

Imaging the Downgoing Waves from OBS

Shuki Ronen, Lynn Comeaux, and Xiao-Gui Miao, VeritasDGC

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Summary

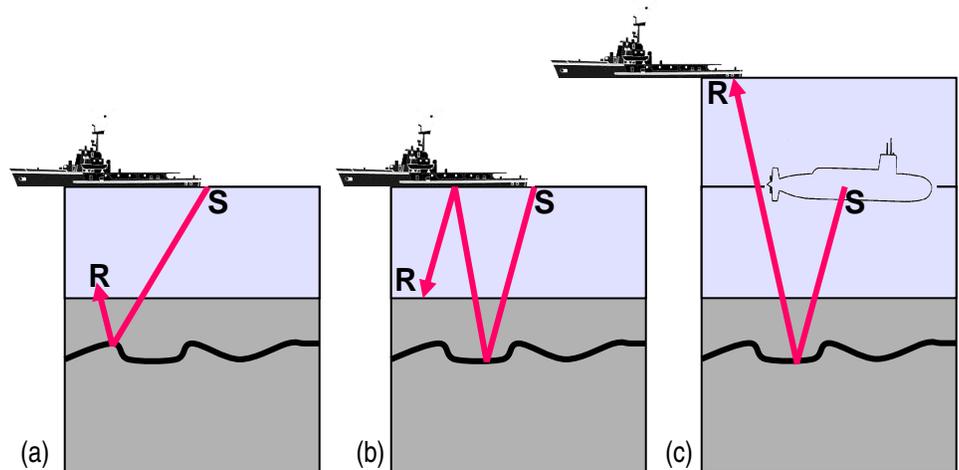
We present a method for imaging the downgoing waves recorded on the sea bed. The first step in our method is a conventional combination of the hydrophone (P) and the vertical geophone (V) data and production of up going and downgoing waves. However, while conventionally one proceeds with the upgoing waves, we also proceed with the downgoing waves, which we know contain no primary reflections, only multiples. We migrate the downgoing waves by pretending that the data were acquired not on the seabed, but above an additional water layer whose thickness is the sea depth. We applied this method to OBS data recorded in the North Sea. We find that the downgoing waves provide a better image than the upgoing waves because of improved illumination and reduced exposure to shallow inhomogeneous anomalies under the sea bed.

Introduction

The four components recorded by 4C seismic data acquired on the seabed by ocean bottom station (OBS) or by ocean bottom cables (OBC) are the pressure recorded by a hydrophone, and the three components of the particle motion velocity (or acceleration) recorded by geophones (or accelerometer). After rotation of the geophones' data to correct for the tilt and orientation of the receiver package, the three motion components are vertical, radial, and transverse. Neglecting far offset effects, converted (PS) waves are recorded mainly on the radial (R) and the transverse (T) components, and primary (P) waves are recorded on the hydrophone (P) and the vertical (V) components. The same P waves are recorded on both the P and the V components. However, neither of them is redundant. It is well known (Barr and Sanders, 1989; Loewenthal, 1994) that the P and the V components can be combined to provide the upgoing P-wave (U) and downgoing P-wave (D). As can be seen on Figure 1, none of the downgoing waves are primary but many of the multiples, such as the peg-leg in Figure 1b are not part of the upgoing waves.

Figure 1. The P-wave field recorded on the seabed is the sum of (a) up going and (b) down going waves. Some of the up going waves but none of the down going waves are from primary reflections.

(c) Equivalent survey in which the multiple in (b) becomes a primary and can therefore be imaged by the same programs used to image (a) but with a different elevation for the receivers.



An effective demultiple method is to simply separate the P wavefield as recorded by dual components (P and V) to up and down (U and D) waves and proceed only with U, discarding D. D is usually used only for quality control. Further improvements for usage of D for the improvement of U were proposed (Amundsen et al, 2001). However, almost all OBC and OBS data today are imaged using upgoing waves. In this paper we use the downgoing waves for imaging. We image the downgoing wavefield using a "trick" outlined in Figure 1c. Similar methods have been applied to ocean bottom hydrophones without separation to up and downgoing waves (Godfrey et al, 1998) and to VSP data (Yu and Schuster, 2004). The schematic figure above shows a flat seabed, but there is no such limitation because the migration program can handle any topography of receivers in either Fig 1a or Fig 1c configuration.

Field data example

We applied this method to OBS data recorded in the North Sea over the Britannia field. We imaged data from 9 OBS deployed at an interval of about 500m and at a depth of about 150m. The OBS was acquired simultaneously with a conventional streamer survey, shot with an array of airguns (Ronen et al, 2003). Wide azimuth data from many shot lines of the survey were recorded by the OBS, but for the purpose of this paper we used only the one shot line which was approximately above the OBS. Being part of a streamer survey the source was dual (flip-flop) with a 50m cross line interval between the interlaced port and starboard lines with 50m in-line interval in each. We present the the images produced from the upgoing waves and from the downgoing waves in Figures 2 and 3, respectively.

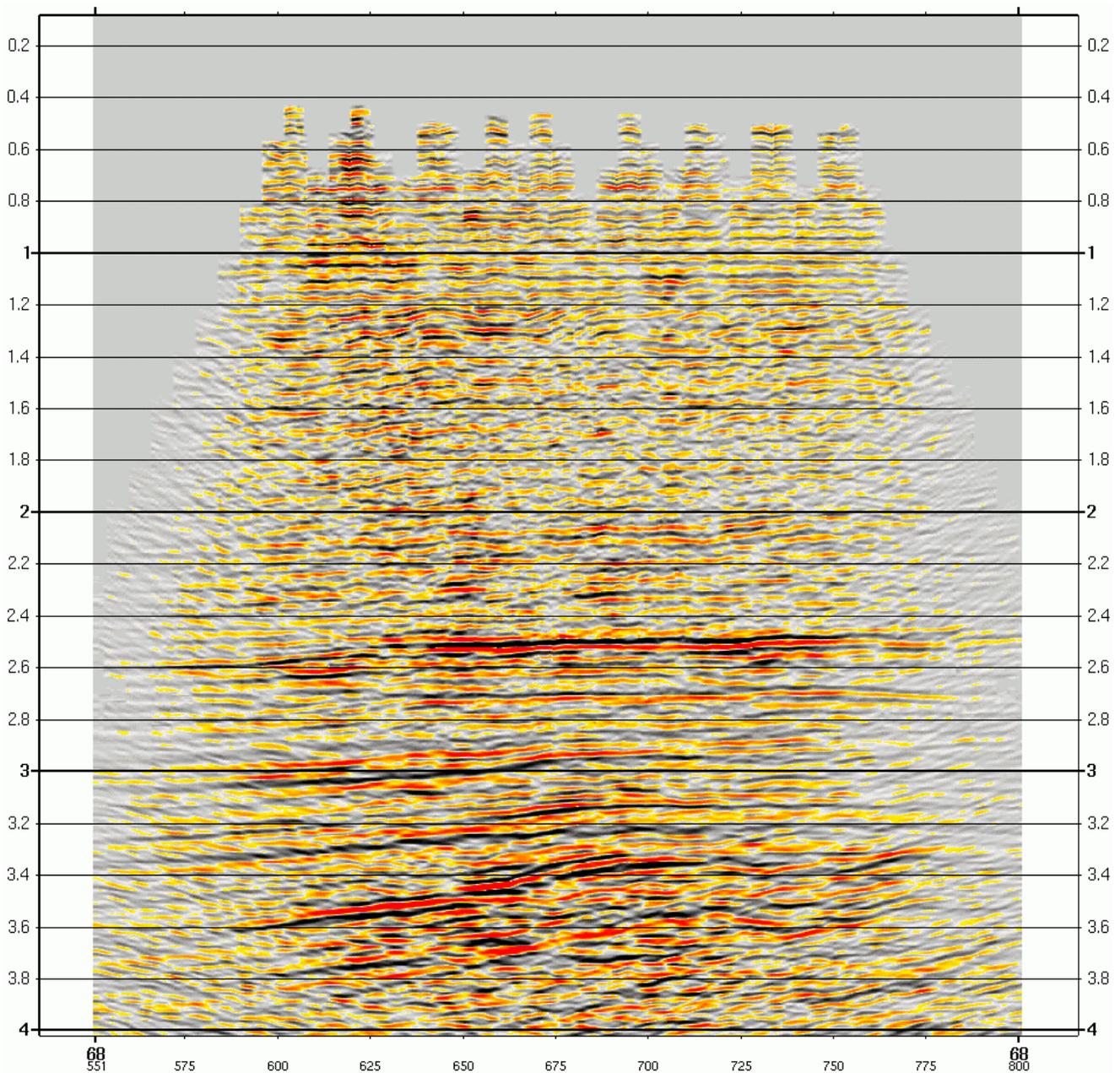


Figure 2. The image produced by conventional migration the up going waves according to the geometry of Fig 1a. Note the poor illumination of the shallow part of the image. Almost all of today's OBS and OBC surveys data are imaged this way.

Why the image from the downgoing waves is better than the conventional image from upgoing waves

The advantage of the downgoing waves are that the illumination is better especially for shallow targets (Figure 4). In addition, the downgoing data are less susceptible to scattering, amplitude variations, and statics due to anomalies in the inhomegenous ground under the seabed because the waves travel through the water twice (up and then down) after going through the near seabed anomalies (Figure 5).

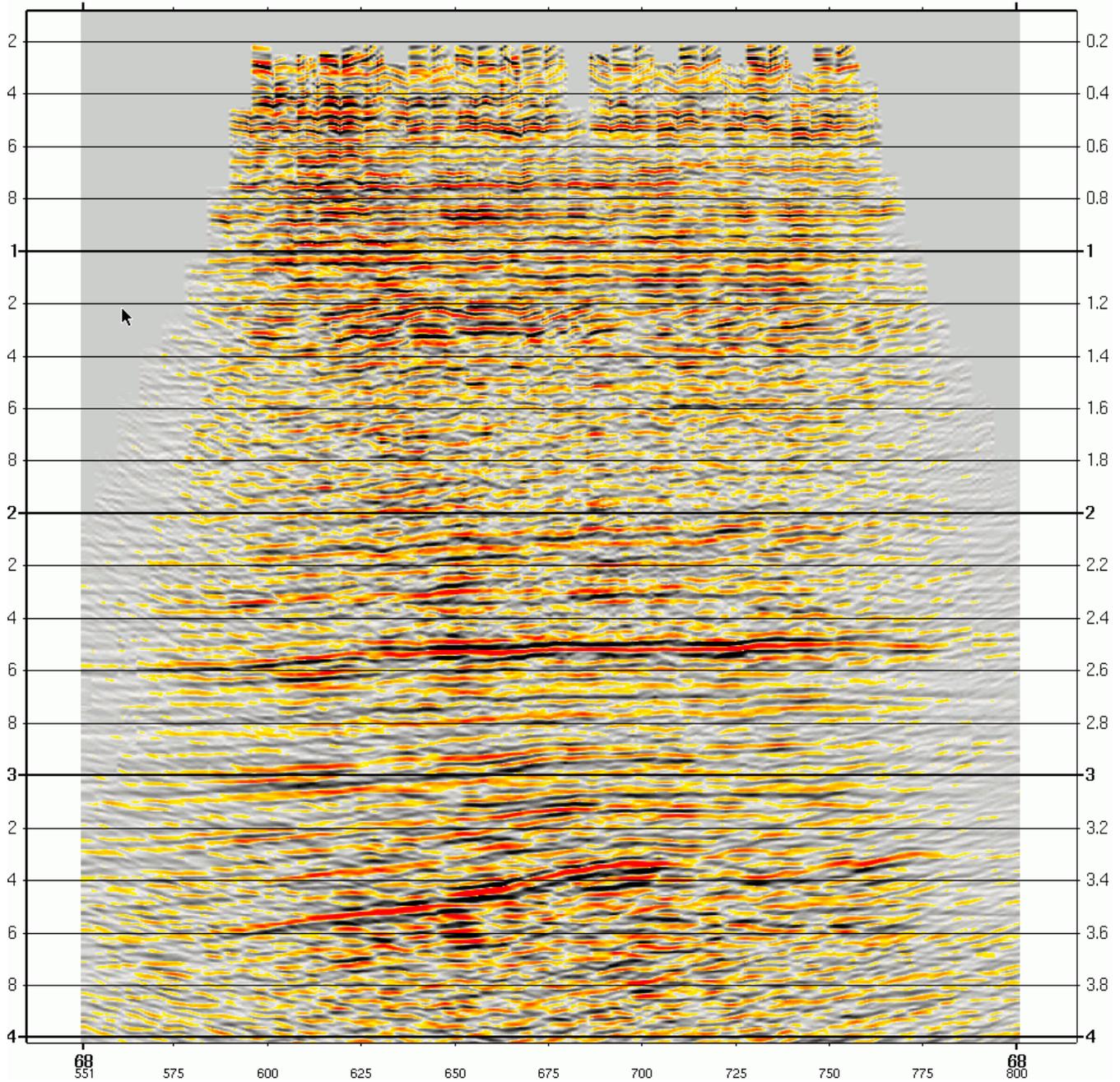


Figure 3. The image produced by migrating the down going waves according to the geometry of Fig 1c. The illumination of the shallow part of the image is much better than the conventional image produced from the up going waves as in Fig. 2.

Figure 4. The illumination of the upgoing wave (a) is much narrower than that of the downgoing waves (b) and (c). This effect is more significant for shallow reflections. In particular, the seabed cannot be imaged with the upgoing waves but it can be imaged with the downgoing waves.

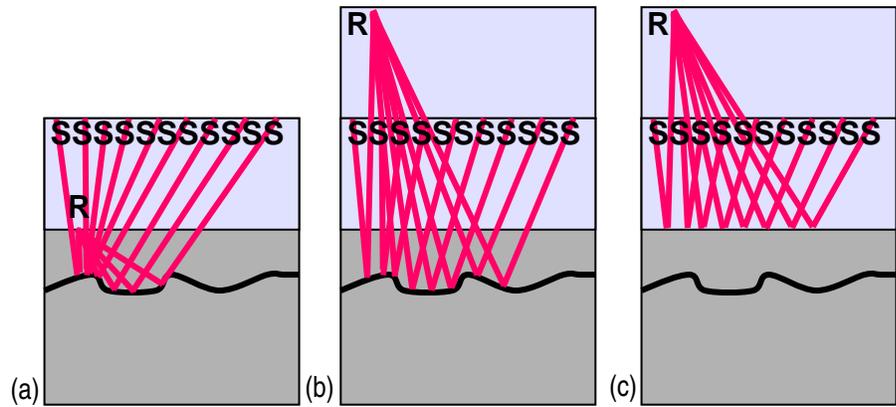
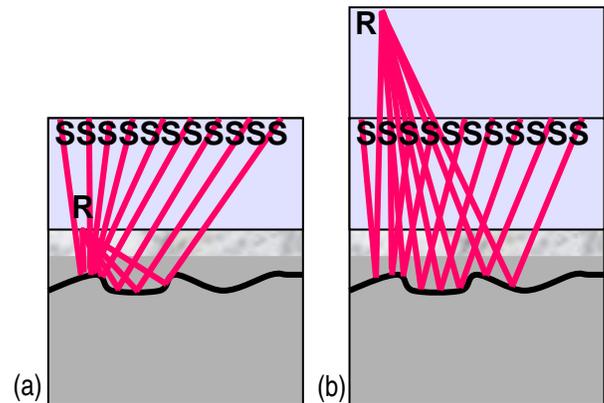


Figure 5. The up going waves (a) are more susceptible to the degrading effect of irregular near seabed than the downgoing waves (b). Inhomogeneous media just under the seabed cause more statics, amplitude variations, and scattering of the upgoing waves. The downgoing waves, on the other hand travel (twice) through the water so the waves go around anomalies and scattering/diffractions heal by the time the waves arrive at the receiver.



Conclusion

We have presented a method for imaging the downgoing waves recorded on the seabed. The first step in our method is a combination of the hydrophone (P) and the vertical geophone (V) data. However, while conventionally one proceeds with the upgoing waves, we also image the downgoing waves. The downgoing waves contain no primaries, only multiples. But they provide a better image than the upgoing waves. We applied this method to OBS data recorded in the North Sea. We find that the downgoing waves provide a better image than the upgoing waves because of improved illumination and reduced exposure to shallow inhomogeneous anomalies under the seabed.

References

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