

## NEWSLETTER OF THE GEOPHYSICAL INSTITUTE

Issue 14, December 2018

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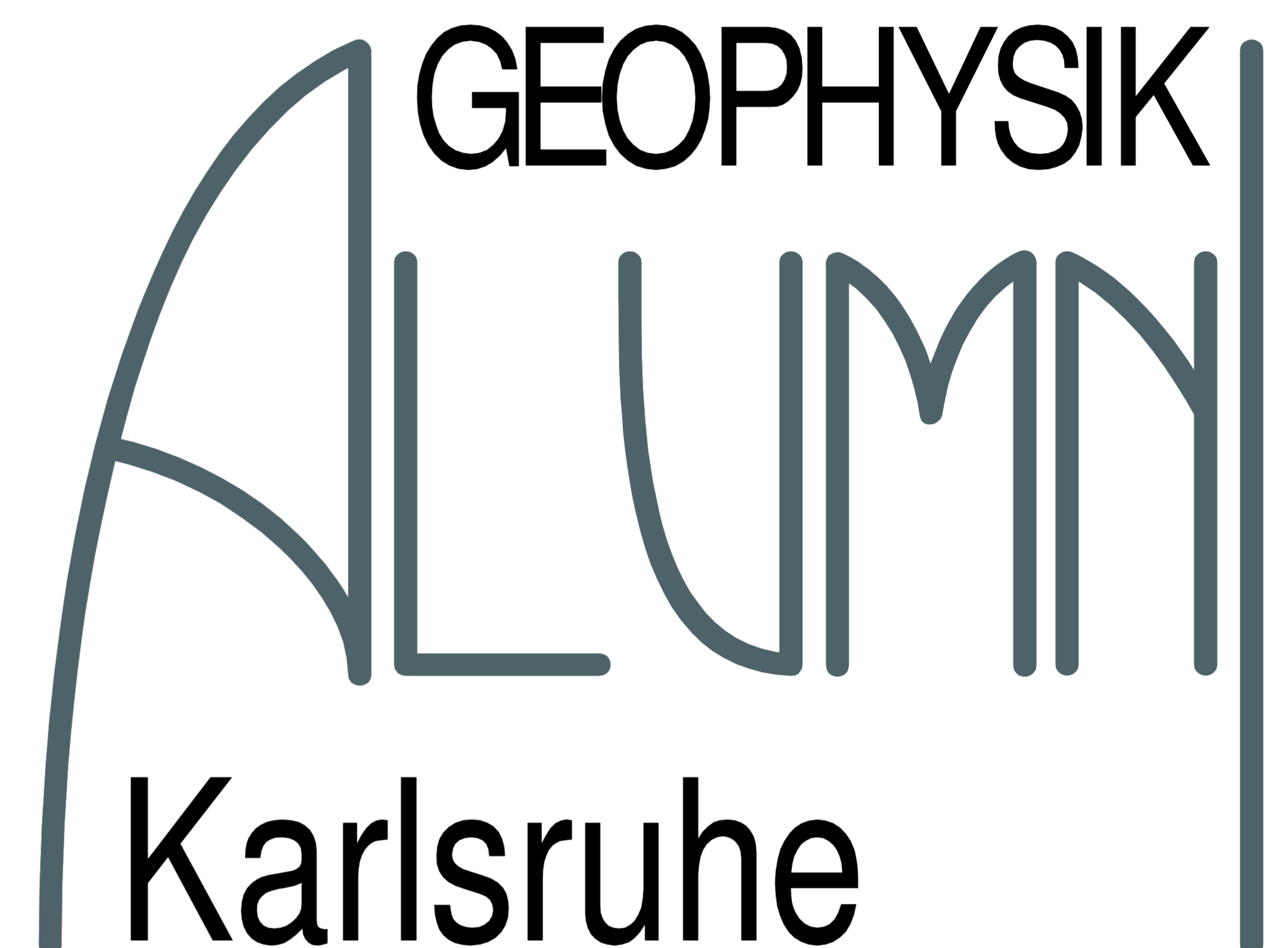
### DEAR GPI ALUMNI

We are looking back on an exciting year 2018 for GPI. You will find some of the stories on research and teaching on the next few pages, but it is nearly impossible to cover all. On teaching GPI is heavily involved in recruiting new BSc and MSc into our geophysical programs. We are also playing an active role in promoting our topics in schools with the newly established ambassador scheme. Our research spans as ever the full breadth and width of Geophysics, ranging from the Earth anisotropy structure at the core mantle boundary to using high resolution seismic Full Waveform Imaging

techniques to assist in tunnel drilling projects like the new Crossrail link in London. An exciting new development in the ANDES-GEO geophysical underground laboratory initiative in which GPI is taking a lead. ANDES-GEO is part of the larger ANDES initiative (<http://andeslab.org>) to develop an underground laboratory for cosmic radiation in the central Andes at the border between Chile and Argentina. The design for the geophysical section of this new laboratory is based on our experience at BFO and hopefully building work will commence in 2019. The first workshop took place in November 2018 and more details on this project will follow soon.

2019 will also bring great change regarding our staff. Petra Knopf is leaving us at the end of 2018 and Werner Scherer will soon leave in February 2019. Both were central to our success in research and teaching over the last decades and they will be greatly missed. We wish them all the best for their future.

Andreas Rietbrock



### TEACHING

By Ellen Gottschämmer

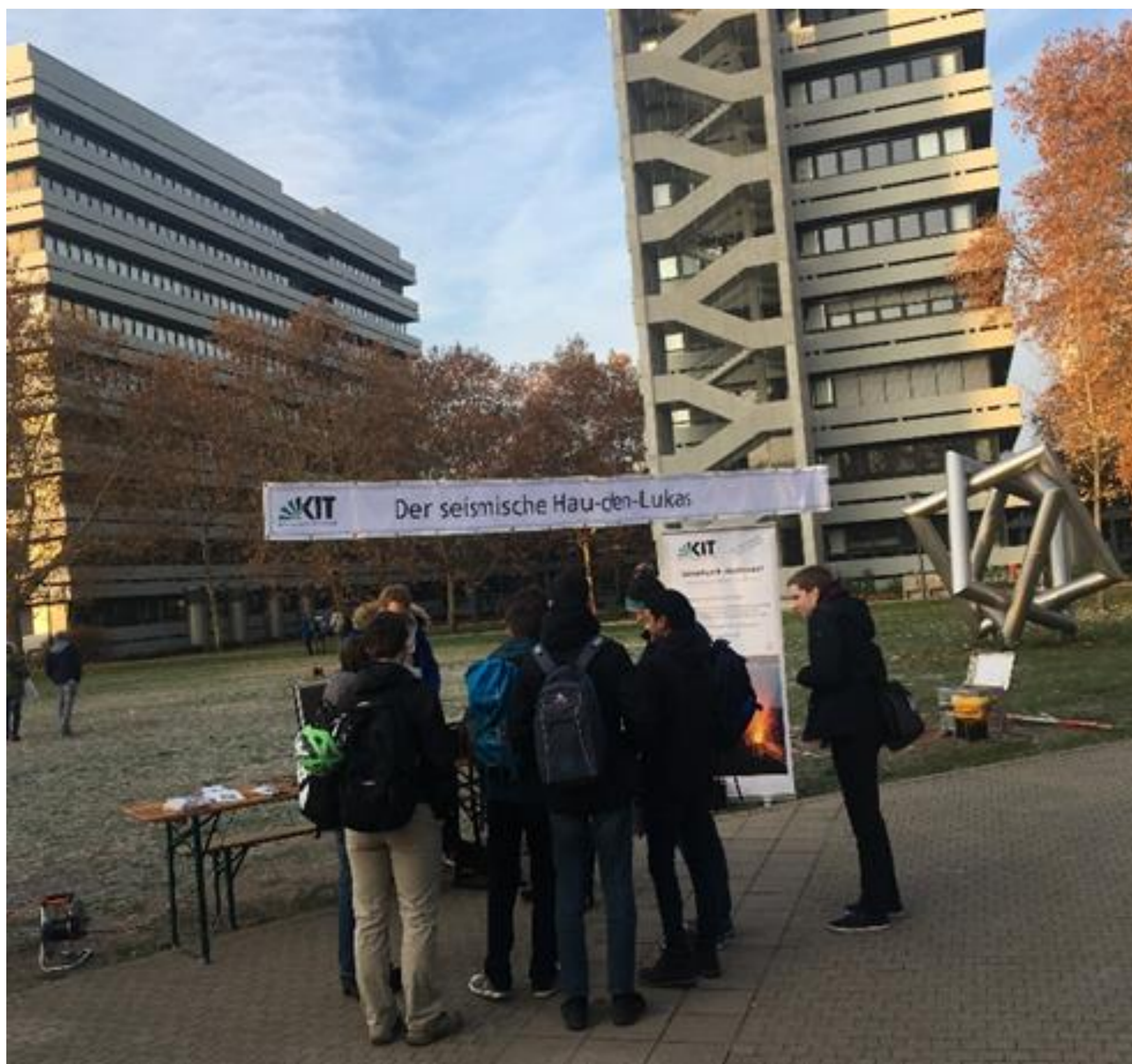
Every year in November, a student information day takes place at KIT. In front of Audimax, the largest lecture hall at KIT, seismic refraction experiments are conducted by the Geophysical Institute. The experiment is set up as a strongman game of 'Ring-the-bell'-type (Hau-den-Lukas in German), and the competition is won by the person who excites the strongest seismic waves.

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Many prospective students were fascinated by the experiment, checked out their strength and received information about our study programs.



Seismic refraction experiment carried out at KIT student information day in November 2018. Photos by E. Gottschämmer.

In October 2018, several new students started in our Bachelor program as well as in our Master program. The Master program is entirely taught in English now and has attracted several students from foreign countries. Since a couple of years, students enrolled in the Bachelor program in Physics can choose Geophysics as an elective during the first two years. This year, 19 Physics students took this chance to get insight into the most fascinating branch of Physics. Some of them might even decide to do a degree in Geophysics, as happened during last years.

In August this year, 12 GPI students took part in an *in-situ* lecture in the Apennines (Italy) to study seismic hazard in that region. *In-situ* lectures are taught in the field at the location which is being studied giving students the possibility to fully appreciate the objective and observe the whole range of parameters involved. For one week, our students stayed in Norcia, a small town close to the epicentral area of the 2016 Central Italy earthquakes, where damage is still omnipresent.

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During the lecture in the Apennines, the students conducted seismic array measurements in the region, recorded local seismicity, mapped the synthetic and antithetic faults of the 2016 earthquakes and conducted a survey of damages in the villages around the fault area. Every student had to prepare a presentation before the *in-situ* lecture which was given during the week. The data collected during the day was analyzed by the students during the week as well.



Seismic measurements in the Apennines during an in-situ lecture in August 2018. All photos by E. Gottschämmer.



Fault mapping in the Apennines during an in-situ lecture in August 2018.

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Fault mapping in the Apennines during an in-situ lecture in August 2018.



Analysis of seismic data recorded during an in-situ lecture in August 2018.

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### Simulation of 3D seismic wavefields for a tunnel environment

By Thomas Hertweck

Although tunnelling by means of tunnel boring machines (TBMs) has come a long way since the early days in the 19<sup>th</sup> century, there is still some risk involved when drilling tunnels despite prior comprehensive geological exploration. For that reason, i.e. to maximize safety of personnel and machinery, geophysical methods based on the seismic principle are used to detect obstacles or difficult geological zones ahead of the TBM as early as possible. While at first glance this sounds fairly easy given that seismic methods are well established, the tunnel environment poses unique challenges: there is limited space available to deploy seismic equipment, the tunnelling operation itself should ideally not be interrupted by any measurements, the seismic wavefield can become extremely complex and high-enough frequencies need to be used in order to detect relatively small geological features.



EPB shield for the Crossrail project in London with a diameter of about 7.1 meters. (source: Herrenknecht AG, [www.herrenknecht.com](http://www.herrenknecht.com))

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For certain geological settings and, thus, for the application of certain types of TBMs, tunnel prediction methods have been in use for many years. However, for so-called earth pressure balance (EPB) shields, the seismic prediction method is still in prototype stage. In a new project in cooperation with Herrenknecht AG, the applied Geophysics group at the GPI is currently investigating the simulation of 3D elastic wavefields for a tunnel environment with the specific goal of better understanding the complex wavefield and developing new processing and imaging techniques to allow reliable tunnel prediction for EPB shields. This MSc project is undertaken by Bessam Alubeyid in cooperation with former GPI student Fabian Kühn (MSc) who has recently started to work for Herrenknecht AG in Schwanau.

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### PhD at GPI

In December 2018 Ms. **Laura Gaßner** (M.Sc.) successfully defended her PhD thesis.

Title: *“Imaging of gas-hydrate deposits with full-waveform inversion of ocean-bottom seismic data”*

Supervisors:

Prof. Dr. Thomas Bohlen (KIT)

Prof. Dr. Andreas Rietbrock (KIT)

Her work was focused on the exploration of gas-hydrate provinces with seismic full-waveform inversion (FWI). In this context FWI was for the first time applied to ocean-bottom seismic data. The successful application of acoustic FWI to a field data set from the Western Black Sea provided highly detailed models of subsurface parameters which were evaluated for potential hydrate and gas occurrence and also served as input for saturation estimation.

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### MISCELLANEOUS

The **Deutsche Physikalische Gesellschaft e. V.** (German Physical Society) invited Dr. Ellen Gottschämmer and Dr. Thomas Hertweck as guest lecturers for the schoolteachers' continuing education course on Geo- and Astrophysics in July 2018 at the society's conference center in Bad Honnef (near Bonn). About 100 teachers from all over Germany attended the week-long course. Ellen's presentation on seismology and Thomas' presentation on exploration seismics raised great interest among the audience and many discussions followed during the subsequent breaks. Some of the teachers will use additional examples with a geophysical background during their classes in the future and they have already pointed out ways to update their teaching material. Some of them have also shown interest in visiting the GPI and its school laboratory.

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The **Geoverbund ABC/J** (a geoscientific network of the Aachen-Bonn-Cologne/Jülich research area) offered a summer school on advanced hydrogeophysical methods in Jülich in August 2018. Dr. Yudi Pan was invited as lecturer to teach about 30 under- and postgraduate students from 11 different universities on near-surface seismic methods including advanced inversion schemes to improve subsurface characterization and the interpretation of the vadose zone and aquifers. Nikolaos Athanasopoulos and Martin Pontius dealt with the practical part of the course and helped students acquire their own seismic data, allowing them to become acquainted with the equipment as well as optimal acquisition set-ups for seismic refraction surveys. Students not only enjoyed the practical work in the field but also the hands-on processing exercises that allowed them to deepen their understanding of near-surfaces seismic techniques and the associated challenges. The course on seismics was complemented by similar courses on surface and borehole ground penetrating radar (GPR), electrical resistivity tomography (ERT), electrical impedance tomography (EIT) and electromagnetic induction (EMI) mapping.

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**Summer School 2018 entitled "Full-Waveform Inversion: Mathematics and Geophysics"**  
organized by the CRC 1173 "Wave phenomena"

By Thomas Bohlen

Full-waveform inversion is a leading-edge imaging technique that aims to exploit the full signal content of seismic data. From September 17-21, 2018, approximately 60 European participants from academia and industry met at the KIT-Faculty of Mathematics to discuss full-waveform inversion for seismic exploration from both perspectives: mathematics and geophysics. The four main speakers were Andreas Fichtner (ETH Zurich), Jean Virieux (Univ. Grenoble Alpes), Russel Hewett (Virginia Tech) and Marten de Hoop (RICE University). In many overview presentations they discussed mathematical problems, implementation issues, high-performance computing aspects and showed various applications on a broad range of spatial scales from seismology to ultrasonic testing. Computer tutorials complemented the lectures and provided an insight into the performance of different algorithms.

Link: <http://www.waves.kit.edu/summerschool2018.php>

### COURSE EVALUATION SUMMER SEMESTER 2018

Similar to the situation in winter semester 2017/18, courses held by GPI lecturers in summer semester 2018 have again scored great results in the KIT course evaluation scheme. The teaching award in the category "Best special lecture" went to Dr. Ellen Gottschämmer for her lecture "Introduction to Volcanology" which was attended by a total of 16 students. In the category "Best overall lecture" the lecture "Seismic Data Processing" by Dr. Thomas Hertweck took second place and was awarded a special commendation. Four additional lectures and exercises given by GPI lecturers and tutors scored among the top five in their corresponding categories.



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### RECENT PUBLICATIONS

In this section we would like to inform those of you who are still active in Geophysics about recently published peer-reviewed journal papers authored by current members of GPI:

Friedrich T., Zieger T., Forbriger T., Ritter J.R.R.: Locating wind farms by seismic interferometry and migration, *Journal of Seismology*, 22, 1669-1483, 2018.

Aydin N.Y., Duzgun H.S., Heinimann H.R., Wenzel F., Gnyawali K. R.: Framework for improving the resilience and recovery of transportation networks under geohazard risks, Elsevier, *International Journal of Disaster Risk Reduction* 31, 832-843, 2018.

Heidbach O., Rajabi M., Cui X., Fuchs K., Müller B., Reinecker J., Reiter K., Tingay M., Wenzel F., Xie F., Ziegler M. O., Zoback M.-L., Zoback M.: The World Stress Map database release 2016: Crustal stress pattern across scales, Elsevier, *Tectonophysics* 744, 484-498, 2018.

Pan Y., Schaneng S., Steinweg T., Bohlen T.: Estimating S-wave velocities from 3D 9-component shallow seismic data using local Rayleigh-wave dispersion curves – A field study. *Journal of Applied Geophysics*, 159, 532-539, 2018.

Wittkamp F., Athanasopoulos N., Bohlen T.: Individual and joint 2-D elastic full-waveform inversion of Rayleigh and Love waves. *Geophysical Journal International*, 216(1), 350–364, 2019.

#### Feedback

If you have any comments, questions or remarks, please do not hesitate to contact us. We appreciate your feedback.

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*Happy Holidays to  
everyone and a Happy  
New Year 2019*

