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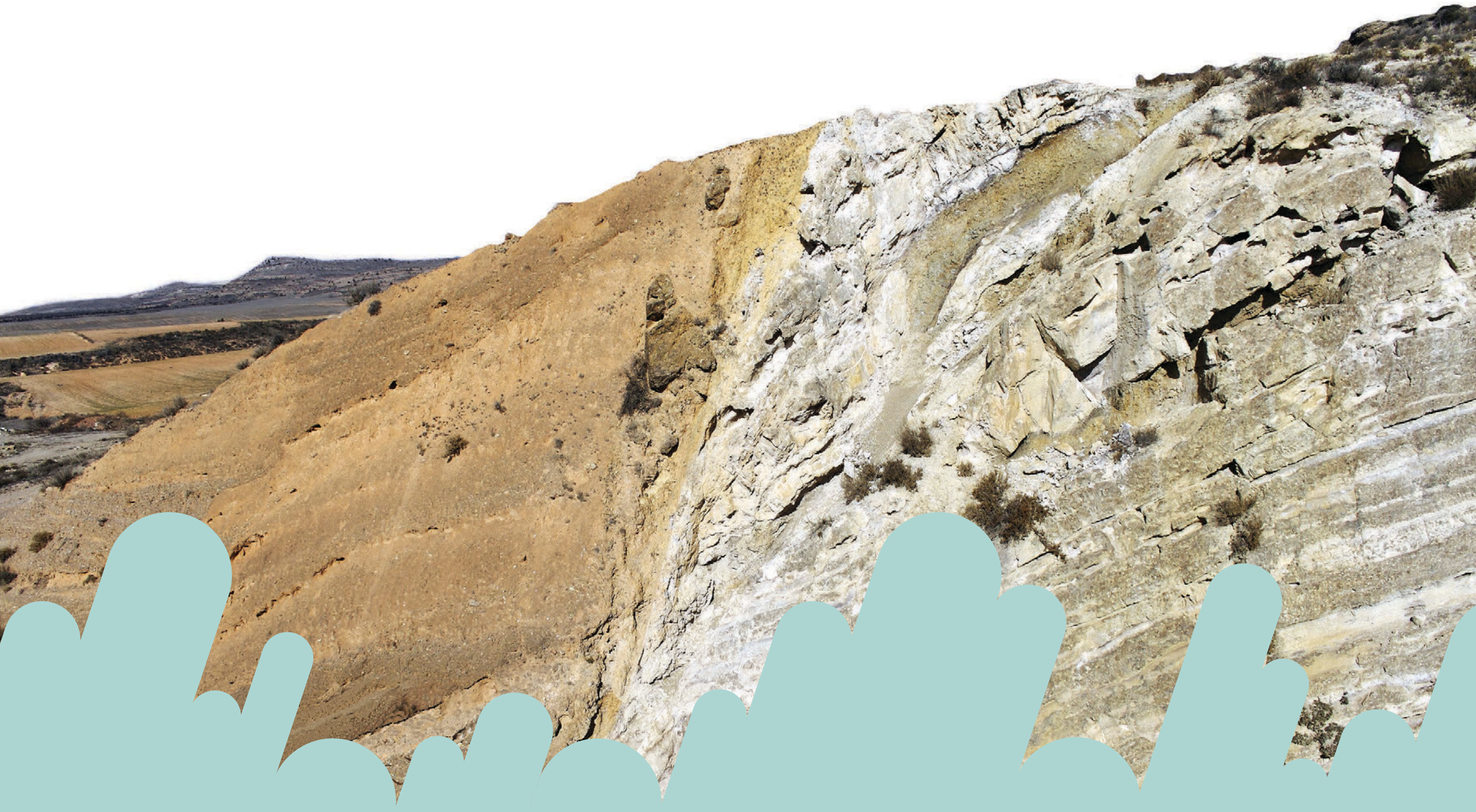
TERUEL · 7 al 10 de septiembre de 2022



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NEW INSIGHTS INTO FAULT SYSTEMS OF THE BURGALESA PLATFORM REVEALED BY SEISMIC MONITORING AT THE HONTOMÍN TECHNOLOGY DEVELOPMENT PLANT (BURGOS, SPAIN)

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Abstract: The seismic monitoring of the Hontomín CO_2 geological storage pilot plant, located in Burgos (northern Spain) and operated by CIUDEN, has provided remarkable insights into the structure of the site, within the Burgalesa Platform. Beyond the geological and geophysical studies previously executed for the Hontomín facility, this work presents high-resolution instrumental seismicity data acquired by a local network in the study area for the first time. The analysis of this dataset yields novel constraints on subsurface fault distribution and kinematics, while it is a valuable contribution to understand the interaction of fluids with rocks and faults in the context of CO_2 geological storage.

Keywords: micro-seismicity, seismic monitoring, CO_2 storage

Introduction

In 2011, Fundación Ciudad de la Energía (CIUDEN) started to build the first and only CO_2 geological storage pilot plant of Spain, in Hontomín (Burgos), located in the Burgalesa Platform, a fold belt in the Southern Basque-Cantabrian Basin (Ramos *et al.,* 2022). As a key test facility to the European Parliament and being part of a full chain Carbon Capture and Storage (CCS) project, the Hontomín pilot plant was developed to demonstrate the feasibility to host 100000 tons of CO_2 in a deep saline aquifer emplaced in fractured Jurassic carbonates (De Dios *et al.*, 2016). After the construction of the pilot plant, the reservoir's hydraulic characterization phase was carried out involving the injection of 14000 m^3 of brine (salt saturated water) and 2300 tons of CO_2 (De Dios *et al.*, 2017).

To ensure safety during operations, seismicity has been monitored in the vicinity of the Hontomín pilot plant since 2011 through a network of 30 3-component

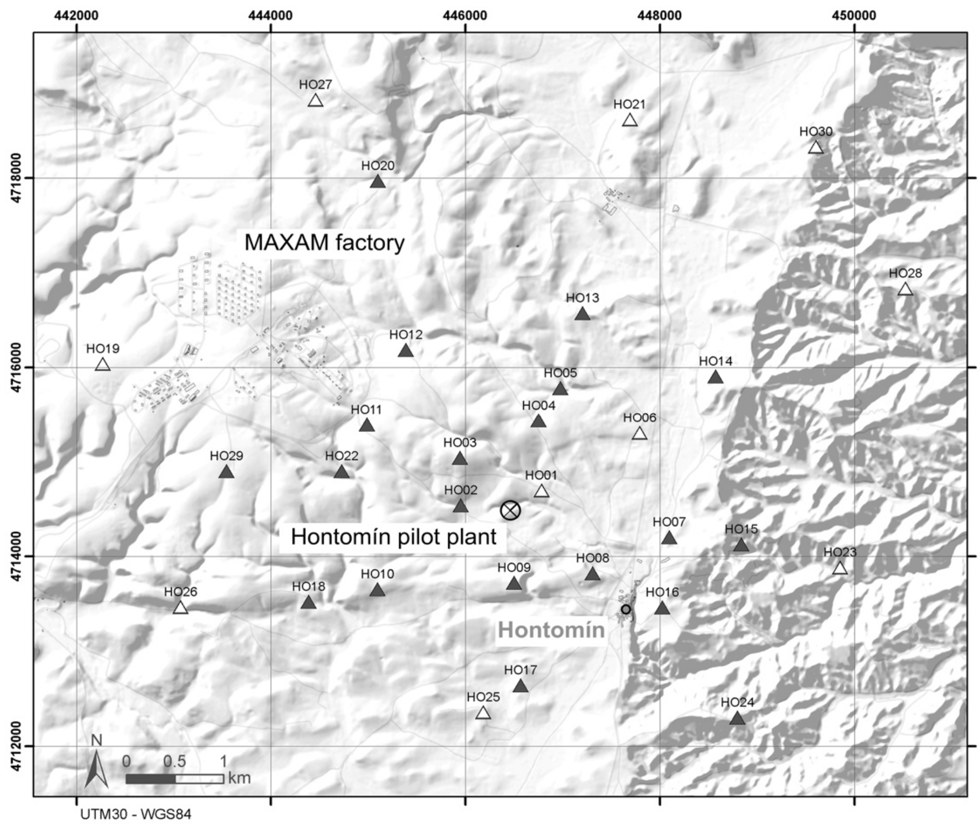

Fig. 1.- Hontomín seismic network (HO) stations distribution, edited from Ugalde *et al.* (2013). Hontomín urban center and the Hontomín CO_2 storage pilot plant are highlighted with a grey dot and a black crossed circle, respectively. The facilities of the MAXAM factory in the western side of the map is also shown. Seismic stations are represented by triangles, with different colors showing different sensor models. White triangles are used for Lennartz sensors, and the black ones correspond to SARA sensors.

seismometers (Ugalde *et al.*, 2013) disposed radially around the injection well (Fig. 1). An automatic seismic event detector system was set for this network and it detected only one seismic event during an injection test, after which a bottom hole pressure control system was installed to reinforce injection security. In this work, the raw seismicity data have been further inspected to understand the origin of seismic activity and contribute to improve deformation monitoring in CO_2 geological storage projects, within the scope of the SENSE (Assuring integrity of CO_2 Storage sites through ground surface monitoring) research project of the ERA-NET ACT programme.

Data and methods

This study focusses on the revision of seismicity data acquired by the Hontomín seismic network (henceforth HO network) during the first stage of the reservoir hydraulic characterization achieved in 2014. During this period, several stations were out of service lessening the network to almost half of its original size. The data obtained from all operative stations have been processed through different steps. First, the data have been visually inspected to manually detect any signal related to seismic activity. Then, the onsets of seismic phases have been used together with a local velocity model to locate the hypocenters of the detected seismicity. Based on the maximum amplitude of the registered S-waves, the earthquakes' local magnitude has been also estimated. Finally, the focal mechanisms of the seismic events occurred inside the network area have been determined using the first-motion polarity of P-waves.

Seismic activity during the hydraulic characterization of the Hontomín reservoir

The HO network registered abundant anomalous ground motion during July and September 2014. Most

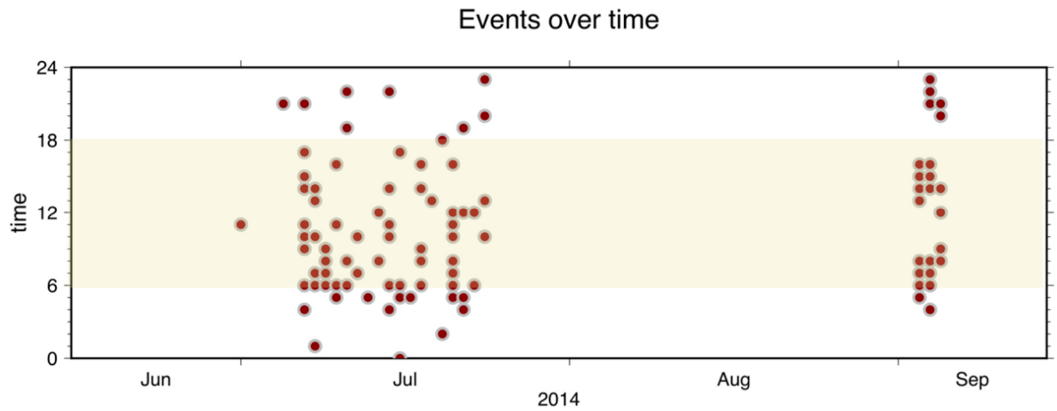

Fig. 2.- Events detected over time. The light orange box highlights daytime (6 am – 6 pm), when most of the events were detected

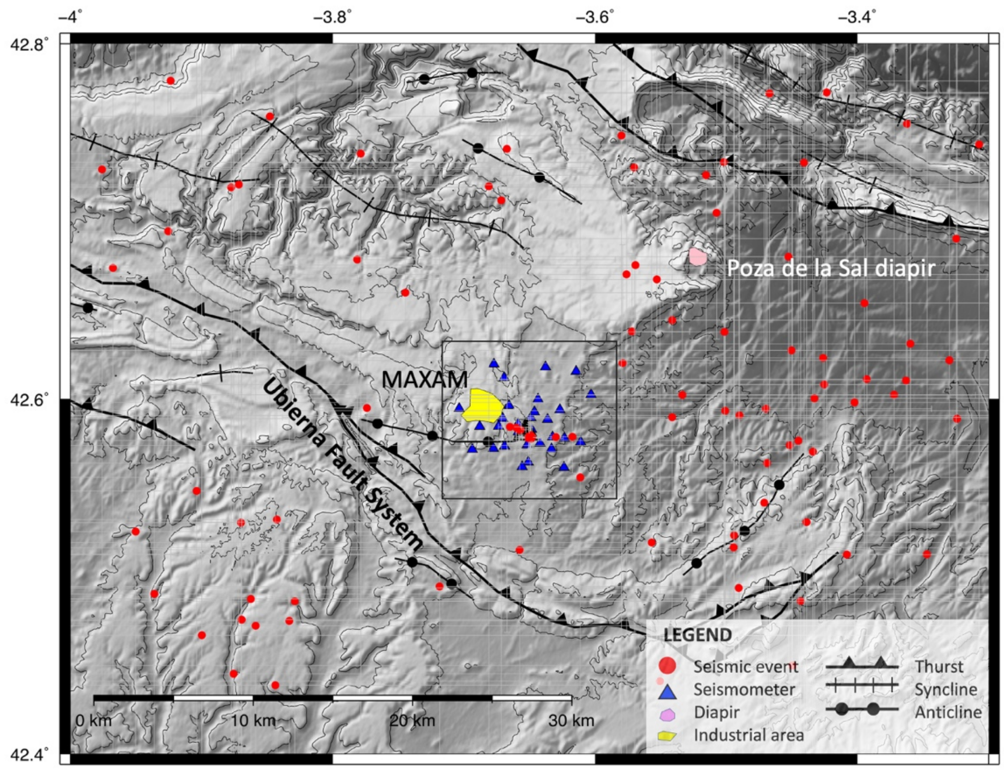

Fig. 3.- Regional seismicity map with SRTM1 30m DEM in the background. Epicenters are shown as red dots with horizontal location errors represented by the grey NS and EW bars. The black inset highlights the location of the Hontomín (HO) seismic network (Fig. 1).

of such activity occurred during daytime hours suggesting a strong influence of anthropogenic activities (Fig. 2), such as the controlled explosions performed by the MAXAM explosives factory, which is located very close to the Hontomín pilot plant (Fig. 1). Moreover, the bulk of these seismic events took place outside of the area covered by the HO network (Fig. 3), where the capability to solve the location of sources is very limited due to the network configuration.

Nevertheless, there was some local micro-seismicity registered near the injection well during July and September 2014 and temporally associated with injection tests. So far, we detected 16 micro-seismic events (-1M_L – 0.4M_L) within the network coverage by manually inspecting the recorded seismograms. The preliminary focal mechanisms of these events appear to be consistent with the fault kinematics expected for the area of study and the Ubierna Fault System (Pérez-López *et al.*, 2020), which is the largest tectonic structure close to the Hontomín pilot plant.

Conclusions

The seismic monitoring accomplished in the Hontomín pilot plant demonstrates that surface networks are able to detect micro-seismicity. This is dependent on the number of stations, the type of sensors and their distribution, but it means that surface seismometers are highly valuable tools to be considered for deformation monitoring in CO_2 storage sites.

The results obtained in this work show that the changes in pore fluid pressure or high fluid flow rates associated with brine/CO_2 injection along rock units and/or faults might promote micro-seismic events.

The seismic activity recorded in Hontomín is a unique piece of information on the fault systems of the Burgalesa Platform, both in terms of fault location and/or geometry and faulting mechanisms.

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