Turbidite outcrops as analogs for deep-water reservoirs
A Case from NW Borneo

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Deep-water reservoirs around Borneo are currently an important target for hydrocarbon exploration. Data used to evaluate potential reservoir geometries and quality include quantitative reservoir models from outcrop analogs.

A reservoir-scale evaluation of a Middle Miocene turbidite outcrop in Brunei Darussalam (Figure 1) with respect to offshore reservoirs, indicates that (a) the larger basin architecture, (b) the stratigraphic framework, and (c) the depositional environment of the outcrop differ significantly from those of the prospective Late Miocene/Pliocene deep-water targets (Table 1).

A detailed sedimentary log of the outcrop (Figure 2) shows sand-dominated intervals (7-22m; 27-36m) separated by shale units up to 5 m thick. The sandstones are generally medium to fine-grained and well-sorted; individual beds are between 2 cm and 1.3 m thick. Most sandstones are characterized by sharp bases with loading structures, a structureless basal unit followed by parallel-laminated sands and a rippled (symmetrical and asymmetrical) unit at the top. Climbing ripples and convolute bedding occur locally. The succession of sedimentary structures matches the basal units of the Bouma sequence and suggests turbidity current deposition. The scarcity of trace fossils may be related to harsh living conditions in an environment characterized by very rapid sedimentation.

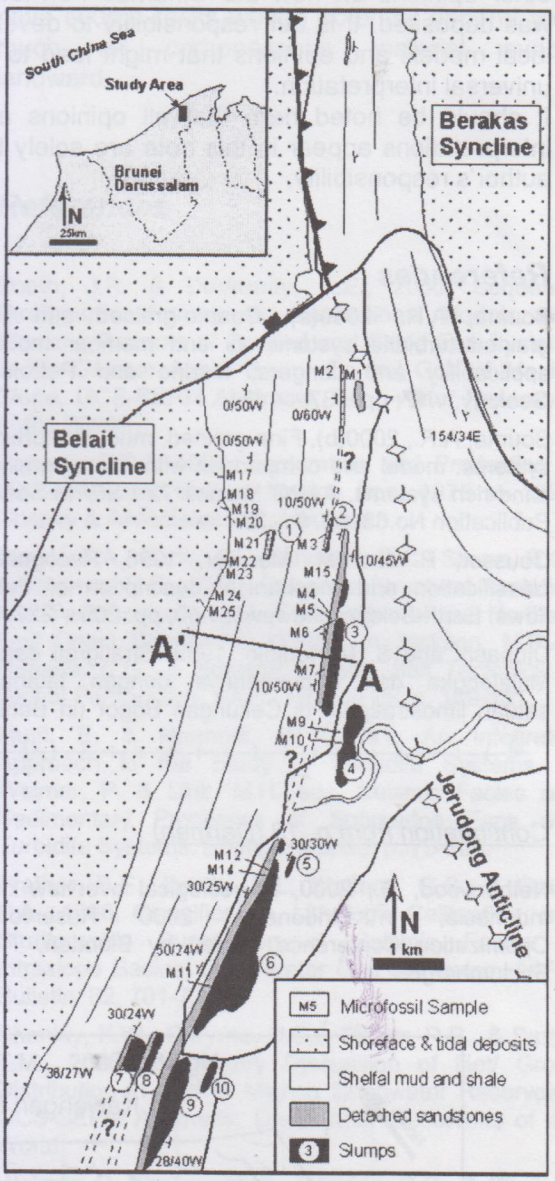


Figure 1: Geological map of the western flank of the Jerudong Anticline, Brunei Darussalam. Studied turbidite outcrop at location 3 (microfossil samples 4, 5, 6).

	Margin setting	Tectonic activity	Distance from source to sediment [km]	Slope gradient [m/km]	Source/sediment delivered	Water-depth of accumulation [m]
Outcrop	Ramp margin	inactive	~ 10	3 - 5	Point source: fluvial/deltaic	<50
Offshore	Growth-fault margin seaward of shelf break	active	20 to >100	5 - 40	Point source/ multiple source: full range of shelf/ slope deposits	> 200

Table 1: Setting of outcrop and offshore turbidites

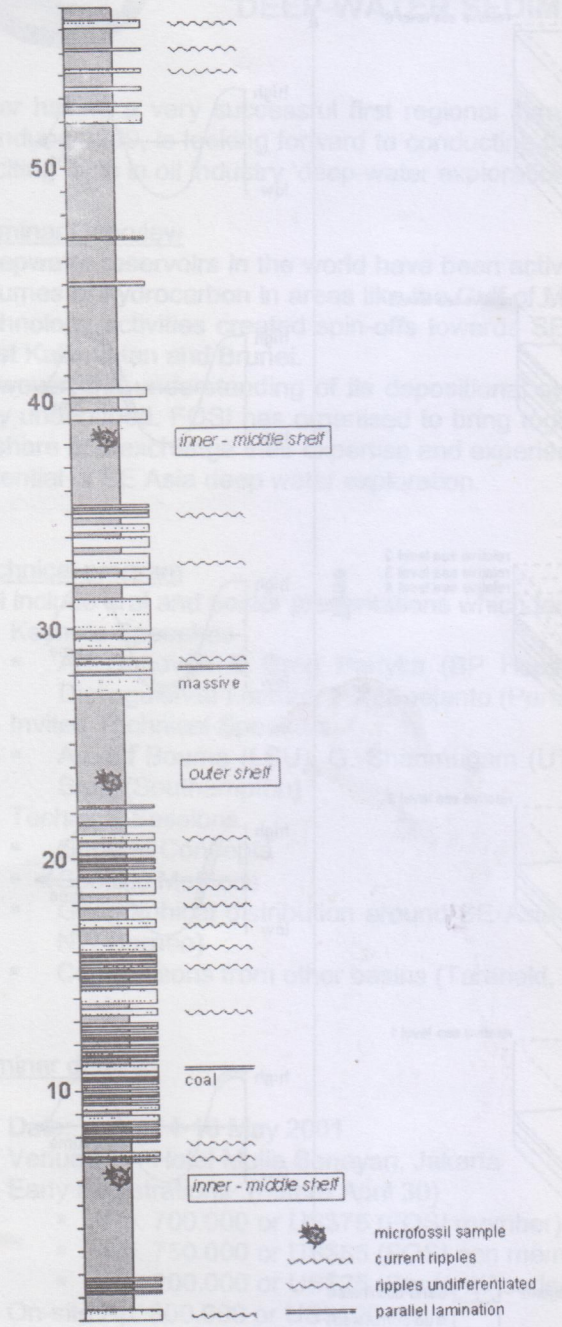


Figure 2: Detailed sedimentary log of the turbidite outcrop.

Foraminiferal assemblages in the interbedded shales are dominated by agglutinating foraminifera indicative of an open marine shelf setting. Planktonic foraminifera are absent. Palynological analyses show moderately rich spores, occasional mangrove, back-mangrove, freshwater swamp and super-abundant palm pollen indicating proximity to a coast.
The association of relatively shallow water microfossil assemblages with turbidites suggests sedimentation in a delta-front setting. A delta-front or prodelta interpretation is supported by the striking abundance of palm pollen, indicating a nearby fluvial feeder system.

Figure 3 is a depositional model of the greater study area based on outcrop information along cross-section A-A' (see Figure 1). The development of detached lowstands (offshore sands) a few kilometers basinward of a deltaic feeder system is typical of a ramp-margin setting (Plint 1988).
The lateral and vertical scale of the section, as well as the stratigraphy, match that of a progradational shelf delta. In contrast, the structural and stratigraphic style of the Upper Miocene to Pliocene units offshore Brunei Darussalam is dominated by major deltaic growth faults on the shelf, and deltaic toe thrusts on the continental slope, with turbidites occuring seaward of the shelf break.
Thus, key factors controlling turbidite architecture and internal character such as basin scale, margin morphology (slope angle/length), and rate, type and source of sediment supply differ significantly from those of the outcropping succession (Table 1). This suggests that the Middle Miocene turbidites have limited value as offshore reservoir analogs.

References

Plint, A.G., 1988: Sharp based shoreface sequences and "offshore bars" in the Cardium Formation of Alberta; their relationship to relative changes in sea level: in Wilgus, C.K., et al., eds., Sea-level changes: an integrated approach: Society of Economic Paleontologists and Mineralogists Special Publication 42, p. 357-370..

Figure 3 on the next page

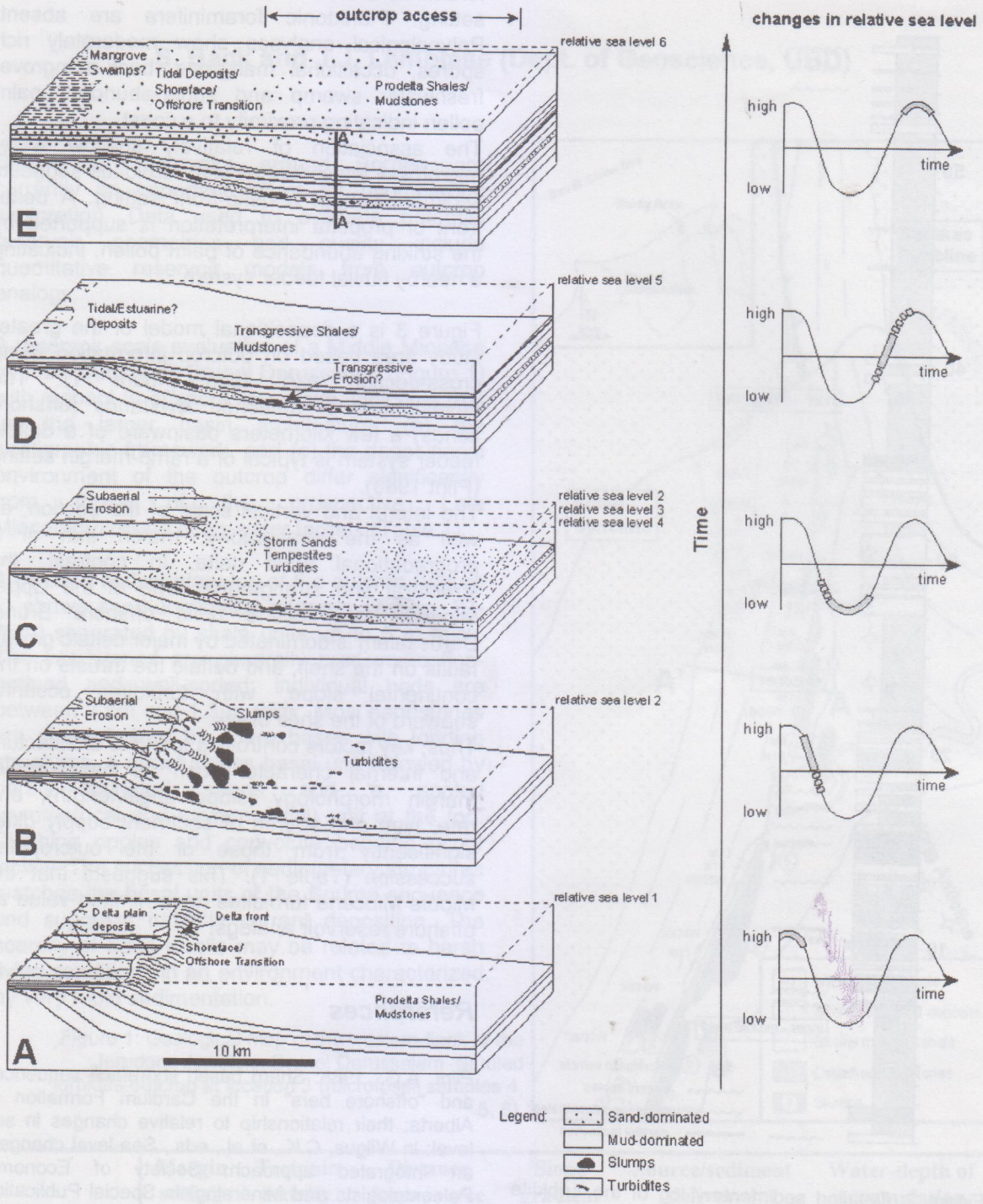


Figure 3: Depositional model related to changes of sea level: (A) Sedimentation during initial highstand systems tract. (B) Slumping during sea-level fall and slump accumulation in a forced regressive/lowstand systems tract. (C) Development of thin sands (storm sands, tempestites, turbidites). (D) Localized erosion of thin sands and subsequent accumulation of prodelta shales. (E) Rapid delta progradation during final highstand. Location of section A-A' see Figure 1.