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Computation of refraction static corrections using first-break traveltime differences

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ABSTRACT

Differences in first-arrival traveltimes between adjacent records in multifold reflection surveys can be used to compute the depth and velocity structure of near-surface layers. The procedure uses the redundancy of first-break data in multifold surveys to enable a statistically reliable refraction analysis to be undertaken for either end-on or split-spread recording geometries. The traveltime differences as a function of source-receiver offset provide a direct indication of the number of refractors present, with each refractor being defined by an offset range with a constant time difference. For each refractor, the time-difference value at a common receiver from two shotpoints is used to partition the intercept time into the delay time at each shotpoint. This procedure is repeated until the delay times at all shotpoints and for all refractors have been computed. Refractor depths and velocities are evaluated from this suite of delay times. A surface-consistent static correction to a selected datum level is then calculated at each surface station, using a replacement velocity equal to that of the deepest refractor.

In a case history from the Canadian Rocky Mountain foothills, short- and intermediate-wavelength weathering static anomalies were resolved successfully. Elevation and weathering static corrections of up to 40 ms were computed, with an estimated error of less than ±3 ms.

INTRODUCTION

In recent years, there has been renewed interest in using the traveltimes of critically refracted seismic energy ("first breaks") to compute weathering static corrections during the processing of reflection seismic data. Automatic residual static methods perform best if refraction static corrections have been applied first, since correlation across a common-midpoint (CMP) gather depends on the quality of the pilot stacked trace. Furthermore, residual statics alone fail to resolve intermediate- and long-wavelength weathering static anomalies.

In this paper, a procedure is developed for the analysis of refraction data from records acquired during multifold reflection surveys. The technique used is based on delay-time analysis (Gardner, 1967) and is an extension of the reciprocal method published by Hawkins (1961). It also uses the concept of differential shot statics, discussed by Hollingshead and Slater (1979) and Chun and Jacewitz (1981). In my procedure, the multiplicity of first-break data available in multifold reflection surveys is used to determine the number of refractors present and to calculate statistically robust delay times and refractor velocities. Operator input is minimized, yet all possible first-break data are used in the analysis. An important feature is that reciprocal records are not required, thus making the procedure applicable for seismic surveys recorded with an end-on shot configuration. For split-spread data, the analysis can be performed by treating the leading and trailing halves of the records separately. This provides a further statistical confidence test for the analysis.

Conventional analysis of first-break data from end-on records makes use of intercept times and inverse slopes of the refracted-arrival segments of traveltime-distance graphs to interpret the depth and velocity structure of the shallow subsurface (Gardner, 1939). However, the reliability of this approach can be hampered in the presence of topography or structure on the refractor, which creates ambiguity in the interpretation with respect to the number of refractors present and their true velocities. Cunningham (1974) examined first-break data from end-on records and used differential common-offset traveltimes to fabricate synthetic reverse profiles.

Recently, refraction interpretation based on inversion methods has become popular, particularly ray tracing and generalized linear inversion (Hampson and Russell, 1984). In

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