A Survey of Land Data Acquisition and Processing

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We shall review aspects of acquisition and processing of land seismic data, including spatial sampling requirements for reflected and refracted waves, surface waves and guided waves, use of surface waves to estimate the near-surface S-wave velocities, and processing methods to attenuate surface waves and guided waves, use of wide-angle reflections to image beneath basalt and carbonates, near-surface modeling, and image-based subsurface modeling.

Irregular topography associated with a rugged terrain, complexity of the near-surface that includes high-velocity layers and outcrops with significant lateral velocity variations, complexity of the overburden caused by allocthonous rocks, and the complexity of the target imbricate structures themselves, all pose challenges to exploration in thrust belts. To image complex structures, it may be necessary to record data with maximum offset up to 30 km or more so as to utilize the large-amplitude, low-frequency, wide-angle, supercritical reflection amplitudes. We shall present case studies for the shot-domain analysis of data from large-offset seismic surveys based on common-spread recording geometry.

We shall present case studies for estimating near-surface P-wave velocities by way of nonlinear traveltime tomography applied to first-arrival times and for estimating near-surface S-wave velocities by Rayleigh-wave inversion. For the latter application, we perform plane-wave decomposition to transform the data from offset-time to phase-velocity versus frequency domain. A dispersion curve associated with the fundamental mode of Rayleigh-type surface waves is picked in the transform domain based on the maximum-energy criterion and inverted to estimate the S-wave velocity as a function of depth.

We shall describe a time-with-depth workflow for earth modeling and imaging in areas with irregular topography, complex near-surface, and complex subsurface. The near-surface modeling is performed by *nonlinear traveltime tomography* applied to first arrivals, which accounts for traveltime gradients and thus resolves lateral and vertical velocity variations. The subsurface modeling and imaging are performed from topography, based on *image-based estimation of rms and interval velocities* at reflector positions, not at reflection positions.

Earth modeling in depth requires combining inversion methods to estimate layer velocities and delineate reflector geometries. The most robust combination is Dix conversion of rms velocities to determine layer velocities and poststack depth migration to pick depth horizons that represent the reflector geometries. The crucial point to keep in mind is that rms velocities must be estimated at reflector positions. The combination of Dix conversion with poststack depth migration usually works for a complex structure, but not for a complex *overburden* structure. For example, use this combination to model the overburden above an overthrust imbricate structure. But when dealing with a target *beneath* such a complex overburden structure, then you will need the *layer-by-layer* application of combination of half-space velocity analysis to determine the layer velocities and prestack depth migration to pick the depth horizon that represent the reflector geometry of the base of the layer under consideration. Land seismic data processing requires an extensive set of geophysical quality control tools at each stage in the analysis. We shall present a unified workflow for land seismic data analysis with demonstrative case studies.