Seismic expression of shelf breaks: Examples from Borneo/Kalimantan basins

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Introduction

Shelf break is a physiographic province in a basin defined by a change in dip from the shelf (dipping less than 1:1000 landward of the shelf edge) to the slope (dipping more than 1:40 seaward of the shelf edge (Figure. 1; Van Wagoner et al 1990). Vanney & Stanley (1983) described it is a point of the first major change in gradient at the outermost edge of the shelf, and its depth, distance from shore and configuration are highly variable. The shelf break is a distinct, critical interface of continental margins, which delineates the major physiographic boundary between two major submarine provinces, shelf and slope.

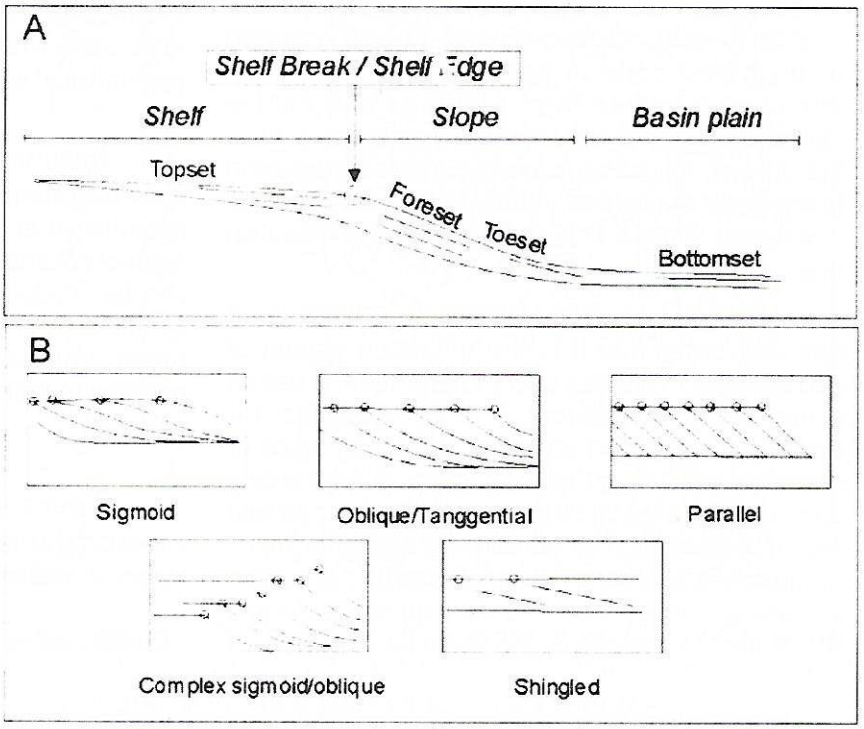


Figure. 1. A) Depositional sequence comprises topset strata at the shelf, foreset and toeset at the slope and bottomset strata at the basin plain. Shelf break or shelf edge is a point where the strata dip change from the shelf to the slope. B) Clinoform types after

On seismic, shelf break features are recorded as a change of reflectors dipping. They are strongly associated with clinoforms, which is a sloping depositional surface commonly associated with strata prograding into deeper water (Mitchum, 1977). The clinoforms are composed of consistently dipping profiles, bounded by flatter surfaces such as topsets, bottomsets, toplap surfaces or downlap surfaces. Clinoforms record the migration of sloping system into deep water. They may be categorized by their shape as sigmoid, tangential, parallel, complex and shingled (Figure. 1). These features may have some relation to the predominant grain sized of the prograding system or the energy level of the system (Sangree & Widmier, 1977), or the progressive change in accommodation space.

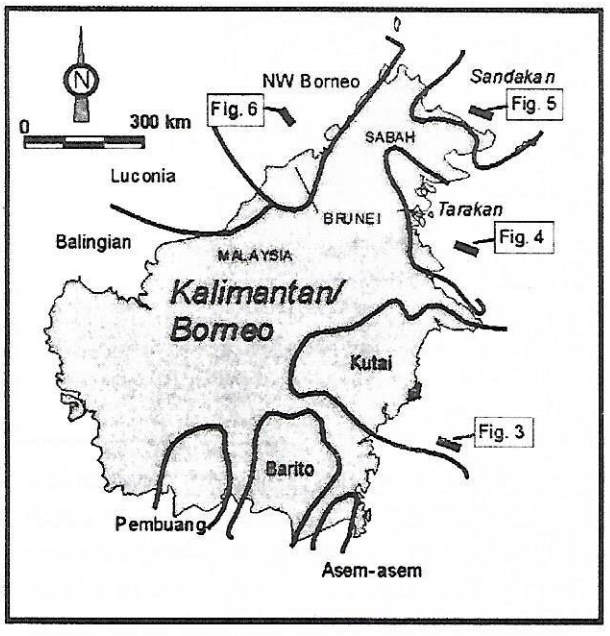


Figure. 2 Borneo basins and location map of the seismic sections

Clinoform features and accordingly shelf breaks are expressed well in some seismic sections in the Tertiary basins surrounding Borneo or Kalimantan Island. Some seismic examples are taken from offshore Kutai, Tarakan, Sandakan, and NW Borneo basins (Figure. 2). The depositional environments of the clastic system of these basins range from fluvial to deepwater environment.

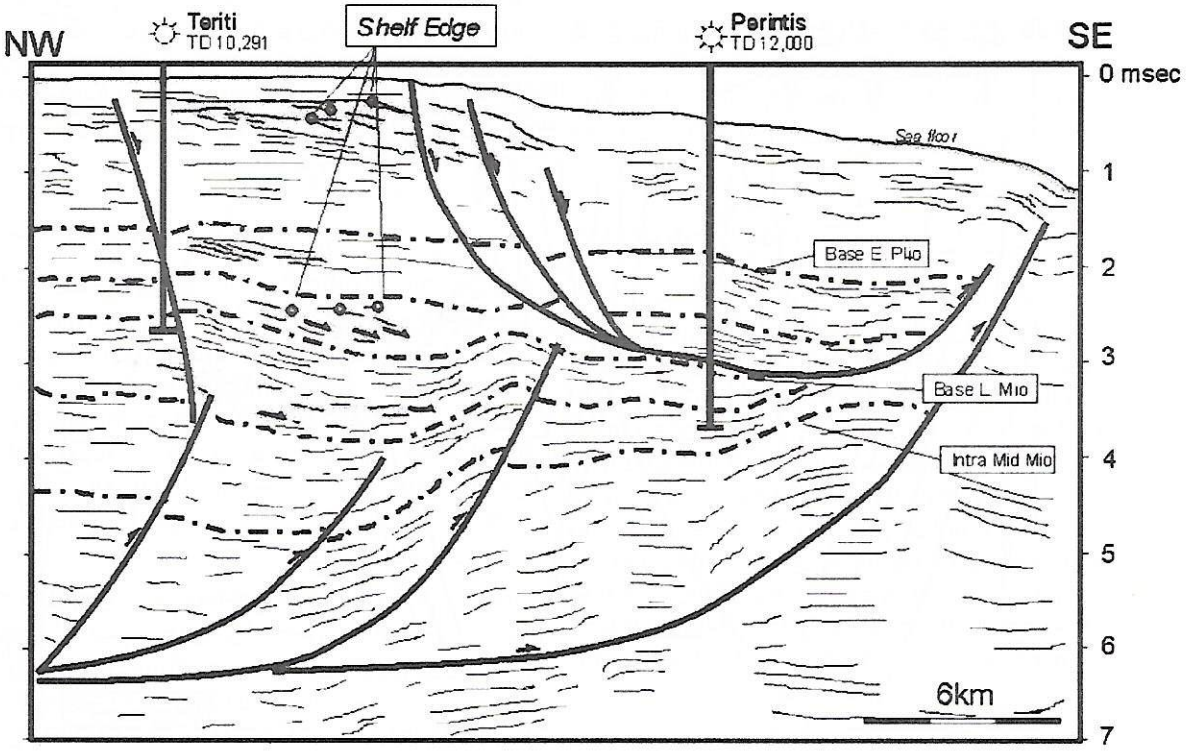


Figure. 3 Sequence stratigraphic interpretation of Mid-Late Miocene lowstand sands in the Makassar strait, offshore Kutai Basin. The lowstand deepwater sands comprise prospective reservoirs (from Malecek & Lunt, 1995)

Kutai-Mahakam Basin

Malecek & Lunt (1995) discussed about sequence Stratigraphic interpretation of Mid-Late Miocene lowstand sands in the Makassar Strait, offshore Kutai Basin. The lowstand deepwater sands comprise prospective reservoirs. These sands were supplied by the Mahakam Delta highstand system, originally from deltaic deposited which were reworked or displaced basinward during lowstand. Depositional patterns and correlation on the slope and basin plain have been modified by regional compressional folding and faulting, which are most evident in the Middle Miocene and older sections. These areas were also deformed by growth faulting and shale diapirism in much of the Late Miocene and younger section (Figure. 3).

Interpretation results indicate that major lowstand influxes occurred within the upper Middle Miocene to lower Miocene interval. A time when eustatic curves also indicate a major second order lowstand event. The shelf breaks occur in some stratigraphic interval, showing consistent sediment supply directions, which came from NW to SE. These features also occur only between Teriti and Perintis well, which shows limited lateral variation of depositional setting through time of these particular intervals. The shelf breaks of the intervals in between probably occur in the NW of this section, in a more proximal setting.

The unconformity surface at approximately 10.5 Ma (Base Late Miocene) associated with this lowstand shows distinctive seismic truncation and onlap, and a blocky gamma ray character occurs at the base of the sands base on well data.

Tarakan Basin

The Tarakan Basin in the NE part of Borneo was initiated simultaneously with the formation of the Sulawesi sea by rifting of north and west Sulawesi from east Kalimantan between the Middle to Late Eocene and the end of the Early Miocene on east hading en-echelon block faults. The thick clastic fill in the Tarakan Basin is an amalgamation of numerous Plio-Pleistocene clastic depocentres located below Bunyu and Tarakan Islands and prograding further offshore. The Pliocene thins regionally to the west and shouth, onlapping Miocene highs and eventually pinching out.

A regional seismic line included in Lentini and Darman (1996) shows the typical expression of the extensional regime and the north-south fault system (Figure. 4A). Deltaic progradation to the east and force

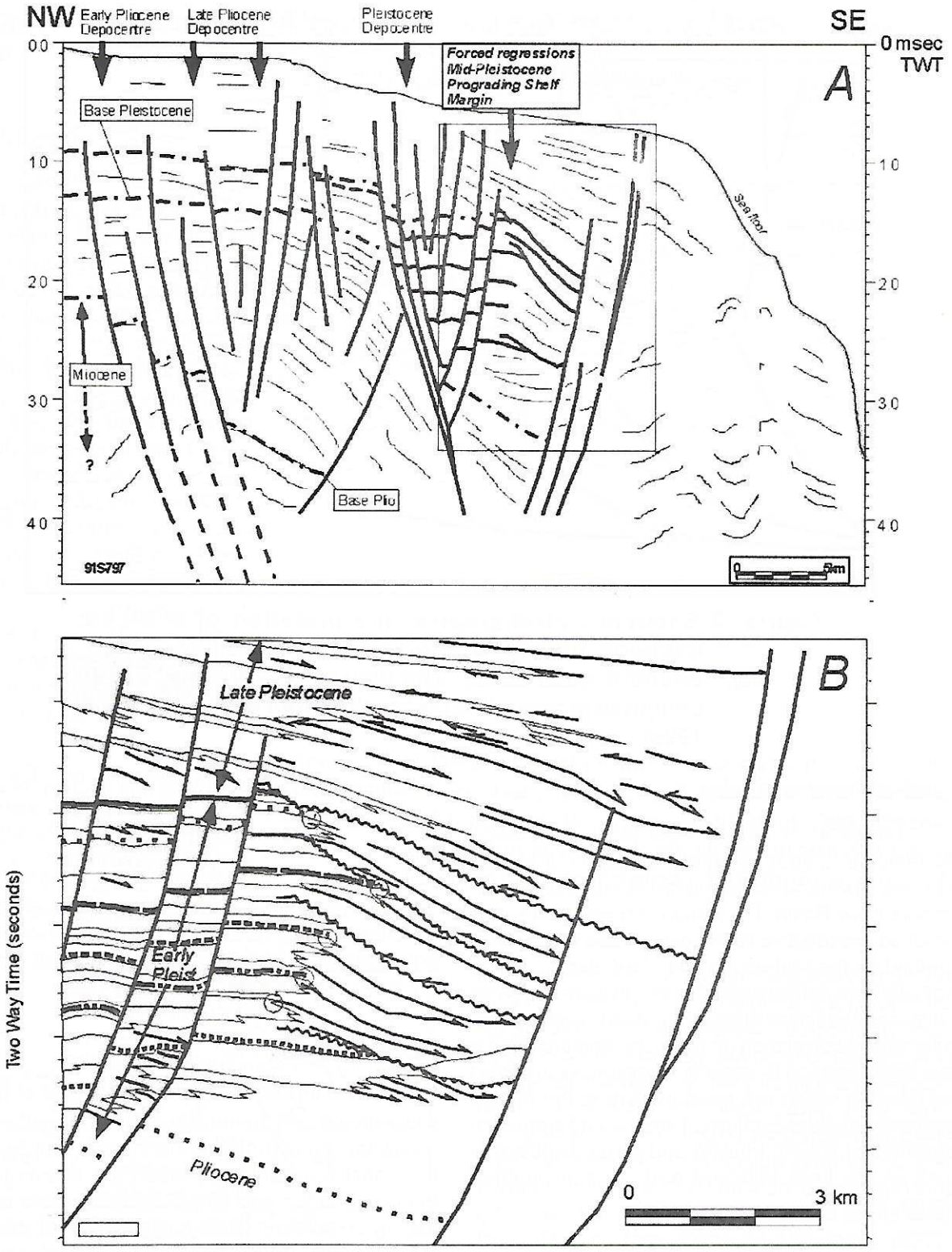


Figure. 4 A) A regional seismic line shows the typical expression of the extensional regime and the north-south fault system; B) A close up of figure 4A, showing deltaic progradation to the east and force regression during drops in sea level to get deposition of reservoir fan down dip of existing well control (Lentini and Darman, 1996)

regression during drops in sea level to get deposition of reservoir fan down dip of existing well control. Seismic suggests forced regressions have caused deposition of deltaic reservoirs fan downdip in present day deep water (Figure. 4B).

Sandakan Basin

The Sandakan Basin is located in the northern part of Kalimantan Island, filled mainly with Miocene-Pliocene age fluvio-deltaic sedimentary rocks up to 15 km thick. In figure. 5, the section shows three chrono-stratigraphic unit , each bounded by Type1 third order sequence boundaries. When combined, these three units make up a 2nd order event with an age rang of about 17Ma.

Each unit comprises one or more third order sequences. A sequence boundary within each unit can be readily recognized seismically by a strong flat event on the shelf changing abruptly by a pronounced shelf edge (circled) to an oblique clinoform and then flattening again towards the basin plain (deep water setting in the SE).

Various seismic facies can also be observed on this section. They include hummocky, discontinuous reflectors (in Unit 2 and lower Unit3), parallel continuous reflectors (in all three units), mounded with internal parallel reflectors (in upper Unit 3); oblique clinoforms with associated chaotic reflectors (in Unit 1 and lower Unit 3); and parallel to gently mounded reflectors at toes of clinoforms (mainly in Unit 1 & 2). Seismic reflectors terminations include onlaps in Unit 1 & lower Unit 3 and toplaps in Unit 2 (Wong, 1993, Figure. 5).

NW Borneo Basin

Interesting seismic section showing shelf break in the western part of Brunei was published in Van Rensbergen & Morley (2000, Fig. 6). The 3D seismic through the Late Miocene Perdana depocentres shows apparent downlap on a high-amplitude event. The sediment transport direction is from SE to NW. In a detail post-stack migrated section, the high-amplitude events cross-cutting the prodelta reflection. The positions of the shelf breaks are almost in the same depth range, suggesting rapid sedimentation and subsidence. Base on the location of the shelf-break points, the sediments in the west are deposited in the deep-water environment.

Conclusion

Identifying shelf break is very important in understanding the depositional environment as it is the point where shallow water setting change to deep water environment. Once the change of the depositional environment identified, the sediment supply and subsidence of the basin can be reconstructed. Shelf break points are normally obvious

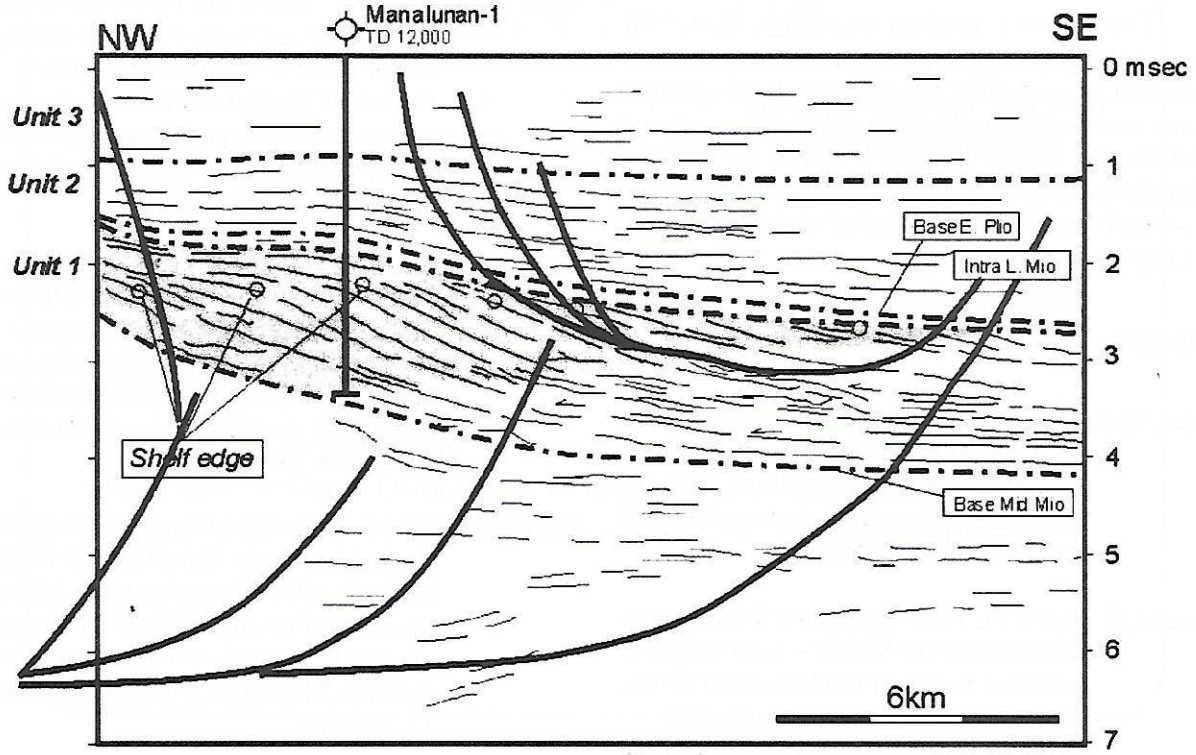


Figure. 5 A seismic section of Sandakan basin showing the stratigraphic units and shelf edges (from Wong, R. 1993)

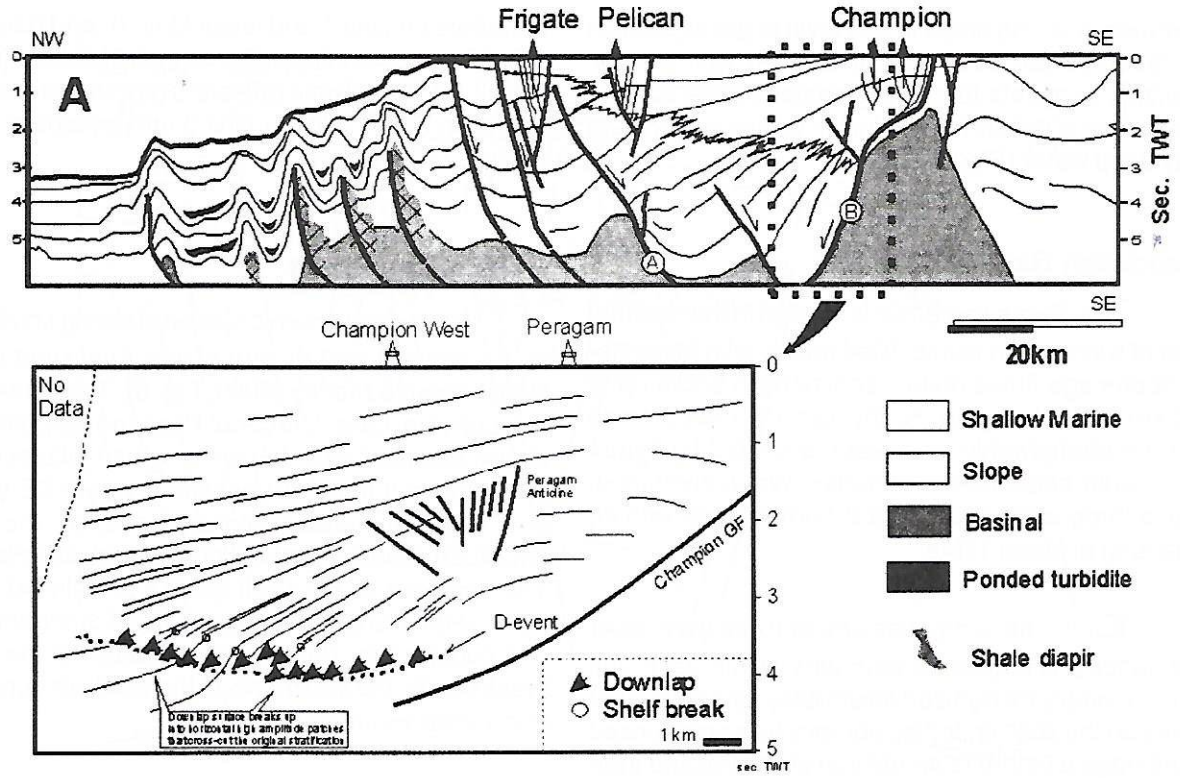


Figure. 6 Schematic cross section of the Champion system (see Fig. 2 for location) and a detail section the Late Miocene Perdana depocentre. Note the apparent downlap on a high-amplitude event (D-event) and the downlap surface (D-event) breaks up into horizontal high-amplitude patches that cross-cut the original stratification.

enough to be identified as shown in the seismic sections from Borneo/Kalimantan basins.

The seismic section examples from four different Neogene Tertiary basins of Borneo, which potentially share similar provenance, tectonics and relative sea level changes, show different depositional architectures. Local variations shown by seismic evidences are due to local differences in sedimentary supply and smaller scale tectonics which control the subsidence rate.

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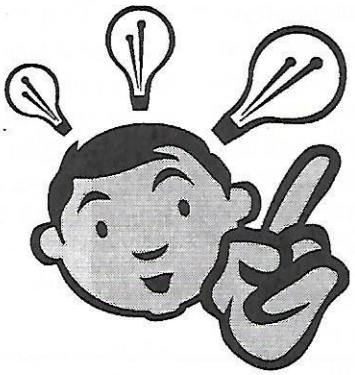
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Around the Corner

FOSI has a new website address at http://fosi.iagi.or.id. Although our web developer (Ferry Hakim, Minarwan and Sachrul Hakim) is still ongoing with the enhancement of the website but all in all thanks to their tireless effort that this website can be launched.

You can find various information about FOSI's activities such as the Low Pay Resistivity Open Discussion part 1 and part 2 which was held recently in Jakarta.

More of interesting activities are yet to come from FOSI in the upcoming future such as Open Discussion, Evening Talk, Seminars, etc. We'll try to keep you updated about this and until then have a great day !!!

See you.