NEAR-SURFACE TOMOGRAPHY PROTOCOL ESTIMATION TO CHARACTERIZE HETEROGENEITIES AT HECTOMETRIC SCALE IN A FRACTURED-POROUS CARBONATE RESERVOIR

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***Keywords**: near-surface, travel time inversion, fault, carbonate reservoir*

ABSTRACT

Obtaining high resolution images of the on-shore geological features at hectometric scale is a major challenge of geophysics because of the extreme variability of the near-surface [1]. A 500 m x 800 m tomographic P-wave velocity image is inferred from a ground level-to-gallery vertical seismic experiment conducted at the inter-Disciplinary Underground Science and Technology Laboratory (LSBB, France) [2]. Geological and petrophysical interpretation of rock properties is presented within the fractured-porous carbonate platform surrounding the laboratory.

94 shots on the surface were recorded by a line of 189 seismometers on the topographic surface and by a line of 150 geophones in the 800 m long, 250-500 m depth gallery. P-wave velocity image was inferred from least-squares first-arrival travel time inversion based on a classic local optimization. The tomography approach used for this study is previously described in [3].

The P-wave velocities obtained after first-arrival travel time inversion display a relatively large set of values in 4000-6000 m/s range. Such seismic velocity variations correlate well with the 5 to 20% porosity variations between the geological units. The main units consist of two sedimentary facies affected by a complex cemented fault zone. The final tomographic image shows local seismic heterogeneities as evidence of perturbations from that fault zone.

Taking advantage of the know geology of the site, this study explores the influence of the acquisition geometry and of the near-surface weathered zone onto the shallow tomography resolution ability. Considering the mesoscopic scale of the targeted medium, reliable imaging of hectometric geological bodies with 10% contrasts in porosities can be achieved only with the simultaneous association of 1) a high density of sources and receivers in the monitoring array geometry, and 2) the consideration of the surface-to-surface first-arrival travel times as an essential constraint to correctly image the underlying structures.

The generation of a 3D realistic model of the LSBB medium is the next step. The geological cross-section of the Apt basin is available, and coupled to the seismic velocities allows to generate the model at a regional scale.

This seismic model is used for the simulation of the ground motion on the topographic surface. The topography is known to significantly affect the ground motion under seismic solicitations [4,5]. The top of the topographies is mostly affected by an amplification of the motion in a frequency band dependant of the dimensions of the relief [6,7]. This waveband is most often included between 1 to 20 Hz, precisely the frequencies of paraseismic interest. Thus this phenomenon is of great concern for the seismic risk characterization of mountainous area.

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