Creating a 3D Image from 2D Data, a Case Study from Hera Subbasin, Offshore Indonesia

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Summary

The area of the study is located in Hera Sub-basin, western Asri Basin, and northwest Java Basin. The subsurface setting is a relatively uniform half-graben structure that formed due to a rifting phase during the Eocene – Oligocene and is overlain by a conformable passive margin sequence which dominated the entire area until recent times. The seismic vintage varies from 1967 to 1993 with three main azimuth orientations: northeast/southwest, northwest/southeast, and north/south. The quality of the seismic ranges from poor (vectorized data) to fair. The main objective of the study is to generate a 3D seismic volume with more reasonable structure and an improved image compared to the 2D results. We use TGS's proprietary technology called 'structurally conformable interpolation', also known as 2D^{cubed}. Input data to the project is the available 2D migrated stacks and velocities from three different vintages, one of which only has vectorized data. The workflow includes survey matching of different vintages, data-driven geological model building to interpolate large distances between existing data and a 3D poststack migration to minimize the 2D migration artefacts. The method successfully creates a 3D migrated image from legacy 2D data with better structure and continuity, which increases confidence in its interpretation. Interpretation of a 3D volume is much more efficient than for 2D data and is free from 2D artefacts. Positive results from this project show that the 2D^{cubed} method gives new life to existing 2D data and maximises its potential by providing a 3D image in an area where 3D data is not available.

Input Data

Three old vintage surveys from 1991 to 1993 contributed to output area(Figure 1). The three vintages had different data character. Vintage 1 had 2D lines with raw stack look. It looked like it had no gain correction or postmigration processing technique applied. Vintage 2 had 2D lines with AGC look. This vintage appears to have gain correction applied. Vintage 3 had 2D lines with vectorized look versions of the hard copy. It looked as if most of the amplitude contrast details were lost in the process of printing hard copy and scanning it back to digitize it.

RMS velocity were received in excel sheets with manual entry of time/velocity pairs, there were typing errors resulting in velocity anomalies when converted to segy format. These anomalies were corrected before using in processing. Figure 2 illustrates the issue encountered with input seismic and velocity data.

Total 55 2D seismic lines(1388 km) were used in 2D^{cubed} processing.

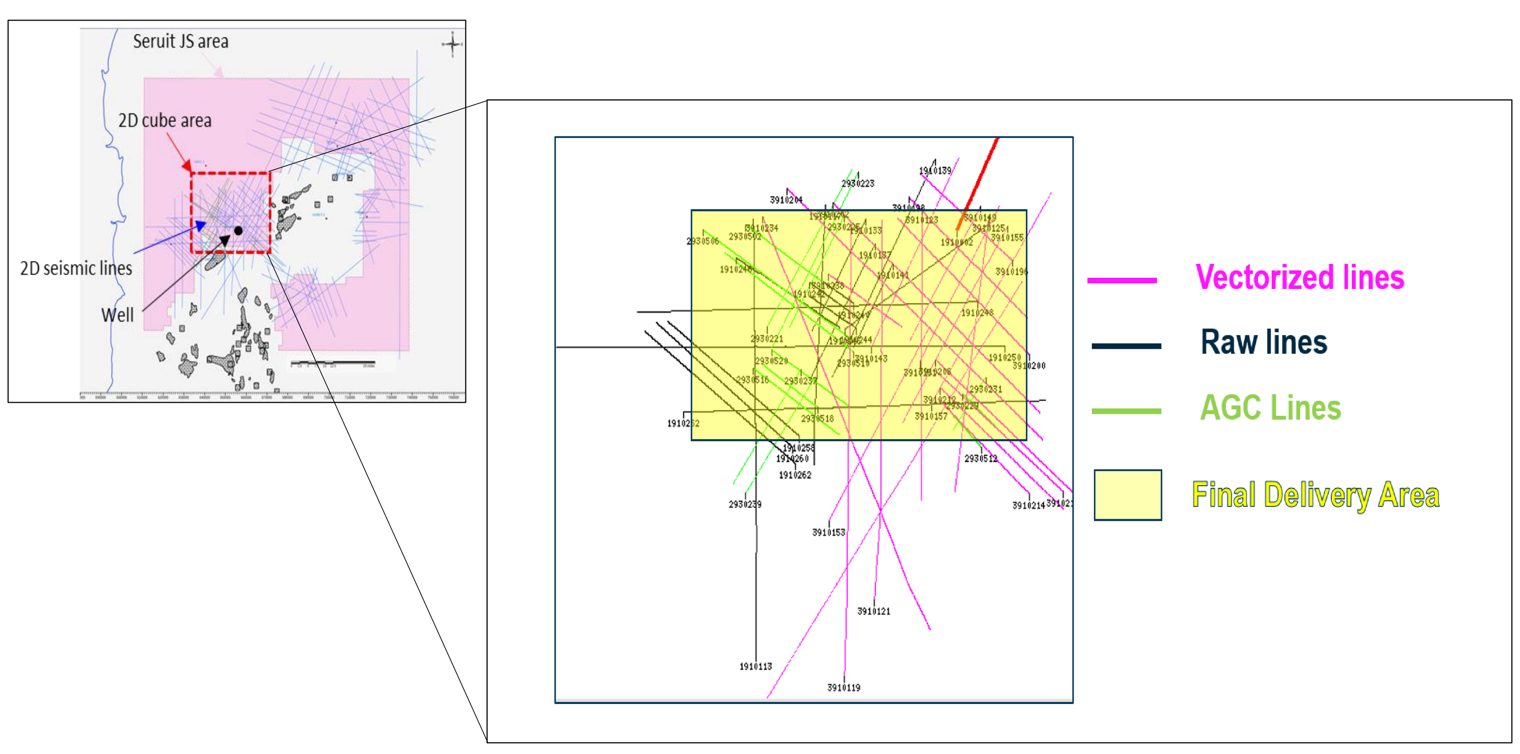

Figure 1. Available 2D data and final delivery area.

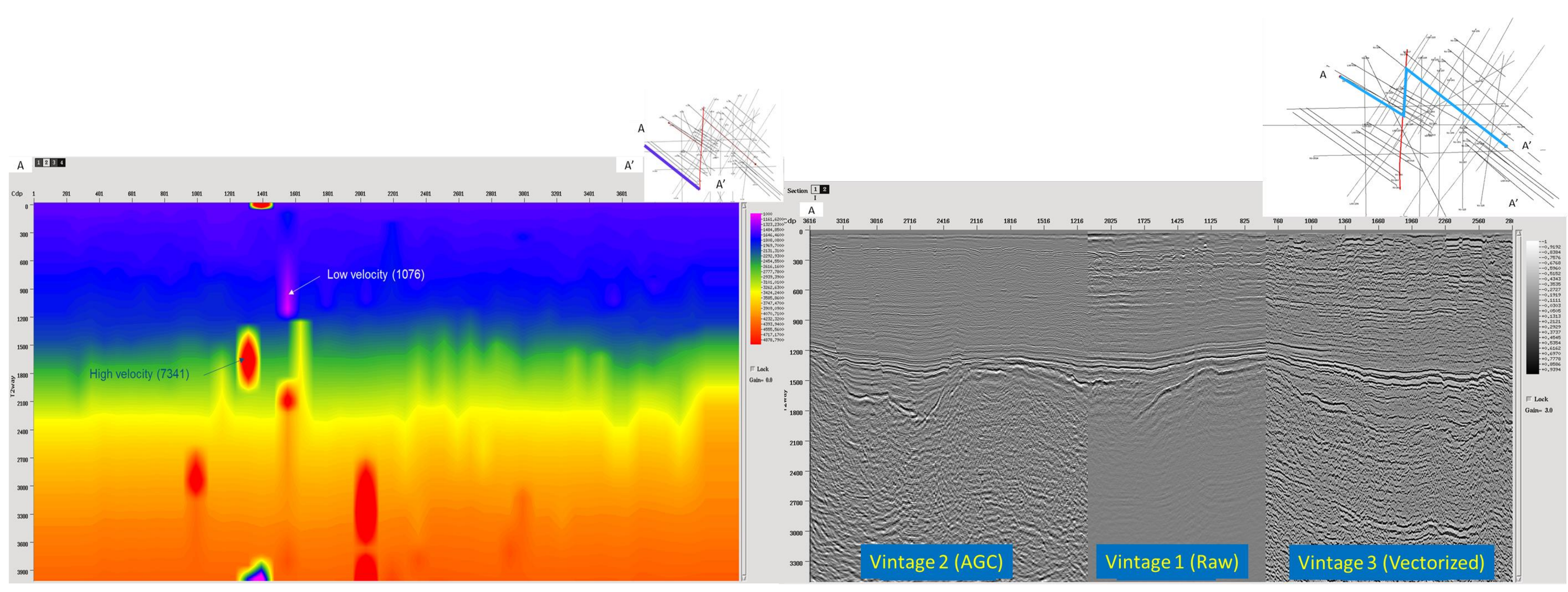

Figure 2. (Left) Digitized RMS velocity error from digitizing and (Right) different amplitude of 2D seismic.

2D^{cubed} Work Flow

Input required for 2D^{cubed} processing is set of 2D migrated stacks and their associated velocities. Overall work flow can be divided into three phases. First phase is data preparation which includes demigration of stacked data and survey matching of different vintage data to a selected base vintage. Second phase is preparing 3D structural model, this a data driven process and starts with apparent dip picking on 2D stacks and subsequently creating 2D and 3D geological model. In the final phase , survey matched 2D data is binned into 3D grid and using 3D structural model interpolation is performed to populate the 3D bins. Interpolated data is then migrated post stack using 3D migration algorithm.

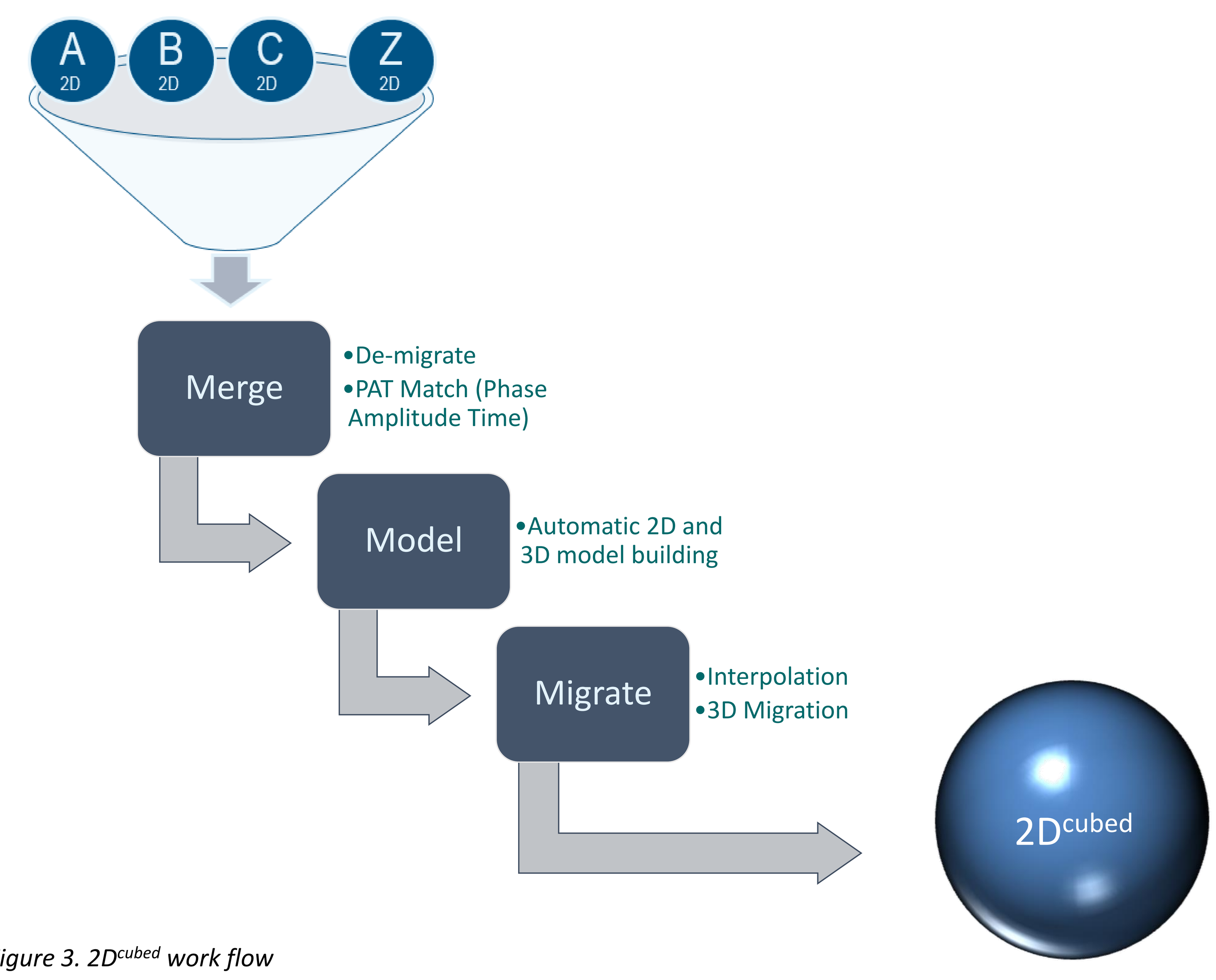

Figure 3. 2D^{cubed} work flow

Survey Matching

Vintage 1 data was taken as base survey to which other two vintage data was matched to. Matching was done for phase, time , amplitude and frequencies. The biggest challenge was to match Vintage 3 vectorized data to the base survey. Scalars were calculated and applied to Vintage 2 & 3 data.

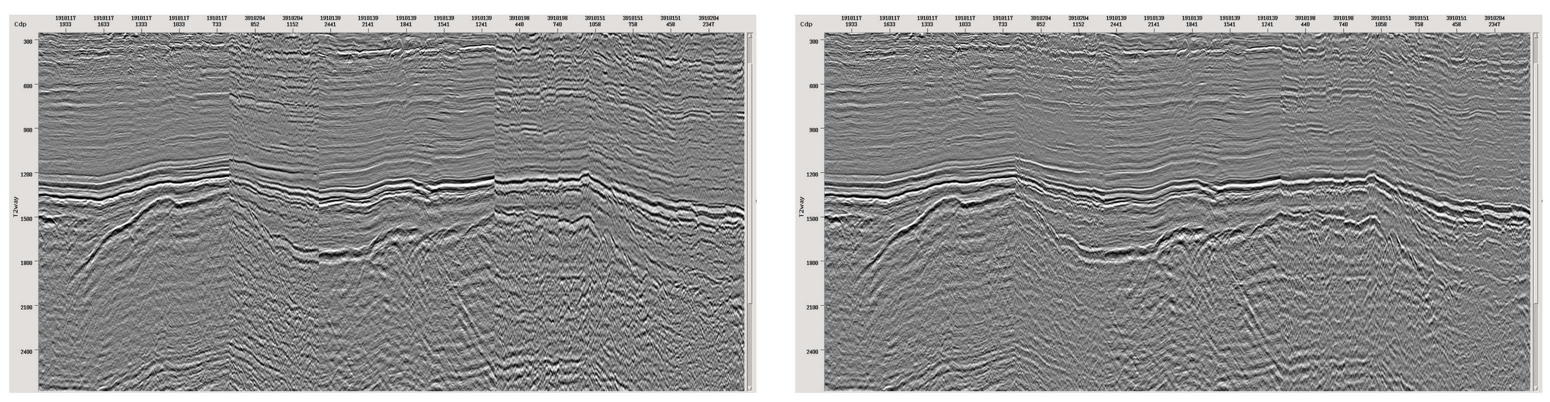

Figure 4. Oblique Line display before and after survey matching.

3D Structural Model

Each 2D line was subjected to analysis for establishing dip trend to create a dip model. The apparent model dips lie within the planes of their respective 2D lines, and are used to generate a continuous field of 2D horizons. This set of horizons provides the framework from which a set of 3D horizons are generated, forming the 3D geological model for the given data.

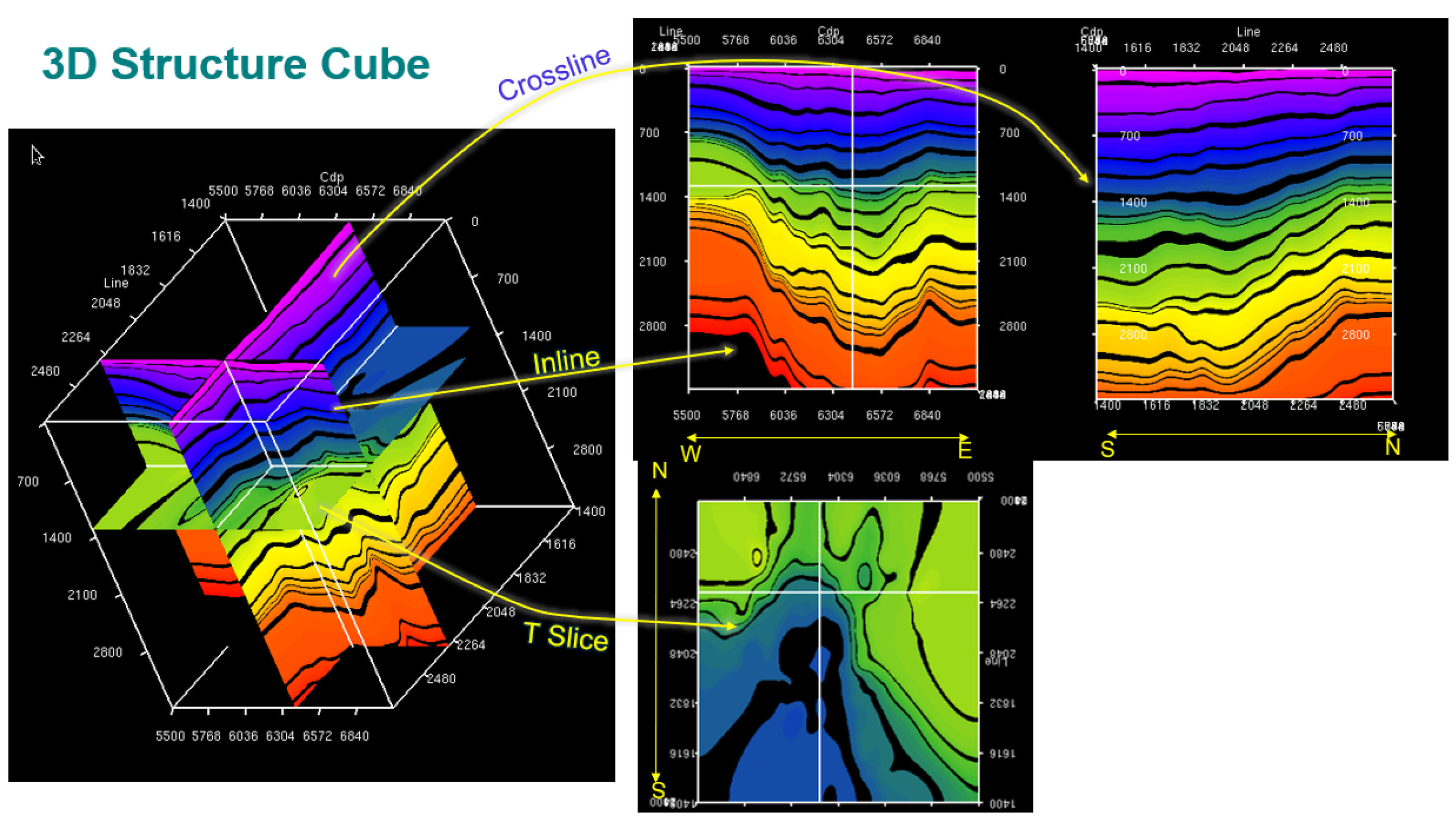

Figure 5. 3D Structural model

Interpolation and Migration

The 3D geological time model generated form previous step was used to guide the seismic interpolation. 2D input amplitudes from around the 3D output point (x,y,t) were drawn together along the 3D layers and then their individual contributions to the output point are identified and the weighted samples are summed together to form a new sample value.
The last step is poststack migration. A unified 3D velocity model is then needed. The velocity model was generated by passing the 2D velocities through a workflow similar to that used to generate the output seismic cube .

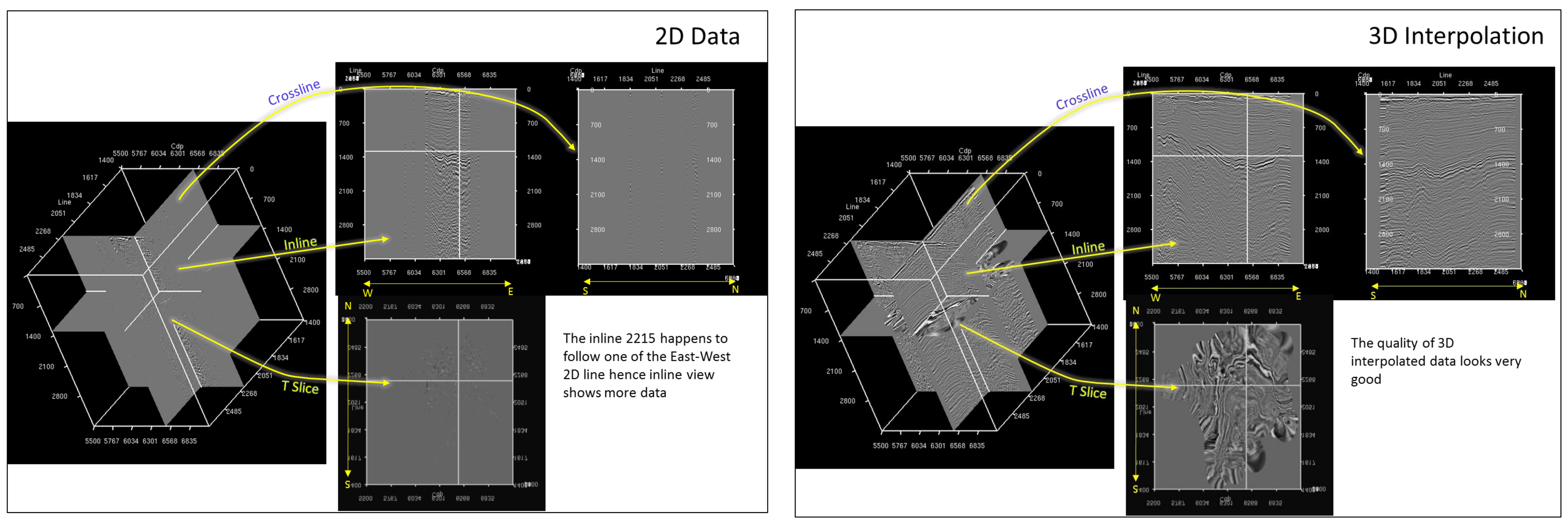

Figure 6. (Left) input 2D data binned into 3D grid and (Right) after interpolation

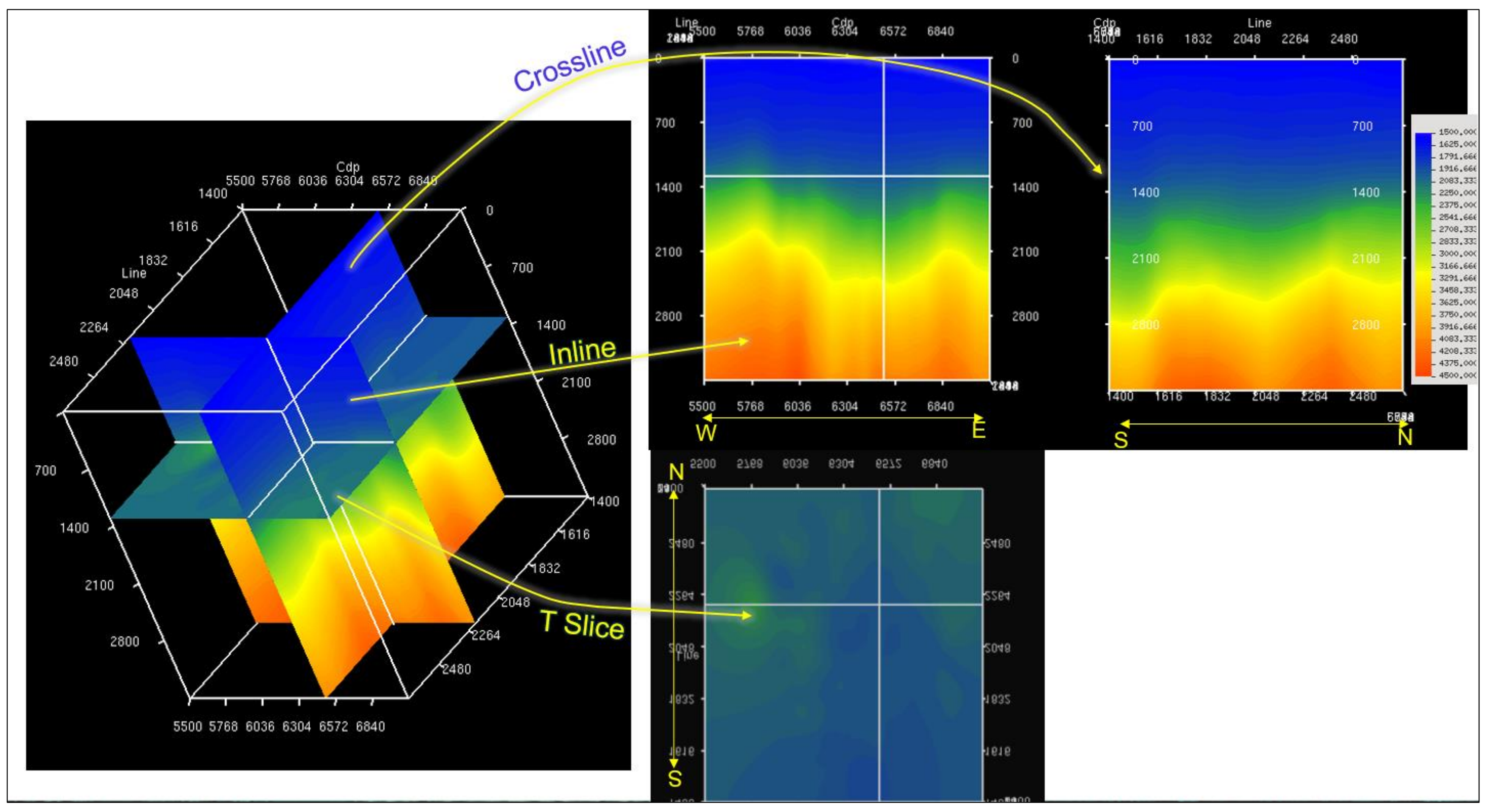

Figure 7. 3D Velocity model used in 3D poststack migration

Results

Project successfully produced a good quality 3D image from vintage data using TGS's proprietary 2D^{cubed} processing technology. There were significant improvement of seismic image with very good seismic continuity and a robust faults image. There was a good tie between geological events and better amplitude balance, which helped in efficient seismic interpretation work. Due to large distance interpolation there was some smearing of events and preferably not to use it in Quantitative Analysis.

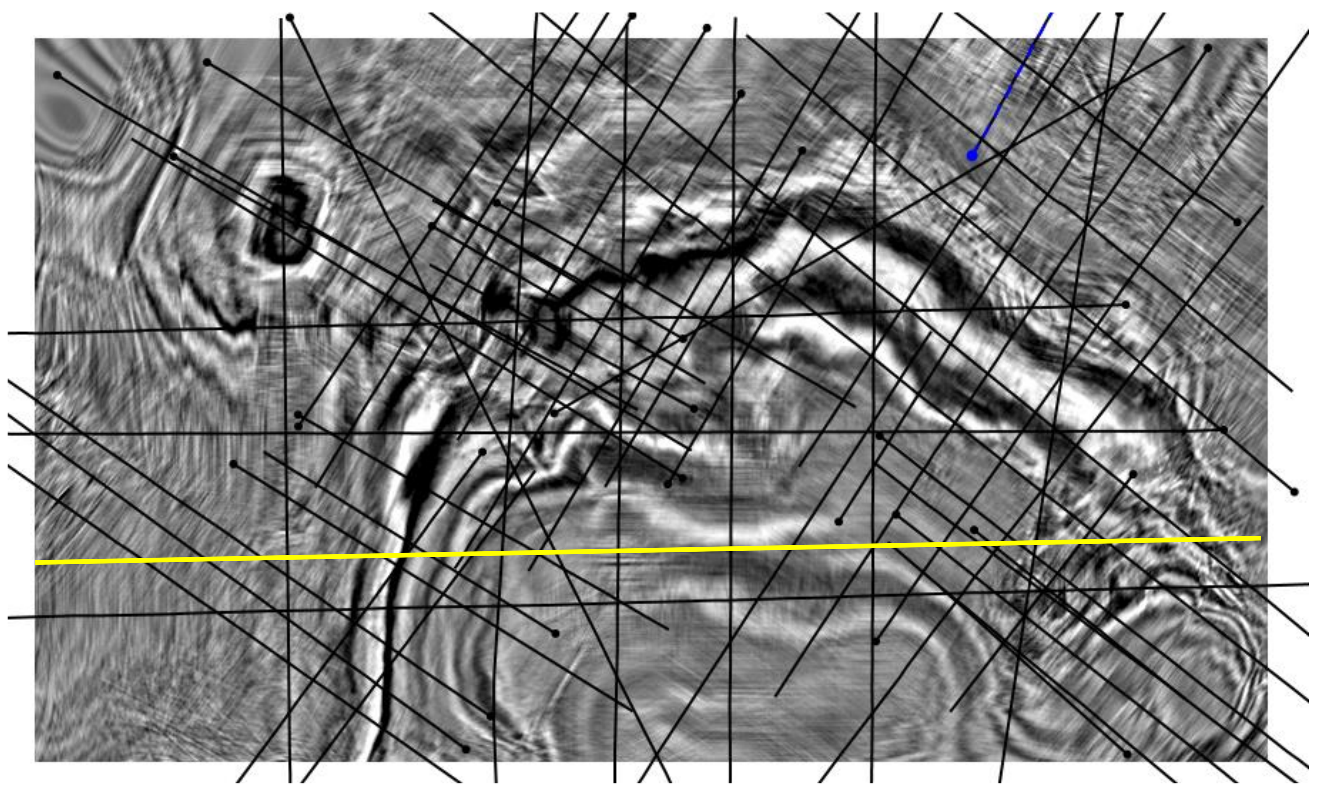

Figure 8. Time slice at 1350ms from 2D^{cubed} volume with Input 2D grid overlaid as black lines

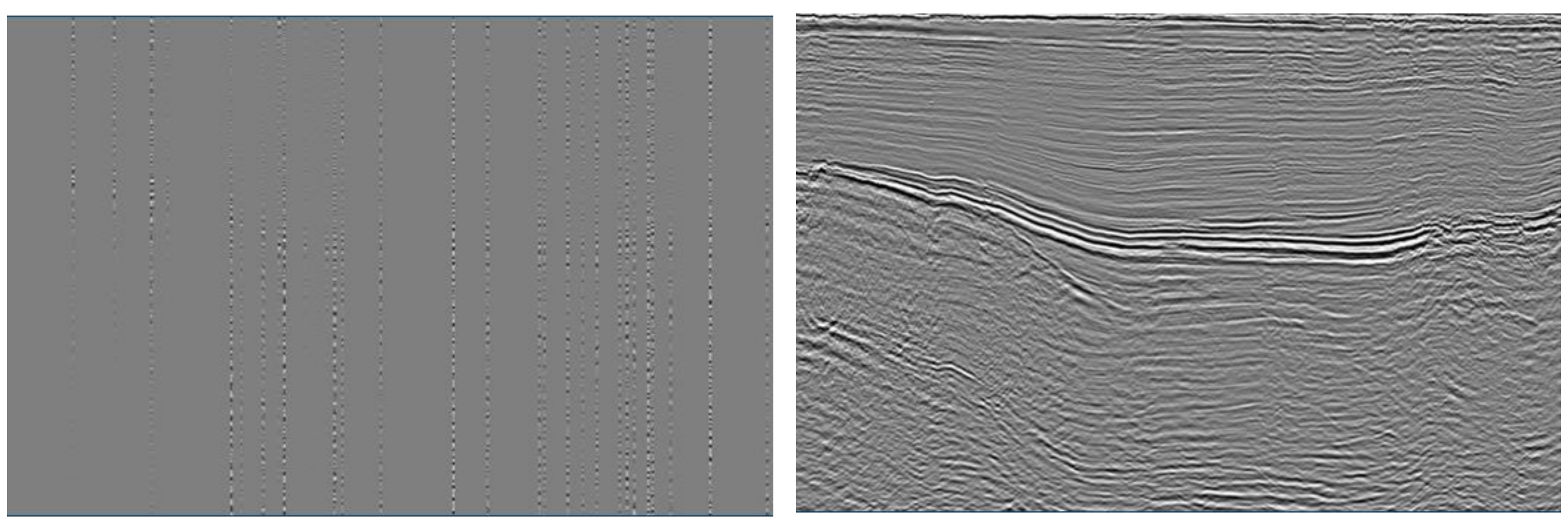

Figure 9. 3D Inline (along yellow line in figure 8) display (left) input 2D data (right) from 2D^{cubed} volume

Interpretation

Compare to the 2D seismic, the 2D^{cubed} gives more efficient time and effort in structural mapping, especially screening the structure. As on normal 3D seismic, tracking reflectors is easier than in 2D seismic. It leads to faster maps result and faster understanding of the structure. In complete structural mapping, the good tie, phase matching, and gain not only give better reflectors continuity but also give more robust discontinuity (faults). The fault pattern can be tracked from the slice even though the foot print is still exist that resulting an instant fault pattern with better confidence of the structure.

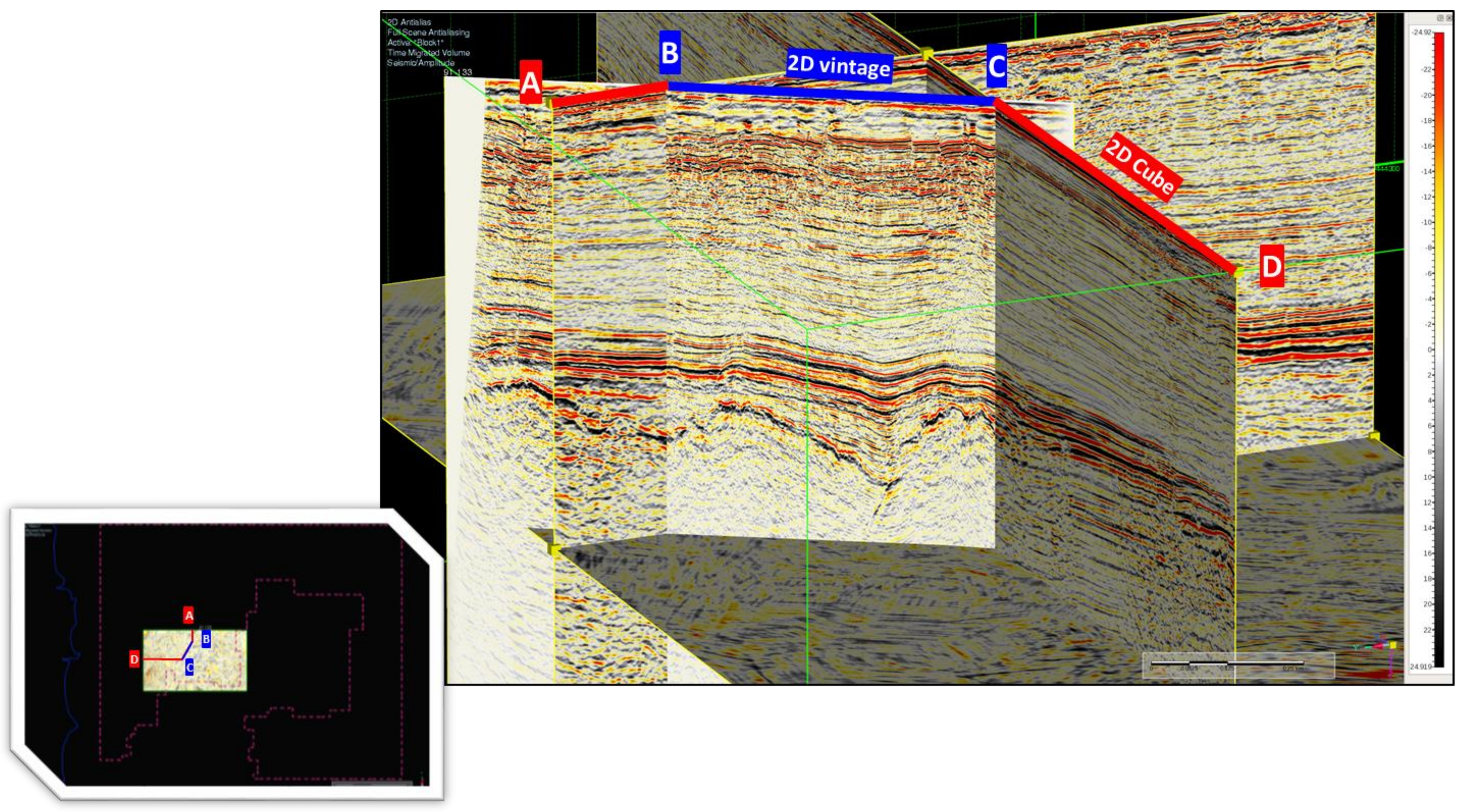

Figure 10. 3D display showing good correlation between existing 2D vintage data and output 2D^{cubed} data

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REFERENCES

Whiteside, W., B. Wang, H. Bondeson, and Z. Li, 2013, 3D imaging from 2D seismic data, an enhanced methodology: 83rd Annual International Meeting, SEG, Expanded Abstracts, 3618–3622,

O'Keefe, S., Ratnett, N., Woodburn, N., Pedersen, C., Bradbury, W., Guo, M., Whiteside, W. ,2017, The development and applicability of structurally conformable 2D to 3D interpolation: 87th Annual International Meeting, SEG, Expanded Abstracts, 2386–2390,