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# PRELIMINARY ANALYSIS OF BOREHOLE ACCELEROGRAMS ACQUIRED ON THE TOP AND A FEW DECAMETERS INSIDE A HILL IN PROVENCE (FRANCE)

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**ABSTRACT -** It is well known that the amplitude and frequency content of the wave fields are modified during their propagation close to the surface in the vicinity of a site. First of all, the incident up-going seismic signal is amplified by the free surface effect with a factor 2. The amplitude and frequency content of the seismic motion also depends on local site effects (local geology or topography among other). These amplifications phenomenon and in particular the topographic effects are not always well quantified and are in general underestimated by deterministic numerical models. In order to quantify the variations of seismic motion with depth, three boreholes have been instrumented with accelerometers. These boreholes have been drilled on the top of a hill, a few meters away the ones from the others. The hill, located in Provence (Southern France), is about 80 m high from the valley at the bottom and the horizontal hill size is of the order of 500 m. Four 3-components accelerometers have been installed, one at the surface and the other three at 35.2 m, 70.3 m, 105.5m deep respectively. Some small events have been recorded by this vertical network since its aperture in early 2004. We illustrate the quantification of the sub-surface motion variability computing the response spectra ratio between subsurface records and surface ones.

## 1. Introduction

A hill mainly composed of limestone inside the site of Cadarache has been chosen to install three accelerometric 3-component stations in borehole. The location of this site in Provence should permit to record several events (earthquakes in the Alps, in the Mediterranean Sea among others …). The presence of a hill offers the possibility to study the topographic effect in a rigid medium and to compare actual data with 3D simulation.

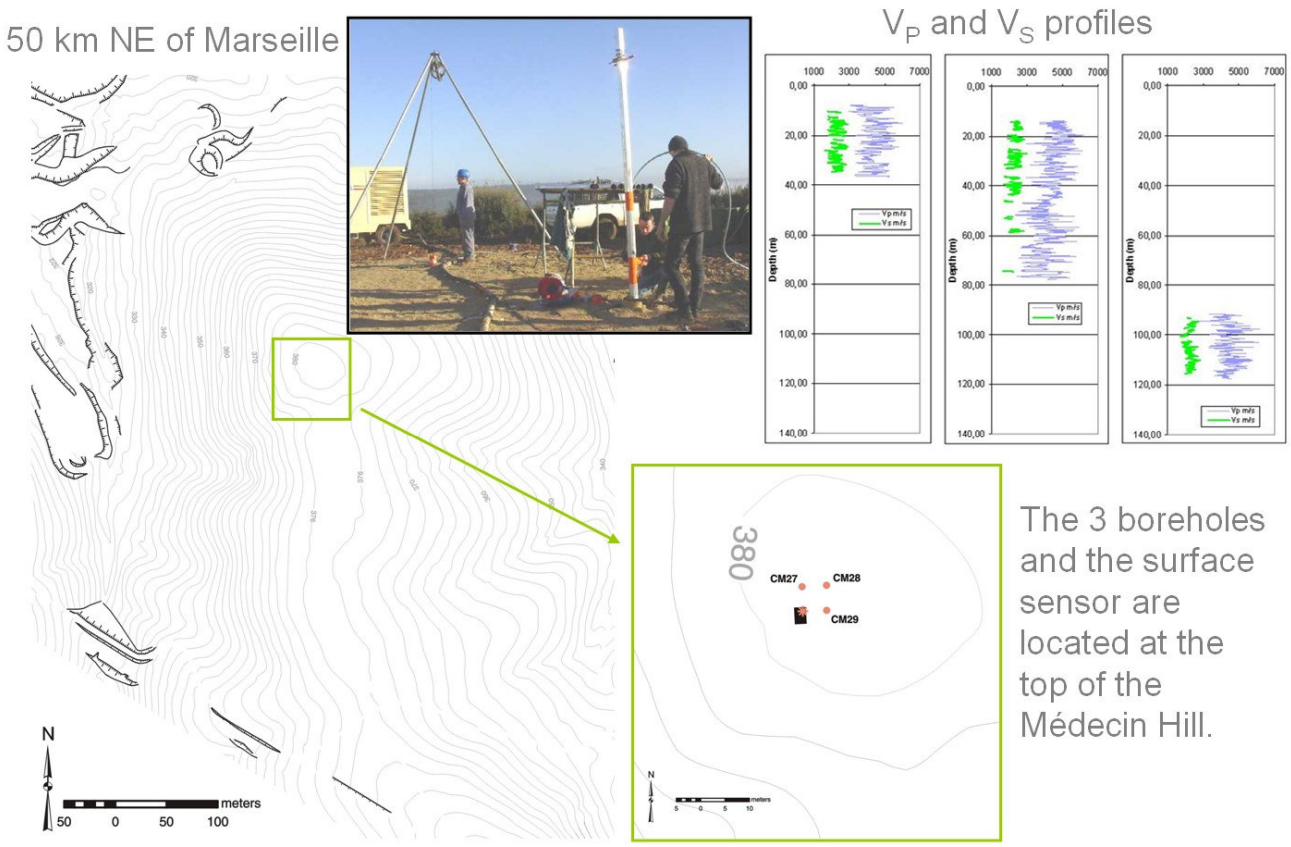


*Figure 1. Location of the experiment and velocity profiles.*

## 2. The experiment

Three triaxial accelerometers have been installed inside 3 distinct boreholes respectively at 0, 35.2 (CM27), 70.3 (CM28) and 105.5 m (CM29) meters deep (Figure 2). Another accelerometer has been installed at the free surface. In order to characterize the subsurface materials velocity profiles have been done before the sensor installation (Figure 1).

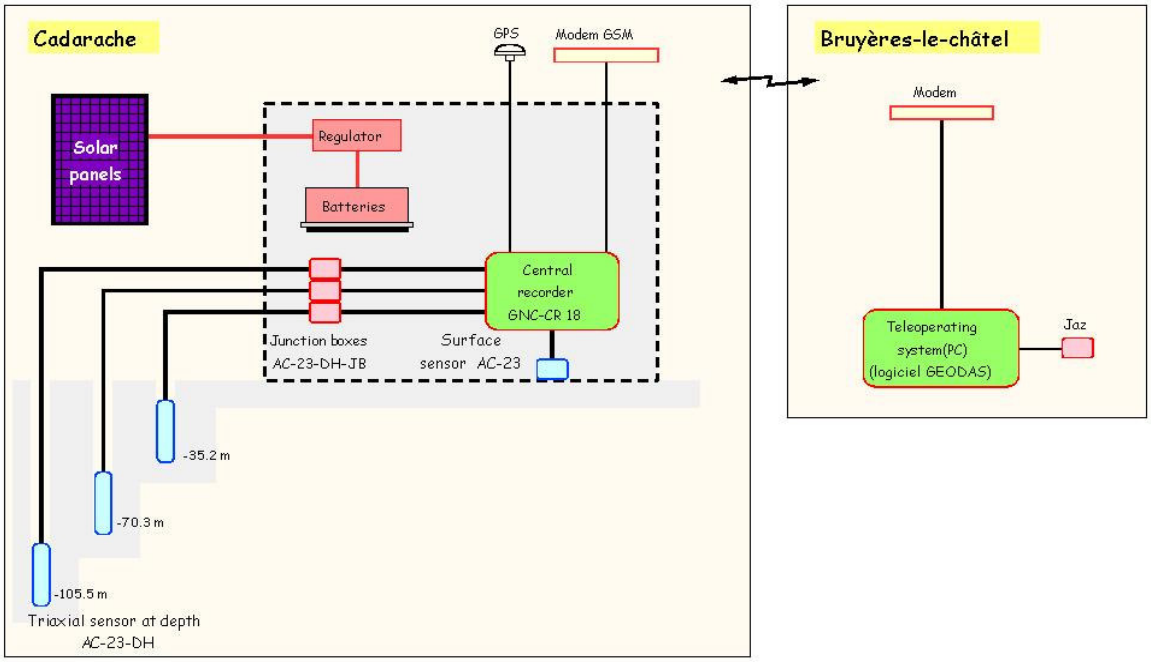


*Figure 2. Acquisition system and data transfer*

Geosig triaxial sensor during installation  Shelter containing the acquisition system

*Figure 3. Pictures of the sensor installation.*

## 3. First data and preliminary analysis

During the year 2004 and 2005, three events have been recorded by the network :

- 23/02/2004, $M_L$ = 3.0, d = 125 km
- 27/01/2005, $M_L$ = 3.4, d = 130 km
- 23/08/2005, $M_L$ = 2.0, d = 13 km

where $M_L$ is the LDG local magnitude and d is the epicentral distance to the network.

These events are small but the Signal / Noise ratio is of a good quality, and we can observe on these small events the signal attenuation between the surface and the subsurface.

On Figure 4 concerning the Levens earthquake (23/02/2004, $M_L$ = 3.0, d = 125 km) we observe about a factor two between the peak acceleration recorded at the free surface and the ones recorded at depth. In term of response spectra, the seismic motion is the same for the 4 sensors at very law frequency and the attenuation of the seismic motion start to appear as the depth increase and the frequency increase

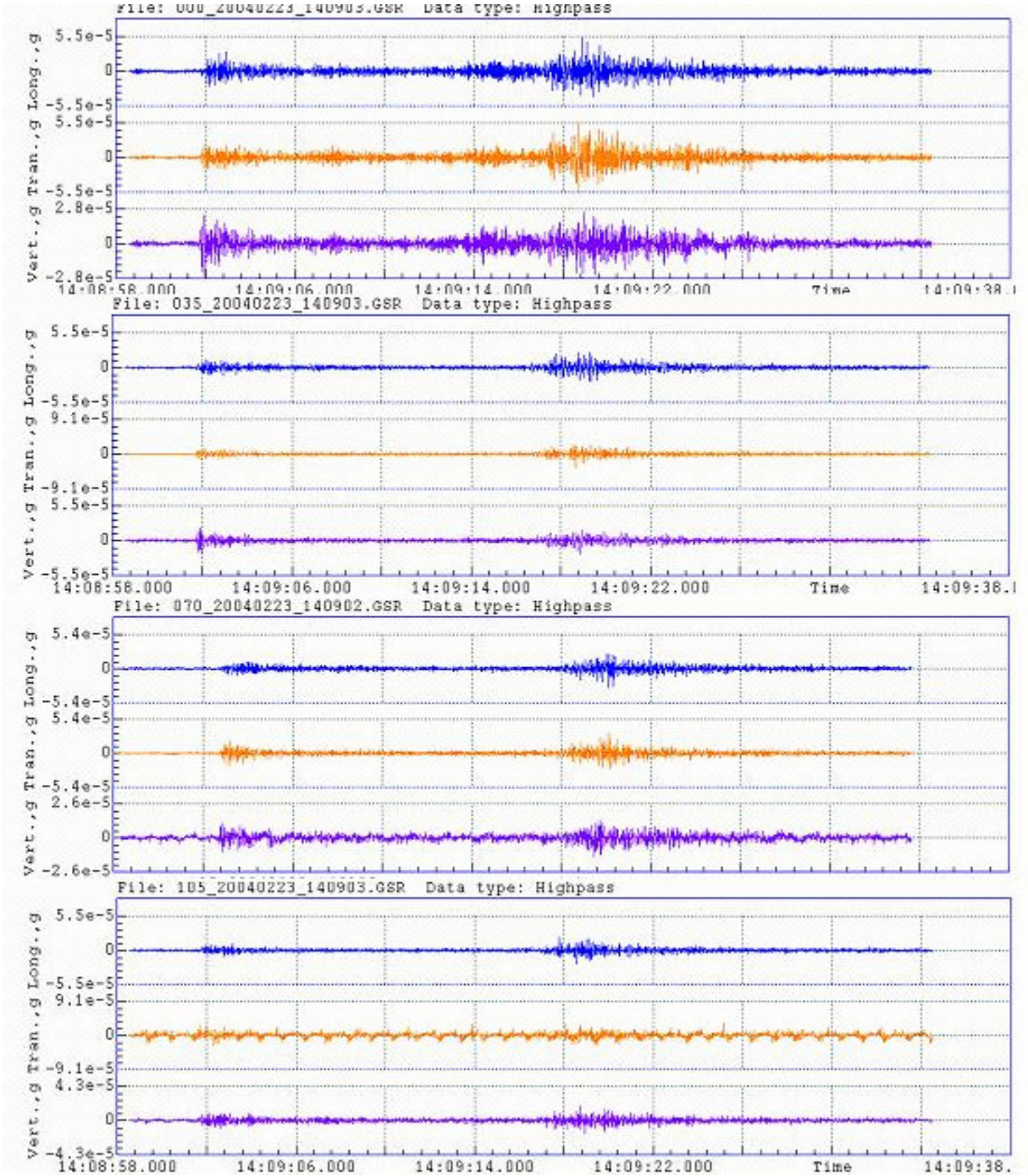


*Figure 4. Recorded acceleration time histories during the Levens earthquake (23/02/2004)*

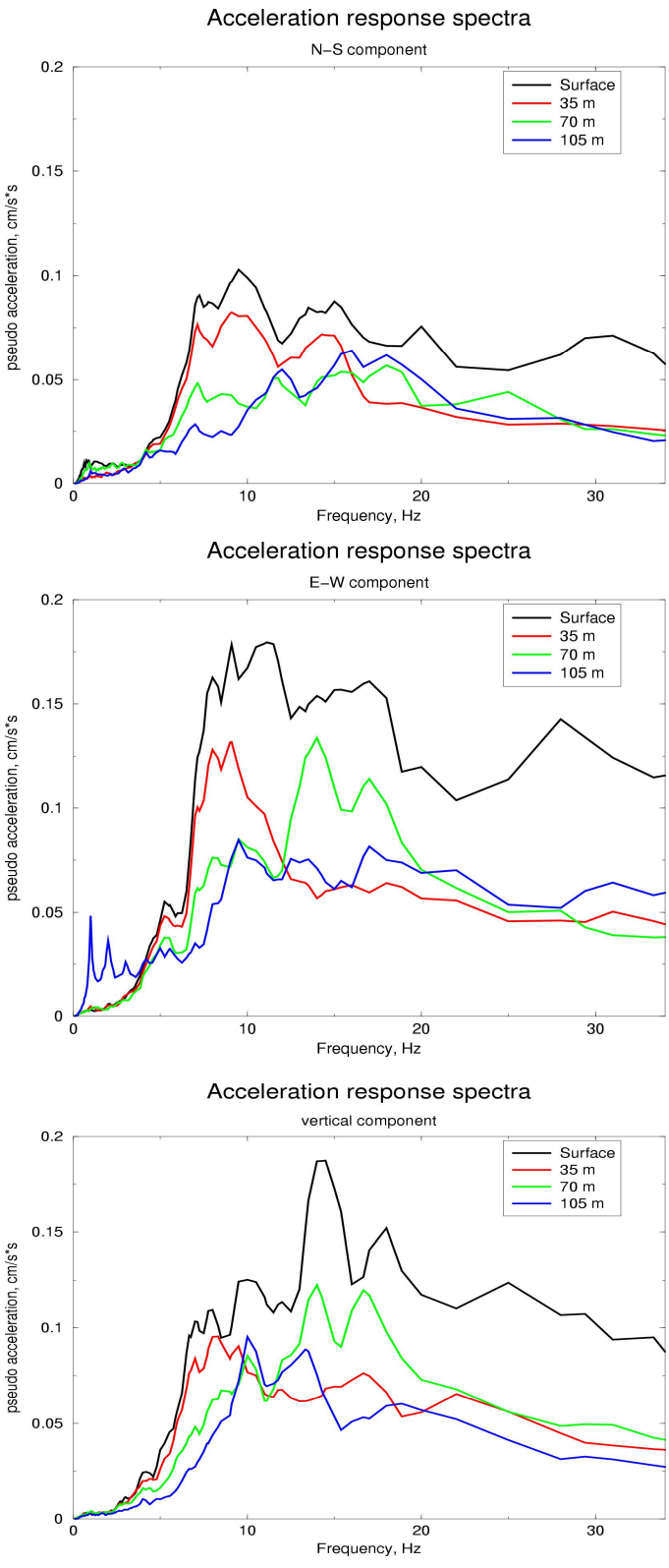


*Figure 5. Response spectra of the Levens earthquake (23/02/2004)on the N-S, E-W and vertical component*

## 3. Conclusion

In this preliminary study, we have analyzed one event recorded by the Medecin Hill network (the Levens earthquake 23/02/04, $M_L$ = 3, Distance = 125 km). The preliminary results are as follow :

- All the sensors have the same acceleration level at very low frequency
- At higher frequency (f> 25 HZ) a factor 0.5 is reach on the 3 sensors located at 35, 70 and 105 m in depth.
- The dominant effect observed is to due the free-surface reflection.