APPLIED SEISMIC INVERSION FOR ESTIMATING VELOCITY-DEPTH MODELS

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Processing and inversion of seismic data differ in one fundamental respect -- the output from *processing* often is displayed in *time*, and the output from *inversion* is intended to be displayed in *depth*. The main goal in inversion is to estimate a geologically plausible subsurface velocity-depth model, which comprises two sets of parameters -- *layer velocities* and *reflector geometries*. To resolve the well-known velocity-depth ambiguity in inversion, these parameters need to be estimated, *independently*.

Estimation of velocity-depth models requires a set of integrated methods of inversion and utilities built around a workstation. Specifically, post- and prestack depth migration, prestack traveltimes inversion and amplitude inversion can be used in some combination to estimate velocity-depth models for structural and stratigraphic targets.

For a structural problem, the subsurface model can be divided into two parts -- the *overburden* in which ray theory is applicable, and the *substratum* in which depth migration is imperative. Typical structural targets are associated with salt and overthrust tectonics. In case of salt tectonics, the top-salt constitutes the boundary between the overburden and the substratum. It also is the boundary where the most severe ray bending takes place.

Consider a 2-D seismic line along the dominant dip direction with minimal sideswipe energy present in the recorded data. The following package is then offered to estimate the velocity-depth model:

	Overburden	Substratum
Layer Velocities	<i>layer-by-layer prestack traveltimes inversion</i>	<i>iterative prestack depth migration, and analysis of image gathers and image-gather stacks</i>
Reflector Geometries	<i>layer-by-layer poststack depth migration</i>	<i>image-gather stacks</i>

This scheme can be extended to estimate a 3-D velocity-depth model for structural targets as follows:

	Overburden	Substratum
Layer Velocities	<i>layer-by-layer 3-D prestack traveltimes inversion</i>	<i>iterative 3-D poststack depth migration</i>
Reflector Geometries	<i>layer-by-layer 3-D poststack depth migration</i>	<i>iterative 3-D poststack depth migration followed by 3-D prestack depth migration along selected traverses</i>

For a stratigraphic problem, the subsurface velocity-depth model can be divided into two parts -- the *macro-model* that represents the trend in velocity variations, and the *micro-model* that represents the details in velocity variations. Since stratigraphic targets are generally associated with low-relief structures and structure-independent velocity variations, the following package is equally applicable to both 2-D and 3-D cases.

	Macro-model	Micro-model
Layer Velocities	<i>prestack traveltime inversion</i>	<i>amplitude inversion</i>
Reflector Geometries	<i>poststack depth migration</i>	<i>not applicable</i>

Aside from inversion methods -- depth migration, traveltime and amplitude inversion, an inversion project also requires a set of utilities available on an *inversion workstation*:

- (1a) Interpretation of time horizons from 3-D stack volume of data.
- (1b) Interpretation of depth horizons from 3-D depth-migrated volume of data.
- (2) 3-D model representation of surfaces and solids.
- (3) 3-D model visualization.
- (4) Editing of layer velocities and reflector geometries.

It is important to note that inversion is not intended to replace processing, rather to complement it. For instance, optimum DMO stack is used in conjunction with depth migration to facilitate accurate and efficient imaging of the overburden. Optimum DMO stack provides picked time horizon information for prestack traveltime inversion so as to avoid picking of reflection times on CMP gathers, and, following time migration, it is the principle input to poststack amplitude inversion.