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NEWSLETTER OF THE GEOPHYSICAL INSTITUTE

Issue 17, July 2020

DEAR GPI ALUMNI

In the last few months life at GPI was also heavily influenced by the Corona pandemic. With a few day's notice, we had to reorganise all teaching for the summer semester and change completely to online teaching and video conferences. With the excellent effort of our IT department at GPI and also with the great support of the SCC, this process was very smooth and managed seamlessly. Now words like "zoomen" and "let us meet in TEAMS" have found their way into everyday conversations at GPI. Unfortunately, also a significant amount of our science projects (especially field work) was hit hard by the pandemic.

You can read in this newsletter where we currently have a significant amount of seismic stations, which were just deployed before the worldwide lock down hit hard. How to continue these projects in the coming months and years is not clear yet, but some solutions are slowly emerging. Finally, I would like to thank everybody at GPI for their tremendous effort in the last few difficult months and wish all of you and our Alumni enjoyable and most important healthy summer holidays.

Andreas Rietbrock

TEACHING

By Ellen Gottschämmer

In February this year, Corona wasn't dominating our teaching yet, and we could conduct an in situ lecture to the Eifel volcanic field for a group of ten international students from our master's pro-gram. We were inspired to conduct this lecture by recent deep low-frequent earthquakes that had been reported by Hensch et al. (2019). Thus, apart from visiting remnants of former volcanic activity in the area, we installed seismometers together with our students and analyzed our own seismic data set.

On 20 April 2020, lectures were planned to start again at GPI after the semester break.

But since study operations were suspended according to the Corona Ordinance of the federal state Baden-Württemberg, we had to decide quickly what to do: which lectures can be given digitally - either as weekly video conference or supplied as prerecorded videos?

Which lectures need physical pres-ence and might need to be postponed? Might some lectures even need to be cancelled completely?

Soon it was clear that we wanted to make the effort and offer as many lectures as possible during the semester. We quickly learned how to produce lecture videos at home and how to use digital classroom tools. We realized seminars as webinars and thus could "invite" speakers from the US to this semester's Institute seminar. Even the Geophysical Field Course (Geländeübungen) could be conducted this summer semester. However, students did not travel to Engen as in previous years but performed field measurements on campus. Now they know exactly what the subsurface of the Westhochschule looks like. Towards the end of the semester, we were allowed to meet again in small groups in the computer pool, always following KIT's hygiene and safety rules, and could con-duct computer exercises and a block course on seismic data processing which made use of com-puter programs available only on campus. KIT’s hygiene and safety rules even allow us to conduct an in situ lecture at Italian volcanoes with a small group of students in September. We will bring our seismic equipment to Stromboli and record the seismic signature of Stromboli’s ongoing activity.

OCHTENDUNG FAULT ZONE SEISMIC EXPERIMENT 1

By Andreas Rietbrock and Joachim Ritter

The seismicity and volcanology of the Eifel Volcanic Fields is a long-time research interest of GPI since the 1970ies. Since 2014 we run a seismic network around the Laacher See Volcano with 15 recording stations from GPI and this summer we installed a new seismological experiment across the Ochtendung Fault Zone (OFZ). The OFZ is a continuously active fault which produces felt earthquakes about once per year (*ML* up to ~3.5) and weekly minor events (*ML* ~1). This seismicity makes it one of the most active faults in Germany. Although its seismicity can be well located (at about 3-15 km depth), there is no known surface trace. Field studies in quarries by Joachim Ritter and Bernd Schmidt (Mainz) could not identify any fault signatures in spring time (just before the Corona lockdown).

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In July we deployed 17 seismic recording stations along Bernd's Line from SW to NE about perpendicular to the OFZ. Data CUBES and three-component geophones were buried along a 5 km long field track. This experiment is a joint effort of GPI, RWTH Aachen (K. Reicherter) and Seismological Service Mainz (B. Schmidt) and it will last for about six months.

Besides recording (micro-) earthquakes from the OFZ we also expect to catch deep low-frequency events which occur just south of the Laacher See Volcano (https://www.3sat.de/wissen/nano/es-brodelt-weiter-100.html).

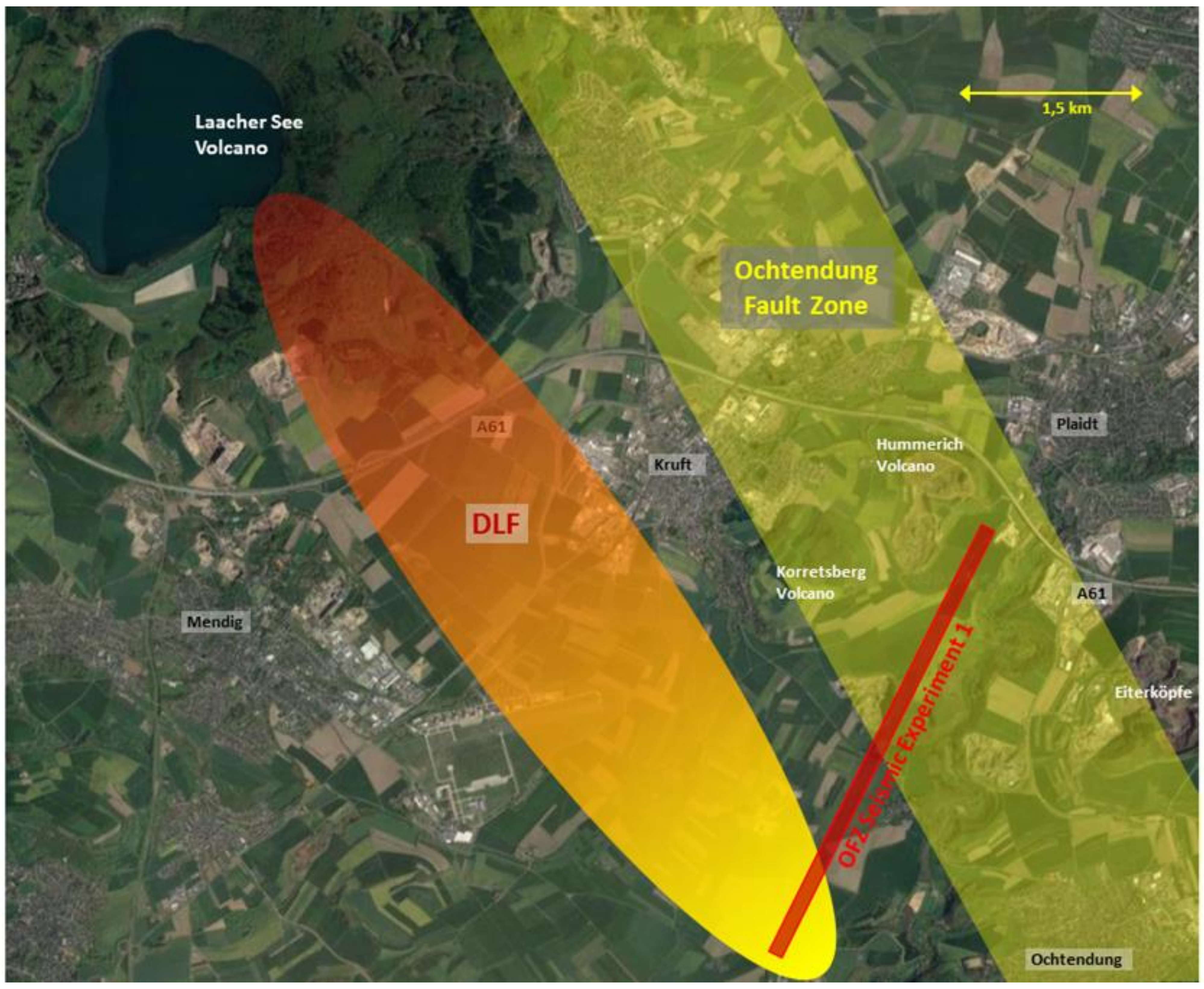

Fig.: Map of the region southeast of the Laacher See Volcano (LSV). The Ochtendung Fault Zone (OFZ) runs from NW (east of LSV) to SE (Mosel River), here we show in yellow the estimated projection to the Earth's surface. The new seismic experiment is plotted in red. To the west is the zone with deep low-frequency events which may be a channel of rising magmatic volatiles and even melt.

Fig.: Buried recording station for the Ochtendung Fault Zone Seismic Experiment 1. A CUBE recorder (grey) with GPS receiver is powered with a battery (green). The sensor (yellow) is a tuned 4.5 Hz three-component geophone. During the recording all instruments are completely buried with soil to avoid any visibleness.

All photos by J. Ritter

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FULL WAVEFORM INVERSION OFOBS DATA OF a 350 km LONG PROFILE IN THE PISAGUA/IQUIQUEEARTHQUAKEREGION

By Laura Gaßner

In 2014 the Pisagua/Iquique earthquake with a magnitude of M_W 8.1 occurred in a large seismic gap along the northern Chilean margin. The full segment had ruptured in 1877 and the southern part remains in a locked state. The PICTURES (Pisagua/Iquique Crustal Tomography to Understand the Region of the Earthquake Source) seismic experiment was conducted to gain insight into why the southern segment had not ruptured during the earthquake. The 2016 experiment consisted of 69 ocean bottom (OBS) and 50 onshore seismic stations and multiple seismic profiles were recorded incorporating approximately 47,000 airgun shots (Figure 1). The experiment and the following data analysis are coordinated by the Oregon State University (OSU) as well as universities and research institutions in Chile and Germany. Members of the GPI are involved in data analysis of the onshore and offshore data sets.

Along an extended north-south line of 350 km length, located approximately 65 km east of the trench, 20 OBS stations were deployed and covered by 1,125 airgun shots. We want to study lateral changes in the crustal structure of the marine forearc across the boundary associated with the rupture zone. In a first step travel time inversion using approximately 17,000 P-wave travel times was applied to the OBS data by our colleagues from OSU. The resulting P-wave velocity tomography model was provided to us for the application of full waveform inversion (FWI).

To gain more insight into the elastic parameter distribution along the profile and we choose a subpart of the model for FWI which is 25 km deep and 330 km long. It includes 12 OBS stations and more than 1,000 shots with a spacing of 300 m. We choose a simulation time of 20 s with a time step of 1 ms for modeling and a spatial discretization of 20 m. We use hydrophone data and apply minimal preprocessing, including bandpass filtering and a 3D-to-2D transformation. The lowest frequency included is 3 Hz. For inversion we simulate synthetic seismograms by applying visco-acoustic modeling. Only inversion for the P-wave velocity is carried out, while the density and attenuation models remain unchanged. We suppress updates in the water column and at OBS positions. Additionally, we amplify updates at greater depth and utilize horizontal spatial smoothing. We use a workflow with increasing time- and offset-windows to improve the convergence of the inversion.

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The data fit is improved significantly during inversion and a good agreement of the inverted source time functions is achieved. Final P-wave velocity models show a prominent structure in 5-10 km depth with a dip in the region of a gravity change observed along the profile (Figure 2). Further north the reflector cannot be observed as clearly. Furthermore, the shallow structure is updated and provides much more detail compared to models derived from travel times only. Despite the challenging data set we are able to recover structures in a depth range where illumination by streamer data is poor and are therefore able to provide valuable input for further geological interpretation.

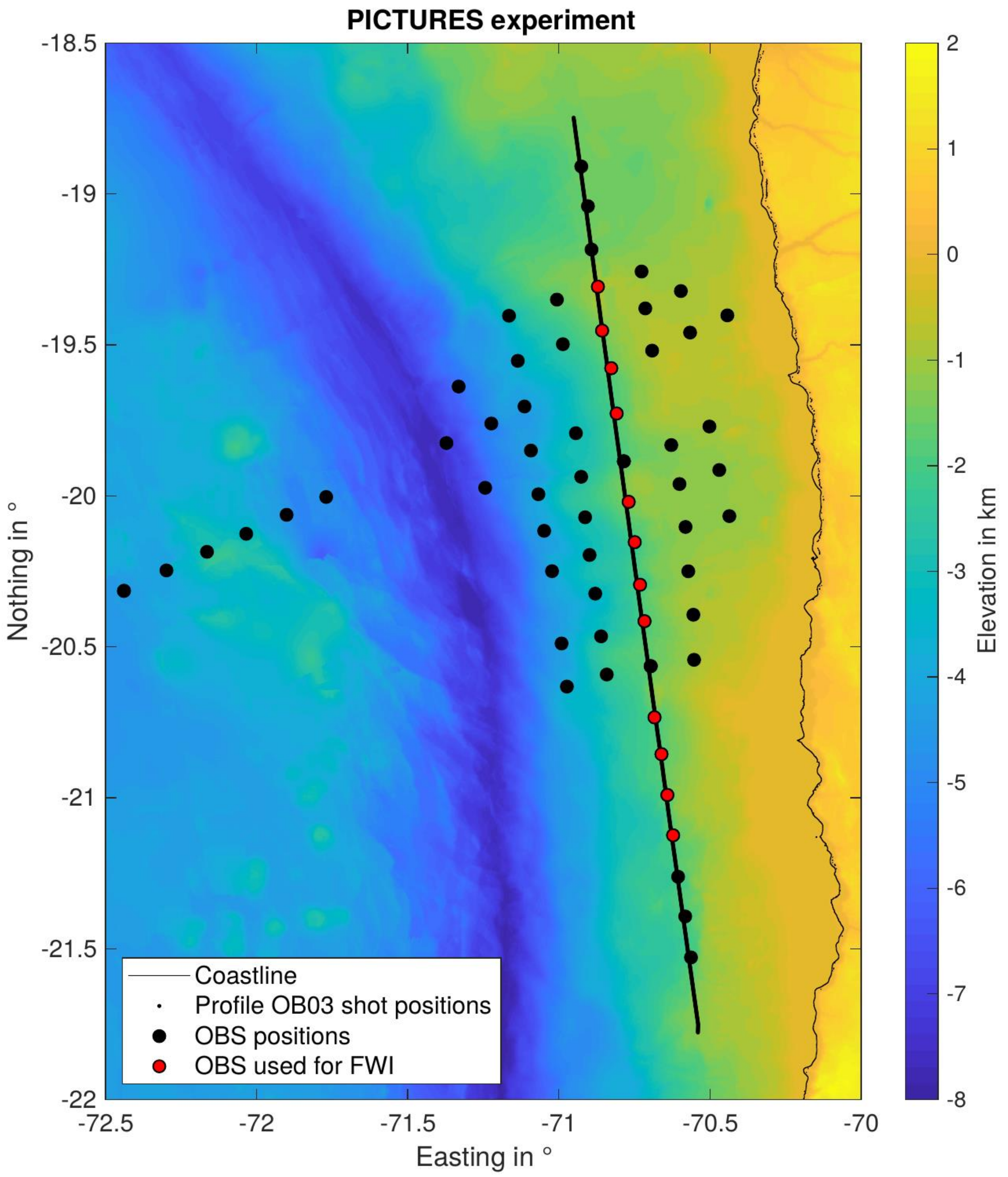

Figure 1: Map of the seafloor depth and onshore topography with the PICTURES experiment geometry. Black dots mark locations of OBS stations, the black line shows the extend of profile OB03. The OBS stations marked in red are used for FWI.

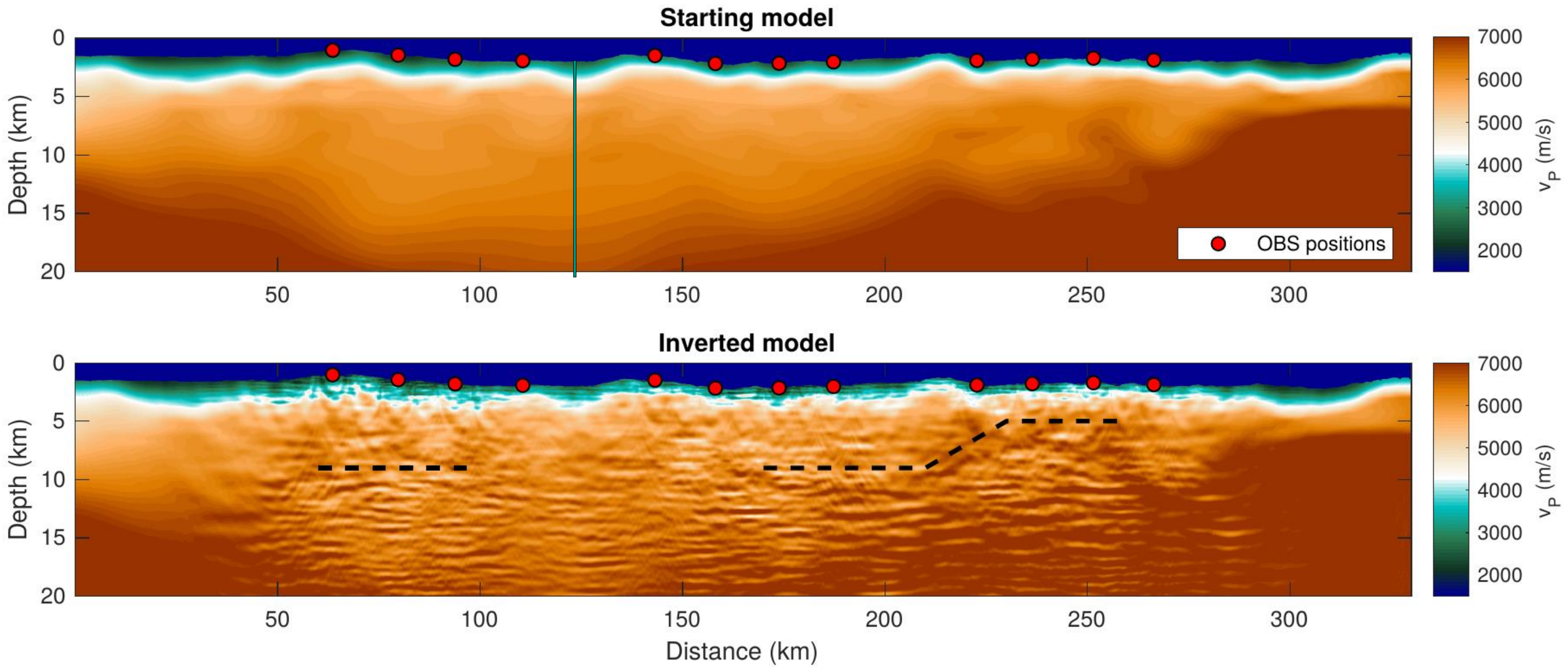

Figure 2: Starting model of the P-wave velocity with OBS positions marked by red circles (top); P-wave velocity model after 60 iterations, the black dashed line indicates the dipping structure (bottom).

MISCELLANEOUS

By Joachim Ritter

Last October a research group from RWTH Aachen (K. Reicherter & J. Hürtgen) together with GPI (J. Ritter & S. Mader) opened a palaeoseismic trench near Ettlingen. Within this project in the Central Upper Rhine Graben we found displacements in the uppermost sediments which can be attributed to 2-3 M > 6 earthquakes. These ruptures occurred at postglacial time and thus may strongly influence our understanding of the current earthquake activity in our region. Recently a short TV science film was released: https://www.3sat.de/wissen/nano/200702-beben-nano-104ct on seismicity in.html.

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GEOTex@GPI: 3D SEISMIC IMAGING FOR GEOTHERMAL EXPLORATION BELOW CAMPUS NORTH

By Lars Houpt, Eva Schill, Thomas Hertweck and Thomas Bohlen

The GPI is involved in the scientific project GEOTex, which concerns the exploration of the subsurface of KIT Campus North. In a first step, the Tertiary sediments at intermediate depth are targeted to establish the Helmholtz research infrastructure DeepStor. In the Helmholtz energy research field, this infrastructure represents an important column of the “Materials and technologies for the energy transition (MTET, 2021-2027)” program. With the experience from DeepStor, KIT aims at reaching CO_2 neutral energy supply at KIT Campus North by 2030 by heat production from the deep subsurface in the GeoHeat project.

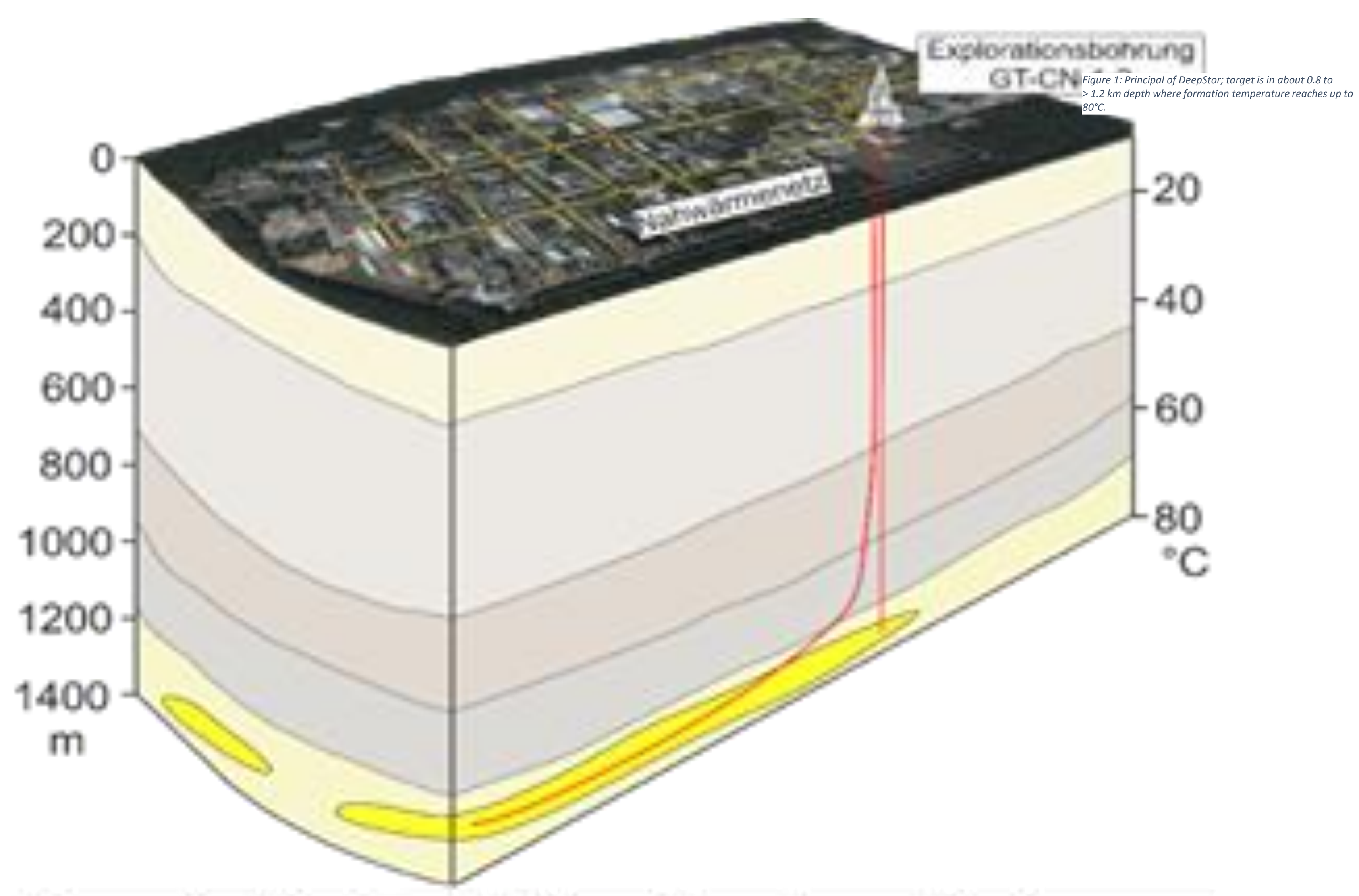

Figure 1: Principal of DeepStor; target is in about 0.8 to > 1.2 km depth where formation

DeepStor aims at demonstrating a high-temperature heat storage at > 150 °C by investigating the capabilities of seasonal storage in the Tertiary hydrocarbon reservoir rocks in more than 800-1200 m depth. The GeoHeat installation shall provide base-load heat for KIT Campus North from more than 170°C hot and naturally circulating fluids from a deep Mesozoic reservoir in more than 3 km depth. For this purposes, KIT holds an exploration permission for the site at its Campus North and the surroundings together with the utility company Energie Baden-Württemberg AG EnBW.

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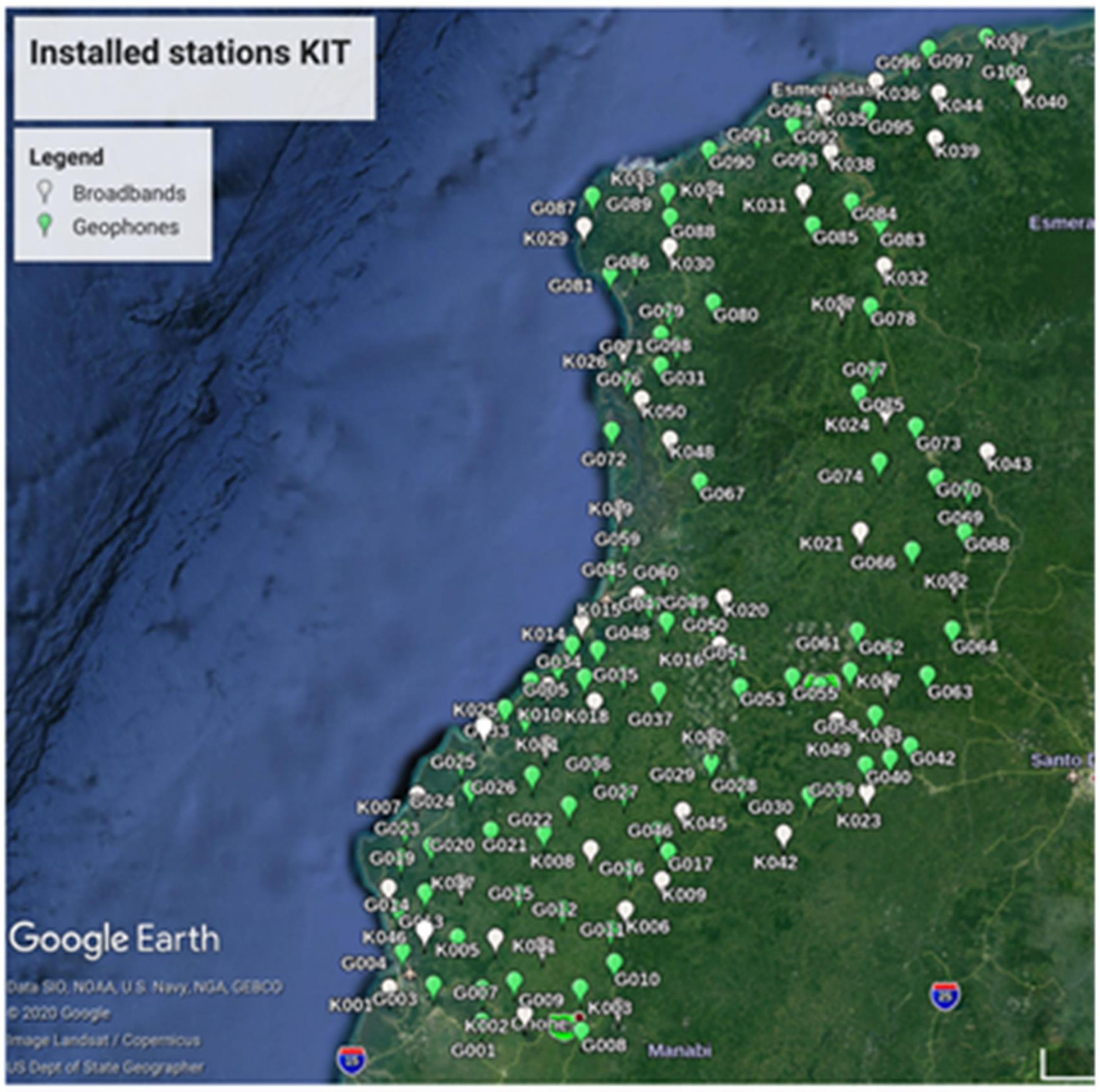
GPI INSTALLED 150 ONSHORE STATIONS FOR A COLLABORATAIVE HIGH RESOLUTION IMAGING EXPERIMENT IN ECUADOR

By Sergio León-Ríos

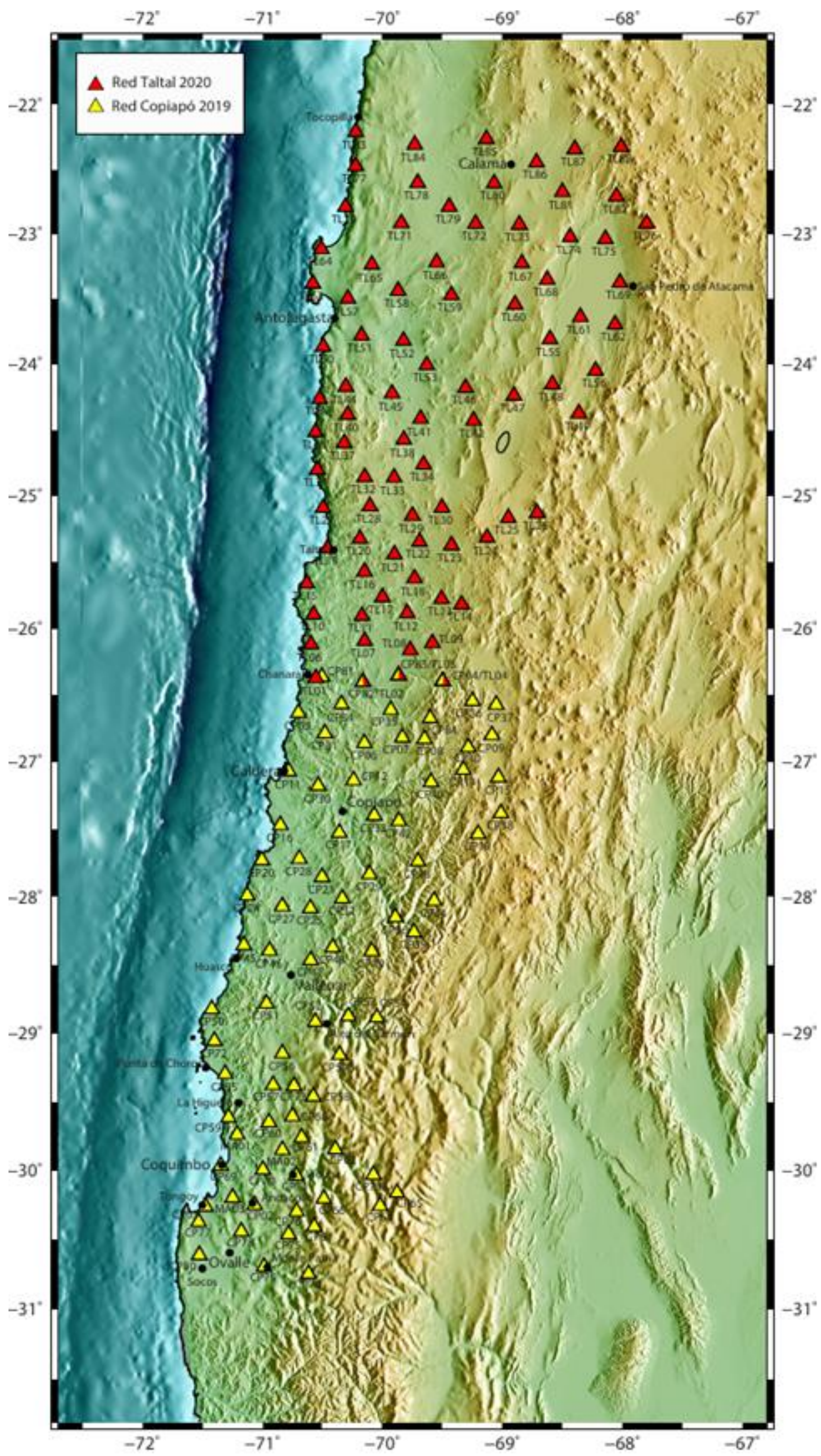
The Geophysical Institute extended his presence in collaborative projects in South America by deploying 150 inland seismic stations in the coastal Ecuadorian region. As part of the HIPER project (France, USA, Ecuador) which aim to image with high resolution the rupture area of the 2016 Mw 7.8 Pedernales earthquake, three teams led by Sergio Leon-Rios, Benedikt Brazsus and Valentina Reyes and supported by the staff of the Instituto Geofisico de la Escuela Politecnica Nacional of Ecuador installed 50 broadband and 100 short period triaxial geophones in an area of ~200 x 150 km2. The inland stations were placed with a spacing of ~10km creating a dense temporary network that was supposed to be complemented by another 50 broadband and 300 seismic nodes from the US institutions to record not only the earthquakes but also the active seismic experiment offshore. Sadly, the corona crisis forced to postpone the experiment to not early than 2022. However, the GPI deployed network it is still active and recording the seismic activity in the region.



All photos by León-Ríos

THE MOBILE SEISMIC ARRAY IN CENTRAL CHILE (MSACC) KEEPS MOVING ALONG CHILE

By Sergio León-Ríos



Mapview for the MSACC-KIT-UChile network installed in north and central Chile. Red and yellow triangles show the deployment of the 88 short period for 2020 and 2019, respectively.

The large MSACC-KIT-UChile installed by GPI and the Advanced Mining Technology Center (AMTC) of the Universidad de Chile during December 2018 continues covering large areas along the Chilean territory. During 2019, the 88 short period, three components, geophones were recording substantial data in the Atacama and Coquimbo regions (yellow triangles in map) including the Mw 6.7 normal-fault intraplate earthquake occurred in January 2019. Currently, the network is installed in the Antofagasta region (red triangles in map), covering an approximate area of 450 x 200 km2, after been moved by two teams of the AMTC. These large installations in an intrinsically seismic country will contribute to improve the imaging of the velocity structure for the northern and central Chile as it is planned by the Chilean coordinator of this project, Prof. Dr. Diana Comte.

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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:

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