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# Hydrological signatures on seismic and strain records at the Canfranc Underground Laboratory (Central Pyrenees).

Jordi Diaz (1), Luca Crescentini (2), Mario Ruiz (1), Antonella Amoruso (2), and Josep Gallart (1)

(1) ICTJA -CSIC, Barcelona, Spain (jdiaz@ictja.csic.es, 34 934110012), (2) Dipartimento di Fisica, Università di Salerno, Fisciano, Italy

The Canfranc underground laboratory (LSC), excavated in the rock under the Central Pyrenees, is mainly devoted to the study of phenomena which needs "cosmic silence", as the detection of cosmic neutrinos or "dark matter" particles. Being located in one of the most active seismic areas in Western Europe, this installation provides a very convenient location to host an advanced integrated geodynamic facility to cover the whole geodynamical spectrum, from near-field seismicity to tectonic deformation, earth tides or earth-core nutation. Since early 2011 a continuously acquiring seismic station, including an accelerometer and a very broad-band sensor is operative inside the tunnel at a depth of about 350 m. Since early 2012, two near-orthogonally oriented high-resolution laser strainmeters are also working at the same location and two external CGPS stations will be operative in the next future.

As expected, the seismic data has a very low level of noise both at low and high frequencies. This fact allows the detection of small energy features that may otherwise remain obscured in the noise. When inspecting the power density spectra of the continuous dataset, several episodes of an unusual spectral signature were detected. Those features have well-defined frequency content, extending from 2 to 8-10 Hz, that is, in the same band where non-volcanic tremors have been identified in subduction zones. The occurrence of those episodes is neither regular in time nor linked to variations in the noise level in the microseismic band, occurrence of local/regional seismicity or changes in the cultural noise level. Even if those episodes have been firstly identified in the spectral domain, a simple band-pass filtering allows to identify them clearly in the temporal domain. Since early 2011 four main episodes have been identified, each lasting 1-2 to 6-8 days and showing some differences in its properties. A limited number of shorter (less than a day) episodes has also been identified, even if its characterization is more difficult.

Strain data provided by the high-resolution laser strainmeters is available for one main episode and some of the shorter ones. A clearly anomalous strain has been identified in all the checked cases, coincident in time with the anomalous seismic signal. This coincidence allows discarding a possible origin related to any kind of instrumental malfunction.

It is well know that even light rain produces large signals in deformation instruments located at superficial or very shallow levels. Even in interferometers located at large depths (as in Grand Sasso), deformation changes related to long-term changes in the aquifer have been identified. Therefore, we estimate that underground water may be related to the observed signals also in this case. We have reviewed data from a close meteorological station, founding a correlation between periods of heavy rain and the presence of a high level of noise in the 2-10 Hz seismic band. Anomalous deformation changes have also been recorded during most rainy days in the strainmeters.

It seems clear that the observed signal does not correspond to water flooding in nearby rivers or creeks, as its frequency content is very narrow. Mechanisms related to changes in fluid-filled cracks have been proposed by Chouet (1988, 1996) to explain similar tremor-like signals. Those models have been originally proposed in volcanic settings, but have also been applied to areas with hydrothermal circulation or in passive margins. In our geological setting, the seismic and strain signals may be generated by changes of pressure in nearby fractured rocks due to water percolation after heavy rain periods. However, those hypotheses must still be taken with care as further theoretical and observational work is clearly needed.