Turbidite Plays of Indonesia: An overview

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In the last decade significant advances in geologic understanding and exploration technology in Indonesia continue to reduce the risks associated with exploration and development in turbidite plays. New plays are defined based on recently acquired seismic and well data. Turbidite is becoming a very important play in Sumatra, Kalimantan, Java, and Irian.

This paper will give a summary of the latest development on the geological concepts of the deep-water successions in Indonesia based on exploration data.

North Sumatra

Turbidite exploration activities in Sumatra were focussed on the north Aceh Basin (Figure 1). This basin is an extension of the Sumatra back arc system and towards the north it becomes part of the Andaman Basin. Maximum sediment thickness is about 15,000 ft.

A mounded, hummocky package of high amplitude seismic reflectors has been interpreted as a sand-prone lowstand basin floor deposit (Nuraini et al., 1999). North-south trending seismic lines across the basin floor mound (Figure 2) show several coalescing lobes of deposition. The sediment lobes filled the lows between previous fans and generally migrate northward to the lower areas.

Trapping mechanism becomes the major risk for this basin floor deposit of North Sumatra, as there are no structural closures (Nuraini et al., 1999) and stratigraphic trap becomes the main potential in this area.

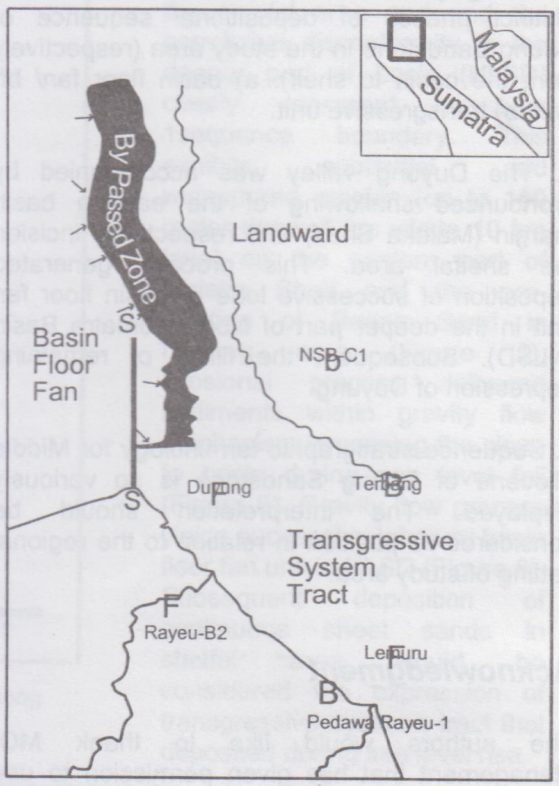


Figure 1: North Aceh Basin location map

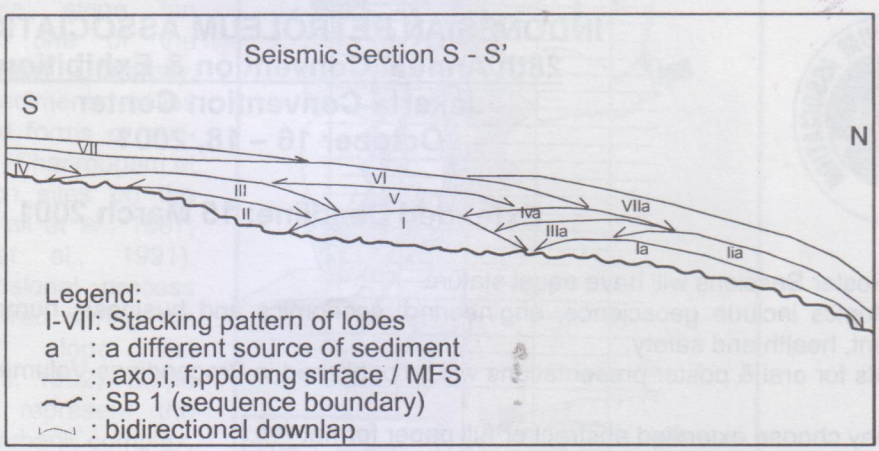


Figure 2: Cartoon of north-south trending seismic lines across the basin floor mound show several coalescing lobes of deposition.

East Kalimantan

Offshore Kutai Basin

Unocal's exploration targets in deep-water Mahakam are Pliocene and Miocene slope channels and base-of-slope fans besides the Miocene shelf-edge reefs (Figure 3). The Merah Besar-1 well (November 1996) was the first commercial deep-water discovery in East Kalimantan, confirming gas pay in Pliocene deep-water sandstones. Significant oil discovery at Seno Prospect (West Seno-2) tested >10,000 BOPD, is a further confirmation of the validity and potential of this emerging exploration play (Lumadyo, 1998).

Core studies from West Seno field shows that most of the sands appear to have been deposited in a middle to upper slope environment in a series of aggrading channel-levee complexes during lowstand periods of sea level (Saller et al, 2000). Sands are dominantly fine to very fine-grained and poorly to very poorly sorted. Bed thickness ranges from less than 1 mm to approximately 6 feet. Reservoir characteristics are practically related to depositional facies. These reservoir sands have been classified as on Table 1.

Based on geochemical work on numerous hydrocarbon and kerogen samples bothe Peters et al (2000) and Dunham et al. (2000) concluded that terrestrial organic matter is the main source for oil and gas accumulations discovered in the deep-water Kutai Basin. Organic matter consists of plant leaves, plant fragments and coal fragments are found in well rock samples. This material is clearly derived from terrestrial sources, and was subsequently transported into the deep-water basin by turbidity currents. The same turbidites that carry sand also carry the terrestrial organic matter into the basin. Specifically, terrestrial organic matters were concentrated in the upper fine-tails of turbidite deposits. The organic matter is not disseminated within the turbidite; rather, the kerogen becomes concentrated into laminae that can reach up to 15% TOC (Dunham et al, 2000). Though the resin and plant fragments making up the oil-prone source material are often in the coarse to very-coarse sand-size range (1 to 2+ mm), the low density of this material leads to the particles having the hydraulic equivalent of silt-size quartz (Dunham et al, 2000). As a result, the organic matter specifically concentrates in the silt and mud-rich fraction of the turbidite deposit

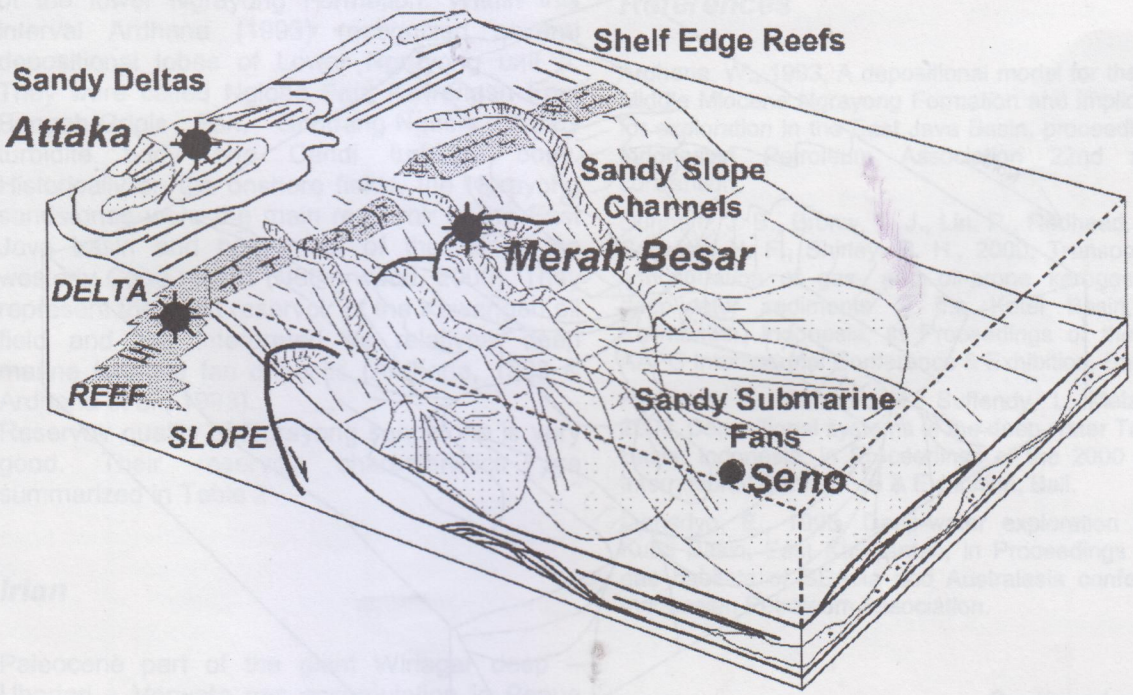


Figure 3: Depositional model of deep-water Mahakam (Lumadyo, 1998)

Facies	Dominant Characteristics	Average Porosity	Average Permeability
Channel fill/splay deposit	Massive sandstone	29.3 %	630 mD
Proximal levee	Horizontal current laminated sandstone	26.6 %	301 mD
Distal levee	Rippled sandstone	24.8 %	147 mD

Table 1: Reservoir properties of deep-water Mahakam (Saller et al., 2000)

Tarakan Basin

Tarakan Basin is located northward of the Kutai Basin and share similar provenance, tectonic and sea level changes as the Kutai Basin. This basin constitutes a passive continental margin with Late Eocene-Recent sediments overlying on continental to oceanic crust, deposited during the Middle-Late Eocene opening of the Sulawesi Sea. Rifting ceased during the early Oligocene with quiet marine conditions prevailing until the Middle Miocene uplift of the Kalimantan hinterland. The latter uplift triggered a massive influx of turbidites in the deep-water area, deposited as unconfined toe of slope fans ahead of the outbuilding Tarakan delta. During Plio-Pleistocene delta outbuilding, this sequence was buried by rapidly prograding slope deposits, which triggered gravity-driven toe thrusting (Figure 3). Small basins were formed between thrust ridges and filled by slope deposits. In the southern part of the delta, westward dipping normal faults limited progradation, resulting in excessive thickening of the Pliocene-Pleistocene deltaic sequences and limiting sediment influx into the deep-water area (Hemmes et al., 2000). Several potential reservoir systems have been recognized in the deep-water area. These include 1) unconfined toe of slope fans, 2) confined intra-slope fans, and 3) intra-slope channel (-levee) systems (Hemmes et al., 2000). Understanding about the charging system of this region is limited and there is only one well drilled so far (Bougainville-1 in 2000).

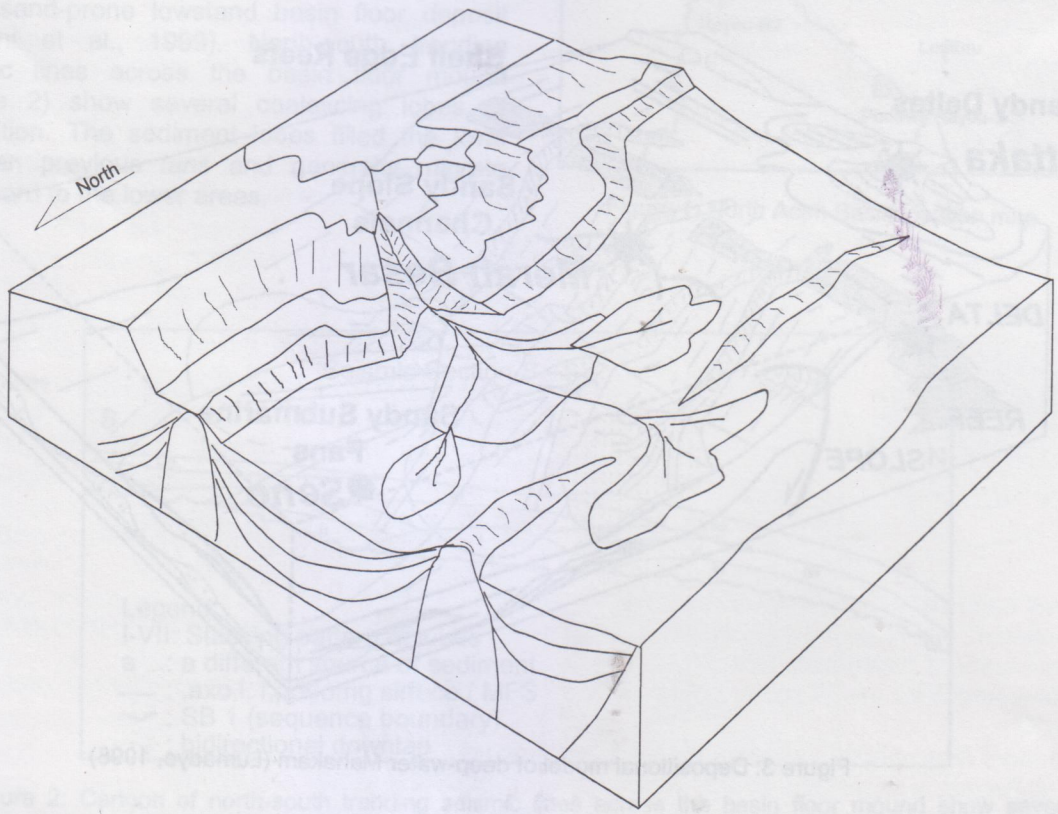


Figure 4: Depositional model of Tarakan deep-water system

Ngrayong Unit	Depositional setting Characteristics	Porosity (%)	Permeability (mD)
Unit I -Lower Ngrayong	Shelf to upper slope; massive sandstone	24-40	1000 - 7080 mD
Unit II - Lower Ngrayong	Deep marine, slope to basinal; sand and shale interbeds.	8.2 – 27.3	0.15 – 193 mD
Unit III - Upper Ngayong	Inner neritic to bathyal; Rippled sandstone	17-20	270 – 350 mD

Table 2: Reservoir properties of deep-water East Java Basin (Ardhana, 1993)

East Java

In the west of East Java Basin, Tuban formation rapidly deposited during late Oligocene to early Miocene, i.e. on the stage II or sag (Ardhana, 1993). This shale-dominated interval fills subsiding depressions and becomes strong source rock candidate for most of oil and gas in the western part of the basin although this is not yet proven (Netherwood, 2000).

From the early to middle Miocene, Ngrayong turbidite sandstones were deposited in the southern portion of the basin during compressional fault block rotation, uplift and erosion. Figure 4 shows the depositional model of the lower Ngrayong Formation. Within this interval Ardhana (1993) recognized several depositional lobes of Lower Ngrayong unit II. They were called Nglobo Fan, Kawengan Fan, Bungoh-Grigis Fan, Gondang-Ngasin Sandy turbidite body and Candi turbidite body. Historically on the onshore fields, the Ngrayong sandstones were the main reservoir in the East Java basin and host most of the oil in the westerly Cepu region (Netherwood, 2000). They represent the main reservoir of the Kawengan oil field and are interpreted as relatively deep marine turbidite fan deposits (Ardhana, 1993 & Ardhana et al., 1993).

Reservoir quality of Ngrayong sandstone is very good. Their reservoir characteristics are summarized in Table 2.

Irian

Paleocene part of the giant Wiriagar deep – Ubadari – Vorwata gas accumulation in Papua (Irian) consists of turbidites (Netherwood, 2000). However, information on reservoir characteristics are hardly available from publications.

Conclusion

Turbidite plays occur in Sumatra, Kalimantan, Java and Papua (Irian). These turbidite reservoirs show good reservoir characteristics with relatively high porosity and permeability. Charging systems are not well understood however since there are only limited wells penetrating the source rocks. Stratigraphic trapping mechanism is common and very important in turbidite plays, although the risk is considered high.

References

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