Poster

Resolving complex structures from vertical seismic profile (VSP) surveys: a case study from the Alpine Fault, New Zealand

***Greenwood, A.[1], Toy, V.[2] and Urosevic, M.[1]**

1) Department of Exploration Geophysics, Curtin University of Technology, Perth, W.A.

2) Department of Geology, University of Otago, NZ

a.greenwood@curtin.edu.au

The Alpine Fault in New Zealand offers a unique opportunity to study the physical properties and mechanics of a seismically active structure, by integrating borehole data with studies of an exhumed fault rock sequence. In the first stage of an International Continental Drilling Program (ICDP) supported project, a 150 m borehole is planned at Gaunt Creek, near Whataroa, South Island, New Zealand. Recovered core will provide the first complete section through the transition from predominately cataclastic to mylonitic fault rocks, and permanent seismicity and groundwater monitoring equipment will be installed in the borehole. Associated site characterization work includes active source seismology.

From surface geological investigations, it is predicted that the fault is moderately-dipping to the SE and juxtaposes two metamorphic/hard rock units over most of its depth. Reflection seismology in such a complex geological environment is not trivial and it is may be appropriate to image steeply dipping structures using borehole-based techniques such as Vertical Seismic Profiling (VSP). One way to estimate the value of field data, and to optimize acquisition geometries and processing procedures, is through numerical models, particularly if the geological model is relatively well known. Here we present results of two synthetic VSP models for the predicted Gaunt Creek sub-surface geology along a two-dimensional section perpendicular to fault strike; (A) a simple case with a single oblique dextral reverse fault and adjacent fault rock sequence; (B) a more complex model where near-surface slip has been partitioned between thrust and strike-slip fault segments. Typically, contacts between hard rocks show low reflectivity due to their low acoustic impedance contrasts, however mature fault zones are often reflective due to seismic anisotropy produced during the alignment of mineral grains. Consequently, a variety of different anisotropic parameters were tested for the cataclasites and ultramylonites within the fault zone model.

The synthetic borehole reflection seismograms generated for the two Gaunt Creek sections illustrate that:

1. Borehole reflection seismic sections suffer from lack of aperture in the down-dip direction. To compensate, large offsets and higher shot density will be required on the down-dip side of the borehole.
2. At large offsets wavefield identification is complex and correct separation of wavefields for imaging is difficult.
3. Due to the steep dips of lithological units, the velocity field varies laterally and it is necessary to determine a 2D velocity model from all shot gathers prior to migration.
4. Seismic anisotropy significantly changes the model response.
5. Modelling of each individual geologic setting is required prior to acquisition.