GRADIENT-BASED SEISMIC INVERSION USING A FINITE FREQUENCY ASSUMPTION FOR IMAGING SUBSURFACE VELOCITY AND ATTENUATION FIELDS

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Various studies operated seismic methods for imaging landslide structures. Among them, different approaches can be used to process the data, analyze and exploit the different kind of waves associated to particular propagation phenomena. Grandjean et al. [1] studied the first arrival traveltimes to recover P-wave velocity distribution across landslides. Finally, based on the work of Virieux and Operto [2], Romdhane et al. [3] showed the possibility to perform a full elastic waveform inversion (FWI) on a real dataset acquired over an earthflow. All those methods are more or less based on strong approximations and/or require complex data preprocessing. The issue of recovering the structural image of a landslide from the seismic velocity field estimated with an accurate, but not too unstable, method is thus posed. We propose here to revisit first arrival tomography approach which is a good compromise between the strong assumptions featuring simple refraction methods and the complexity of FWI approach when used in heterogeneous contexts. The Quasi-Newton (QN) method is based on the Tarantola's Gradient / Hessian formulation [4] ensuring an optimum convergence:

$$s(m) = \frac{1}{2}\left[(f(m) - d_{obs})^T C_D^{-1}(f(m) - d_{obs}) + \left(m - m_{prior}\right)^T C_M^{-1}(m - m_{prior})\right]$$

Where C_D and C_M are respectively the covariance operators on data and model, f represents the theoretical relationship between the model m and the data d, d_{obs} the observed data and m_{prior} the *a priori* information on the model. The QN method consists in minimizing the misfit function iteratively using its gradient and approximated Hessian functions, giving respectively the direction of steepest descent of the misfit function and a metric indicating its curvature, approximated locally by a paraboloid. The tomographic linear system in the case of no a priori information on the model can finally be written in its matrix form:

$$[(W^k)^T C_D^{-1}(W^k)]\,\delta m = [(W^k)^T \delta t] \quad \text{with} \quad W_{ij} = \frac{\omega_j}{l}$$

where k is iteration, ω represents the Fresnel volume, l is the length of the Fresnel surface along a direction perpendicular to the ray path i and for cell j. We only use here the first arrivals of the seismic signal due to direct or refracted waves. Nevertheless, we show that some regularization strategies allow detecting sharp velocity variations tending to reach FWI inversion performances (Fig.1).

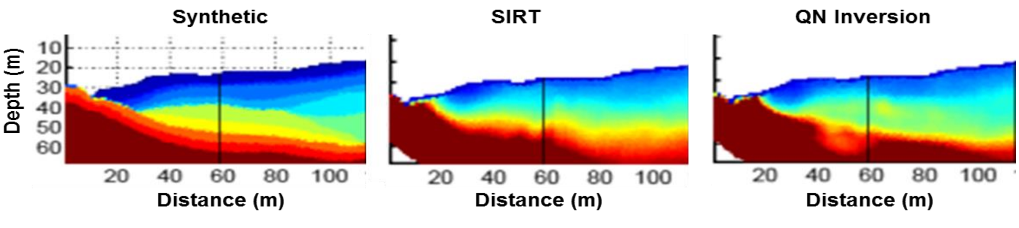

Figure 1. Initial (left), final velocity model inverted with SIRT (center) and with QN algorithm (right).

References

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