Mass Transport Complex (MTC) control on the basin floor stratigraphic succession and sand deposition: An observation from deepwater Brunei

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INTRODUCTION

Mass transport complexes (MTCs) are one of major geological features observed in many deepwater provinces, including in Deepwater Brunei, where MTCs are commonly initiated and deposited on the slope and basin floor settings. MTCs are broadly characterised on the basis of their internal characteristics and external morphological features. Posamentier (2004) offered a simple observational guideline for describing MTCs: 1) the underlying surfaces of MTCs usually are extensively scoured in a form of deep and linear grooves 2) the MTCs' overlying surface is mostly irregular - hummocky relief bounded laterally by gentle to steep flanks 3) MTCs often have transparent to chaotic seismic reflections, amalgamation of MTCs stacks is not uncommon, and 4) MTCs could have a morphology of channel or lobes.

This guideline was utilised in describing the recent Brunei Mega MTC (i.e. McGilvery, *et al.*, 2004) though in much larger scale. This paper uses the same set of guideline to describe older MTCs observed in study area. We will also attempt to investigate MTCs' control on the overall basin floor stratigraphic succession and, in particular, sandstone deposition as it appears to be one of the key factors in delivering potential sands further into the basin floor.

METHOD AND WORKFLOW

Nearly 5,000 km^2 of 3D seismic data is available within the study area, all of which have been re-processed to enhance the seismic imaging. The reprocessed data reveals significant increase in imaging quality, which allows highly confident horizon interpretation and also enables reliable seismic attribute extraction work. Detailed interpretations were conducted on the zones of interest that is bound by the top horizon, referred here as the Blue Horizon, which lies approximately 300-600ms below the seafloor. One well was drilled within the study area. Despite it has only basic log data at the zones of interest, the well provides a good tie and a direct calibration for all geological features observed on the seismic.

Once the subsurface mapping was finished, proportional horizon slices were then applied and interpolated in between the horizons. We tried to extract several seismic attribute types from the proportional horizon slices, namely RMS amplitude, relative acoustic impedance, reflection strength and sweetness. Sweetness is a function of dividing reflection strength by the square root of instantaneous frequency. This mathematical definition captures qualitative attribute relationships, traditionally applied for isolated sand bodies in shale dominated successions; however, the density contrast of the lithologies within the MTCs appears to be shown distinctively by sweetness.

MASS TRANSPORT COMPLEXES

An analogue was taken from the recent Brunei Mega mass transport complex (MTC) described in details by McGilvery, *et al.* (2004) and Gee, *et al.* (2006). The MTC is a seismically chaotic and generally low amplitude body that extends for 120 km from the Baram Canyon head. The MTC base is irregular and truncates underlying reflections and the overlying surface is characterized by subdued topography.

Our observation on recent seabed also suggests multiple MTC systems within the deepwater Brunei, where it is uniquely bounded by two shelves and slopes, albeit the Luconia System is a less active system compared to the Baram System (Figure 1). These mega MTCs consist of slumps and debrites that indicate sediment gravity flows transported from the shelf/slope; the recent penecontemporaneous turbidite lobes which appear to have been restricted, suggesting the MTC control on the turbidite depositional lobes (Figure 1).

The Blue Horizon mass transport complexes consist of 3 distinguishable, stacked up MTCs of various thicknesses. The gross package appears to be thinning towards the inboard structural high. Each MTC shows distinctive similarities, they have chaotic seismic facies, generally low amplitude forming slumps and becomes significantly brighter toward the edge of the lobate body. The lobe extends ~ 80km from the same Baram Canyon head. Low angle thrust faults and pressure ridges are very apparent at the MTC termination in the basin floor environment (Figure 2a).

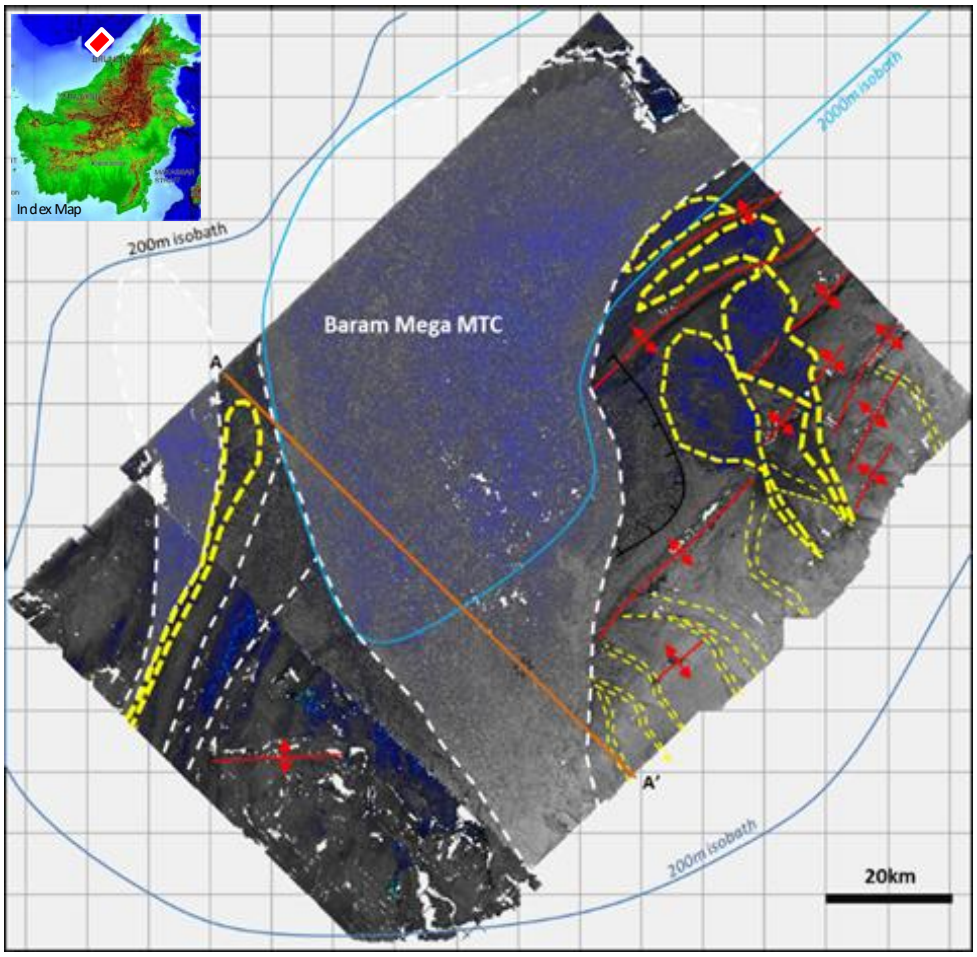


Figure 1. *RMS amplitude extraction on recent mass transport complex (MTC) system in Deepwater Brunei shows the influence of two shelves/slopes systems with penecon-temporaneous turbidite constrained by the MTCs.*

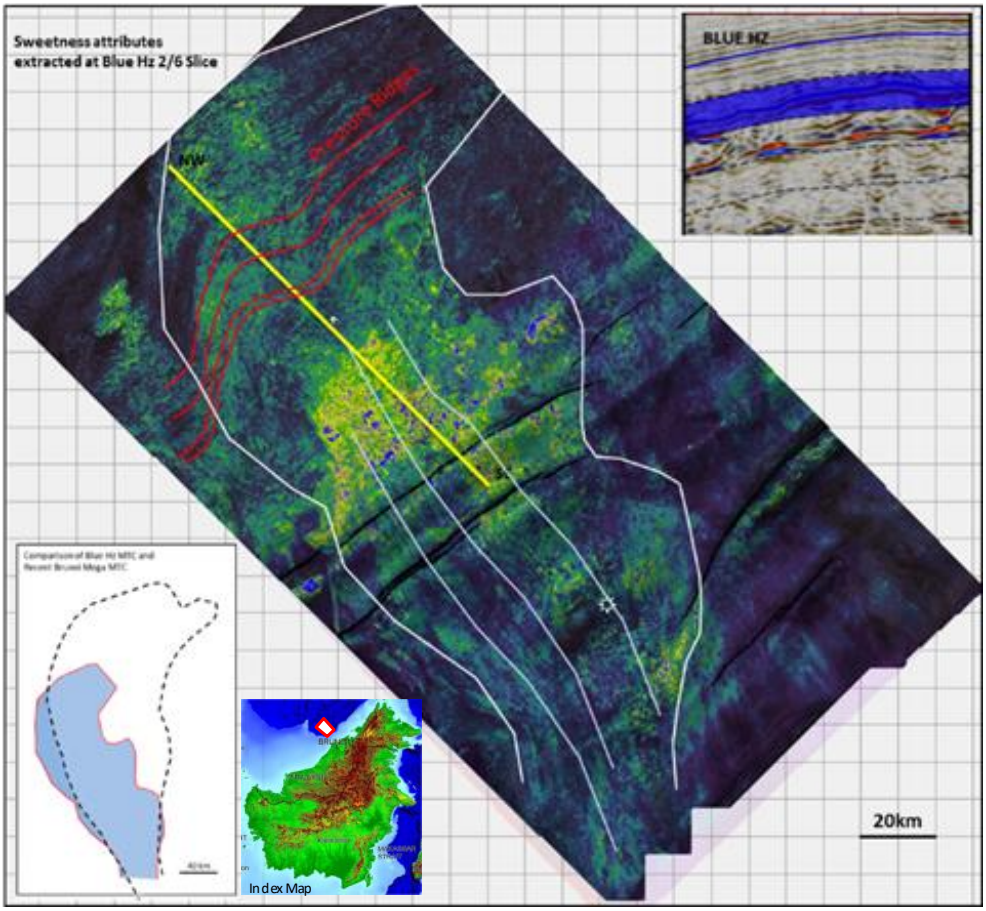


Figure 2a. *Sweetness extraction of the Blue Hz MTCs. The lobate form extends approximately 80km from the Baram Canyon to the South. Pressure ridges and low angle thrust faults are evident from the extraction which characterise this Blue MTCs. The red star indicates location of an exploratory well drilled in the study area.*

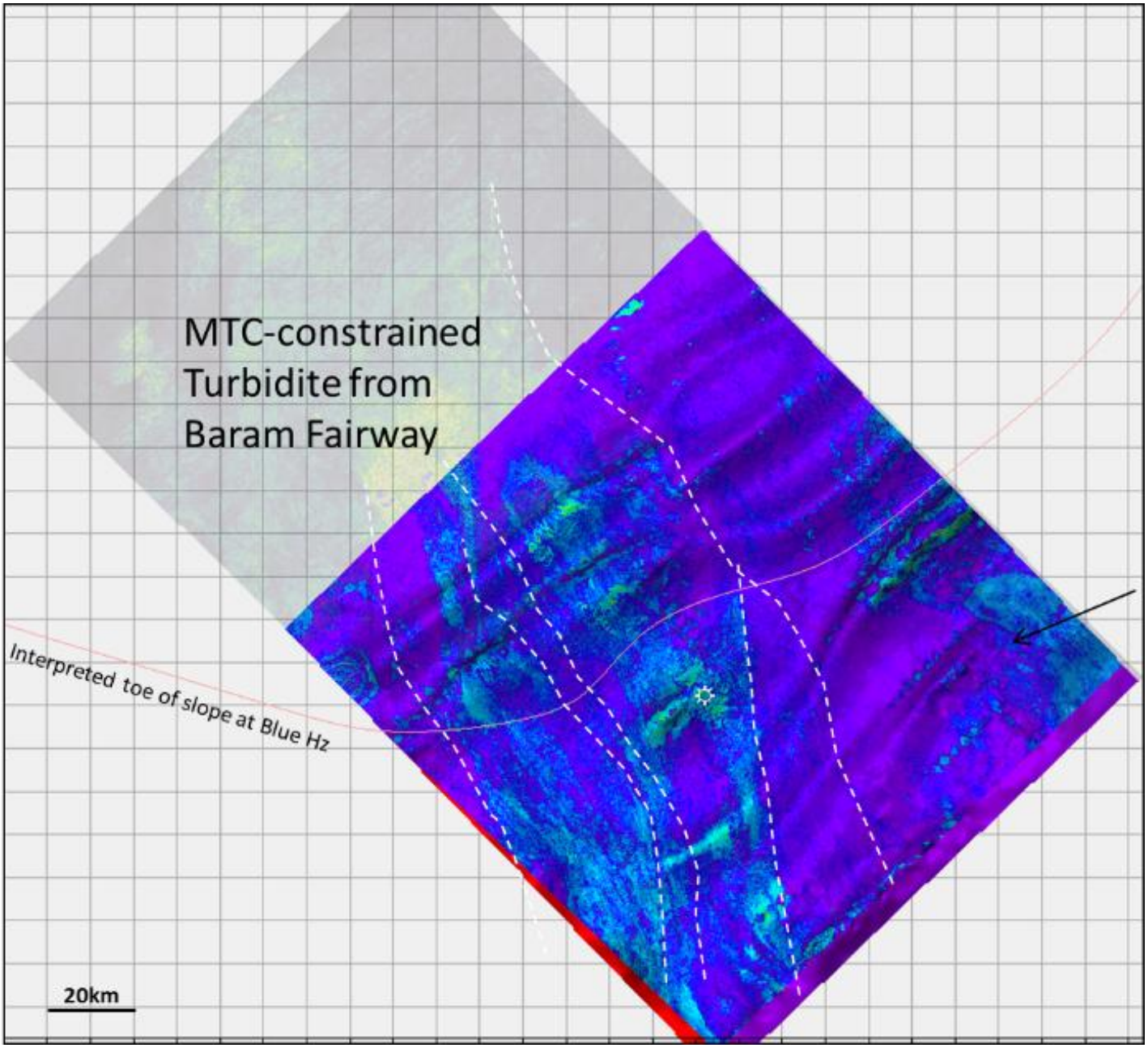


Figure 2b. *RMS extraction at the overlying sediment above Blue Horizon MTC calibrated by an exploratory well shows sand distribution toward the basin floor. The dispersal appears to be controlled by the underlying MTC.*

The size of this Blue Horizon MTCs is smaller than the current Brunei Mega MTC, probably due to the more quiescence tectonic prior to Pleistocene thrusting and folding. Nevertheless, the size is significant enough to influence the basin floor geometry.

INTERACTION OF MTCs – OVERLYING SEDIMENTS

A well was drilled within the study area and it penetrated 8m sand sitting on top of the Blue Horizon MTCs. Sweetness extraction on the sand revealed a distribution that follows the underlying Blue Horizon MTC's linear striation inboard and the sand becomes unconstrained toward the basin floor. The sand dispersal has NW-SE direction which is the direction of the underlying Blue Horizon MTCs (Figure 2b).

It is postulated that the sand's preferential depositional route is controlled by the underlying MTC's irregular surface. In deeper stratigraphic level, a similar sand deposition might have occurred as well, but it could have been eroded off by the subsequent MTC. Some sands might remain "sandwiched" in between these MTCs and it will be difficult to distinguish from the MTC rafted blocks which could be sandy (Figure 3).

SUMMARY AND DISCUSSIONS

The study area provides a calibrated MTC-controlled sand deposition in Deepwater Brunei and reveals the importance of the Baram Canyon

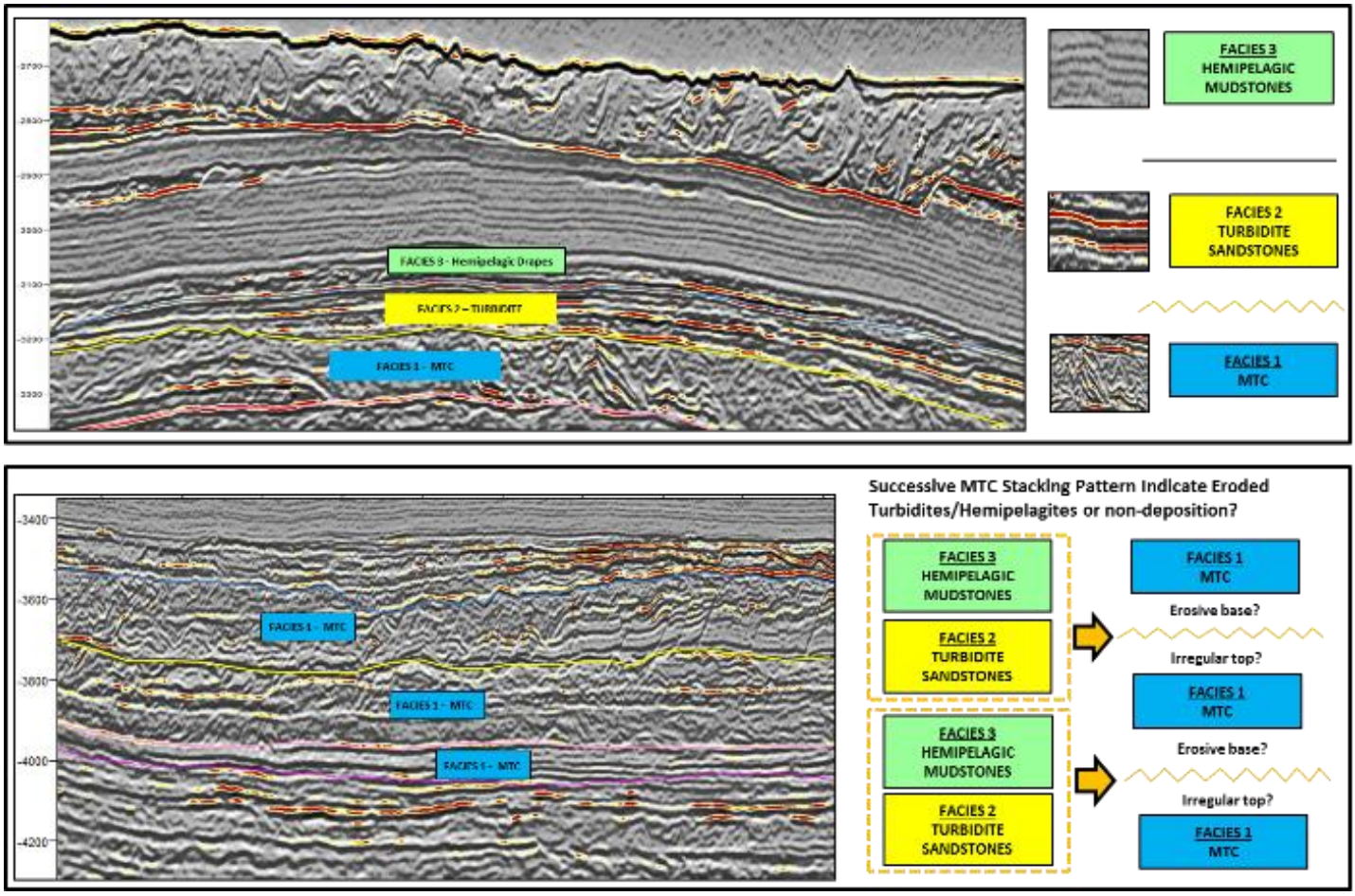


Figure 3. *Ideal basin floor stratigraphic successions of MTC, sandy turbidite and hemipelagite (top) in contrast with other successions of stacked MTCs.*

for the sediment dispersal. It appears that MTC provides preferential pathways for the overlying sand deposition through its irregular surface although not always distin Lithofacies A1 is made up of thick, highly guishable.

In one complete sediment cycle, there is a strong indication that MTC is overlain by turbidite which could be sandy and hemipelagites. This model is used to devise the succession of MTC stacks where the subsequent MTCs could erode off the whole turbidite and the hemipelagites, however, there will be some remnants of these turbidites though will not form a classical lobes or fan geometry. The key is to have detailed maps of various MTC facies that could have different influences on the sand terminal lobes.

Some questions remain unanswered such as major mechanisms for the MTCs emplacement (e.g. earthquake, methane degassing, pore water pressure), why some MTCs eroded off the tip of the anticline and some are gently draping over, and temporal and spatial relationship between MTC and sandstone turbidites. This study is expected to open up further detailed studies and to help understand and model sand deposition in this MTCs dominated environment.

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