Detecting slow deformation signals preceding dynamic failure: a new strategy for the mitigation of natural hazards (SAFER)

(Article begins on next page)

Detecting Slow Deformation Signals Preceding Dynamic Failure: A New Strategy For The Mitigation Of Natural Hazards (SAFER)

European Geosciences Union
General Assembly 2014
Vienna | Austria | 27 April – 02 May 2014

Sergio Vinciguerra[1,2,3], Chiara Colombero[1], Cesare Comina[1], Anna Maria Ferrero[1], Giuseppe Mandrone[1], Gessica Umili[4], Andrea Fiaschi[5] and Gilberto Saccorotti[6]

[1]Dipartimento di Scienze della Terra, Università degli Studi di Torino, Italy ; [2]Department of Geology, University of Leicester, UK ; [3]British Geological Survey, UK
[4]Dipartimento di Ingegneria Civile, dell'Ambiente e del Territorio, Università degli Studi di Parma, Italy ; [5]Fondazione Prato Ricerche, Prato, Italy; [6]Istituto Nazionale di Geofisica e Vulcanologia, Pisa, Italy

Contacts: sergiocarmelo.vinciguerra@unito.it; chiara.colombero@unito.it

1. Introduction and background

Pre-failure monitoring is a major aim in territorial risk assessment and mitigation. Detecting slow deformation signals preceding dynamic failure is a main goal for developing early-warning systems.

We deployed a a microseismic network for monitoring a rockfall at Madonna del Sasso (VB, Italy) with the aim to identify the characteristic signs of pre-failure processes. The array consists of 4 triaxial geophones (4.5 Hz).

2. The site

Madonna del Sasso site is located in NW Italy (Fig. 1a). It is a granitic cliff **(Granito di Alzo)**, with a height of about 200 m (Fig. 1b).

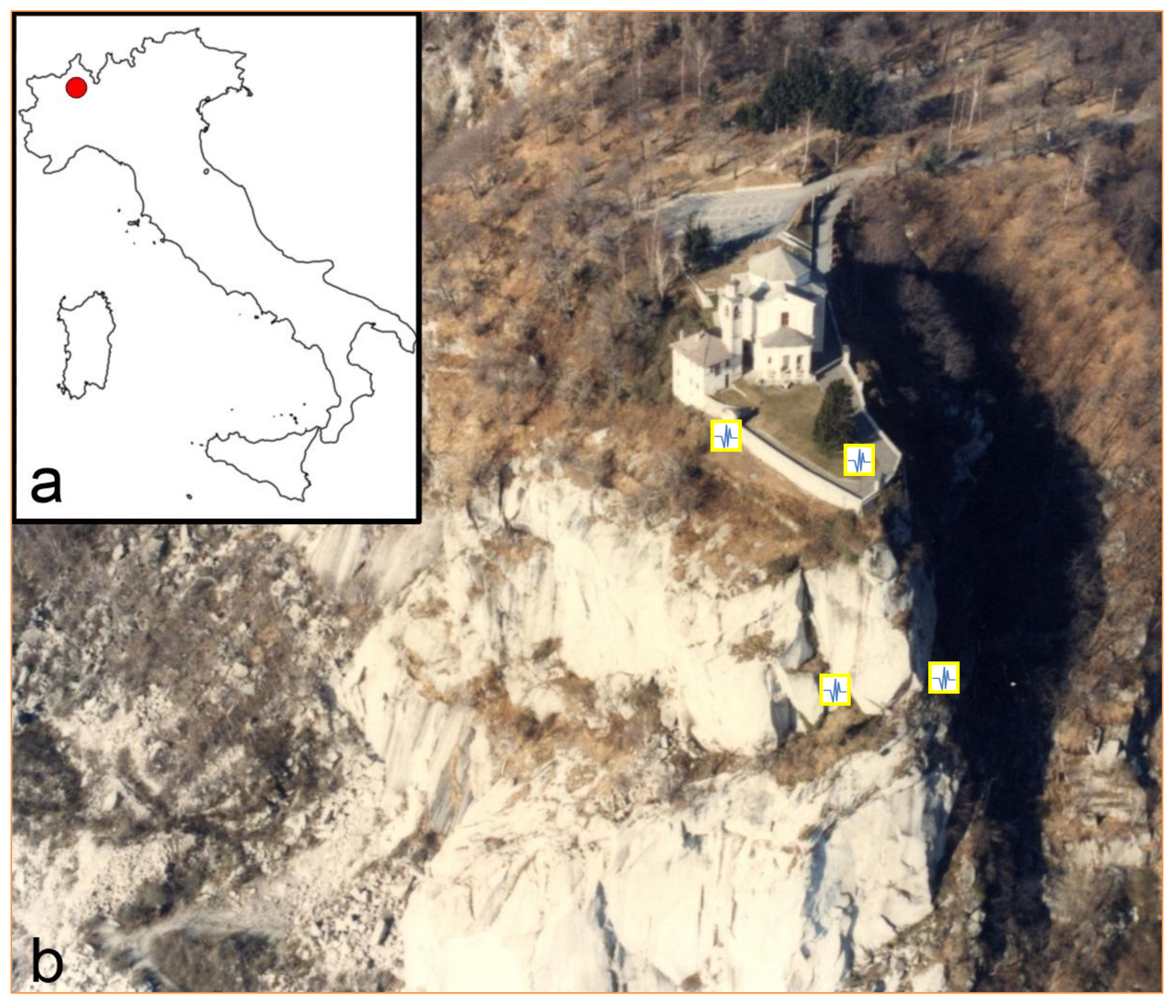
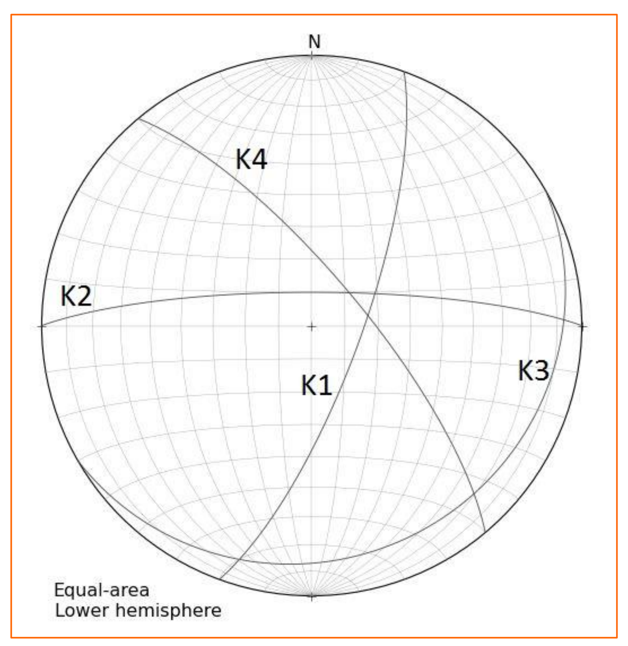


Figure 1. *Location (a) and aerial view (b) of the cliff of Madonna del Sasso. The symbols indicate the network nodes positions.*



Four main discontinuities (Fig. 2) tend to dislocate the frontal portion of the cliff, involving a volume of about **12,000 m³**.

Figure 2. *Main joint systems projection.*

3. Geophysical characterization

Electrical Resistivity Tomography (ERT)

- 72 electrodes with 1 m spacing
- Wenner-Schlumberger and Dipole-Dipole array
- Data inversion with Res2DInv software (Fig. 3)

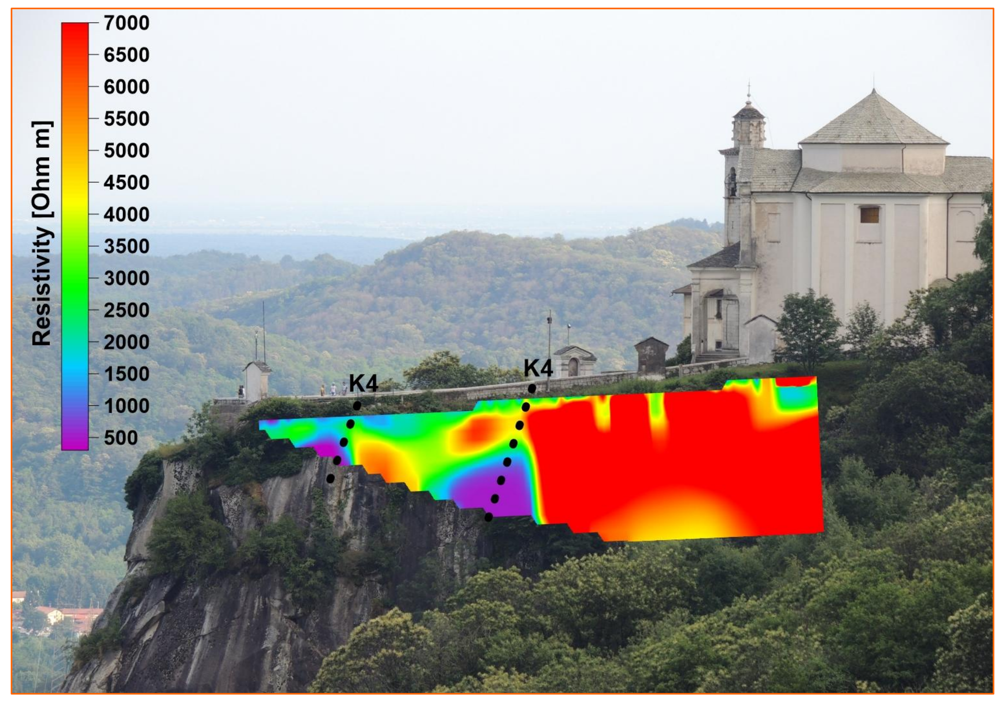


Figure 3. *ERT section (Dipole-Dipole configuration).*

Cross-hole Seismic Tomography

- Borehole impacter source
- Prototype borehole string with 8 three-component geophones (10 Hz)
- Hammer (P and S waves)
- Three-component surface geophones (4.5 Hz)
- Manual picking of the first arrival time for P and S waves
- Dataset inversion with GeoTomCG software (Fig. 4 e Fig. 5)

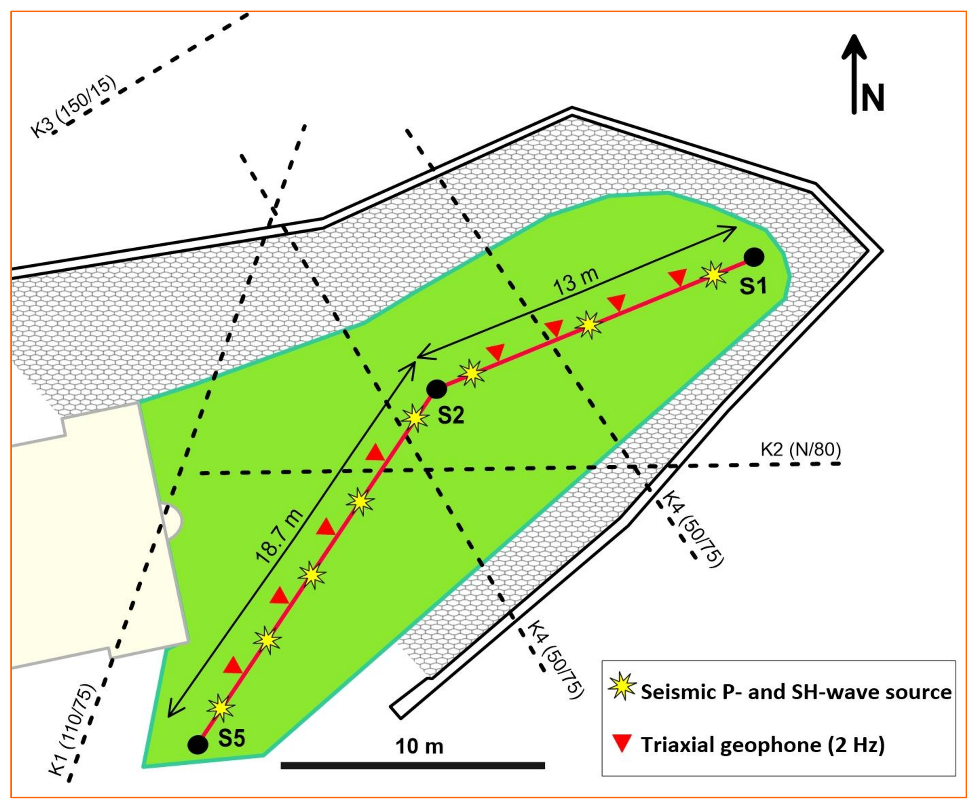


Figure 4. *Planar sketch of the site with the traces of the fracture systems and the seismic survey configuration.*

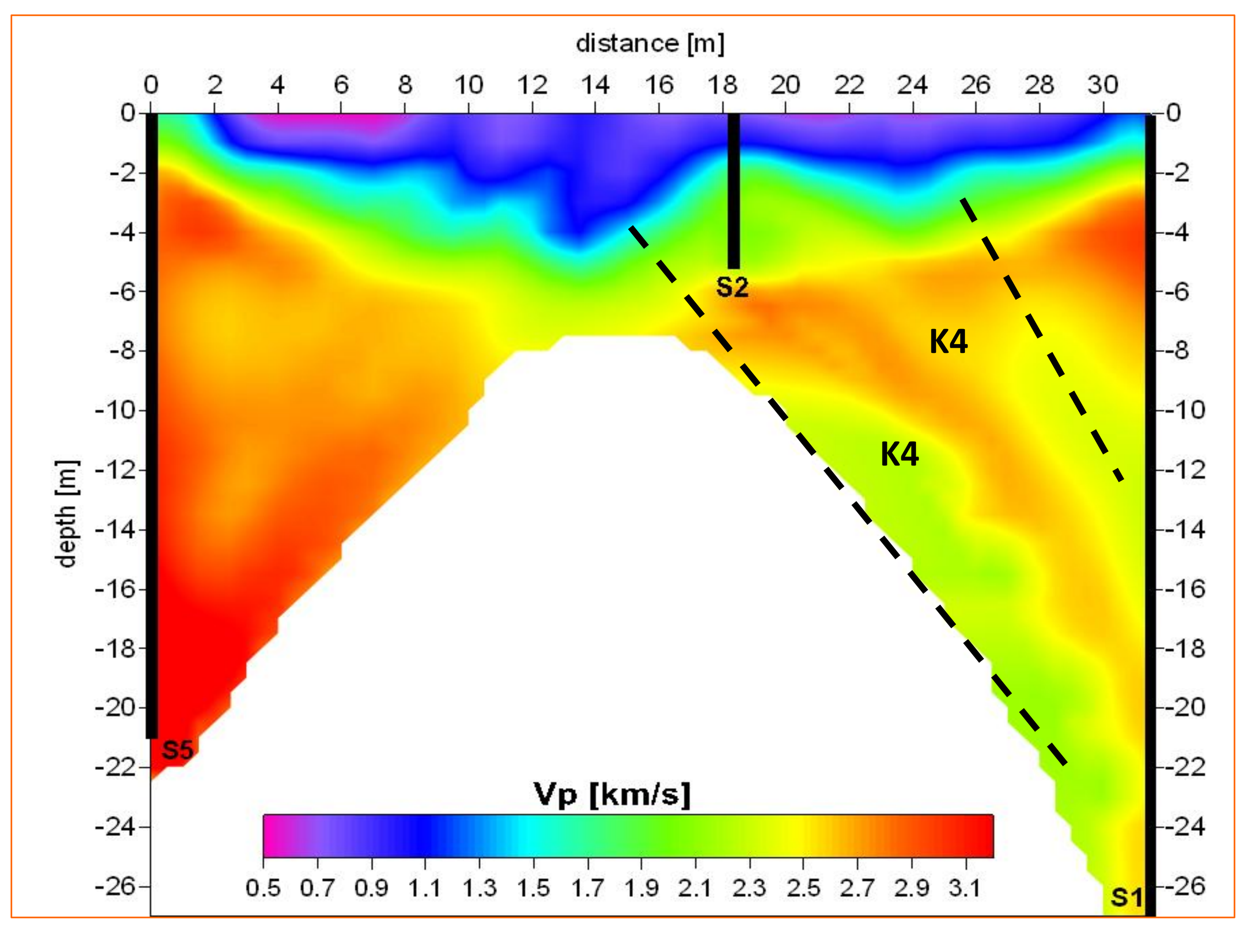
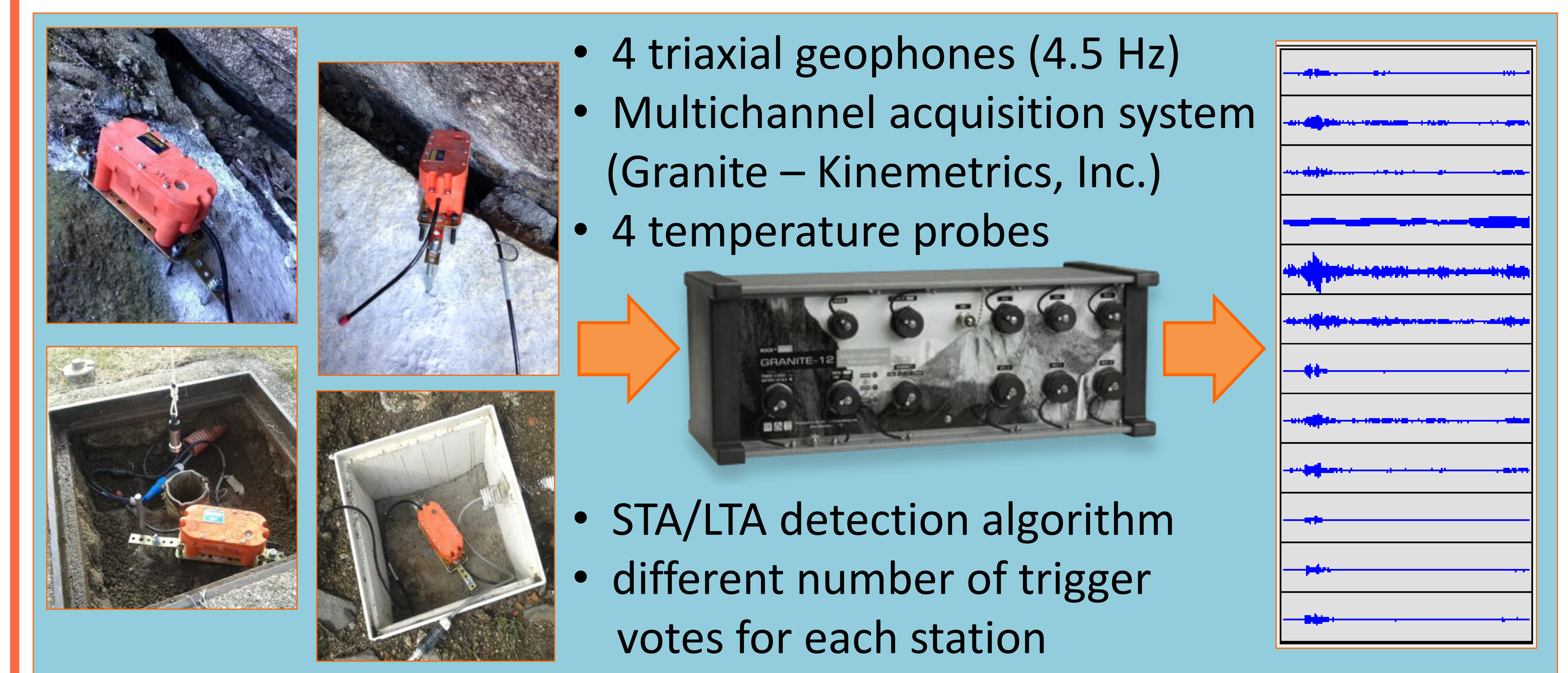


Figure 5. *Results of the cross-hole seismic tomography for P waves.*

4. Microseismic monitoring



First results:

14 Nov 2013 – 31 Mar2014

Nearly **1500 recorded events** (Fig. 7) with different waveforms, duration and frequency content.

Figure 6. *Microseismic monitoring network scheme.*

From a preliminary analysis and classification, less than 20 events **(~1%)** seems to have signal properties (Fig. 8) related to micro-fracturing processes inside the rock mass.

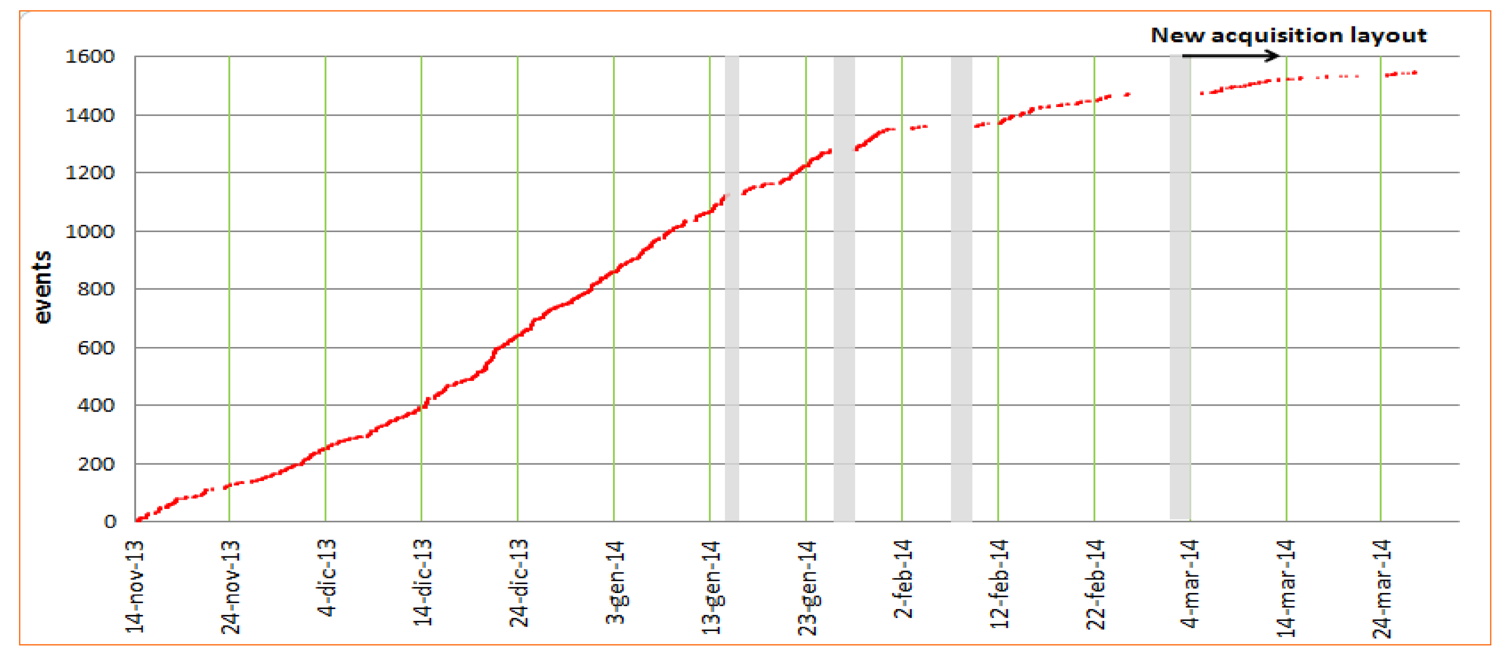


Figure 7. *Cumulative curve of the events (Nov 2013 – Mar 2014).*

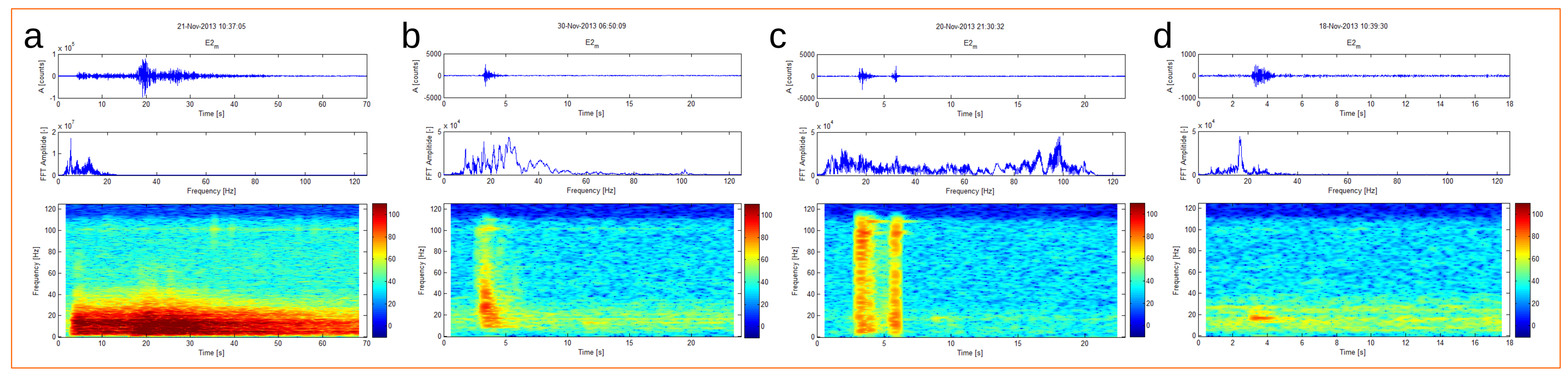


Figure 8. *Selection of different types of signals. From the top to the bottom: seismogram recorded on channel EW of Station 2, frequency content and spectrogram for different types of events: (a) an earthquake (Northern Italy, M_L=3.8, 2013-11-21 10:36:49.0 UTC, 44.91N 9.03E; (b) a microseismic event; (c) electrical transients and (d) still unclassified events.*

5. Conclusions and future work

- Preliminary recorded data indicate the occurrence of microseismic swarms with different spectral contents.
- A small but significant percentage can be related to micro-racking processes inside the rock mass.
- A 3D reconstruction of the cliff will be carried out to obtain a seismic velocity model for the localization of microseismic events.
- Additional geophones and accelerometers provided by SEIS-UK will be installed in the next future.
- Rock physical and mechanical characterization along with rock deformation laboratory experiments will be carried out.