AVO analysis of sediments at the toe of the Cascadia accretionary prism

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Summary

AVO analysis has been performed on 2D marine reflection data, collected in 1989, across the Northern Cascadia convergent margin. P wave reflectivity and S wave reflectivity are extracted from 36-fold CDP gathers according to Fatti et al's (1994) approximation of the Zoeppreitz equations. The reflectivities are inverted to create then λρ and μρ sections, which identify lithological changes in the sedimentary section.

Introduction

The Cascadia convergent margin extends from the Medocino triple junction offshore of northern Califronia to north of Vancouver Island. West of Vancouver Island the Juan de Fuca oceanic plate subducts beneath North America at a rate of 45 mm/year (Hyndman et al. 1994). Over the last 40 Ma a large accretionary prism comprising of sediments scraped from the downgoing plate has evolved. Seismic surveys were aquired in 1985 and 1989 across the northern convergent margin by the Geological Survey of Canada. In the deep sea basin, these reflection surveys show mostly-continuous horizontal sedimentary layers overlying a basaltic basement. Approaching the deformation front a number of these layers become progressively fractured. The deformation front itself is the most seaward of three major landward dipping thrust faults that intersect the sea floor and continue down close to the top of the basaltic basement. Landward of the deformation front the contintental slope steps up with each thrust fault and the sediments become progressively deformed until individual reflectors are no longer descernible. Anomalously high reflection amplitdue anomalies can be observed within the horizontally layered sediments both seaward of the deformation front and within the fault blocks. To gain a better understanding of the origin of these amplitidue anomalies, we perform an amplitude variation with offset study to extract the Lame parameters on one of the lines from the 1989 survey (eg Goodway et al, 1997).

The data used in this study is from a 2-D marine seismic reflection (89-04) line shot with a tuned airgun array with a total volume of 128 l. The data were recorded using a 144-channel hydrophone streamer with 25 m group interval and a maximum offset of 3600m. The 50 m shotpoint seperation provided 36-fold data with12.5 m common midpoint spacing. The seismic line runs perpendicular to the subduction front and intersects Ocean Drilling Program site 888. In the deep water region, the maximum angle of incidence varies from 35° at the sea floor to about 20° at the base of the sedimentary section.

Method

In order to recover the amplitude versus offset behaviour of the subsurface care has been taken in processing so as not to introduce any trace to trace variation. We applied a shot average decon to remove any shot to shot wavelet variation, and a correction for geometrical spreading.

P and S wave reflectivites were extracted from NMO corrected CDP gathers using a linearized approximation to the Zoeppriz equations for angle dependent reflection coefficient (Fatti et al., 1994).

$$R(\theta) = \tfrac{1}{2}\Delta I/I\left(1+\tan^2\theta\right) - 4\left(V_S/V_P\right)^2\left(\Delta J/J\right)\sin^2\theta$$

where θ is the average of the incident and transmitted angles at the boundary producing the reflection, I is the average P-wave impedance of the two layers on either side of the boundary and ΔI the change in P-wave impedance across the boundary, J and ΔJ are the average and change in S-wave impedances across the boundary respectively. This approximation is valid for small changes in material properties, angles of incidence less than 30°. This also assumes that the change in density across the boundary is negligable, and the average Vs/Vp is known.

As no S-wave velocity data is available for the area, a general Vs/Vp relationship similar to the mudrock line described by Castagna et al. (1985) has been derived from ODP logs acquired in similar sedimentary environments (Figure 1).

P and S wave reflectivities were inverted to obtain impedances, and from these we calculated λρ and μρ sections (Figures 2 and 3). These sections show λρ and μρ part of the horizontally lying sediments just seaward of the deformation front, and indicate that the main changes in both λρ and μρ are associeated with changes in lithologies.

References

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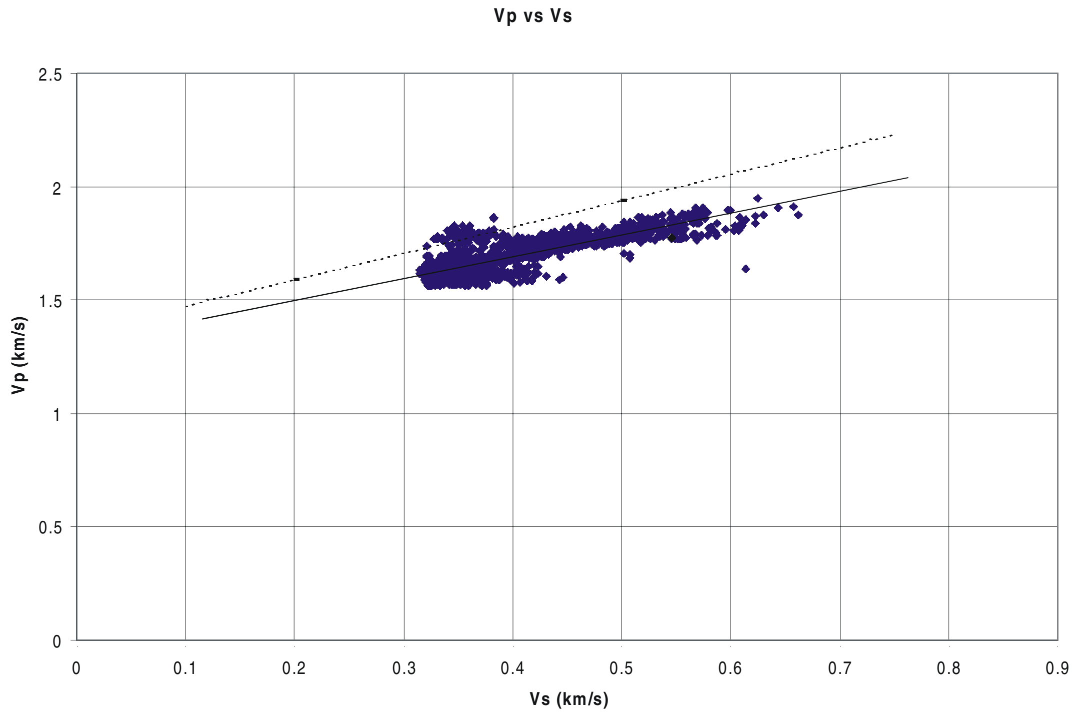

Figure1: Vs/Vp Relationship. Solid line represents the mudrock line derived from well logs, dotted line shows the mudrock line from Castagna et al. (1985)

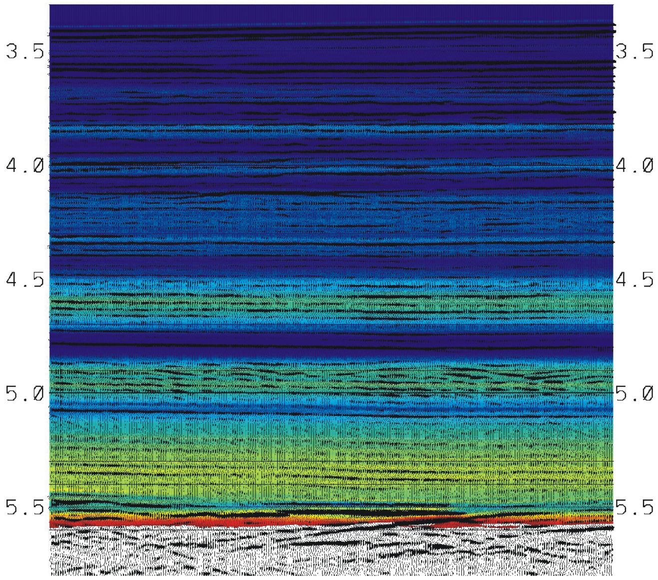

Figure 2, $\lambda\rho$ section from the toe of the Cascadia accretionary prism.

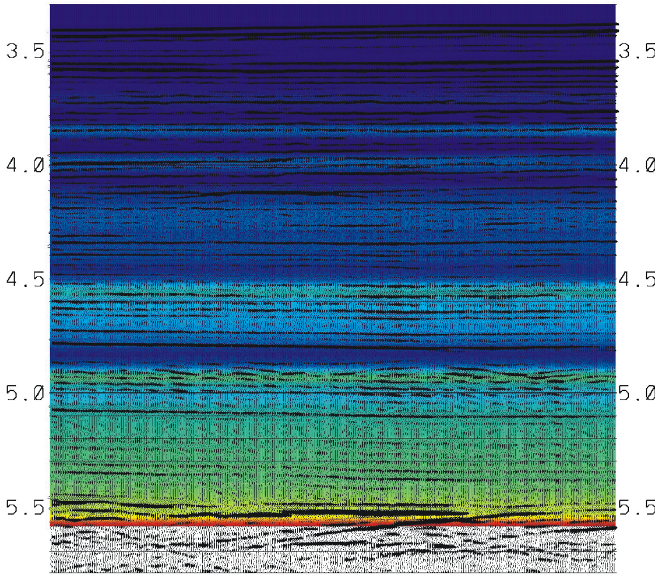

Figure 3, $\mu\rho$ section from the toe of the Cascadia accretionary prism.

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