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Combined velocity and structure stacked sections

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Introduction

Refraction and reflection data are generally treated separately, one part of the data set being discarded or treated as noise. Near offset reflection data containing amplitude, phase and reflectivity information is processed with tools such as normal moveout correction, velocity analysis and migration, to obtain a depth image of the sub-surface that can be interpreted. Conversely refraction data is often used as the input to tomographic and inversion processes designed to obtain a velocity model of the sub-surface. The use of wide-angle refraction data in this way, rather than in the processing approach, has historically been due to the low sampling density associated with wide-angle refraction data acquisition methods. Additionally, refraction data usually has to be picked, a technique that may lead to an element of subjectivity entering the processing procedure.

Recently wide-angle data have been acquired using multi channel streamer (mcs) surveys, allowing the production of densely sampled data with offsets ranging from 20-30 km. This raises the possibility of including the wide-angle refractions within the processing sequence to obtain velocity information that could be used in conjunction with the near-offset reflection images to better constrain the sub-surface. Previous acquisition methods have obtained refraction data using ocean bottom seismometers (obs) and reflection data with a conventional streamer. The advantage of using long offset streamer data is that the reflections and refractions are part of the same densely sampled data set.

Stacking method

The method described here involves initially transforming the offset-time domain shot gathers to the tau-p (intercept time-slowness) domain followed by downward continuation of the tau-p wavefield to the of p-z (slowness-depth) domain by applying a phase shift in the frequency domain and a subsequent imaging condition (Clayton & McMechan 1981). The phase shift depends on the input velocity function v(z), downward continuation results in a focusing of the energy down each trace as the velocity function approaches the correct one. The procedure is iterative, with a new velocity function extracted at each iteration. The extraction process is automatic and is based on locating the depth at which the maximum amplitude occurs down each trace. The iterations proceed until convergence criteria are satisfied resulting in a range of possible velocity functions. The velocity function used in the next stage of the processing is simply the average of the final two iteratively produced velocity functions. It would be computationally prohibitive to process all the shot gathers in this way. Instead every tenth shot gather undergoes the iterative downward continuation. To determine velocity functions for the intermediate shot gathers, a linear interpolation is performed between iteratively determined velocity functions, downward continuation is then performed on each of the intermediate shot gathers.

From the slowness-depth (p-z) wavefields it is possible to identify regions that contain either predominantly structural information or velocity information. At low values of slowness, $p < 0.2$ s/km, the wavefield consists of the near offset reflection information and strong horizontal events correspond to reflections from interfaces at depth. At higher values of slowness the p-z wavefield represents the wide-angle data and as such gives information about the background velocity field at depth.

The final stage of this processing sequence is to stack the near offset information to enhance coherency of events and to reduce the effect of random noise. The stacked information can be readily displayed overlying the velocity field allowing structural features to be correlated to changes in that field.

Application to the Faeroe Basin

The method was applied to data obtained during an industrial survey carried out by Veritas DGC in the Faeroe Basin southwest of the Faeroe Islands. The Faeroe Basin is one of a number of basins along the Atlantic margin of northwest Europe, which result from the evolution of the margin from the end of the Caledonian orogeny until the early Eocene.

The Veritas survey was carried out with two ships to produce an extended long offset dataset. The result of the process presented here is shown in figure 1. The seabed reflector can be seen at about 1 km depth A strong reflector can be seen extending across the section at 2.5 km depth: this is interpreted as top basalt reflector and is overlain by a 1.5 km layer of relatively un-deformed sediments. Beneath the top basalt

Journal of Conference Abstracts
Volume 7(2), 157

interface interpretation is more difficult because the velocity model used to downward continue the tau-p gather is less well determined at this stage. However there appear to be a number of coherent events within the sub-basalt region. Multiple energy may also be present in this region, further complicating the interpretation. The near offset data has also been stacked in a more conventional manner (Carpenter 2000) using Stolt f-k migration. The depths to the reflection interfaces down to the top basalt correspond well in both methods.

Conclusions

This abstract presents an unconventional method of producing a depth migrated stacked section that includes velocity information. The method forms a complete processing algorithm that inputs individual shot gathers and utilises both the refracted and reflected regions of the input wavefield to produce a stacked section without resorting to traveltime picking or tomographic techniques to determine the velocity field.

References

Clayton, R. W. & McMechan G. A., 1981. Inversion of refraction data by wave field continuation, *Geophysics*, **46**, 860-868.

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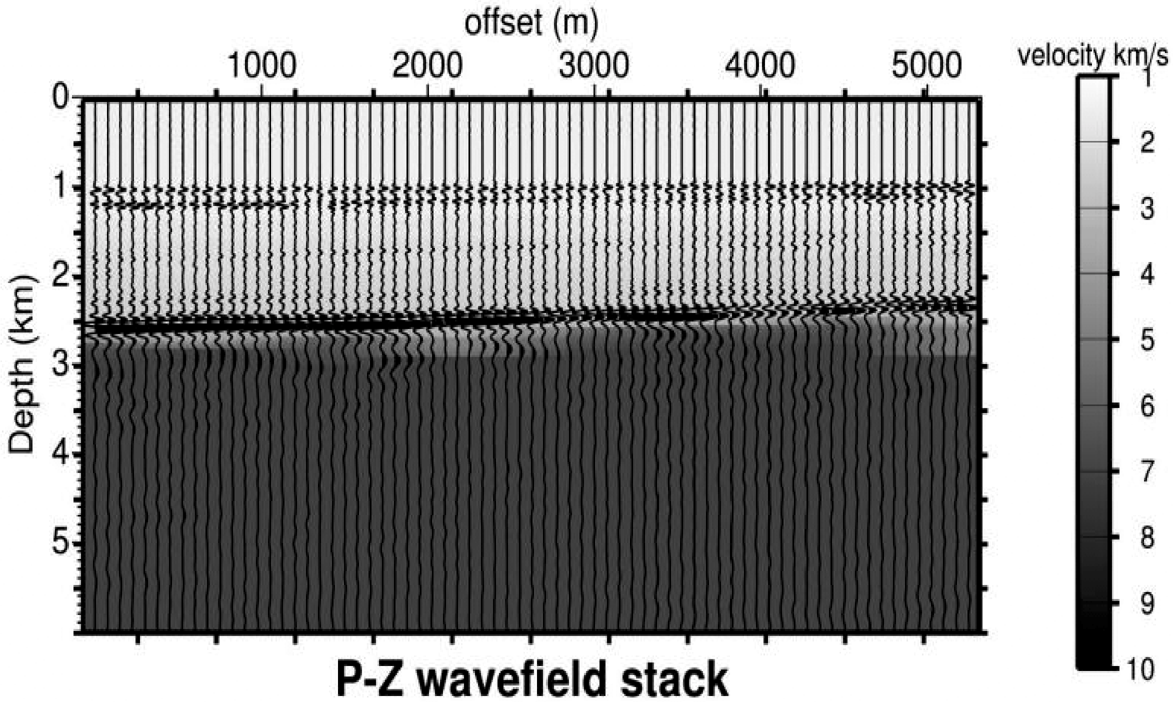

Figure 1: A combined structure and velocity image stack of a section of data from the Faeroe Basin survey. The top basalt reflector extends from 2.5 km-2.3 km depth across the section and can also be identified by a sharp velocity discontiuity at approximately the same depth. Some sedimentary features can also be identified above the basalt reflector, and some coherent events may also be identified beneath.