# Paleogeographic and tectonic evolution of Sarawak and the adjoining area

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Sarawak and its adjoining area consists of at least three tectonic blocks which were separated from one another during several phases of its geological evolution. The West Sarawak block **(Wesara block)** had a span of history from pre-Late Carboniferous while the recorded history of the North Sarawak block **(Norsara block)** started in Late Cretaceous. Another block consisting of the basement of West Kalimantan which was probably separated from the Sarawak blocks in parts of the Mesozoic.

*Warta Geologi, Vol. 22, No. 3, May–Jun 1996*

## Wesara block

Pre-Late Carboniferous tectonic and metamorphic events affected the sediments and volcanics of West Sarawak before the deposition of Upper Carboniferous and Lower Permian Terbat Limestone. A subsequent folding and inversion phase post-date the deposition of the Terbat Limestone prior to the deposition of the Late Triassic Sadong Formation and the Serian Volcanics. The late Triassic basin was probably marine towards the north with terrigeneous and volcanic clasts derived from a southerly source, where fluvial and deltaic deposition preserving several thin coal beds occurred. Granitoid clasts in the conglomerate of the Sadong Formation suggest that the exposure of pre-Late Triassic granitoid in the source area. A basin inversion and folding phase in the early to middle Jurassic terminated its deposition.

During late Jurassic-early Cretaceous the shallow water Bau Limestone accumulated in several paleohighs in the Bau-Krokong, the fringes of Jagoi and Kisam "islands" and the NNW-SSE chain Penrissen-Batang Kayan area. Relative rise in sea level terminated the shallow water limestone deposition in early Cretaceous. In the deeper marine environment, the thin and thick graded beds of feldspathic sandstone, coarse-tail graded, polymictic extraformational conglomerate sheets and channels and several horizons of mass-flow deposits were sedimented intermittently within black carbonaceous shale. Several lenses of limestone with predominantly packstone texture are found towards the base of the Pedawan Formation.

In the Siniawan area, mass flow deposits are well developed with stratigraphic thicknesses ranging from a meter to very thick, in excess of 80 meters. They occur within a variety of facies association; thinner ones within sequences of thin-bedded turbidite sandstone and shale, and the thicker ones within coarse, thick-bedded sandstone, channel and sheet conglomerate and minor shale sequence.

Blocks of various sizes in the thicker deposits consists of contorted beds of thick turbidite sandstone which exhibits a spectrum of soft sediment deformational features resulting in the beds being in coherent, semi-coherent to incoherent state. Closely associated with these contorted beds are shale diapirs, supporting the interpretation that beds were deformed under high pore pressure condition through elastic and plastic behavior. Minor cobble-sized volcanic and chert fragments are present. The matrix of these deposits consists of mainly of mud, but in some of the thicker beds the matrix are muddy sand.

The sedimentological features suggest that the thicker mass flow deposits originated in the slope and base of slope environments where thick-bedded turbidite and conglomerate were initially deposited. Thinner bedded mass flow deposits could either represent the collapse of the basinal sediments or that they are the distal portion of a much larger mass flow deposits.

The closure and inversion of the Jurassic-Cretaceous basin may vary in space and time. To the north of Bungo basin, the sedimentation of the Pedawan formation continued into Late Cretaceous. A similar scenario probably existed in the Pedawan Formation in the Sungai China area in west Kuching. In the southern part of the Santubong Peninsula, a recent exposure shows a spectacular angular unconformity surface separating the deformed Pedawan Formation from the overlying gently dipping Kayan Sandstone. No age is yet determined for the Kayan Sandstone exposed at this locality.

A large part of the Serabang formation shows similar resedimented facies as the Pedawan formation and is interpreted to represent an extension of the northwestern open marine Jurassic-Cretaceous basin. Jurassic and Cretaceous(?) cherts blocks with basic igneous rocks possibly suggests a more oceanic crustal nature of this part of the basin. If the Late Cretaceous age of the intrusive Pueh Adamellite is true, then it would imply that closure of this part basin must not be later than Late Cretaceous.

Regional consideration suggests that the late Jurassic-late Cretaceous of west Sarawak could have been deposited in several small basins separated by uplifted landmass in the present south and an open marine condition to the present north. The scenario probably ended in the Tertiary with the uplift and erosion of the Mesozoic rocks, resulting in unconformable relationship with the overlying Tertiary sequence, as seen in the south of the Santubong peninsula.

To the south, in Kalimantan, cherts, turbidites and basic igneous rocks and serpentinites of the Boyan Mélange and the Selangkai Formation suggest that a deep marine basin separated **Wesara** from the West Borneo Basement at least in Cretaceous. The closure of this basin probably occurred in Late Cretaceous.

To the northeast, deep marine condition between separating Wesara from Norsara persisted from Jurassic to Eocene (?). Closure of this basin occurred led to the formation of the arcuate Rajang mountain range.

However, if the paleobiogeographical constraints based on work done by previous workers the Permian fusulinids and algae of the Terbat Formation, the Triassic Krusin Flora, the Late Jurassic and early Cretaceous

corals and rudists are taken into consideration, a relatively northerly paleoposition may be interpreted for west Sarawak during the Late Paleozoic and Mesozoic. If the post-late Cretaceous counterclockwise rotation of West Borneo based on paleomagnetism work is correct, then its Mesozoic paleogeography would be a land mass to the west or north and the marine basin to the east and south.

## Norsara block

The onshore North Sarawak Basin (NSB) comprises of three thick unconformity-bounded lithostratigraphic units, each with its own sedimentological characteristics and structural style and history. The depocenters of these units successively shifted northwards. A trend towards a simpler structural style is also observed in the same direction.

The oldest unit is the intensely folded late Cretaceous-middle Eocene shale-turbidite sandstone sequences forming the Rajang Group, now exposed as the arcuate Rajang Mountain range. Inliers of this group outcrop to the north of the Rajang range in the Mulu-Temala Anticlinorium. Paleontological and sedimentological evidences suggest deposition occurred in a relatively deep marine setting. Basin inversion with concomitant folding and thrusting affected this unit in the late(?) Eocene. Subsequent erosion and subsidence of the northern margin of this unit led to its formation as the basement for the younger sequence.

The second unit is the middle Tertiary succession which represents the infill of an alluvial valley and shelf initiated in late Eocene times. Along the southern margin of this basin, massive shedding off the Rajang hinterland resulted in a relatively short phase of alluvial deposition followed by an extensive deltaic sedimentation and progradation. Thick proximal deltaic facies showing repetitive coarsening upwards, coal bearing sequence were formed, while the finer fractions were redistributed as muddy components on the shelf and near-shore sediments.

A deeper marine basin (the proto-South China Sea) existed in the northeast of Nosara in the Oligocene. The earliest marine incursion occurred along this northern margin of Norsara and subsequently spread southwards by late Oligocene times. This middle Tertiary basin is characterised by the development of broad shelf with tracts of shelf sands, carbonate shoals and reefs. The earliest carbonate bodies were developed unconformably on areas of uplifted basement while the younger Miocene carbonates were formed on topographic highs composed of sand shoals and islands.

Sedimentation of the middle Tertiary succession were terminated in middle Miocene by the onset of regional tectonic events that caused the inversion of the eastern and southern margins of the basin. However, in the offshore area, subsidence continued in the Middle Miocene as witnessed by the prolific growth of carbonate in the Luconia Province.

A new depocenter created in the north saw the influx of coarser clastics of the Lambir, Beliat and Miri Formations. These thick sand-prone formations were deposited in coastal environments. The Lambir Formation represent the initiation of the Baram delta deposition. Northwards migration of the Baram delta led to the deposition of the Miri formation which were then unlifted in the Pliocene(?).

Further convergence of the Norsara and Wesara occurred in the Late Miocene resulted in the folding of the pre-Late Miocene of Norsara especially in the southern portion and led to its inversion.