Tectono-stratigraphic Evolution of the Simeulue forearc basin, NW Sumatra

Edyta Frankowicz – Shell International E&P

Introduction

This paper presents a tectono-stratigraphic evolutionary model for the Simeulue forearc basin. The Simeulue basin is located offshore NW Sumatra and it is bounded to the west by Simeulue Island and the dextral strike-slip (transpressive) Mentawai Fault System (Fig. 1). The basin extends over 260 km in NW-SE direction and 100 km in SW-NE direction. It consists of a deep water area with maximum water depth of approx. 1300 m and contains up to 6 sec TWT of Neogene sediments, most of which are siliciclastics expected to have been derived from Sumatra mainland. The Miocene carbonate build-ups have been the main hydrocarbon exploration target in the basin.

1. Mesozoic – evolution of the Woyla Nappe

The Simeulue basin is part of the western Indonesian Sundaland forearc basin extending for more than 1800 km from northwest Aceh basin to southwest Java. The forearc is underlain by the oceanic group assemblages of the Jurassic-Cretaceous Woyla Nappe that was accreted to Sundaland in the late Middle Cretaceous.

In the Mid-Jurassic the Meso-Tethys began to subduct eastwards beneath the western Sumatra, with the accretion of ocean floor material against Sumatra. In the Late Jurassic subduction also commenced towards the west, generating a mid-oceanic island arc. The Woyla Group was formed in the Cretaceous by imbrication and accretion of the ocean-floor material against the mid-oceanic island arc (Bennett et al., 1981). By the early Late Cretaceous the arc and its associated accretionary complex collided with, and was thrusted over, the margin of Sumatra to form the Woyla Nappe (Barber et al, 2005). Subduction of the Meso-Tethys oceanic plate re-commenced outboard of the Woyla terrane. The timing of the renewed subduction is different according to different authors and varies from the Late Cretaceous (Barber et al, 2005), Mid-Eocene (Hall et al., 2009) through the Late Oligocene (Karig et al., 1979). During the renewed subduction the accretionary prism which bounds the Sundaland forearc in the west has developed (Fig. 2a).

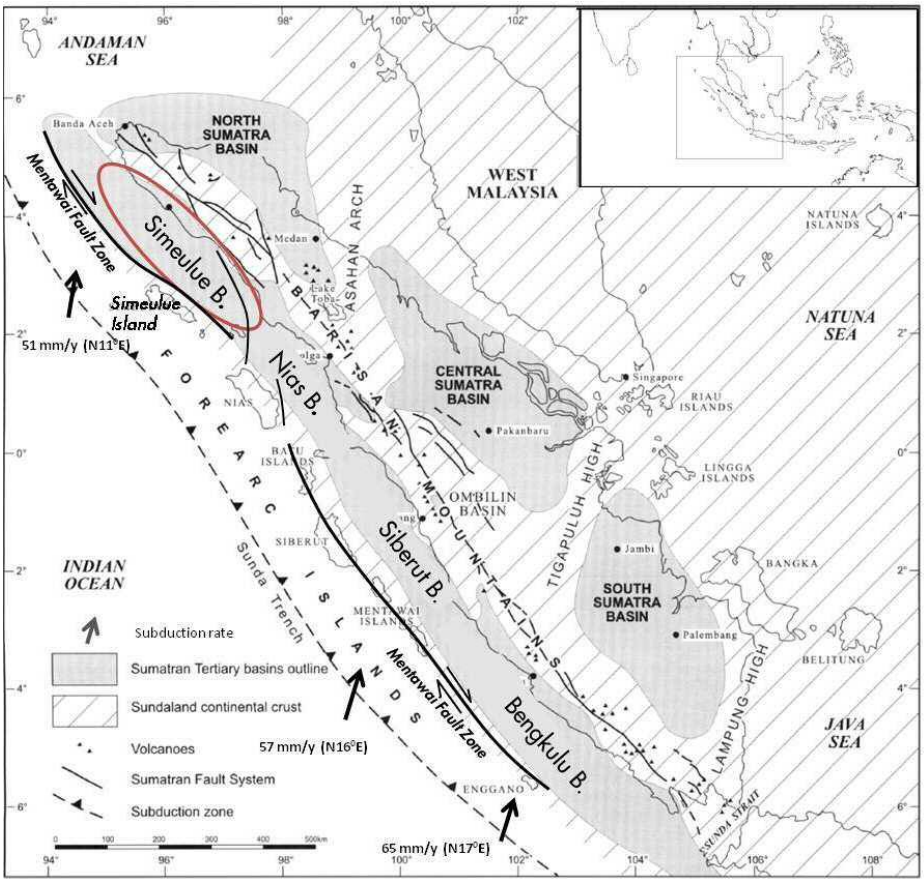


Figure 1. *Structural elements of Sumatra showing Tertiary Sundaland forearc basins (Simeulue, Nias, Siberut and Bengkulu), the Barisan Mountains and the backarc basins (modified from Barber et al., 2005). The red circle marks the location of the Simeulue basin.*

2. Cenozoic – evolution of the forearc basin

Following the emplacement of the Woyla Nappe in the late mid- Cretaceous, the whole of Sumatra appeard to have been subaerially eroded as no Late Cretaceous or Early Palaeogene sediments have yet been found in situ, and the earliest Tertiary rocks rest unconformably on the older units (Barber et al, 2005). In the Early/Mid Paleogene the forearc area was subjected to the regional extension (Fig. 2b), that lead to formation of grabens occupied by lakes with alluvial fans around their margins as well as fluvial and lacustrine sediments; the last considered to be potential source rocks in the basin. This pattern of sedimentation common in the Northern Sumatra back-arc most likely extended into the forearc area, but it is poorly imaged in seismic and rarely penetrated by wells. The regional extension is attributed to the extrusion and rotation of continental blocks to the SE of the site of collision of India with Asia (Tapponnier et al., 1982).

The oldest rocks penetrated by wells are the Upper Eocene to Lower Oligocene dolomitic limestones, calcerous mudstones and pyritic shales. The nature of the basement is difficult to establish. As suggested by Barber et al. 2005, the forearc basement is probably the western extension of the Bentago-Saling volcanic arch and associated Woyla accretionary complex, overlain by Paleogene sediments and volcanics. In the Late Oligocene the forearc underwent uplift and subaerial erosion, which resulted in formation of Top Paleogene unconformity - the deepest traceable horizon in the Simeulue basin (Fig. 2b). The Paleogene rocks are overlain by the Lower Miocene and younger transgressive carbonates, shelfal to littoral sands and shallow water siltstones.

The Oligocene uplift was followed by the Early Miocene marine transgression. According to Barber et al., 2005 the Barisan

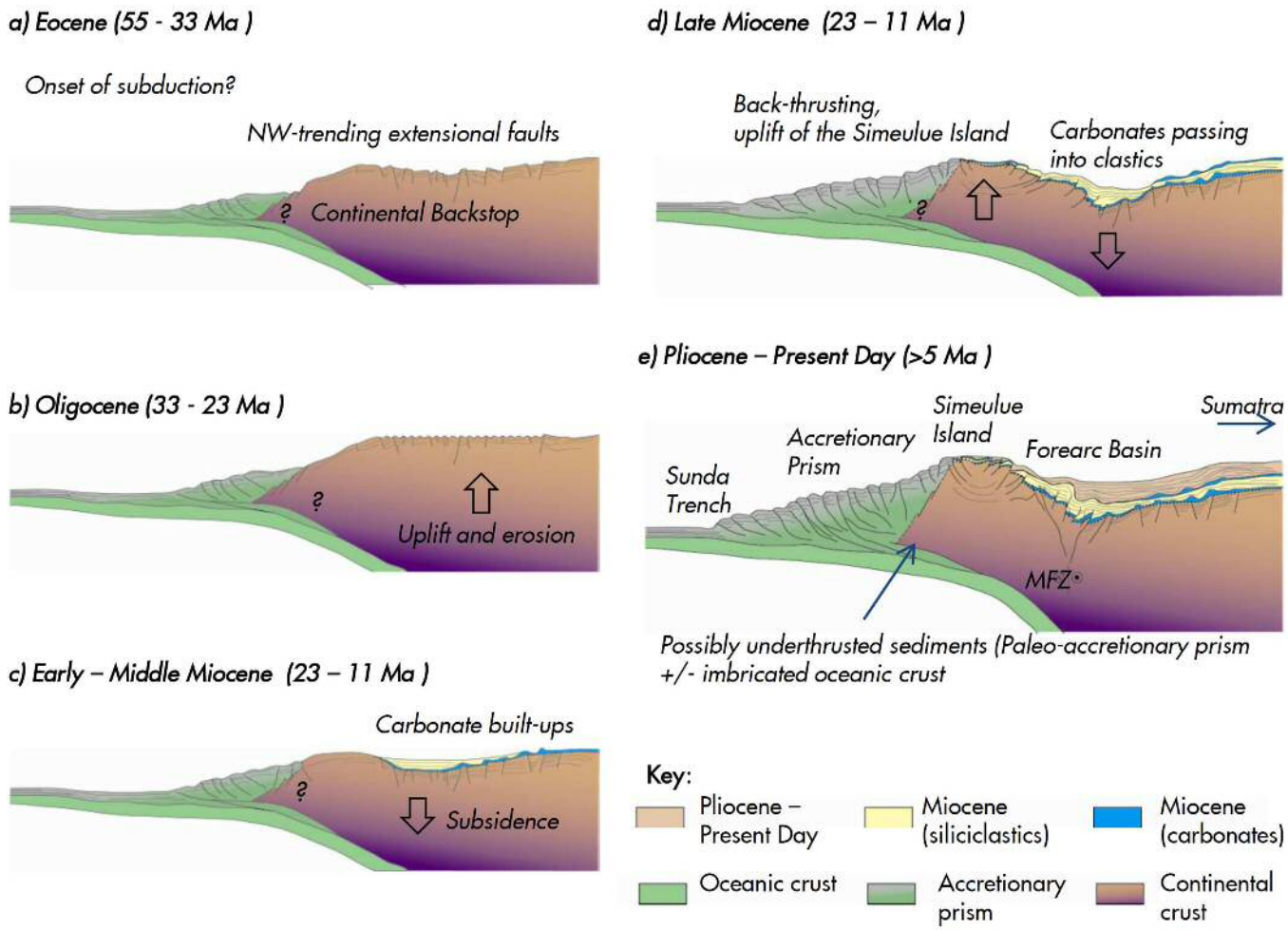


Figure 2. *Synoptic diagram showing tectonic evolution of the NW Sumatra forearc basin in the Cenozoic. MFZ – Mentawai Fault Zone.*

Mountains (Fig. 1) started to form in the Late Oligocene, but were probably too restricted to become a significant source of the clastic material deposited in the forearc at that time.

In the Early (?), Mid-Late Miocene carbonates developed in the shelf area (Rose, 1983) (Fig. 2c). In the Late Miocene the Barisan Mountains were already uplifted and erosion of these mountains supplied significant amount of sediments into the forearc. These sediments were distributed along broad canyons and deposited in several NW-SE-trending depocentres. At the same time the forearc underwent substantial subsidence. Prograding shallow water clasitics overwhelmed the carbonates and the sediment supply exceeded the subsidence, which led to building out of the continental shelf to the west. Whereas the Lower Miocene transgressive carbonates form a distinctive high-amplitude package that can be recognized almost across the entire paleo-shelf of the Simeulue forearc (Karig et al., 1979, 1980) (Fig. 2c), the Upper Miocene carbonate build-ups developed on structural highs are restricted to limited shelfal areas and probably pass into siliciclastics in the deeper part of the basin (Fig. 2d).

The Pliocene (Late Miocene?) wrench tectonics resulted in uplift along the Barisan Mountains in Sumatra midlands and separated the North Sumatra Basin from the forearc region including the Simeulue Basin. This was followed by formation of the Mentawai Fault in the Pliocene (Late Miocene according to Berglar et al., 2010) – Pleistocene that offsets the western flank of the basin and overprints the accretionary prism (Fig. 2e).

Clastic sedimentation with shelf progradation and deposition of pelagic turbidites in the deep basins has continued since the Late Miocene to present day.

3. Conclusions

- The Simeulue basin developed during the Early-Middle Paleogene extension and contains up to 6 sec TWT of the Neogene siliciclastics and carbonates.

- The majority of the Mio-Pleistocene clastics were derived from erosion of the Barisan Mountains formed in the Sumatra mainland. Input from the Bengal Fan acting at that time as the main sediment supply north of the Simeulue is considered to be minor.

- Upper Miocene carbonate build-ups (major exploration target so far) developed only in the shelfal areas.

Acknowledgments

I would like to thank my colleagues from Shell International E&P: Paul Janssen, Peter Bormann (former Shell), Daniel Steffen and Jose de Vera for useful comments and stimulating discussions. Dieter Franke and Kai Berglar from Bundesanstalt für Geowissenschaften und Rohstoffe (BGR) are also acknowledged for helpful discussions.

References

Barber, M., Crow J. &. Milsom, J. S., 2005., Sumatra: Geology, Resources and Tectonic Evolution: Geological Society Memoirs, no. 31, Geological Society, London, p. 1-290.

Berglar, K., Gaedicke, C., Franke, D., Ladage, S., Klingelhoefer, F. & Djajadihardja, Y.S., 2010. Structural evolution and strike-

slip tectonics off north-western Sumatra. Tectonophysics, v.480, 119–132.

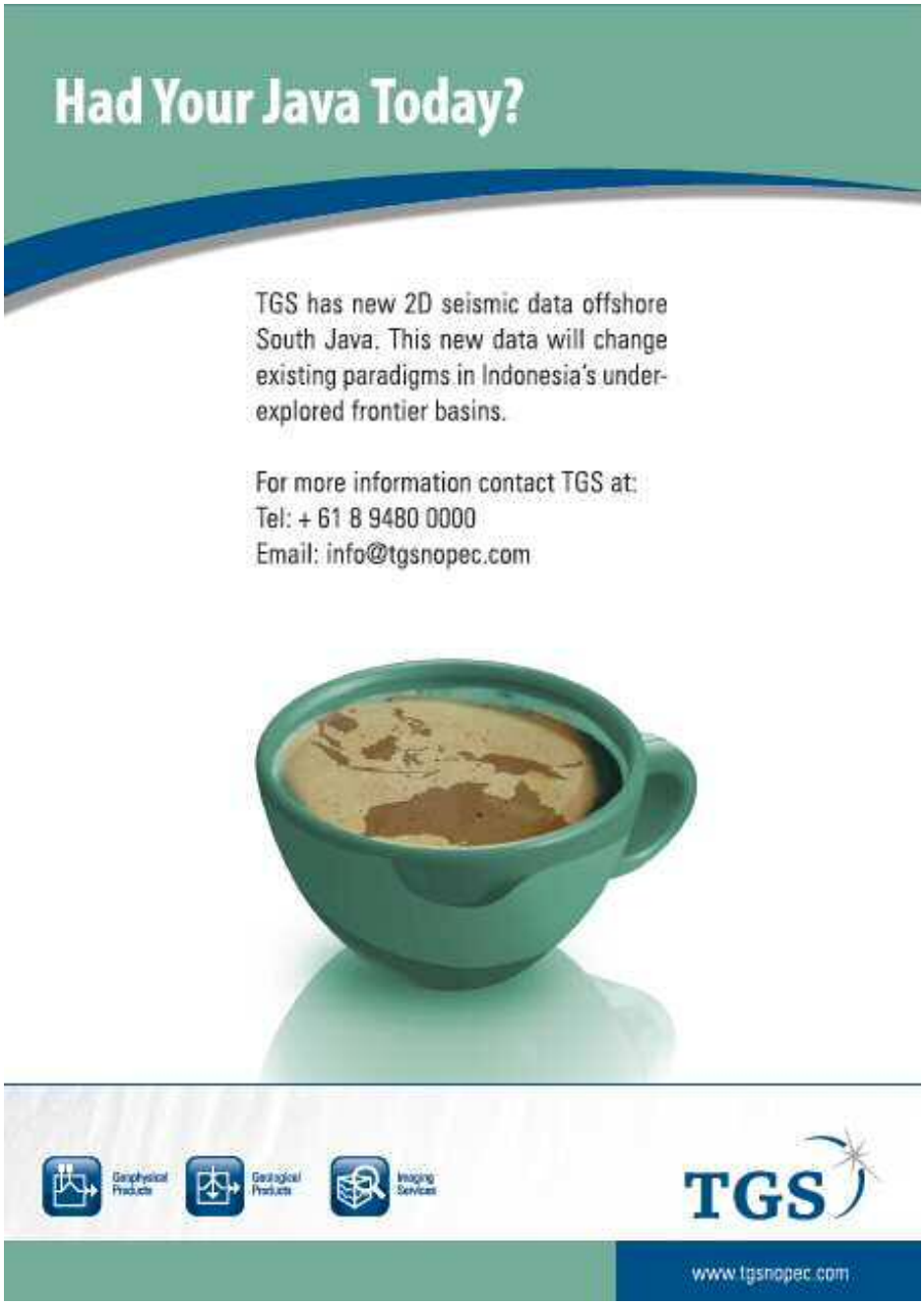
Hall, R., Clements, B., & Smyth, H., 2009. Sundaland: Basement Character, Structure and Plate Tectonic Development. Proceedings, Indonesian Petroleum Association Thirty Third Annual Convention & Exhibition. IPA09-G134.

Karig, D.E., Suparka, S., Moore, G.F. & Hehunassa, P.E., 1979. Structure and Cenozoic evolution of the Sunda Arc in the central Sumatra region, in: Watkins, J.S., Montadert, L. & Dickerson, P.W. eds., Geological and Geophysical Investigations of the Continental Margins. American Association of Petroleum Geologists Memoirs, 29, 223-237.

Karig, D.E., Lawrence, M.B., Moore, G.F., & Curray, J.R., 1980,. Structural framework of the fore-arc basin, NW Sumatra: Journal of the Geological Society of London, v.137, Part 1, 77-91.

Rose, R.R., 1983, Miocene carbonate rocks of Sibolga Basin, Northwest Sumatra: Proceedings Indonesian Petroleum Association, v. Twelfth Annual Convention, June, 1983, 107-125.

Tapponnier P, Peltzer G, Le Dain AY, Armijo R, Cobbold P. 1982. Propagating extrusion tectonics in Asia: new insights from simple experiments with plasticine. Geology 10: 611-16.



JOB VACANCY FOR AN EXPERIENCED CHEMIST

Weatherford®

- *Busy, challenging and lots of variety*
- *Permanent full time position*
- *Opportunities for Domestic and Overseas Travel and Training*

Weatherford is a leading international oil and gas field services company. Due to our rapidly expanding laboratory operations in Indonesia, we currently have a position for an experienced chemist. The role requires G.C. analysis of gas and liquids in addition to physical property testing. The vacancy will be laboratory based, although successful applicants may be required to work in other facilities and client locations on temporary assignments (up to 50 days field work per year). Candidates with experience operating Varian Micro GC systems are strongly encouraged to apply.

Personal characteristics are as important as qualifications to develop the position to its full potential.

Please send your resume along with covering letter to :

Jakarta.Recruitment@ap.weatherford.com