, 2017, http://meetingorganizer.copernicus.org/EGU2017/EGU2017-8388.pdf
- Lasocki, S., Urban, P., Kwiatek, G. and Martinez-Garzón P. Probabilistic properties of injection induced seismicity – implications for the seismic hazard analysis, Vol. 19, EGU2017-3019-1, 2017, http://meetingorganizer.copernicus.org/EGU2017/EGU2017-3019-1.pdf
- Leptokaropoulos, K., Staszek, M., Lasocki, S., Kwiatek, G., and Martinez-Garzon, P. Space-Time Evolution of Seismicity in North-Western Geysers Geothermal Field and its Connection to Stimulation Processes, Vol. 19, EGU2017-2804, 2017, http://meetingorganizer.copernicus.org/EGU2017/EGU2017-2804.pdf
- López-Comino, J. A., Cesca, S., Kriegerowski, M., Heimann, S., Dahm, T., Mirek, J. and Lasocki, S. (2017). Assessing the induced seismicity by hydraulic fracturing at the Wysin site (Poland), Vol. 19, EGU2017-1874-1, 2017, http://meetingorganizer.copernicus.org/EGU2017/EGU2017-1874-1.pdf
- López-Comino, J. A., Cesca, S., Heimann, S., Grigoli, F., Milkereit, C., Dahm, T. and Zang, A. (2017). Full waveform approach for the automatic detection and location of acoustic emissions from hydraulic fracturing at Äspö (Sweden). Geophysical Research Abstracts, (2017). Vol. 19, EGU2017-1875, http://meetingorganizer.copernicus.org/EGU2017/EGU2017-1875.pdf
- Orlecka-Sikora, B., Lasocki, S., Staszek, M., Olszewska, D., Kwiatek, G., Urban, P., Jarosławski, J., Cielesta, S., Mirek, J., Wiszniowski, J., Picozzi, M., Solaro, G., Cassidy, N., Toon, S., Cesca, S., Kuehn, D., Ruigrok, E., Gunning, A. and Isherwood C. (2017). EPOS Thematic Core Service Anthropogenic Hazards for SHEER project: maintain, process and manage your project research data, (2017). Vol. 19, EGU2017-16734, 2017 http://meetingorganizer.copernicus.org/EGU2017/EGU2017-16734.pdf

New Publications

López-Comino, J. A., S. Cesca, M. Kriegerowski, S. Heimann, T. Dahm, J. Mirek and S. Lasocki (2017 online). Monitoring performance using synthetic data for induced microseismicity by hydrofracking at the Wysin site (Poland), *Geophys. J. Int.*, 210, 42-55. DOI: https://doi.org/10.1093/gji/ggx148
Available at http://gfzpublic.gfz-potsdam.de/pubman/faces/viewItemOverviewPage.jsp?itemId=escidoc:2171924:2

Picozzi M., Oth A., Parolai S., Bindi D., De Landro G., and Amoroso O. (2017), Accurate estimation of seismic source parameters of induced seismicity by a combined approach of generalized inversion and genetic algorithm: application to The Geysers geothermal area, California, *Journal of Geophysical Research: Solid Earth,* Article DOI: 10.1002/2016JB013690

Westwood, R.F., Toon, S.M. & Cassidy, N.J. (2017) A sensitivity analysis of the effect of pumping parameters on hydraulic fracture networks and local stresses during Shale Gas operations. *Fuel* DOI: 10.1016/j.fuel.2017.05.004

SHEER Participation at other meetings and events

Three presentations, relating to SHEER work, were given at the **Second Schatzalp Workshop on Induced Seismicity**, held in Davos, Switzerland between the 14th and 17th March 2017:

- López-Comino, J. A., S. Cesca, M. Kriegerowski, S. Heimann, T. Dahm, J. Mirek and S. Lasocki, 2017. Assessing the monitoring performance and the induced seismicity by hydraulic fracturing at the Wysin site (Poland).

- López-Comino, J. A., S. Cesca, S. Heimann, F. Grigoli, C. Milkereit, T. Dahm and A. Zang, 2017. Detecting and locating acoustic emissions from hydraulic fracturing experiments at Äspö Hard Rock Laboratory (Sweden).

- Ruigrok, E., Spetzler, J., Dost, B., van den Hazel, G.-J., Domingo-Ballesta, J., Evers, L., 2017. Current state of the Groningen seismic network.


Deutsche Geophysikalische Gesellschaft e.V.

Herr José Angel López Comino

Die Deutsche Geophysikalische Gesellschaft prämiert Ihre Leistung mit einem Preis für das Poster

J.A. López Comino, S. Cesca, M. Kriegerowski, S. Heimann, T. Dahm, J. Mirek, S. Lasocky:

„Hydraulic fracturing at the Wysin site (Poland): detection performance using a microseismic synthetic catalogue and real data"

präsentiert auf der 77. Jahrestagung in Potsdam

Deutsche Geophysikalische Gesellschaft (DGG) e.V.

Potsdam, den 30. März 2017

At the **77 Jahrestagung der Deutschen Geophysikalischen Gesellschaft (DGG),** held in Potsdam, Germany, from 27 to 30 March 2017 the below were presented, with the first title winning a best poster certificate (left) . Well done again to Jose!

- López-Comino, J. A., S. Cesca, M. Kriegerowski, S. Heimann, T. Dahm, J. Mirek and S. Lasocki, 2017. Hydraulic fracturing at the Wysin site (Poland): detection performance using a microseismic synthetic catalogue and real data.

- López-Comino, J. A., S. Cesca, S. Heimann, F. Grigoli, C. Milkereit, T. Dahm and A. Zang, 2017. Detecting, locating and characterizing acoustic emissions of hydraulic fractures at Äspö (Sweden).

Dr. Nelly Montcoudiol (left), University of Glasgow, gave an overview of the SHEER project during a presentation at the department of Civil Engineering of Universidad Nacional Autonoma de Honduras, on 21st March 2017.

SHEER Key Facts

Project acronym: SHEER

Project full title: Shale Gas Exploration and Exploitation Induced Risks

*Project duration:*01.05.2015 – 30.04.2018

Funding Scheme: EU Horizon 2020

Project Partners:

8 partners from 6 countries

AMRA (Italy), IG PAS (Poland), Keele University (UK), GFZ Potsdam (Germany), KNMI (Netherlands), RSKW Ltd (UK), University of Glasgow (UK), University of Wyoming (USA)

Project Coordinator

Prof. Paolo Capuano
AMRA S.c. a r.l.

Via Nuova Agnano, 11
80125 Napoli, Italy

pcapuano@unisa.it
www.amracenter.com

Project Manager

Alfonso Rossi Filangieri
AMRA S.c. a r.l.

Via Nuova Agnano, 11
80125 Napoli, Italy

alfonso.rossifilangieri@amracenter.com
www.amracenter.com

Communication and Dissemination

Dr Glenda Jones
Geography, Geology and the Environment, Keele University

Keele, Staffordshire ST5 5BG
United Kingdom

g.m.jones@keele.ac.uk
www.keele.ac.uk/geophysics