



Synkinematic Channel Depositional Architecture in Active Fold and Thrust Belt Revealed by 3D Seismic Visualization, Example from Deepwater South East Asia

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Summary

The details of the depositional architecture of slope channels in the deepwater Borneo, South East Asia have been resolved by 3D seismic visualization and quantitative seismic geomorphology analysis. The data shows a remarkable example of the pounded slope channel system deposited in an extremely active margin, adjacent to large river and delta systems. The Pliocene-Recent synkinematic depositional package was initially deposited in synclinal axis/topography low in an intra-slope basin above a regional shale unit equivalent to the late Miocene post-rift strata (Hutchison, 2004). The deformation contemporaneous with the regional collision of the Australian and Southeast Asian plates governed the incipient of thrust-fold belt propagation, which further controls the development of axial and transverse channel systems. The quantitative seismic geomorphology analysis shows a substantial trend variation, interpreted to be associated with the equilibrium profiles modification which strongly affects the parameters of the down flow channel evolution such as incision, avulsion, abandonment and channel overspill. Specific to this area, it shows how the underlying morphological modification could become a major factor in controlling accommodation space leading to the internal architecture complexity, presume the relative constant sediment budget from adjacent river system and degraded fold and thrust belt.

Introduction

The NW Borneo slope and trough, SE Asia, which lies about 85-170 km offshore from the island coastal line, represents a complex deformed fold and thrust belt, which evolved as an active margin starting from Eocene-Early Miocene (Hutchison, 2004). The margin has a net shortening rate of 4 cm/y (Rangin et al., 1999, Kreemer et al. 2000 in Ingram et al. 2004) and it is actively fed by a large siliciclastic influx from major river and delta systems. Along the slope margin, several distinct intra-slope basins have been identified with widths ranging from 3 to 25 km and depths ranging from 450 to 800 meters, mostly filled with Pliocene-Recent turbidite package deposited as a low stand bypass and valley canyon sequence (Hiscott, 2001).

A detailed study on the channel morphology focused on the variability in depositional architecture caused by tectonic activity has been done, expected to provide information related to channel form geometry. In this case, the internal characteristics of channels are expected to vary significantly, as a function of accommodation space availability.

Method

Seismic visualization is a key to success for this study. The selected seismic subset was investigated using a volume based seismic visualization tool (Paradigm VoxelGeo). The optical adjustment was then applied to the data subset by arranging the Gaussian shape threshold in the amplitude histogram, where the positive amplitude was set to 100 % transparent and the negative amplitude was rendered as approximately 60-100% opaque, enabling the interpreter to quickly highlight the channel geo-body and pick the channel surface to propagate it using a certain level of confidence (Figure-1).

Measurements of channel width, depth, gradient area profile and sinuosity were made on the interpreted channels (e.g. method by Pirmez et al., 2000, Gee and Gawthorpe, 2007), along the channels longitudinal profile every 200 m, where they can be observed in the most proximal area until the data subset extends. An estimated velocity ranging from 1900 m/s to 2100 m/s was used to convert the twtt in channel depth and thickness measurement. The morphometric trend variation was then observed and compared with the internal seismic character from an arbitrary vertical section to find any possible correlation between the curve trends with channel development stages (figure-2). The stacking from several transparent slices from the seismic volume (e.g Method by Worrel, 2001), enabled the interpreter to see the spatio-temporal channel evolution (horizon slices in Figure-3) and linked it with the tectono-stratigraphic history.

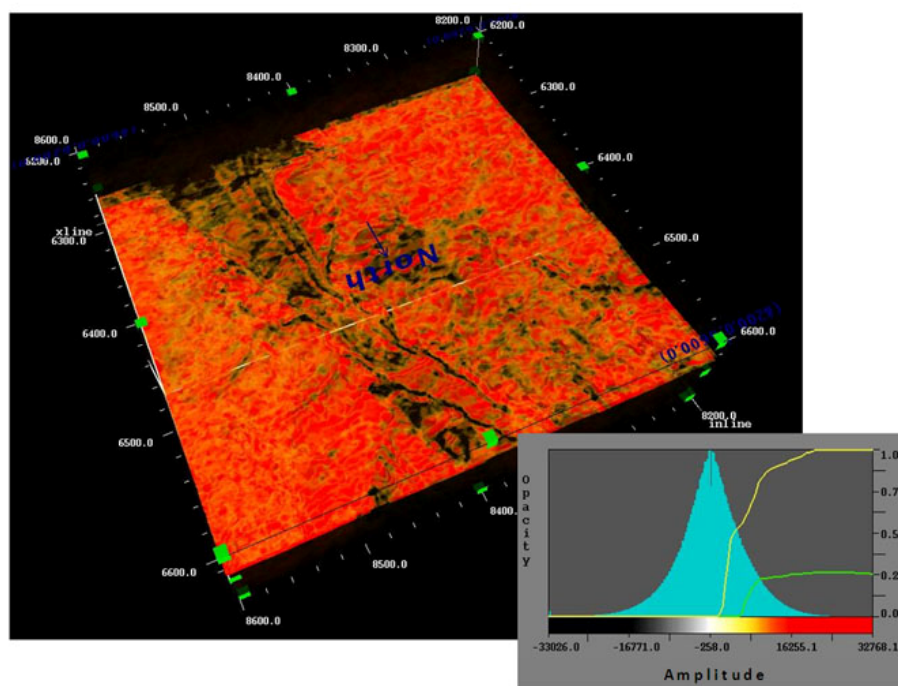


Figure 1. The optical adjustment in amplitude histogram to highlight the channel geobody.

Example

The sample data was taken from an intra-slope basin, NW Borneo. It was found that many extracted objects showed shapes that could confidently be interpreted as axial and transverse channel fills and its associated depositional elements (e.g. Posamentier and Kolla, 2003), such as levee, overbank complex, crevasse splay, and fan correlated to the lower unit of Pliocene-Recent synkinematic depositional system.

The package was initially deposited parallel to the synclinal axis in an intra-slope basin above the regional shale unit (RSU) equivalent to the late Miocene post-rift strata. The major axial channel trending Northeast-Southwest, shows moderate to high sinuosity, extending for a distance in excess of 200 km, with a gradient of 0.1-0.78⁰. The regional NW-SE compression initiated thrust-fold belt propagation which furthermore

created lateral movement in the synclinal axis, forcing the channel to laterally shift and avulse towards the Northwest. When the headwall uplift reaches the critical gradient (approximately 3.3^0 in this study) landslides were triggered, this further promoted the incision and canyon enlargement on the frontal slope which is considered an embryonic stage of transverse channel development.

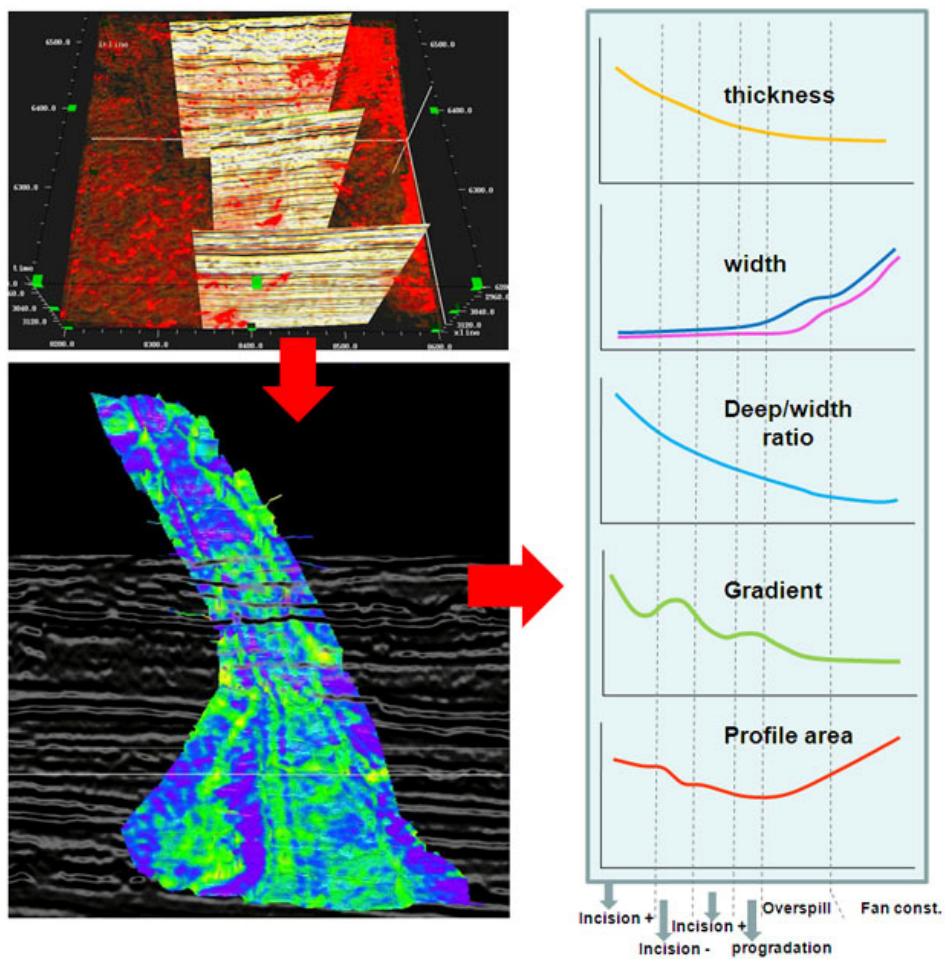


Figure 2. The surface propagation and morphometric trend analysis from longitudinal channel section.

Conclusions

The internal architecture complexity in the NW Borneo slope channel is derivative from the response of the accommodation space modification presumed by relative constant sediment budget from the adjacent river and delta system and degraded fold and thrust belt along the slope margin during the Pliocene-Recent period.

This case study shows how the seismic visualization method allows the rapid interpretation of highly irregular geobody and could be applied to other depositional models such as fan and lobes, slump, contourite deposits and mass transport complexes.

This knowledge also provides opportunity for more advanced applications such as to enhance the accuracy and confidence level in geo-modeling and reservoir connectivity analysis.

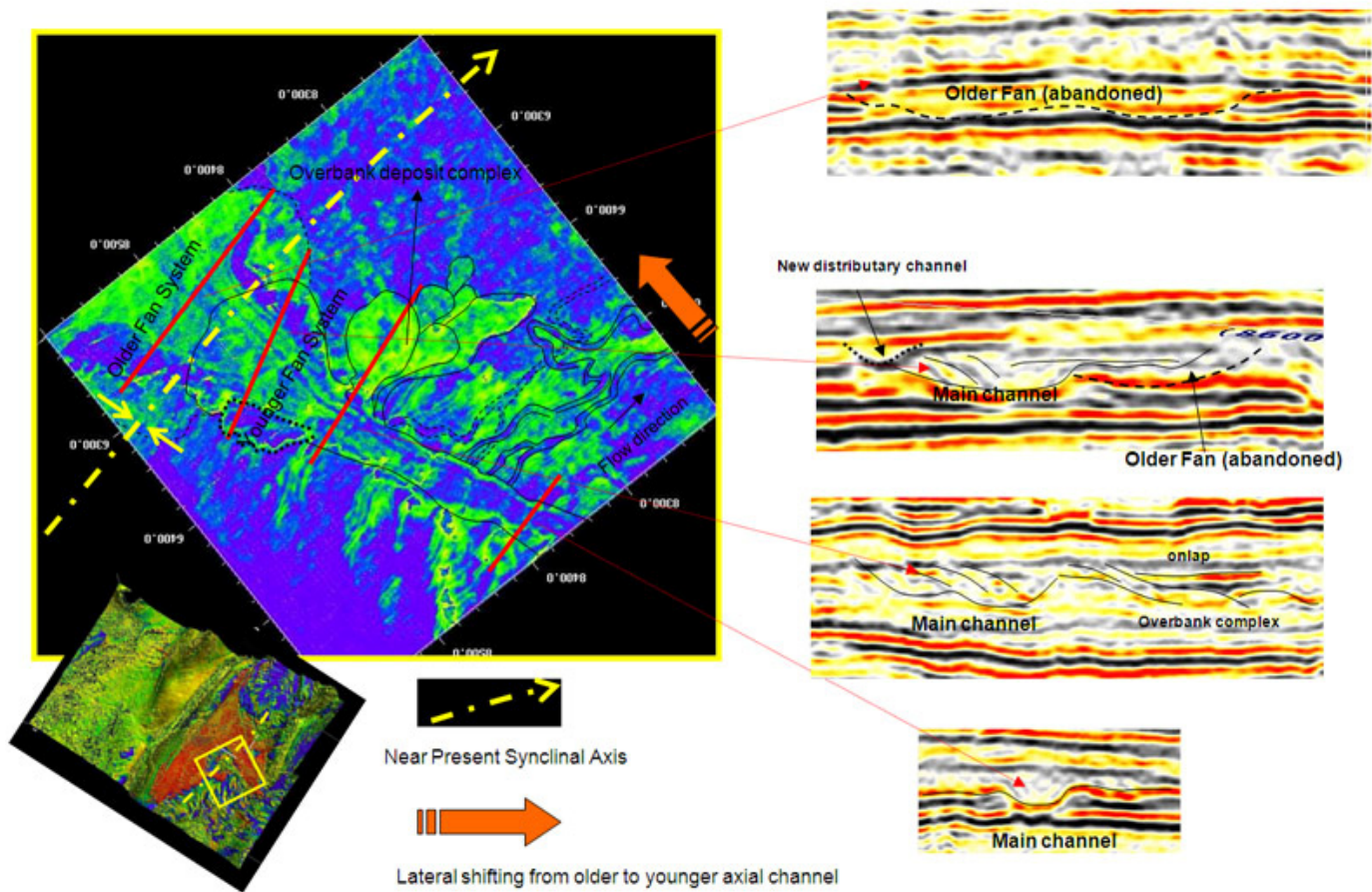


Figure 3. The depositional elements as interpreted from seismic section showing channel development stages in deformed intra-slope basin. The map shows a stack of several semi transparent horizontal slices.

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