Multiple attenuation in shallow water

Application of a technique called SWD in providing clearer seismic images for interpretation by effectively removing shallow water multiples.

CGGVeritas

This article describes a seismic data reprocessing project on a dataset that was acquired in the Gippsland Basin. Like much of Australia's offshore data, most of the basin has a shallow, relatively hard seafloor. Conventional techniques such as Tau-P decon fail to completely remove short-period surface multiples generated by the seafloor. Surface-related multiple elimination (SRME) cannot work at these depths due to lack of near offset data. The presence of remnant multiples significantly reduces the effectiveness of inversion and AVO, key tools in understanding the geology. We demonstrate that a method called shallow water demultiple (SWD) can provide a greatly enhance degree of multiple removal, significantly increasing the value of the seismic.

Area characteristics

The Gippsland Basin (see Figure 1), which is located on the southeastern coast of Australia and covers an area of approximately 41,000 km², has been a significant source of oil and gas in Australia. About two thirds of the basin lies offshore in mainly shallow water (less than 200 m). The hydrocarbons are predominantly sourced from non-marine facies of the upper Latrobe Group. The principal difficulty faced by interpreters in revealing the structures of the reservoirs in this region is that the deep seismic image contains strong multiple noise below the extensive Latrobe Group coal sequence as illustrated in Figure 2. The majority of this multiple package is the surface peg-leg multiples generated by the coal sequence and the shallow seafloor.

Seismic data processing issue

To attenuate surface multiples, surface-related multiple elimination (SRME) has been acknowledged as an effective data-driven method. However, in shallow water environment, the acquisition geometry results in the distance between the source and streamer is significantly larger than the water bottom depth. In this circumstance SRME cannot model the water bottom correctly and therefore cannot attenuate shallow water multiples. Conventionally, predictive deconvolution, either T-X or more usually Tau-P, is generally used in these cases for attenuating shallow water multiples. A hard hard water bottom can result in multiples higher in amplitude than the primary, in which case deconvolution cannot attenuate fully the multiple and usually also attacks primary events that have a periodicity close to that of the water-layer. Hence, a more effective method is needed to handle this kind of multiples.

Field data

The field data was acquired in the Gippsland Basin with a configuration of dual source and eight cables. The cable length is 4.6 km with the channel spacing of 12.5 m. The cable separation is 100 m. The sources and streamers were towed at shallow depths of 6 m and 7 m, respectively. The guns were fired flip/flop at an interval of...
18.75 m (i.e. 37.5 m per gun) which results in a nominal fold of 61. The nearest channel at the central cable is 182 m from the source. Since the seafloor depth in this area is 60 to 90 m, the water-bottom reflection is close to the critical angle. This poses problems to SRME as the water bottom reflection was not properly recorded.

**Shallow water demultiple (SWD)**

The new attenuation method for shallow water multiples, SWD, used by CGGVeritas is based on the concept of estimating shallow primary reflections from multiples. The idea can be illustrated by a diagram depicted in Figure 3. For a particular shot (S1) fired by the gun, the water bottom reflection in the near offset, labeled by the path BC, is not recorded because of the gap between the source and the nearest receiver. The reflection will not be properly recorded either in the farther offsets because it is in the post-critical range due to the shallow seafloor. Nevertheless, it is possible to recover the reflection BC because it is embedded in a multiple reflection (indicated by the path ABC) of another shot S2. Therefore, by reconstructing the water bottom reflection (or other shallow events) from the multiples in the recorded data, the problem faced by SRME can be resolved.

**Reprocessing results**

By using the peg-leg multiples generated by the coal sequence and the seafloor as shown in Figure 2, we reconstructed the water bottom reflections for this dataset. They were then utilised for predicting the water-layer multiples. Since multiples predicted by SWD generally match well with those in the data in terms of amplitude and phase, we used very short matching filters in the subtraction process to minimise the risks of affecting those primary events that are close to the multiples. Figure 4b displays the multiple attenuation result after the application of SWD. It can be observed that most of the water-layer multiples have been effectively attenuated. Its effectiveness can be compared with that of Tau-P prediction deconvolution and SRME which were used in the previous processing workflow for removing short-period multiples. Figure 4c shows the result obtained by Tau-P deconvolution; whereas, Figure 4d depicts the conventional SRME result. Comparing with the SWD result, it can be seen that both the Tau-P deconvolution and SRME are less effective in attenuating the water-layer multiples with the conventional SRME had the worst performance. This can be further confirmed by comparing the extent of the multiple suppression between SWD and the other two methods. Figures 5 and 6 show that there are a lot of residual multiples left behind in the seismic sections when Tau-P and SRME were used, but these residual multiples were removed by SWD. It is quite clear how well the multiple attenuation has worked beneath the dipping channel event, but on flat events, the presence of contaminating multiples is more difficult to recognise and can lead to errors in interpretation.

**Summary**

To facilitate detailed seismic interpretation of the hydrocarbon reservoirs in the shallow water area of the Gippsland Basin, one of the necessary seismic data processing steps is to effectively attenuate the shallow water multiples. It has been shown that traditional methods are not adequate in suppressing these multiples. Through the successful application of SWD in this reprocessing project, we recommend that this advanced technique can be considered as one of the effective multiple attenuation methods in the processing workflow for data acquired in this area.

![Fig. 4. Magnified stack sections. (a) Input. (b) SWD result. (c) Tau-P deconvolution result.](image)

![Fig. 4(d). Conventional SRME result.](image)

![Fig. 5. Difference in the amount of multiples removed by SWD and Tau-P deconvolution.](image)

![Fig. 6. Difference in the amount of multiples removed by SWD and SRME.](image)