Basin development and deposition of the Bongaya Formation in the Pitas Area, Northern Sabah.

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Abstract: Development of a small, shallow basin for the deposition of the Bongaya sediments of late Miocene age in the Pitas region was controlled by earlier faults trending NE-SW, N-S and NW-SE on the underlying rocks of the area (Crocker and Chert-Spilite Formations). This nearly circular-shaped basin was filled by sediments sourced from older uplifted rocks to the east, south and southeast by the overlapping of numerous fluvio-deltaic fan lobes.

INTRODUCTION

The occurrence of Upper Tertiary basins for the deposition of thick sediments in Sabah is widespread, yet studies on them is quite scarce. This is probably due to the inaccessibility of most of these areas in the past and previous efforts have been mainly concentrated on Upper Tertiary offshore basins where oil occurs. The presence of new road cuttings due to logging activities provide a new avenue for studying these sediments. One such basin occurs in the Pitas region in the Bengkoka Peninsular of Northern Sabah (Fig. 1), where the Bongaya sediments have been deposited. Good exposures of the formation in this region and the availability of good aerial photographs provided an opportunity to study the probable development mechanism of this basin.

The Bongaya Formation in Northern Sabah occurs in several isolated basins lying unconformably on older deformed sediments which includes the Crocker, Kudat and Chert-Spilite Formations (see Fig. 1). The Bongaya sediments have been dated as Upper Miocene in age based on foraminifera and was deposited in a shallow water environment (Wilson, 1960). In the Pitas region the Bongaya sediments rest with marked unconformity on the Crocker Formation (Fig. 2).

SEDIMENTOLOGICAL FEATURES

The Bongaya sediments consist mainly of grey sandstones interbedded with carbonaceous shales with minor occurrences of conglomerate beds. The sandstones are texturally immature, consisting mostly of quartz grains with mud matrix as its cement. The conglomerate clasts mainly of sandstones and cherts which is typical of the Crocker and Chert-Spilite sediments.



Fig 1. Geological map of Northern Sabah showing the occurrence of the Bongaya Formation as isolated circular basins.

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Fig 2. Geological map of the Pitas area. The undeformed Bongaya sediments sit unconformably on the folded-faulted Crocker sediments. The nearly circular-shape of the Bongaya basin was controlled by major faults trending N-S, NW-SE and NE-SW.

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The sandstone beds vary in thickness from a few centimetre to several metres thick. The sandstone beds mostly pinched out laterally (Fig. 3). Some of the thick sandstone beds have conglomeratic bases. Sedimentary structures most commonly found in the sandstone beds are cross-beddings and cross-laminations (Fig. 4). Small lobe structures are also quite common (Fig. 5). Current directions derived from these structures varies from about N330°E to N60°E (see Fig. 2). This wide distribution of paleoflow probably indicate local changes in the source area and depositional system during the filling of the basin. The shale beds also vary in thickness from a few cm to several metres. They are mostly carbonaceous showing cross liminations and parallel laminations. Vertical trace fossils (Fig. 6) are quite common in them indicating a shallow water depositional environment.

Measured sections from different parts of the region indicate that the thickness of the Bongaya sediments varies from one area to another, usually thicker towards the side of the basin. Its total thickness is uncertain but is estimated to be less than 200 metres. The stratigraphic sequence consists of several thick sandy and shaly sequences (each about 20–30 metres thick) alternating with each other. Sequence analysis indicates the presence of



Fig 3. Pinching out of sandstone beds interpreted to represent lobe migrations. Locality: Near Kg. Senaja.



Fig 4. Carbonaceous planar cross-bedding. Paleoflow direction measured here trends N-S. Locality: Near Pitas School.

several fining upward sequences (FUS) interpreted to represent several migrating channels or fan lobes (Fig. 7).

STRUCTURAL FEATURES

The Bongaya sediments occur as gently dipping beds (5–25°) with a general strike direction trending approximately NE-SW, NW-SE and E-W in the southeastern, northeastern and northern part respectively forming a nearly circular shaped-basin. A major NE-SW trending fault clearly bounds the southeastern part of the Bongaya Formation from the underlying rocks as seen on aerial photographs. Parallel to this major fault several smaller NE-SW trending faults affecting the Bongaya sediments were observed in the field (Fig. 8). Steeper dips occur near this major fault. Local structures found in different parts of the region are mostly normal faults trending N-S, NW-SE and NE-SW with displacements ranging from a few cm to a few metres (Fig. 9). The small faults are mostly syn-depositional while the bigger ones are clearly post-depositional.

The gently dipping nature of the Bongaya sediments and the absence of folds suggest that it has not experienced intense compressional deformation. The presence of numerous normal faults suggests that the Bongaya sediments may have undergone extensional phase during and after its deposition. F. TONGKUL



Fig 5. Nearly horizontal sandstone and shale beds showing small lobe structures. Locality: Near Pitas School.



Fig 6. Vertical trace fossils in grey shale beds of the Bongaya Formation indicating shallow water depositional environment. Locality: Near Kg. Senaja.



Fig 7. Lithostratigraphic sequence of the Bongaya sediments showing several fining upward sequences (FUS) probably representing migrating lobes or channels. 1. Conglomerate 2. Sandstone 3. Shale 4. Trough cross-bedding 5. Planar cross-bedding 6. Vertical trace fossils 7. Laminations.

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Fig 8. Horizontal fault trending N40E cutting through the Bongaya sediments with an oblique sinistral movement. Locality: Near Kg. Kabatasan.

DISCUSSION: DEPOSITIONAL MODEL

The sedimentological and structural features of the Bongaya sediments suggest that the deposition of these sediments was closely controlled by earlier major structures. Based on earlier studies (Tongkul, 1989), the underlying sediments were found to have been folded and thrust-faulted with their fold axes trending approximately NW-SE. These NW-SE trending lineaments are cross-cut by several sets of N-S and NE-SW horizontal faults as a consequence of continued N-S compression in this region up to late middle Miocene. The extensional features observed in the Bongaya sediments having a similar trend to the structures on the underlying rocks, indicate that the former was a manifestation of the latter (inverse structure). This is seen to be the case in other parts of Sabah (Tongkul, 1990). The existence of the earlier fault systems significantly controlled the shape of the basin and subsequently the depositional system (Fig. 10).

The Bongaya basin probably started to develop by extension during the uplift of the underlying rocks as a late stage accommodation structure. Extension utilized the existing N-S and NE-SW fault system here to form a shallow V-shaped graben-type basin. The narrow southeastern part of the basin was probably relatively shallower compared to the northeastern part of

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Fig 9. Several normal faults and fractures cutting through gently dipping Bongaya sediment. Vertical displacement is about a metre. Locality: near Kg. Tambilidon.



Fig 10. Schematic diagram to illustrate the probable development of the Bongaya basin. (a) Structural features present on the underlying rock prior to the development of the basin; NW-SE trending faults and fold axis; N-S and NE-SW horizontal faults. (b) Extension in this region utilizing the existing major faults producing inverse structures (graben-type). The NE-SW and N-S horizontal faults marked the edge of the basin. (c) The narrow and elongate shape of the basin controlled the depositional system. (1) Bongaya Formation (2) Crocker Formation (3) Basement Rock (Chert-Spilite Formation) (4) Horizontal fault (5) Thrust and fold axis (6) Current directions (7) Lobe migrations.

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the basin which connected with the open sea during this period. This basin configuration controlled the major flow of sediments from the southeast fanning-out towards the northeast. Fluvial sediments represented by the conglomeratic beds filled the southwestern and southeastern side of the basin which gradually gave way to deltaic fan lobe sediments towards the deeper part of the basin. The continuous deposition of sediments from the uplifted surrounding rocks (Crocker and Chert-Spilite Formations) by the overlapping or coalescing of several deltaic lobes gradually filled the entire shallow basin. As a result of this filling the basin probably sagged a bit causing steepening of beds towards the side of the basin and the normal faults. Overall uplift of the Bengkoka region gradually exposed this sediment.

CONCLUSION

This case study has demonstrated that the development of a particular basin and subsequently the deposition of its sediments are closely related to earlier major structures. In trying to understand and reconstruct the depositional history of the Upper Tertiary sediments, especially the circular-shaped basin in Central Sabah, it is necessary to know the major structures present on the underlying rocks.

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