ÉCOLE DOCTORALE SCIENCES DE LA TERRE

Subject offered for a contract starting in October 2014

SUBJECT TITTLE: Automatic seismic sources detection and characterization: application to induced seismicity monitoring (attention: still modifying!)

Advisor: **VILOTTE, Jean-Pierre, PR, vilotte@ipgp.fr**
Second Advisor/ Supervisor: **BERNARD Pascal, PR, bernard@ipgp.fr, SATRIANO Claudio, Post-Doc, satriano@ipgp.fr**
Host lab/ Team : **IPGP – Seismology - UMR7154**

Financing: GPX or École doctorale IPGP

For more information go to http://ed109.ipgp.fr, section: Offres de these (PhD offer), You must apply on the Doctoral School website

Identifying, locating and characterizing subsurface seismic sources are crucial for a variety of geophysical problems at all scales. Sources include earthquakes, subduction zone tremors, volcanic tremors, and stimulated events during reservoir production or CO2 storage, hydro-fracturing and mining exploitation. Traditional techniques based on picking of ballistic arrivals - P or S – face severe limitations in the case of very low frequency and tremor-like energy sources; as well as for low signal-to-noise, heterogeneous media and/or reverberant propagation contexts.

Improving the resolution and the sensitivity of classical approaches can be potentially achieved increasing the density of boreholes and/or the density of surface arrays instrumentation but at prohibitive high costs. Recent statistical methods for signal analysis and coherent interferometry using wideband acoustic and seismic signals open new perspectives for source monitoring that overcome the limitations of classical approaches. Those new methodologies will also allow the design of a new generation of sensors monitoring networks.

We have developed a new methodology exploiting the frequency selective coherence of the wave field at dense seismic arrays and local antennas that leads to stable and reliable detection, blind source separation, and location of distributed non-stationary sources. The methodology consist of: (1) a signal processing scheme yielding a simplified representation of the acoustic or seismic signal by an adaptive time-frequency characterization of its statistical properties; (2) a fully probabilistic detection and location algorithm based on back projection of stacked local cross-correlations of the simplified signals.

During the project this new tool will be assessed and refined through the analysis of two data sets: (1) a coal mining induced seismicity data set – recorded during one year by a dense temporary array of 15 stations – with more than 7000 seismic events with

magnitudes -1.7 < ML < 2; (2) an induced seismicity data set associated to CO2 enhanced oil recovery operation, and recorded by a 900 m borehole geophone array, with more than 3800 seismic events with moment magnitude ranging from -1.2 to 0.8.

References:

An array method for detection, location and characterization of multi-scale seismic energy release associated to the deformation processes of active subduction zones, N. Poiata, C. Satriano, P. Bernard, J.-P. Vilotte and K. Obara, American Geophysical Union, Fall Meeting 2013, abstract#S42_05.

Micro-seismic Monitoring During CO2 Injection at the Aneth Oil Field: Constraining Source Depths Using Reflected Phases Detected on a Single Vertical Receiver Array, J.T. Rutledge and N. Soma, American Geophysical Union, Fall Meeting 2011, abstract #GC51A-0916

Indications for different types of brittle failure due to active coal mining using waveform similarities of induced seismic events, S. Wehling-Benatelli, D. Becker, M. Bischoff3, W. Friederich, and T. Meier, Solid Earth Discuss, 5, 655-698, 2013.