STRUCTURE INDEPENDENT SEISMIC VELOCITY ESTIMATION

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Many commonly used seismic velocity estimation procedures assume that the reflectors are horizontal. Because of this their performance tends to degrade as the reflectors become curved or discontinuous. Much of this degradation can be traced to the fact that data recorded over non-horizontal reflectors need not resemble in detail the subsurface in the area where they were recorded. Diffraction and scattering are the major complicating factors.

Using general principles of reflector mapping it can be shown that surface recorded seismic reflections which have been downward continued to the depth of their source reflectors must resemble those reflectors in detail. This property of downward continuation can be exploited to improve velocity estimates by using downward continuation as a pre-processor for velocity estimation techniques. The estimates resulting from this kind of approach should not exhibit diffraction effects and should not be dependent on reflector dip.

Since much reflection seismic data are described to a good approximation by the scalar wave equation, this equation is an obvious starting place in deriving a downward continuation operator for seismic data. Beginning with the scalar wave equation and using a small dip assumption, approximate wave equations which quite accurately model both near and wide angle reflections generated by one or more sources can be found. Finite difference formulations of these equations can be used as stable and economic downward continuation operators for reflection data.

These wave equation continuation operators allow the demonstration, with both synthetic and field data examples, that downward continuation represents an economically viable process for removing the effects of reflector geometry from seismic velocity estimates. Additionally, synthetic data examples illustrate the fact that the use of downward continuation allows accurate velocity estimates to be made from no-record data recorded over an earth in which the reflectors are random functions of the horizontal and vertical coordinates. For reasonable data parameters, theoretical considerations indicate that the semblance of properly downward continued random reflector data measured along the true velocity hyperbolic is approximately 50% greater than a similar measure on the corresponding surface data. This semblance increase should make velocity estimates based on downward continued random reflector data less susceptible to noise than estimates based on surface recorded random reflector data.

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