Sedimentary Cycle Best Practice: Potential Eo-Oligocene Sediments in Western Indonesia*

Mellinda Arisandy[1] and I Wayan Darma[1]

Search and Discovery Article #11008 (2017)**
Posted November 6, 2017

*Adapted from extended abstract based on oral presentation given at AAPG Asia Pacific Region Technical Symposium, Hidden Potential in Mature Basins: Play Analogs and Best Practices, Bandung, Indonesia, September 13-14, 2017

[1]Petronas Carigali Muriah Ltd, Indonesia (mellinda.arisandy@petronas.com.my)

Abstract

There are 60 sedimentary basins in Indonesia, which include Tertiary basins in western Indonesia and Mesozoic to Tertiary basins in eastern Indonesia that contain an estimated of 93 billion oil equivalent discovered recoverable resources (IHS, Nov 2016) and around 165 billion oil equivalent of yet-to-find (YTF) recoverable resources (IHS, 2015). To date, only 38 basins have been explored and only 14 are producing oil and gas. 73% of these basins are located offshore with one-third of them located within deep-water area (water depth exceeds 200 m).

In general, Indonesia's geology can be divided into western and eastern provinces. Western Indonesian basins were formed mainly during the Tertiary and had gone through of syn-rift, post-rift, and inversion periods. The underlying pre-Tertiary "basement" consists of igneous, metamorphic and meta-sediment rocks associated with the collision and accretion of continental blocks against Eurasia to form the "Sunda Craton". Continental blocks consist of granitic and metamorphic rocks while sutures in between consist of complex lithology from meta-sediments, various igneous of mainly extrusive igneous and ophiolites. To date, 75% of exploration activities and productions are concentrated in western Indonesia, with significant discoveries from existing as well as new and overlooked plays. However, eastern Indonesia is still considered a frontier region with much less exploration activities and discoveries being made so far.

In western Indonesia, source rocks could be found in the Paleogene syn-rift lacustrine shales, marginal marine and deltaic coals as well as in Miocene deltaic coals, carbonaceous shales and transported coals. In addition, eight play types have been identified in western Indonesia, all of which have been producing oil and gas. One of eight plays is Paleogene syn-rift fluvio-deltaic to shallow marine sandstones and volcaniclastics. Although this play is major oil and gas producers in all Western Indonesian basins, it remains emerging for major hydrocarbon play which has large potentials in North, South Sumatra as well as East Java Basins.

In East Java Basin, Eo-Oligocene Ngimbang Clastics play comprises of fluvio-deltaic sand-coal with possible lacustrine and alluvial fan restricted in the NW-SE trending half-grabens. Shallow marine sand and shale transgressed the high, deposited in estuarine and marine sand bar. Whereas, in North Sumatera Basin, Eo-Oligocene Bampo Sandstone play is characterized by deep-water marine sandstone. Bampo Sandstone play encountered in the MR-1 and NF-1 wells showing widely deposited facies according to seismic correlation and well

intersections. The P21 and P22 sequences of Bampo Mudstone overlie fluvial to coastal sandstone units and basin floor fan sandstones. On the other hand, in South Sumatra Basin, Oligocene Talang Akar play deposition was controlled by the NE-SW trending half-grabens. The section comprises of alluvial deposits (conglomerates, grit sandstone) and fluvial (sandstone, siltstone, shale and coal) deposits.

By comparing Eo-Oligocene sediments in these three basins, the Eo-Oligocene Ngimbang Clastics play is the most promising example since oil shows have been encountered in MA-2, WA-1 and WD-1 wells in North Madura Platform. The major discoveries were represented by Pagerungan, L46-1 and JS14A-1 fields located in East Sepanjang Trough and Central Deep area. A similar exploration discovery hypothesis could be postulated for North and South Sumatera Basins based on facies succession, lithology type, reservoir and seismic characterization. These emerging opportunities represent future big exploration projects in Indonesia.

Introduction

Indonesia has around 60 Tertiary basins that spread from Sumatera in the west to Papua in the east, include Tertiary basins in western Indonesia and Mesozoic to Tertiary basins in eastern Indonesia that contain an estimated of 93 billion barrel oil equivalent discovered recoverable resources (IHS, Nov 2016) and around 165 billion barrel oil equivalent of yet-to-find (YTF) recoverable resources (IHS, 2015). To date, only 38 basins have been explored and only 14 are producing oil and gas. 73% of these basins are located offshore with one-third of them located within deep-water area (water depth exceeds 200 m).

Throughout the years, petroleum exploration was focused in western Indonesian basins. Petroleum exploration began in the nineteenth century with Telaga Said-1 exploration well, which is located in North Sumatera, being the first commercial discovery in 1883. This leads to the establishment of the Royal Dutch Company for Exploration of Petroleum Sources in the Netherlands Indies in 1890. Exploration efforts continued until today resulting in an accumulated resource of 93 MMBOE 2P recoverable (38 Bbbls of oil, 4 Bbbls of condensate, and 309 TCF of gas) discovered from around 1495 fields across Indonesia.

Nine producing basins located in western Indonesia. The most prolific oil basin is the Central Sumatera Basin, with its huge Minas and Duri fields containing 5.5 Bbbls and 3.5 Bbbls oil recoverable resource respectively, coming from the Early Miocene Bekasap and Duri plays. The fields were discovered just prior to World War II by Caltex, a joint venture between the American companies Chevron and Texaco. Although production did not begin until the 1950s, by 1963, the Duri and Minas oil fields accounted for 50 percent of total oil production in Indonesia.

Western Indonesia Tectonic, Structural and Stratigraphic Frameworks and Play Types

In general, Indonesia's geology can be divided into western and eastern provinces. Western Indonesian basins were formed mainly during the Tertiary and had gone through syn-rift, post-rift, and inversion periods. The underlying pre-Tertiary "basement" consists of igneous, metamorphic and meta-sediment rocks associated with the collision and accretion of continental blocks against Eurasia to form the "Sunda Craton". Continental blocks are consist of granitic and metamorphic rocks while sutures in between are consist of complex lithology meta-sediments and various igneous of mainly extrusive igneous and ophiolites (Figure 1 and Figure 3).

For the time being, hydrocarbon only discovered in shallow target in Western Indonesia. By using Sedimentary Cycle best practice, Eo-Oligocene sediments would be defined easier as deeper potential in mature basin.

A sedimentary cycle begins with a renewed clastic influx caused by a relative uplift of clastic source area (Figure 2). When the uplifted area has been peneplained by erosion, the sea transgressed and eventually maximum flooding occurs over a much larger area. On the other hand, unconformities and maximum flooding surfaces represent a major shifting of facies belt characterized by discordance seismic reflectors (onlap/downlap/truncation). A number of sedimentary cycles (Figure 1) may stack landward to form a Transgressive Mega Sequence capped by a major Maximum Flooding or they may stack seaward to form a Regressive Mega Sequence often capped by a major Unconformity.

Western Indonesia Hydrocarbon Plays

In western Indonesia, source rocks could be found in the Paleogene syn-rift lacustrine shales, marginal marine and deltaic coals as well as in Miocene deltaic coals, carbonaceous shales and transported coals. Eight play types have been identified in western Indonesia, all of which have been producing oil and gas. The plays are (Figure 4):

1. Pre-Tertiary “Basement” play including fractured igneous, metamorphic and meta-sediment rocks as well as weathered granite and granite outwash. Proven to be productive in South and Central Sumatra. This is an emergent play, which has large potentials in North, Central and South Sumatra as well as West and East Java.
2. Paleogene syn-rift and post-rift fluvio-deltaic to shallow marine sandstones and volcaniclastics. It is a major oil and gas producers in all Western Indonesian basins.
3. Paleogene carbonates which has been proven with oil and gas discoveries in East Java.
4. Lower Miocene Carbonate play: proven to be major oil and gas producers in North Sumatra, West and East Java and relatively small to moderate size oil/gas discoveries in South Sumatra and Central Kalimantan.
5. Miocene clastic play consists of fluvio-deltaic-shallow marine sandstones. It is oil and gas producers in North, Central and South Sumatra, West and East Java, as well as onshore and offshore Kalimantan. Turbidite play is productive in North Sumatra, East Java and offshore Kalimantan, but under explored in East Java.
6. Miocene carbonate play, productive in West Java and NE Sulawesi.
7. Pliocene clastic play which consists of fluvio-deltaic sandstones and turbidites, proven as main oil and gas producers in Kutei and Tarakan basins in East Kalimantan. Identified sand rich turbidite play is still under explored in East Java.
8. Pliocene carbonate play is a major biogenic gas producer in East Java comprising of globigerina limestone. This play has been maturely explored in East Java.

A similar exploration discovery hypothesis could be postulated for Western Indonesia basins based on facies succession, lithology type, reservoir and seismic characterization. These emerging opportunities represent big exploration projects in Indonesia.

Selected References

Allen, P.A., and J.R. Allen, 2005, Basin Analysis-Principles and Applications: 2nd Ed. Blackwell Publishing, Oxford.

Posamentier, H.W., 1993, Sequence Stratigraphy and Facies Associations: International Association of Sedimentologists Series Book 18, 644 p.

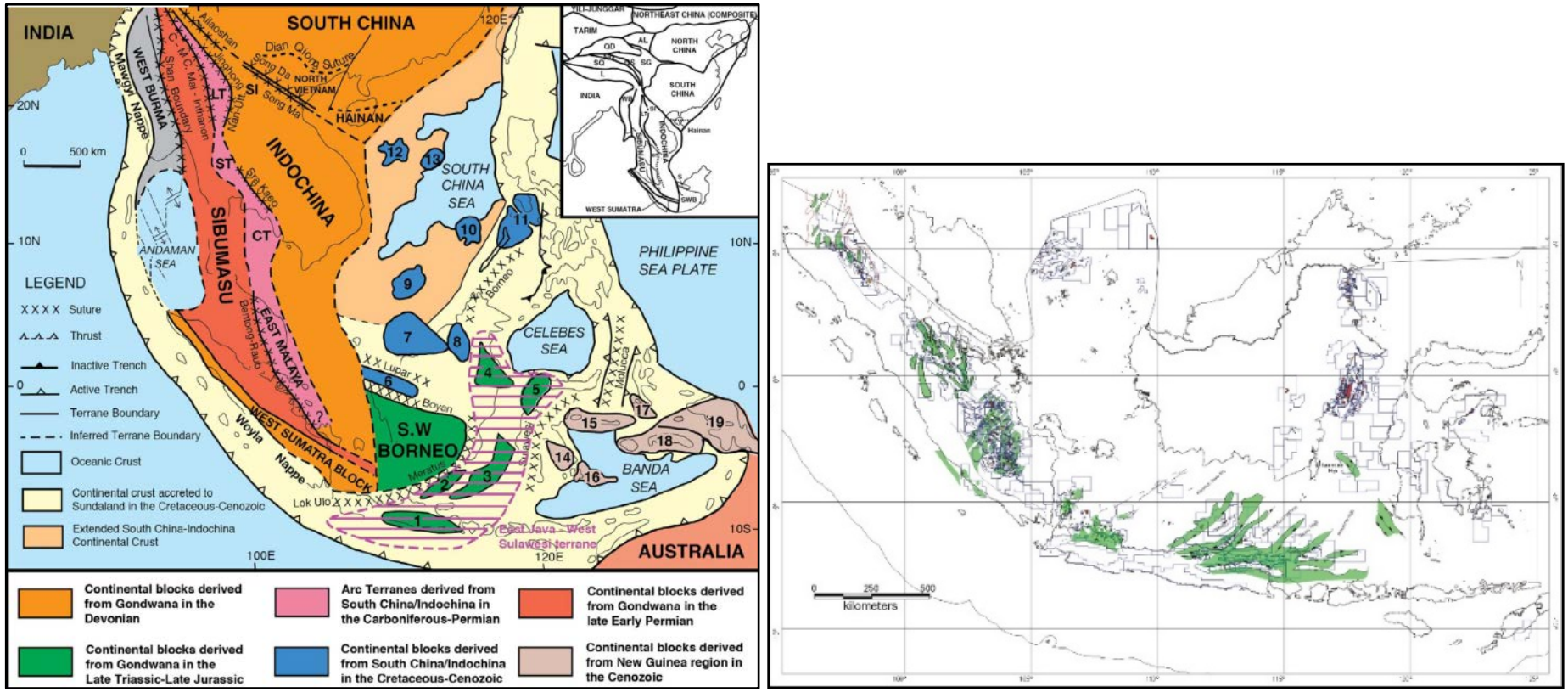

Figure 1. Pre-Tertiary Tectonic and Paleogene Structure of Western Indonesia.

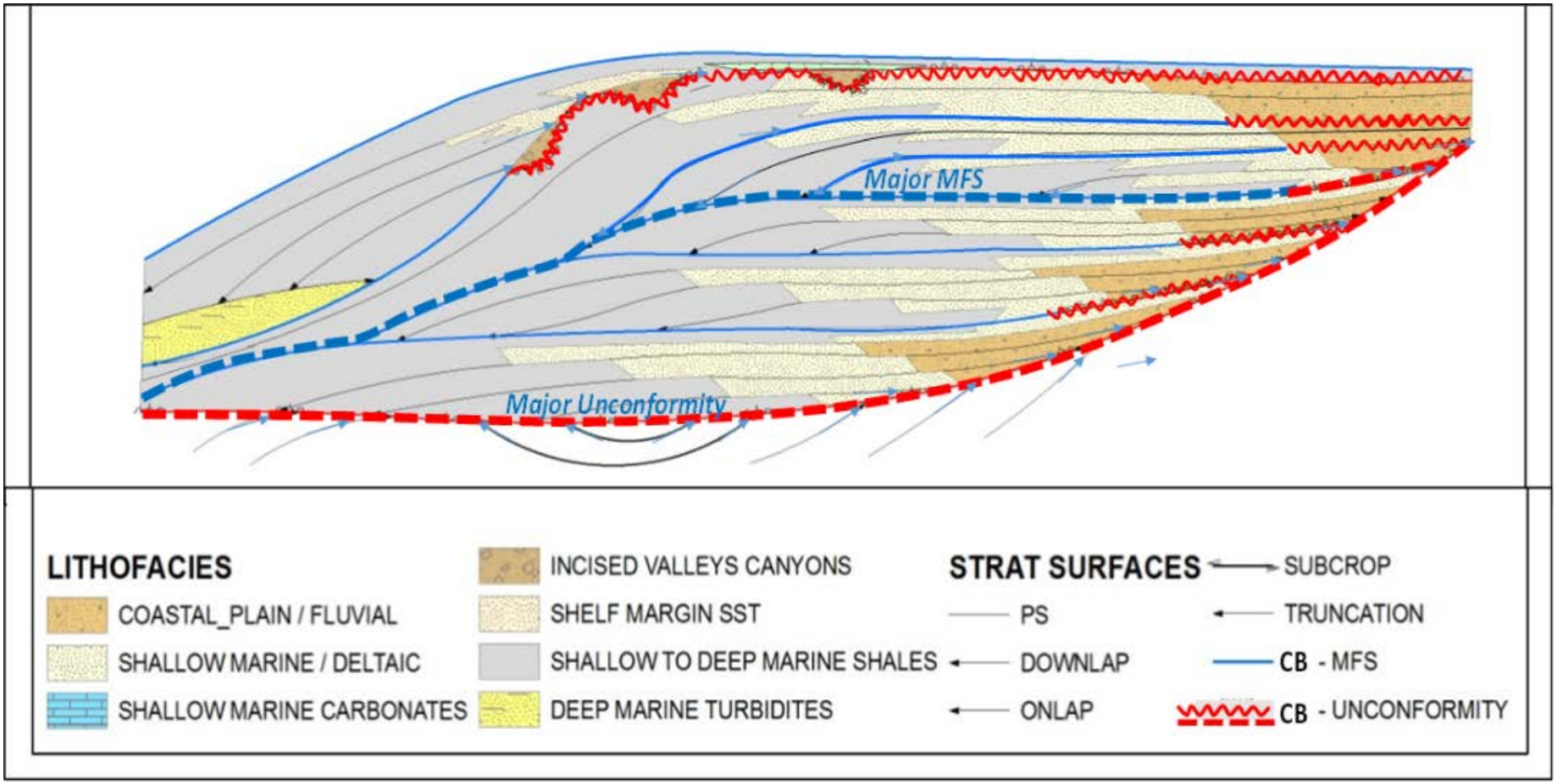

Figure 2. Sedimentary Cycle Concept.

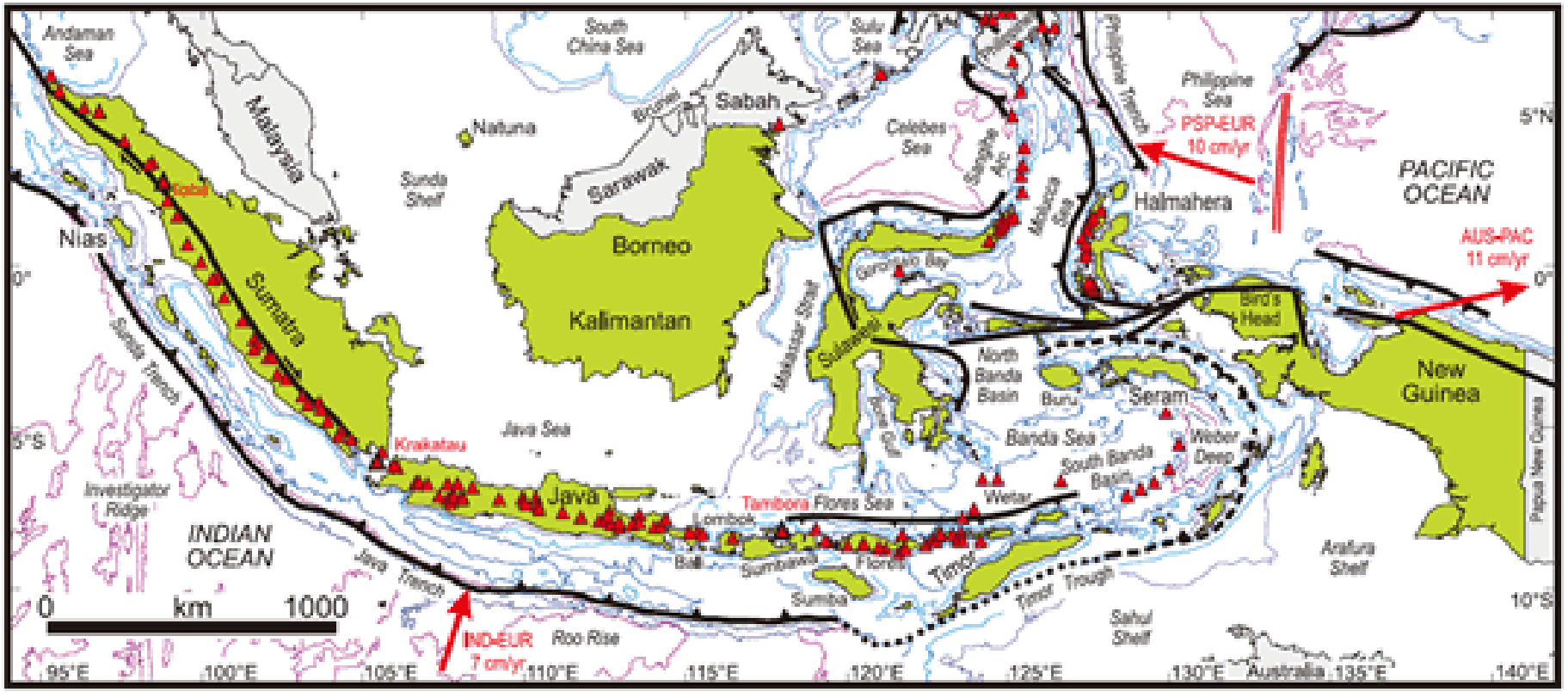

Figure 3. Late Neogene – Present Day Structure of Western Indonesia.

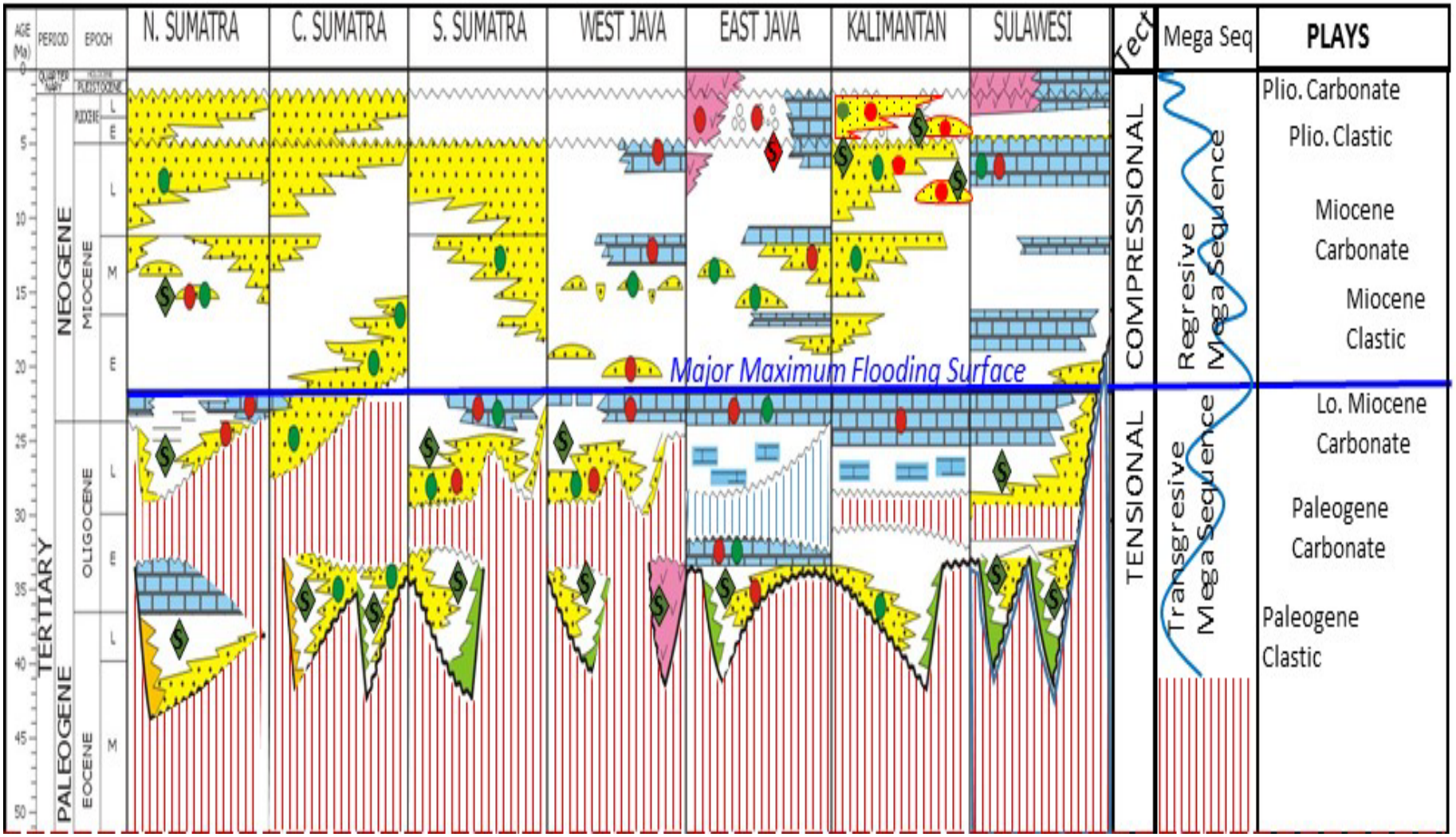

Figure 4. Chrono-stratigraphy and play types of Western Indonesia.