Subject offered for a contract starting October 2017

**SUBJECT TITTLE: Application of waveform inversion to 2D long streamer seismic data acquired in sedimentary basins.**

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**ENS- Laboratoire de Géologie de l'ENS- UMR 8538**

Financing: Doctoral contract with or without teaching assignment

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Presentation of the subject: (1 or 2 pages)

Full waveform inversion (FWI) uses phases and amplitudes of a seismic dataset to invert for a high resolution velocity field. Theoretical advances and computing advances now allow application of this highly non-linear inversion to 3D real datasets, and anisotropy, attenuation and elastic wave equation can sometimes be dealt with. In the industry, these efforts are of significant interest for reservoir imaging as a high resolution velocity field can significantly improve all kinds of attributes. In academia however, field applications are more rare due to the scarcity of suitable "academic" data. Consequently, most (marine) geologists and sedimentologists did not yet seize the opportunity to explore what this new tool could mean for them.

Today, 2D long streamer seismic datasets are available to us mainly from cruises using the R/V Marcus Langseth from Columbia University, NY and also from equivalent 2D prestack datasets available from joint academia and industry research projects. Although several issues remain, these kind of datasets can lead to practical results with 2D acoustic FWI codes, particularly in shallow sedimentary basins when first-arrival refracted waves are recorded on the long streamers and P to S wave conversions are not significant. Among the remaining issues, the most problematic is the high frequency of conventional MCS data bandwidth (not lower than ~6-8 Hz) leading to a wavenumber gap in the inverted velocity structures. These wavenumbers are difficult to cover in the initial models.

A first topic of this PhD project will be to look for robust and reproducible ways to build an accurate enough starting velocity model from reflections and refraction traveltimes. Academic softwares from various authors are available to perform refraction traveltime tomography and can lead, as required, to synthetic first arrival waveforms within half a cycle

of the field data first arrivals. However, as the result of the traveltime inversion is non unique, it is useful to perform a Monte-Carlo analysis to ensure the robustness of the initial model obtained from refraction tomography.
In addition, while the synthetic first arrivals can be correctly modeled in the initial model, it is often not the case with the main secondary arrivals that are often wide angle reflections, which can also lead to damaging cycle skipping. For instance, in the case of a wide angle reflector originating from a basement with a complex geometry, it is clear that traveltime tomography from refracted waves will not be accurate enough to lead to a proper initial modeling of that basement. As reflection tomography codes, widely used in the industry, are not available, we suggest in this project to adapt joint refraction and reflection tomography codes (e.g. Tomo2D, Jive3D...) to the MCS case. Then, different ways of performing waveform tomography will be tested on several real MCS datasets each related to specific marine geology and geophysics research topics, possibly with different codes (Pratt, Seiscope). Choices of several parameters can be investigated: Source estimation vs source models, attenuation, frequency strategies, amplitude preconditioning, objective functions, mitigation or exploitation of guided wave effects… Finally, the robustness of the results will be tested by using as input all the converging starting models from the traveltime Monte-Carlo analysis.

The second main topic of the PhD project consists in the interpretation of the results. Both datasets are acquired with an 8km long streamers and a large 6500+ cu.in. tuned airguns arrays. The first dataset images the surface expression of a normal fault rooting at depth in the Alsaka subduction interface. FWI imaging of this basin will greatly help in interpreting the history of the fault activity and may give evidences for fluid flow in that tsunamigenic fault system. The second dataset was acquired in a passive margin environment in the South China Sea and images several “chimneys” of chaotic sedimentary facies that can be interpreted as either fluids escapes or volcanic dikes with possible buried coral reefs on top of the structures. In function of the results, high resolution velocity imaging will help to better understand the subsidence history of the margin and the properties of post-extension volcanism in the area. In both cases, the velocity fields will be used to perform prestack depth migration to gain additional details in the geometry of the structures. Two of the lines have been shot alongside coincident OBS refraction lines that can be used to image the deeper structures.

The successful candidate is expected to have good computing skills (unix, C or Fortran) and to be interested in the interpretation of the data in the different geological contexts.

Possible collaborations: Anne Bécel, Donna Shillington (marine geophysicists, LDEO, NY), Mladen Nedimovic (marine geophysicist, Dalhousie U, Canada), Boris Mercaillou (Geoazur), Ludovic Bodet (P6), Mathieu Rodriguez (marine geologist/sedimentologist), Nicolas Chamot-Rooke (marine geologist/geophysicist, ENS Paris).