Z-99 Combined Ocean Bottom Stations and Surface-Towed Seismic Streamers

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Abstract

We propose to combine sparse multi-component (MC) seismic data with dense single component (1C) data. Such combination of both acquisition operations and data analysis can provide a better value/cost ratio compared to either 1C data alone or MC data alone.

Introduction

MC seismic data have been acquired on the seabed for over a decade. Compared to surface towed streamers, such data are of higher cost but have the promise of additional value. The list of promises is long: imaging through gas clouds and mud volcanoes, multiple attenuation, imaging reflectors with low normal incidence P impedance and, in general, improved ability to characterize lithology and fractures. After a decade or so, we can point to many technical successes. However, MC technology is used marginally and the commercial viability of providing a MC service is a promise yet to be delivered. Why?

One problem with MC is data quality. Ocean bottom cable (OBC) data sometimes do not have the fidelity needed for detailed analysis. Another problem is lack of analysis methods. However, the main problem with seabed data is that streamer data are not only too cheap but also too good. Many of the promises of MC data can be delivered by long offset (and wide azimuth) 1C data. For example, low normal incidence P impedance reflectors can be imaged with long offset streamer data. In general, streamers give seabed seismic a good run for its money leaving too small a niche to be commercially viable with the available capacity.

In this paper we present an idea for a type of seismic service, which is currently not offered. Rather than attempting to replace streamers altogether, we propose to add sparse multi-component data to the streamer data.

Combined Ocean Bottom stations and Surface streamers (COBS)

We propose to combine sparse but high fidelity MC data with dense and high quality 1C data. Such a combination increases the value of the data much more than it increases the cost of acquiring and analyzing these data.

In Figure 1 we show high-fidelity data we acquired in combination with a streamer survey. We deployed self landing and ascending (SLA-)OBS (Buttgenbach et al, 2002) from a low-cost chase boat working together with a streamer vessel. We used high-quality-high-cost SLA-OBS. However, the cost for our combined operation was an order of magnitude lower than the cost of a conventional MC survey with a much larger number of sensors embedded in an OBC deployed from dedicated cable vessels.

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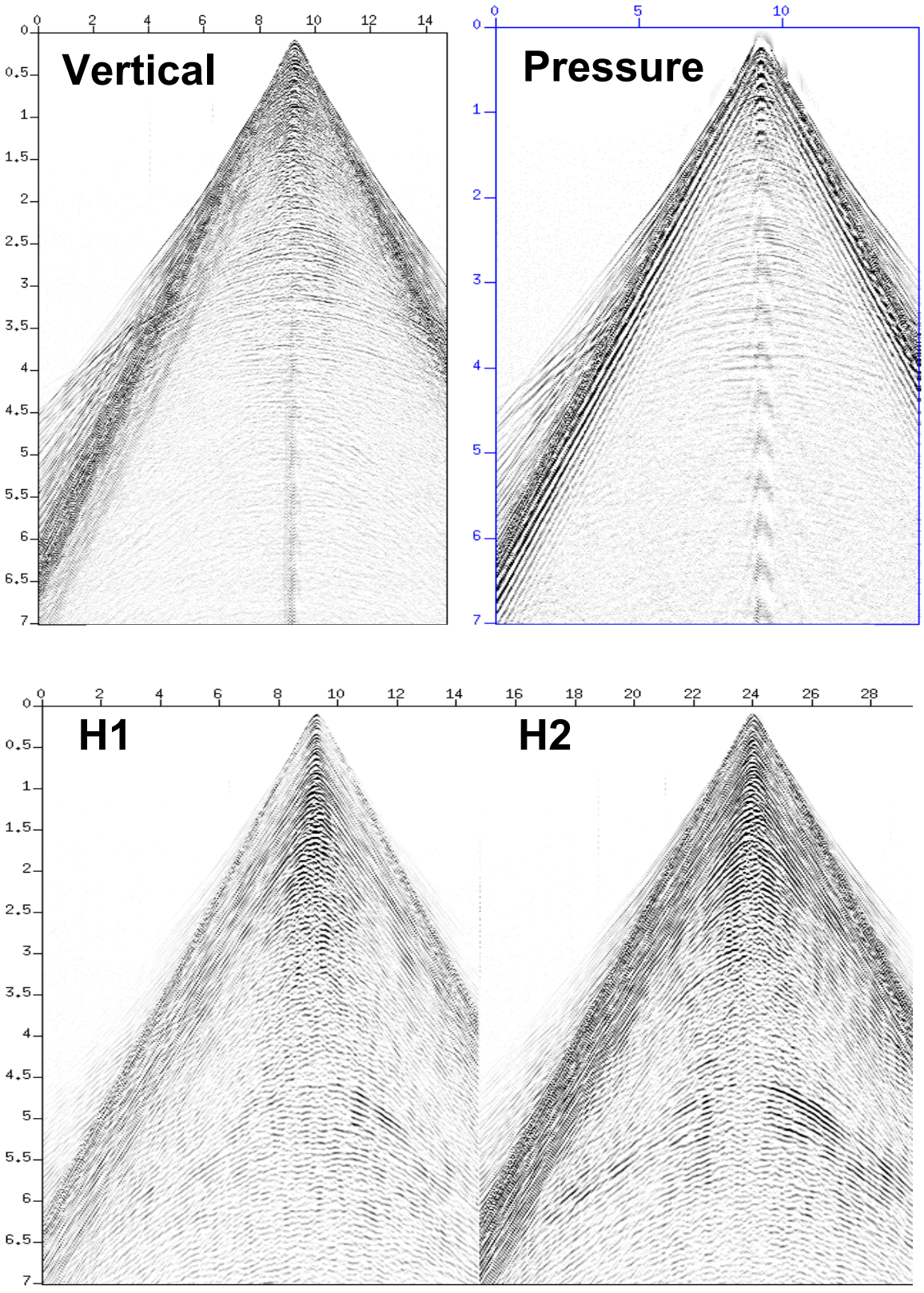


Fig. 1: High fidelity data acquired on a SLA-OBS in the North Sea. Minimal processing included gain, filter, and rotation to vertical and horizontal. The Pressure and the Vertical components include P waves. The horizontal components include shear waves.

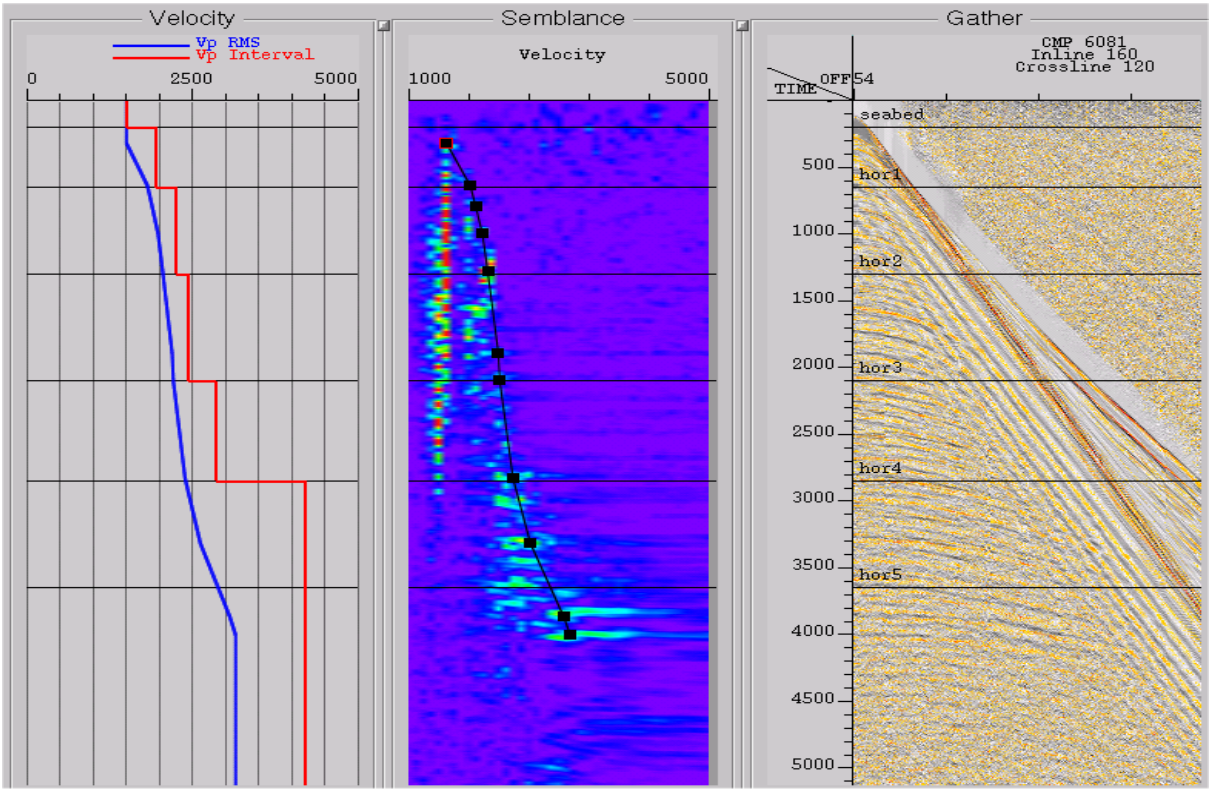


Fig. 2a: PP Velocity model (left) built by picking moveout velocity semblance (center) of P waves (right).

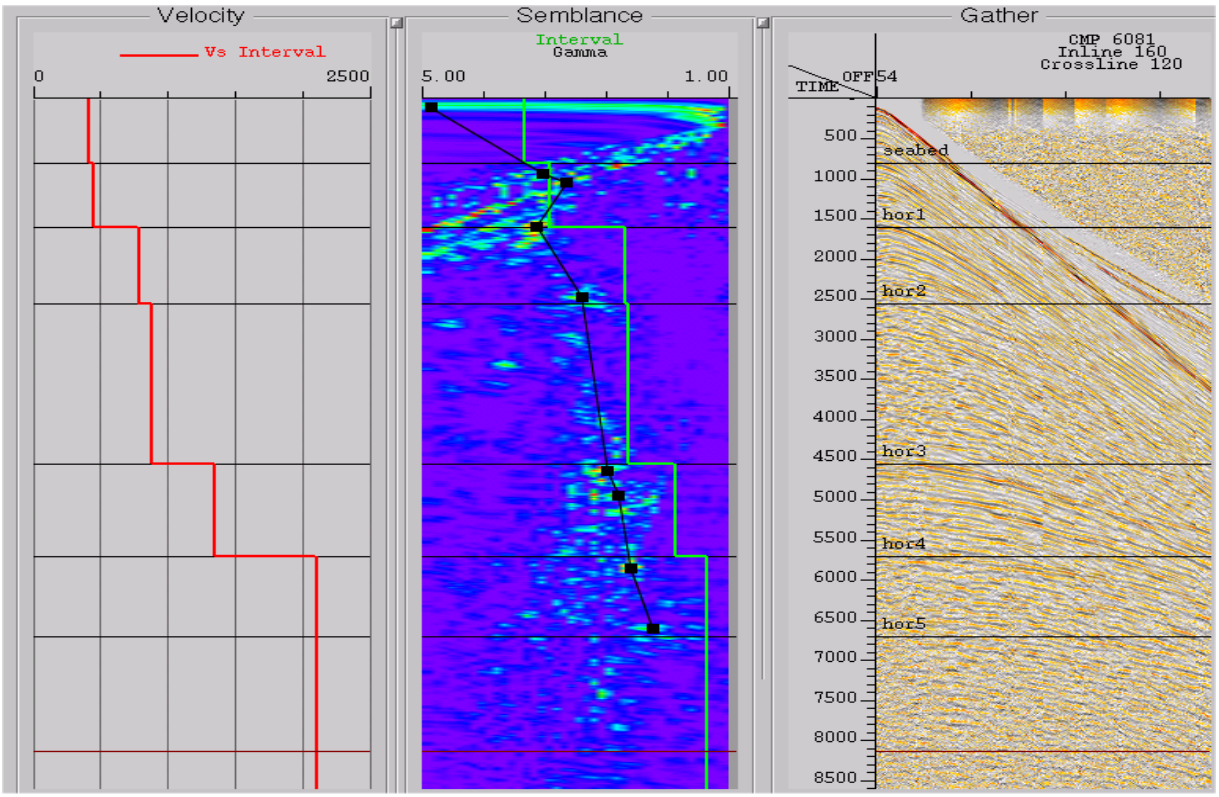


Fig. 2b: PS Velocity model (left) built by picking V_P/V_S ("Gamma") semblance (center) of converted PS waves (right) following the P velocity analysis of Fig. 2a.

AVO analysis of streamer data depends on a priori V_P/V_S ratio, which is usually provided by well data. The sparse seabed data provide excellent V_P/V_S ratio from moveout velocity analysis (Fig. 2) and from PP and PS event linking. Thus COBS provide an alternative to well data. In addition, the direct measurement of PP and PS AVO from the seabed data is used for joint PP and PS inversion to validate and calibrate the 1C AVO. COBS can thus substitute for VSP and well log data to provide V_P/V_S ratio and calibration of the attributes generated from AVO and inversion of 1C surface seismic data. The sparse MC data provide excellent Azimuthal Anisotropy analysis (Fig 3). This information is very valuable for fracture and lithological characterization and can be further enhanced by collecting streamer data in multiple azimuths. The COBS also provide good multiple identification via P-Z combination and improved illumination sub-salt and sub-basalt. SLA-OBS can be deployed in deep water down to 6km. Above all, the vector fidelity of OBS (stations) is better than that of most OBC (cables) because the cables often introduces differences between the in-line (X) and the cross-line (Y) horizontal components due to the linear configuration of the cable.

Summary

COBS provide great additional value for a small additional cost of acquiring and analyzing 1C streamer data. They have a much higher added value per added cost compared to conventional MC data from OBC. The benefits include improved lithological, fluid, and fracture characterization, improved illumination sub salt/basalt, and multiple identification.

References

Buttgenbach, T., Schleisiek, K., and Ronen, S., 2002, Self-landing and ascending OBS: opportunity for commercial seismics in ultra deep sea: First Break, **20**, no 12, 770-772.

Garotta, R. and Granger, P. Y., 1988. Acquisition and processing of 3C x 3-D data using converted waves: SEG Annual Meeting Abstracts, Session S13.2.

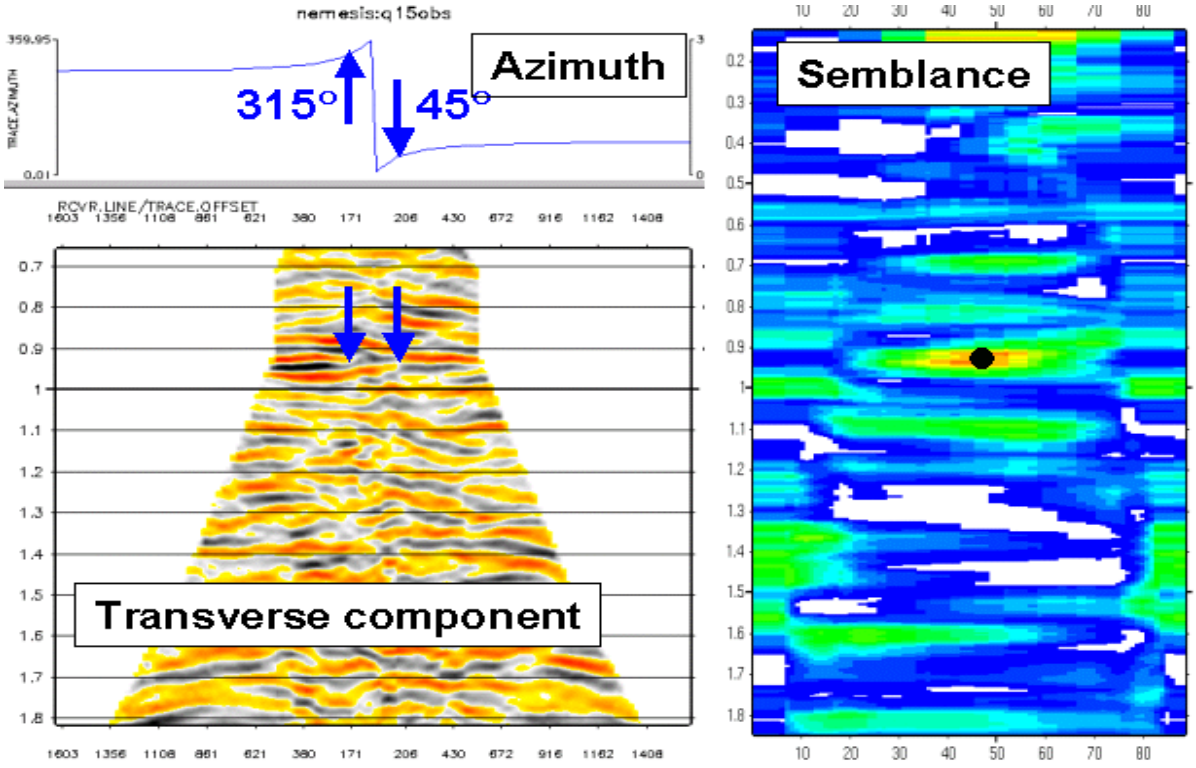


Fig 3: Azimuthal Anisotropy analysis by picking the maximum coherency of PS events on the transverse component. The semblance panel was calculated with variable-angle sign flips at 90° following Garrotta and Granger (1988).