Course title:

Seismic Imaging: from laboratory to field scale

Duration [number of hours]: 20

Name and Contact Details of Lecturer(s):

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Course Description [150 - 300 words]:

The increasing of energy geo-resources exploration (gas, oil, geothermal energy) and the needing of man-made hazard assessment (induced seismicity, etc) drives us to improve our knowledge of the earth's subsurface in terms of medium parameters at different scales. Seismic imaging from active or passive data is a key method for reconstructing images of the subsurface elastic and anelastic properties, and their spatial and temporal evolution. Besides, rock physics provides the understanding to connect the obtained geophysical observables at the filed scale (velocity, attenuation, resistivity) to the intrinsic properties of rocks and materials (lithology, porosity, pore fluids content) at the micro-scale.

In the last decades, several techniques have been introduced to solve the non-linear tomographic inverse problem for the reconstruction of velocity images from seismic passive, both using as data single phase arrival times (time tomography) or the complete waveforms (wave tomography). Starting with the theoretical framework, we will introduce these techniques by analysing benefits and drawbacks, with specific focus on the solution of forward model and the associated spatial resolution of final images.
Besides, to understand how can be interpreted the obtained images in terms of medium parameters at the micro-scale, we will explore examples of rock physics models, with a focus on the important role of fluids in porous materials.

At the end of the course the student is expected to be familiar with the main technique for seismic imaging, understand the main micro-parameters affecting the macro-scale properties and be able to define simplified rock models to use for image interpretation.

Syllabus [itemized list of course topics]:

Introduction to the course (2 hours):
Introduction to the course. Seismic tomography and Rock Physics example of applications.

Seismic tomography (8 hours):
- Hints of Inverse Methods
- Solution of Forward Model
- Time tomography
- Wave equation tomography (hints)
- Resolution assessment

Rock Physics (6 hours):
- Scale of application
- Porous medium micro-parameters
- Effective medium Theory
- Biot's theory of poroelasticity (hints)
- Gassman's fluid substitution (isotropic form)
- Empirical relations

Example of Application (4 hours):

Application of seismic tomography and rock physic upscale in a simplified case, to be completed as homework.

Assessment [form of assessment, e.g. final written/oral exam, solutions of problems during the course, final project to be handed-in etc]:

Discussion of the proposed exercises or of a scientific paper on the topic

Suggested reading and online resources:

1. Zollo Emolo. Terremoti e Onde. Liguori editori (seismic tomography)
2. Rawlinson, Nicholas, S. Pozgay, and S. Fishwick. "Seismic tomography: a window into deep Earth." *Physics of the Earth and Planetary Interiors* 178, no. 3-4 (2010): 101-135.
3. Rawlinson, N. & Spakman, W. On the use of sensitivity tests in seismic tomography. Geophysical Journal International. 205(2), 1221-1243 (2016).
4. Guéguen, Yves, and Victor Palciauskas. Introduction to the Physics of Rocks. Princeton University Press, 1994.
5. Mavko, G., T. Mukerji, and J. Dvorkin (2009), The Rock Physics Handbook, Second Edition: Tools for Seismic Analysis of Porous Media, pp. 177–178, Cambridge Univ. Press, Cambridge, U. K.
6. Amoroso, O., Russo, G., De Landro, G., Zollo, A., Garambois, S., Mazzoli, S., Parente, M. and Virieux, J., 2017. From velocity and attenuation tomography to rock physical modeling: Inferences on fluid-driven earthquake processes at the Irpinia fault system in southern Italy. *Geophysical Research Letters*, *44*(13), pp.6752-6760.
7. Papers suggested during the course