Reducing fault-related structural uncertainties by ranking models using seismic data misfit functions

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Abstract

Fault interpretation, and structural interpretation in general, can be challenging because of complex wave interactions in fault zones and limited seismic bandwidth. A single seismic image can lead to multiple structural interpretations, thus illustrating interpretation uncertainties inherent in structural modeling. Typically, this uncertainty is captured by generating several possible structural geometries (e.g Bond et al. 2007), but these models are seldom quantitatively compared to the initial seismic data. In this work, we propose (1) a strategy to obtain reflection data consistent interpretations, and (2) to rank available valid interpretations by integrating vertical seismic profiling (VSP) data. The method requires a seismic image and its migration velocity model as inputs. First we generate multiple interpretations of the seismic image in order to sample uncertainties associated to it. Second, we build a structural model for each interpretation. Using the structural models and the input migration velocity model, we build a macro-layered velocity model for each interpretation. The macro-layered models are first used to compute a couple of synthetic reflection shot gathers that are compared against observed data; if the data are inconsistent, interpretations are updated accordingly. The macro-layered models are then used to compute synthetic VSP data, for a better illumination of sub-vertical structures like faults. Synthetic VSP data are then compared against observed data, allowing us to rank all interpretations. We have successfully tested this method on a realistic synthetic model with a complex fault-network and fine-layered structures. We have found that, provided a correct account of the seismic illumination, our VSP data misfit match the model misfit.

Keywords : structural uncertainties, seismic interpretation

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