G025 FROM SEISMIC SURFACE MEASUREMENTS TO PSEUDO VSP DATA

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Introduction

Vertical seismic profile (VSP) has been accepted as an important tool for the calibration of seismic surface data processing and for the improvement of geological interpretation in the direct vicinity of the borehole. In this paper we describe a new technique for the transformation of surface data into VSP data, being referred to as *Pseudo VSP* (containing the same information but presented in a different format). The nucleus of pseudo VSP generation is downward extrapolation of a wave field from the surface into the subsurface. The pseudo VSP will improve the integration of surface data with real VSP. The generation of pseudo VSPs along a line, where well information is not available, will allow us to extend the geological knowledge in all lateral directions. The pseudo VSP generation technique requires high quality shot records, a description of the source properties and a macro model of the subsurface. For extensive discussion of different extrapolation operators we refer to Berkhout (1982) and Wapenaar and Berkhout (1989).

Examples

The pseudo VSP generation technique will be illustrated with a synthetic data and a field data example. Two-way wave field extrapolation (performed in the space frequency domain) is used for the downward wave field extrapolation of the surface data. The synthetic example is based on the 2-D acoustic subsurface model given in Fig. 1d, with an irregular water bottom (after Verschuur, 1991). The pseudo VSP generation method is applied on data with multiples as well as after surface multiple elimination. Fig.1a shows the pseudo VSP generation from the shot record with multiples (due to synclinal shapes the multiple behaviour is very complex). The VSP is in this case situated at zero offset (see Fig.1d). The surface data has been pasted above the generated pseudo VSP at the position of the well for an easier interpretation of the different events. Fig.1c illustrates for comparison the result of direct VSP modeling (acoustic finite difference algorithm) related to the same area. Internal multiples can be clearly identified in this figure (see arrows in Fig.1a and Fig.1c). Fig.1b shows the pseudo VSP after surface-related multiple elimination, in which the four primaries can be easily observed. The internal multiples in the generated pseudo VSP are still visible and are handled correctly (up to the second order). Due to numerical errors some non-causal effects occur because the two-way extrapolation is very sensitive for macro model errors. The non-causal parts before the direct wave have been zeroed because they are not correct and meaningless. It is important to notice that the generation of the pseudo VSP provides us with an unambiguous tie between seismic events on a time section and their geological interface in depth.

The field data example is generated with the proposed technique applied on a land dataset from the North of Netherlands (courtesy of N.A.M., Assen). The dataset contains 301 split spread shot records with shot spacing 30m. The number of detectors per shot is 120 with detector spacing 30m; near offset 115m, far offset 1935m. The record length is 4s and time sampling interval 4ms. The missing near offsets were interpolated using a CMP interpolation technique. Fig.2 illustrates the integration of the shot and the generated pseudo VSP and the migrated section. The prestack depth migration was performed using a 2-D shot record, recursive depth migration in the space frequency domain (after Rietveld and Berkhout, 1994). The displayed macro model (at the well location) is used for the pseudo VSP generation and also for the migration. The correspondence of the different events in these figures is remarkable. The reflection shown with the arrow is not represented in the macro model. Still we observe a corresponding event (target reflection, see arrow) in the generated pseudo VSP and in the migrated section.

Conclusions

In this paper the application of the pseudo VSP generation method from surface data is demonstrated on synthetic as well as field data. This method provides a new tool for interpretation of surface seismic data by adding a depth dimension to it.

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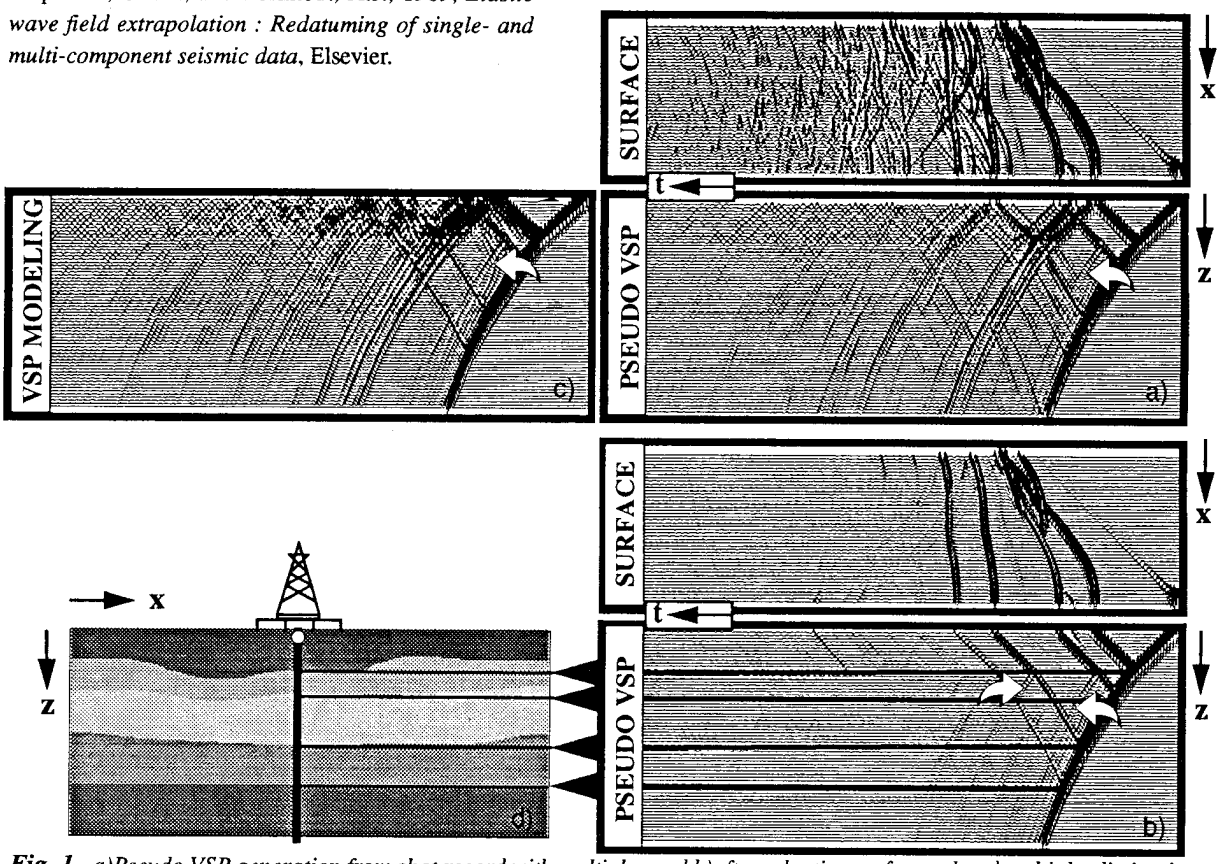

Fig. 1. *a)Pseudo VSP generation from shot record with multiples and b)after adaptive surface-related multiple elimination. c)VSP modeling and d)2-D acoustic macro subsurface model.*

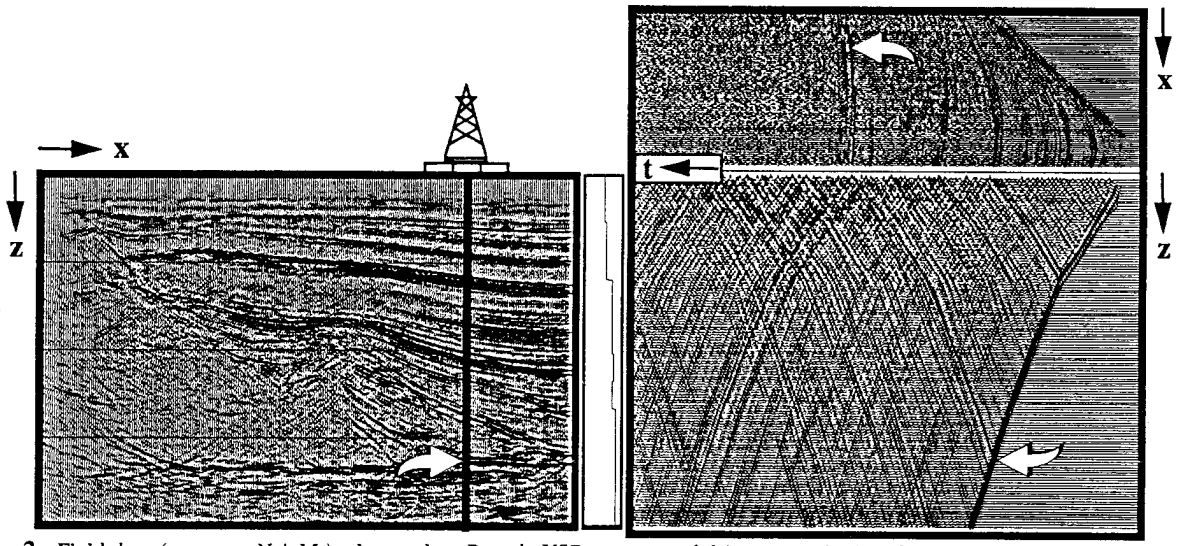

Fig. 2. *Field data (courtesy N.A.M.): shot gather, Pseudo VSP, macro model (cross section) and prestack migrated section.*