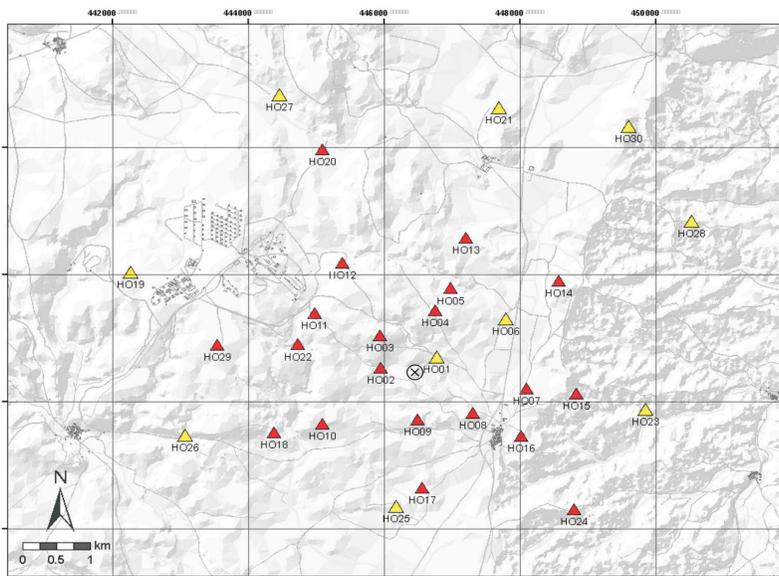


Passive Seismic Monitoring of an Experimental CO₂ Geological Storage Site in Hontomín (Northern Spain)

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The Spanish Foundation "Ciudad de la Energía" (CIUDEN) is developing a CO₂ Geological Storage Program in saline aquifers in Spain. One of the main objectives of the program, which is now at its pre-operational stage, is to set up a pilot plant to develop technology and test methodologies on CO₂ storage operation, with the final goal of making the geological storage environmentally safe and technologically viable. The site selection and characterization studies performed on several target geologic formations have identified a suitable **experimental and demonstration site in Hontomín** (northern Spain). Numerous geophysical techniques are currently being performed for the subsurface characterization of the small (approximately 5x3 km) dome-like structural trap. This work is essential to establish a baseline for future monitoring of the reservoir in order to assess and predict the behaviour of CO₂ after the injection.



Distribution of the 30 seismic stations of the Hontomín Seismic Network (HO). Red triangles correspond to the 20 SS-45 sensors whereas the LE-3D seismometers are plotted with yellow triangles. The cross symbol marks the location of the possible CO₂ injection point.

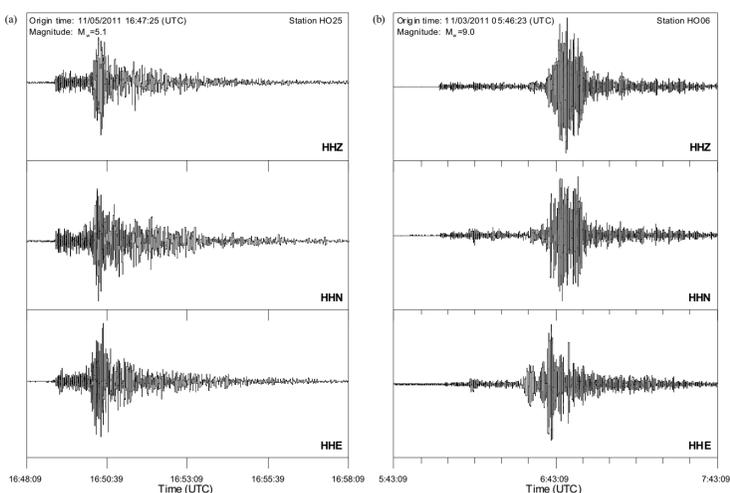
In addition to site characterization, CO₂ monitoring will play an essential role to control the possible leakage of the injected fluids to the atmosphere or other geologic formations and will help to track them in the subsurface over time. In this sense, it is important to have extensive baseline models before CO₂ injection, in order to detect later induced perturbations in the reservoir due to the CO₂ plume. **Passive seismic monitoring** is a complementary technique that has potential as long-term, cost-effective method. Passive seismic arrays provide near real-time continuous data, and the maintenance cost is low, as compared with other techniques. A passive seismic monitoring network has been deployed as part of the CIUDEN CO₂ Geological Storage Program



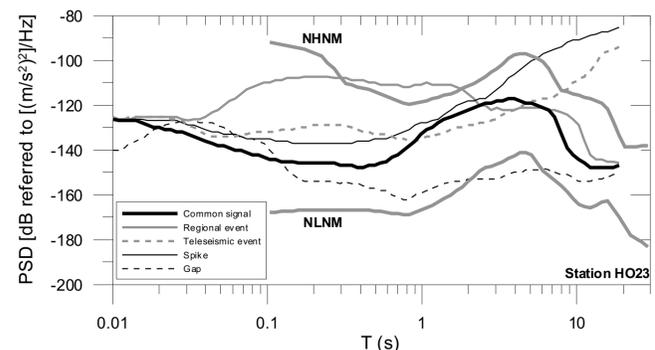
Image of the installation of one seismic station at the field.

With presently 30 seismic stations already operating, the network is composed of 20 three-component SARA SS-45 sensors with natural frequency 4.5 Hz, and 10 Lennartz LE-3D seismometers with natural period 20 s, which have been deployed at about 2-meters in depth. The stations were distributed, within logistical constraints, in concentric ellipses around the planned CO₂ injection well. The interstation distances range from 1 to 2 km, thus covering an area of about 9 x 8 km². Seismic data are acquired by means of SARA SL-06 digitizers at a sample rate of 200 Hz and they are continuously recorded on-site. The implementation of a digital radio link transmission to a recording data centre is in progress.

We have computed the **seismic ambient noise levels** at the network seismic stations which are critical to detecting and locating injection-related events. We are now exploring the capability of the seismic network configuration for detecting very small seismic velocity perturbations at the reservoir using **Passive Image Interferometry (PII)**, which may be ascribed to the CO₂ injected plume. PII is a recently developed technique in seismology (Sens-Schönfelder and Wegler, 2006) that allows identifying temporal changes of the mean shear wave velocity within the Earth using ambient seismic noise recordings, thus constituting a promising monitoring possibility.



(a) Seismogram of a regional earthquake occurred in Lorca (southeastern Spain) at about 568 km from the site; (b) teleseismic recording of the Tohoku (Japan) earthquake occurred at a geodetic distance of about 10,410 km from Hontomín.



Spectral characteristics of the vertical-component Power Spectral Density (PSD) for the LE-3D seismometer. The gray lines represent the New High Noise Model (NHNM) and New Low Noise Model (NLNM) of Peterson (1993). Several noise sources and signal transients are considered.

ACKNOWLEDGMENTS

This research is being funded by the "Fundación Ciudad de la Energía" (CIUDEN). CIUDEN is a State Foundation joint venture of the Spanish State Departments: Ministry of Sciences and Innovation, Ministry of Industry and Ministry of Environment. Additional funds provided by REPSOL are supporting A. Ugalde and B. Gaité.

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