Seismic studies at Sos Enattos and other ET candidate sites

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Big thanks to Luca Loddo and the entire Sos Enattos team!
The idea

• Design and build low cost seismic sensors
• Make them work with time synchronisation
• Deploy them at candidate sites
• Gather as much data as possible
• Characterize and compare sites
The sensor

- Based on 2.5 Hz geophones
- Custom electronics
- Connected in series for data acquisition and time synchronisation
- Data gathered to a PC and also on SD cards in each sensor
Seismic sensors
Sensitivity study

• Cross callibration with a Trillium detector at NiKHEF

• Noise measurement in a seismically isolated vacuum chamber at NiKHEF
Sensitivity estimate

![Graph showing sensitivity vs. frequency]

- 4.5Hz geophone (not used)
- Vertical and horizontal sensors
Locations

• Książ Castle – south-western Poland, testing facility
• Matra mine – Hungary
• Sos Enattos mine – Sardinia, Italy
• Canfranc Underground Laboratory, Spain
Matra mine

• The station approximately 1km underground

• Accessible only to local trained personnel

• One sensor only
Laboratorio Subterreno
Canfranc
Railway tunnel
Connector tunnel
Locations of sensors

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LAB 2500

Φ = 75,2073°
Son Enattos mine
Data acquisition

- Amount of data accumulated:
  - Ksiaz – 4150 h
  - Hungary – 20078 h and more
  - Sardinia – 4358 h
  - Spain – 4227 h and more

Available http://foka.isepw.edu.pl/aspera/
Data analysis

• Seismic spectra
  – Daily variability
  – Range

• Quake analysis
Sos Enattos - spectra

- 7 sensors, 3 axis each
- 1 sensor on the surface

Vertical acceleration spectrum                               Horizontal acceleration spectrum
Matra
Canfranc

- Site specific: spectra depend on the distance to the road and the main lab
- Daily variation
- Seasonal variation
Daily variability
Site comparison
Earthquake analysis

- Analyze 1 sec pieces of data
- Look for maxima in 3d velocity in each segment
- Define earthquake as segment with maximum above 0.5 micrometer/s
- Define earthquake as a set of such segments followed by at least one minute quiet time
- Find list of events for each site
Sos Enattos

Sos Enattos earthquakes

Number per year

Peak velocity [m s\(^{-1}\)]
Canfranc earthquakes

Number per year vs. Peak velocity [m s\(^{-1}\)]
Matra

Matra earthquakes

The graph shows the number of earthquakes per year on a logarithmic scale against peak velocity in meters per second. The data follows a power-law distribution, indicating a frequency-magnitude relationship characteristic of earthquake catalogs.
Other considerations

- Environment:
  - Underground humidity
  - Forms of life: rodents

- Underground humidity, chemistry
Conclusions

• Site comparison
• Estimate of seismic spectra, variability
• Correlation analysis – to be done
• Sos Enattos is a really quiet site!
• More sensors, ground studies, calibration