Multicomponent Seismic Data Interpretation Cycle

Mariusz Lukaszewski*, Jan Piatek, Artur Przybylo
Geofizyka Torun Sp. z o.o., Poland

Summary

High frequency conventional P-wave seismic data (PP) coupled with converted-wave (PS) seismic data provide new insight into the depositional history as well as more complete information about rock properties. The ability of multicomponent data to reduce the uncertainty in predictions about lithology, porosity and possible reservoir fluid contents is high and looks promising for the exploration and development of oil and gas reservoirs. The question is how to choose the most appropriate approach for best understanding and interpreting elastic-wave data.

Introduction

The paper concentrates on interpretation techniques of elastic-wave data which were applied to obtain the best images of the subsurface. The big 2D3C onshore seismic project, multicomponent recording, processing and interpretation was carried out by Geofizyka Torun in 2005. The study area lies in the central part of Cambay Basin, India, where exploration encounters many challenges. Complicated geological structures, variable P-wave velocity change in sand versus shale in Older Cambay units, lower seismic resolution and S/N below Kalol formation, amplitude and frequency attenuation due to the presence of overlying coal seams create imaging problems associated with P-wave seismic data. Since recording of multicomponent data provides complementary images of the subsurface, the strategy was to use 3C digital seismic methods. Possessing three-component seismic measurements gives the interpreter great opportunities to disclose desired information in area, where the data quality is poor or the interpretation is unclear.

Multicomponent seismic data analysis

The interpretation cycle for elastic-wave data is as follows:

- fully interpret the P-wave data,
- converted-wave data interpretation,
- integrate both results,
- create plots, maps, crosscorelations and point interesting anomalies.

P-wave data interpretation is performed in the conventional manner of all main horizons identification on VSP data, well data, synthetic seismograms and surface seismic. Radial component requires the same procedure to be applied for interpretation. Figure 1 shows correlation of both components through PP and PS log-based synthetic modeling.

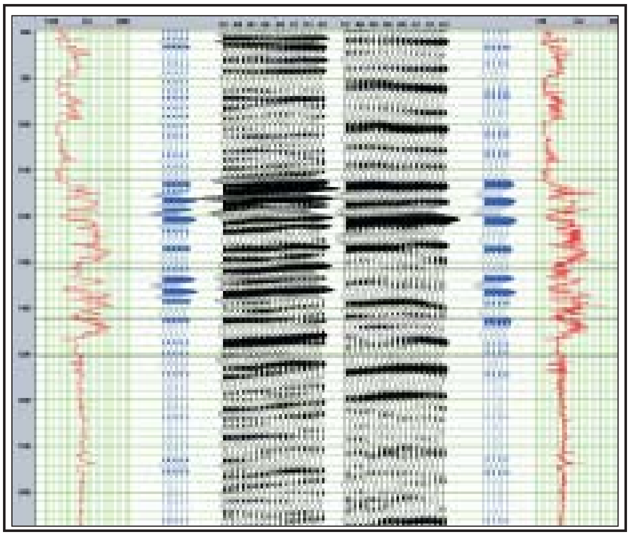

Fig. 1: Correlation of vertical (left) and radial (right) components through PP and PS log-based synthetic modeling, (for better visibility only P- and S-wave logs are shown).

Having limited access to measured and real information about shear-waves the best solution is to make assumptions about S-wave log. In the study area the most relevant relationship between measured P-wave log and calculated S-wave log is that one provided by Castagna equation. Such obtained S-wave log along with wavelet extracted from PS seismic data produces synthetic trace which can be easily tie to the surface seismic. This seismic to well correlation can be next verified by simple calculation of interval gamma value at the well location. When the data are tied and all horizons in both data sets are interpreted, this kind of verification mentioned above can be extended to the whole seismic section. In areas where interpretation becomes unclear or data quality is poorer it is easy to track wrong event. In such situation interpreter can use one of the multicomponents recording benefits which is comparing the resultant interval Vp/Vs values with expected ones due to geological variations (Miller et all., 1994). Use of this technique provides quick confirmation of properly done interpretation or indicates mispicks.

The next step in multicomponent analysis is integration of both vertical and radial components interpretation results. This can be summarized as follows:

- interval Vp/Vs calculation using PP and PS isochrons and then search for Vp/Vs decreases as a stable sand indicator (Figure 2),
- identification of sand structures from PS section (Figure 3),
- identification of bright spots – sand indicator,
- calculation and interpretation of seismic instantaneous attributes - indicator of fluid contents.

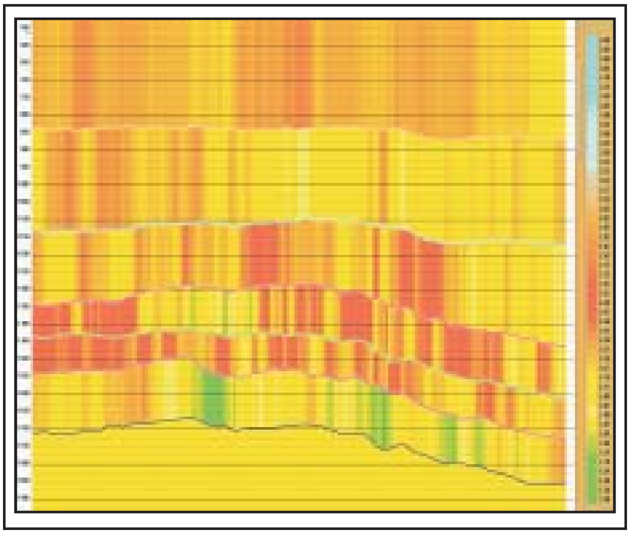

Fig. 2 : Time section showing interval Vp/Vs values calculated using PP and PS isochrons.

Finally, all given results produced at previous stages of interpretation can be incorporate to create maps and crossplots. The map of interval distribution of Vp/Vs values (Figure 4) is the promising sand indicator. Since S-waves are more sensitive than P-waves to lithology change (shale-sand-shale), what is proven by wells measurements, the PS reflection intensity map within the target zone is a

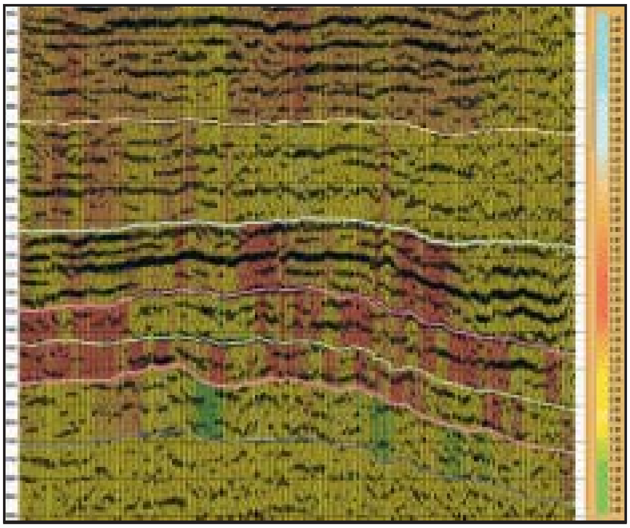

Fig. 3 : Time section showing interval Vp/Vs values with wiggle PS seismic data superimposed.

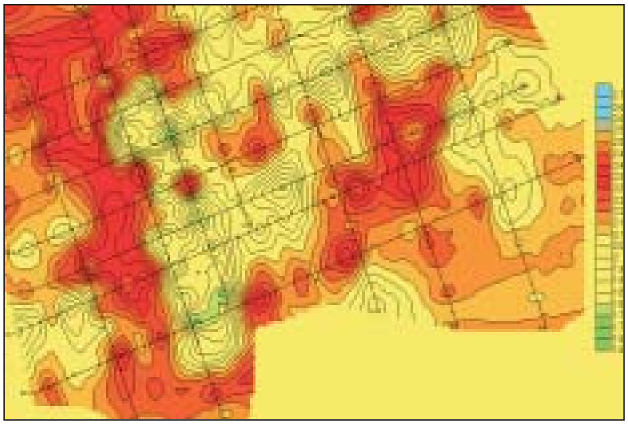

Fig. 4: Interval distribution of Vp/Vs values within target zone, color scale values decrease from blue to green.

good sand quantity factor. It means that every event on PS section points to the sand presence within shaly environment.

Combination of different instantaneous attributes supplements the results of interpretation and is fluid, especially gas indicator. A good example could be "sweetness factor" – a quotient of instantaneous amplitude (A_i) and frequency (f_i). Both parameters point out the most desired changes associated with fluid contents. A_i indicates velocity contrasts and f_i is a factor of attenuation. Within interested zones both attributes are significantly changed creating anomalies called "sweet spots".

Conclusions

Multicomponent recording is a significant enrichment of the information provided by conventional P-wave data. The appropriate and carefully leading interpretation of elastic-wave data can be critical in better understanding and exploring of difficult areas.

References

Stewart R.R., Pye G., Cary P.W., Miller S.L.M., 1993, Interpretation of P-SV seismic data: Willesden Green, Alberta; CREWES Research Report, Vol. 5.

Miller S.L.M., Harrison M.P., Lawton D.C., Stewart R.R., Szata K.J., 1994, Analysis of P-P and P-SV seismic data from Lousana, Alberta; CREWES Research Report, Vol. 6.

Radovich B.J., Oliveros R.B., 1998, 3-D sequence interpretation of seismic instantaneous attributes from the Gorgon Field; TLE, 1286-1293.