

Paleo-environment of the Miocene Sediments, Central Belt, Myanmar

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Abstract

In the case of the Paleo-environment of Hukawng subbasin and Chindwin Subbasin, most sediment are considered to be deposited under non-marine to deltaic, swampy conditions, because of the occurrences of palynology species such as *Retistephanocrlpites williamsi*, *Tsugaepollenites velatus*, *Magnastriatites howardi*, *Alnipollinillites verus*. In the southern part of the Chindwin subbasin and Central Myanmar subbasin, there is a special feature in these sediments; fossiliferous limestones which are interbedded with sandstone, with clays and shale beds in some localities. The distribution of species diversity and species population is more flooded in the southern part of the subbasin than that of northern part. And also the morphology character, the sediments in the southern part (south of North Latitude 19°) is considered to be deposited in relatively shelf type of deeper marine whereas the northern part (north Latitude 19°) is under a shallow marine influenced by brakish water condition because of the highest population of *Rotalia* group.

Keywords: palynology species, Foraminifera species, Non-marine, Shallow marine

Introduction

Based on the foraminifera evidence obtained from the examination of various localities in the central belt, description is made as the depositional condition of the area especially during early Miocene time. Myanmar is the region of transition between the main Himalayan collision belt and the Andaman arc, where, since the Cretaceous, the Indian plate has been subducting under Asia (e.g. Curray et al. 1979; Mitchell 1993; Acharyya 1998). The main territory of Myanmar is situated on the Burma micro-plate between the Asian plate to the east and the Indian plate to the west (Fig. 1) (Fitch 1972; Curray et al. 1979; Pivnik et al. 1998; Bertrand & Rangin 2003). It is the relatively low-lying Central Belt drained by the Ayeyarwady, Chindwin and Sittaung rivers. Locally, hills, ridges, and small mountain ranges are present, especially in the northern part. It comprises mainly of Cenozoic sedimentary rocks consisting of sandstones, shales and clays. Mesozoic clastics and Cretaceous limestones occur locally in the northern part. The Cenozoic molassic sediments were laid down under deltaic and fluvial conditions in the north, and under shallow marine conditions in the south. The Cenozoic rocks generally were broadly folded, and were locally thrust and NNW-SSE trending en echelon anticlinal folds, formed on the eastern flank of the Minbu Basin, are sites of major oilfields of Myanmar. The well-known Sagaing Fault, a right-lateral strike-slip fault that runs north-south for a distance of nearly 600 miles is located near the eastern edge of the province. It is still an active fault, and the intermittent movements along it have caused some major earthquakes in Myanmar. Limited metamorphism occurred in the north; elsewhere, there is little or no metamorphism in these rocks. All the sediments were deposited under shallow marine to fairly deep marine conditions. One of the special features of the Central Belt of Myanmar (i.e. Hukawng Subbasin, Chindwin Subbasin, Central Myanmar Subbasin, Pyay Embayment Subbasin and Ayeyawady Delta Subbasin) is the development of Limestones in the Cretaceous and

Tertiary formations. Most of them contain very distinct species of larger foraminifera, associated with some algal species and other microfossils.

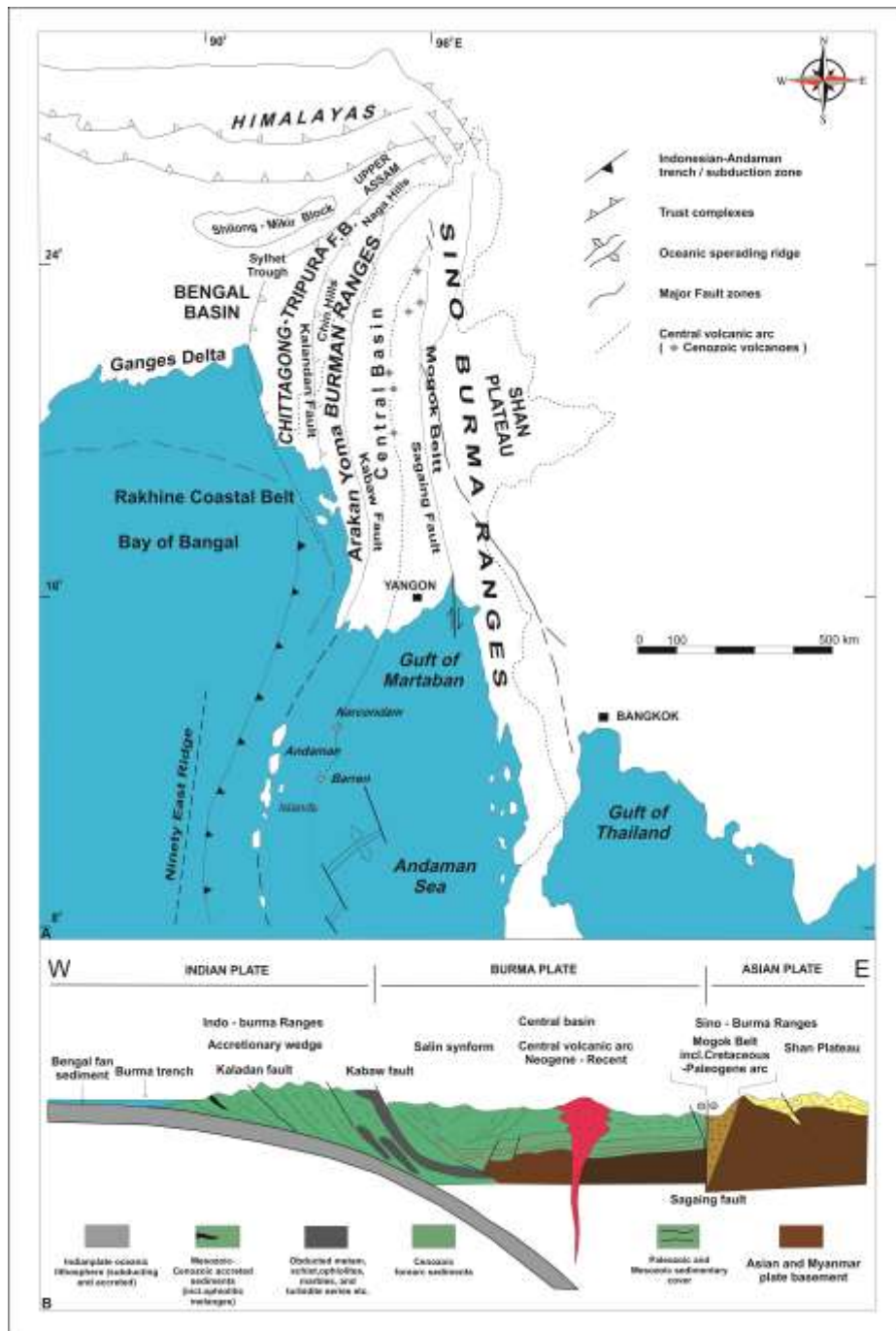


Fig. 1. (a) Structural map of Myanmar and adjacent regions adapted and modified from Bender (1983), Pivnik et al. (1998) and Alam et al. (2003). (b) Schematic tectonic section (not to scale) across Myanmar at about latitude 20°N adapted and modified from Pivnik et al. (1998), including results of Barley et al. (2003) and Bertrand & Rangin (2003).

Geological Framework of Myanmar

Geomorphologically and tectonically Myanmar has been divided into four main belts (Stamp 1922, Chibber 1934, Tanish 1950, Win Swe 1981, Maung Thein 1973, 1983, 2000). They are;

- | | |
|--------------------------|------------------------|
| (1) Eastern Highland | Shan-Tanintharyi Block |
| (2) Central Lowland | Central Cenozoic Belt |
| (3) Western Ranges | Western Fold Belt |
| (4) Arakan-Coastal Plain | Arakan-Coastal Belt |

Eastern Highland, which is a part of the Shan-Thai Block, a large tectonic domain connect to the Pacific tectonic plate, is composed mainly of older rocks groups containing plateau limestone and metamorphic complex. Among them, the research area is situated in the central low land.

Central lowland is separated into fore-arc and back-arc by the Central Volcanic Line (CVL) which are trending N-S. Central Cenozoic Belt is low lying central belt, drained by the Ayeyarwady, Chindwin, Sittaung Rivers. A large active fault, the Sagaing Fault (Win Swe, 1981) is passing through the eastern margin of these provinces. Locally hills, ridges and small mountain ranges are present especially in the northern part. Cenozoic sediments, sandstone and shale were deposited in the Central lowland under deltaic and fluvial condition. Neogene sediment of the Pegu Series and Irrawaddy Formation is found in the Central Lowland. Central Cenozoic Belt possesses three depositional basins and uplifts. They are Chindwin basin, Central Myanmar basin, and Pyay Embayment basin. The Central Myanmar Basin lies between the Rakhine Yoma in the west and the Shan Plateau in the east with a length of 1100 km. The basin is N-S elongated fore – arc parallel to the Rakhine Yoma accretionary wedge in the West and a volcanic arc in the east, sitting on the Shan Plateau. The Central Myanmar Basin is in fact a series of an enclon depocenter affected by inversion process. This basin extends southward in the Andaman Sea and is considered as a couple of fore – arc and back – arc basins for the Bengal subduction system.

The central volcanic line outlined by the Narcodam volcano, the Mt. Popa, the volcanoes near Monywa and the Taungthone lone volcano is interpreted as the volcanic arc separating the thick fore – arc basin into the west from the relatively thin back – arc basin into the east (GIAC Report, 1996-1999). This Basin can be divided into several sub-basin, namely –The Ayeyarwaddy Delta basin, The Pyay Embayment, The Salin basin (Central Myanmar), The Shwebo-Monywa basin, The Chindwin basin and The Hukawng basins from South to North (Figure. 2).

North of 20° uplift, the axis of the Saline syncline plunges northward. The Saline syncline runs more than 200km in length, running in north-south orientation and about 70km in width. The east edge of the Saline syncline is formed by a series of narrow elongated anticlines. These are Mann-Minbu anticline, Yenangyaung anticline, Yenangyat-Chauk anticline and Lepento anticline.

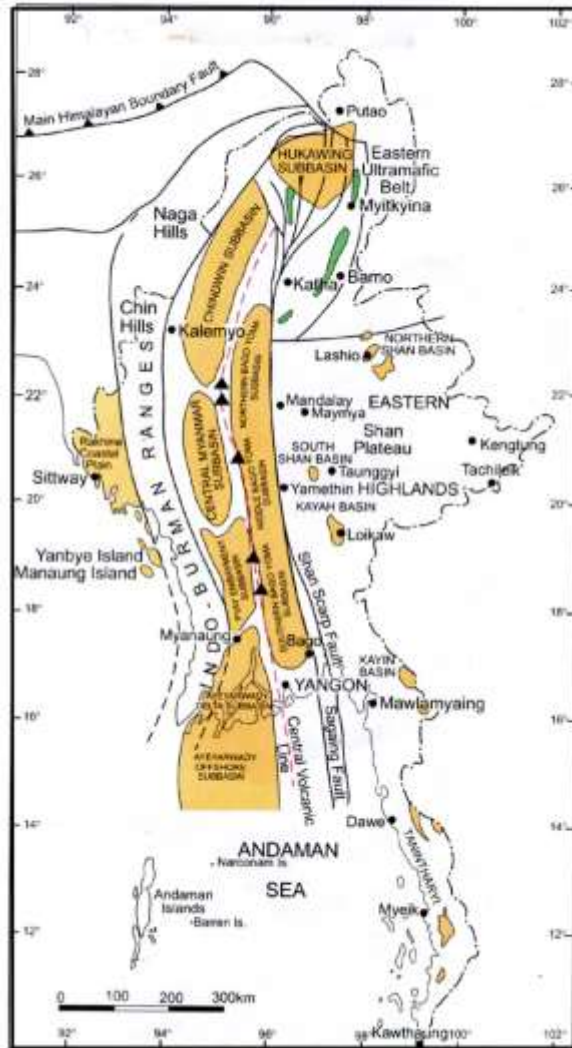


Figure (2). The sub basin in Myanmar (Chit Saing, 2003)

Paleo-environment of The Hukawng

The Hukawng Subbasin is located in the northernmost part of the Central Belt of Myanmar, lying between 24°N and 26.30°N latitudes and 96°E and 97°E longitudes. The subbasin is inverted triangle-shape, with a length of about 130 miles (208 km) and a width of more than 80 miles (128 km). It is bounded in the west by folded beds of Cretaceous and Tertiary flysch strata of the Nga Hills and the Patkoi Ranges in the west. In the East and North, it is bounded by the Precambrian gneiss and schist of the Eastern Highlands. The Southern boundary is a belt of metamorphic rocks, (Soe Myint 1979, Mitchell, Jademines uplift area 2006) together with ultrabasic ophiolite that separate the Hukawng Subbasin from the Chindwin Subbasin at round about 24° North latitude. The regional geological mapping in the south- western part, and eastern and southeastern parts (Suprabum and north of Myitkyina area) were done by Ngaw Cin Pau (1966) and Zaw Pe (1963). The detailed geological mapping on a scale of one inch to one mile was recently carried out by Tin Tun Aung and Thein Win (2001).

Takam Hka Formation is well exposed along the Takam Hka and Mawngyaung streams in the Tanai area, and other small streams as a Miocene Formaton. This Formation

is fairly thick as compared to the underlying and overlying formations. This Formation is composed mainly of a shaly sequence in the upper part, the middle and lower parts are made up of thick packages of stack sandstones with subordinate amount of thin clay interbeds. The palynomorphs are fairly rich in flora. The *Beaupreaidites* sp, *Magnastriatites howardii*, *Margocolporitis tsukadai*, *Piceapollenites* sp., *Magnastriatites usmensis*, *Acaciapollites miocenicus*, *Rhaipites* sp., *Pinuspollenites* sp. have been recorded from this Formation. This sediments were deposited under deltaic terrestrial conditions.

Paleo-environment of Chidwin Subbasin

The Chidwin Subbasin lies approximately between 22° and 24° N latitudes and 94° and 95°45' E longitudes with an estimated sedimentary area of 17715 square miles (28,344 square kilometres). It is a wide, elongate, and asymmetrical basin in NS direction. The western boundary is marked by the conspicuous outcrops of flysch sediments of Chin - Naga mountain Ranges (northern part of Indo-Burman Ranges). The east flank of the Subbasin gradually thins out eastwards, towards the basement Highs, generally known as "Wuntho Massif". The Chindwin subbasin was formed as early as Triassic as indicated by the occurrence of *Daonella lommeli* of Thanbaya (Pane Chaung) Formation. In the north, the basin is bordered by the metamorphic complex of Tanai Hka generally known as Natmauk Taung and Central Ridge of Hukawng Subbasin, the Uplift of Jade Mines (Mitchell, 2006).

The stratigraphic succession of the west flank of Chindwin Subbasin as determined by Aung Khin and Kyaw Win (1969) consists of Thanbaya Formation (Triassic), Kabaw Formation (Cretaceous), Paunggyi Formation (Paleocene), Laungshe Formation (Early Eocene), Tabyin-Tilin Formation (Middle Eocene), Yaw Formation (Late Eocene), Tonhe Formation (Oligocene), Latkat Formation (Early Miocene), Natma Formation (Middle Miocene), Shwethamin Formation (Middle Miocene) and Irrawaddy Formation (Pliocene).

Engelhardt and Wren (1991) modified their palynological classification in 1993, when they studied the samples from the Central Myanmar Subbasin, the Mid-Tertiary formations. Letkat Formation of the Chindwin Subbasin is considered to be correlated with Pyawbawe Formation of Early Miocene age. Letkhat Formation is the Early Neogene formation, lying unconformably over the Yaw Formation in the southern part of the subbasin, and again overlapped by the Tonhe Formation in the northern part of the Chindwin Subbasin. This Formation is an arenaceous sequence consisting of yellow to orange, medium- to coarse- grained, micaceous, massive sandstone which are fairly hard and compact. There is a number of conglomerate beds which are developed usually at the basal part with variable thickness. The palynological species have been recorded as *Retistephanocrlpites williamsi*, *Retitricopites triregularis*, *Meyerinaharkotensis* (very distinct, abundant), *Gothanipollis bassensis*, *Liquidambarpollenites* sp., *Palmaepollenites communis*, *Florchuetzia trilobata*, *Florchuetzia semiloba*, *Magvaceoipollis diversens*, *Piruspollenites* sp., *Tsugaepollenites velatus*, *Magnastriatites howardi* (very Abundant), *Alnipollinillites verus* (Common), *Piceapollenites* sp. (very Abundant), *Magcopollenites tsukadai*, *Pterocaavapollenites* 01, *Verrucatosporites usmensis*. According to the lithological and paleontological character, the sediments in the Chidwin Subbasin may be deposited under freshwater origin.

Paleo-environment of Central Myanmar Subbasin

The Central Myanmar Subbasin generally known as Minbu Basin (Mitchell, 2006) (Salin Synclinorium, Pivnik et al. 1998) is located due southwest of the Hukawng Subbasin, lying between the Rakhine Yoma – Chin Hills in the west and Central Volcanic Line and Bago Yoma in the east. Structurally, this Subbasin is bounded by Cross-high 22° North latitude, and extends southward to 20° North latitude. In other words, the Monywa-Shinmataung-Salingyi-Popa Volcanic Line forms the eastern boundary of the subbasin. Geographically, the Subbasin lies between 19° 30' N to 20° N latitudes and 94° 00' East to 95° 15' East longitudes. The Subbasin consists of more than 90,000 feet of sediments (28125 m) which were classified into (16) formations by the Geological Survey of India (Vredenburg, 1921), the Burmah Oil Company (Lepper 1933, Tainsh 1950) and Eames (1950). Later classification of Tertiary and Mesozoic rocks were done by various institutions, the Myanma Oil Corporation (Aung Khin and Kyaw Win 1969), United Nations Developments Programme (UNDP) and Directorate of Geological Survey and Mineral Exploration Department (DGSE) and other senior staffs of the Departments of the University of Yangon and University of Mandalay. The formations are as follows:-

Table 1 Showing the Mesozoic and Tertiary Formations in the Central Myanmar Subbasin

Formation name	Thickness (metres)	Geological Age
Irrawaddy Formation	3125 m	Pliocene
~~~~~ Unconformity ~~~~~		
Obogon Alternation Formation	1313 m	Middle Miocene
Kyaukkok Formation	1250 m	Early Miocene
Pyawbwe Formation	2031 m	Early Miocene
~~~~~ Unconformity ~~~~~		
Okhmintaung Formation	1250 m	Late Oligocene
Padaung/Tiyo Formation	1250 m	Middle Oligocene
Shwezetaw/Kyaukpon Formation	1438 m	Early Oligocene
Yaw Formation	1500 m	Late Eocene
Pondaung Formation	2031 m	Middle-
LateEocene		
Tabyin Formation	2031 m	Middle Eocene
Tilin Formation	1625 m	Middle Eocene
Laungshe Formation	1875 m	Early Eocene
Paunggyi Formation	1843 m	Paleocene
Kabaw Formation	1334 m	Late Cretaceous
Paung Chaung Formation	938 m	Albian-Cenominian
Thanbaya Formation	2781 m	Triassic
(=Pane Chaung Formation)		

The Pyawbwe Formation is an argillaceous unit, which is composed mainly of thick clays and shales with sandstone interbeds. The clays and shales are fairly soft, bluish gray in colour and thin bedded, and massive. The interbedded sandstones are calcareous, fairly hard, thick bedded to massive, fine to medium grained, and gray in colour. Generally, the sandstones are massive in the lower part and become well bedded in the upper part of the formation.

The shale and clays are rich in foraminifera fossils, by means of which the formation can be differentiated from the overlying Kyaukkok Formation. In the field, the megafossils, mostly both pelecypods and gastropods, are found very commonly in the calcareous sandstones. The Pyawbwe Formation is characterized by explosive distribution as there are a large number of species occurring. The most common species are found in the lower part of the Pyawbwe Formation.

Rotalia beccarii, *Uvigerina multicosata*, *Uvigerina sparsicostata*, *Uvigerina crassa*, *Globigerina praebulloides*, *Globigerina trilocularis*, *Globigerinoides quadrilobatus primodius* and *Globigerinoides triloba immature* occur abundantly in the lower part of the Formation. From the lower part, the fauna becomes abruptly decreases to about 7 species after which there is another cycle of faunal occurrence.

The Middle Pyawbwe Formation is characterized by abundant occurrences of the following species *Rotalia beccarii* (Linne), *Uvigerina multicosata*, *Uvigerina sparsicostata*, *Bathysiphon abuillotensis*, *Rotalia* aff. *Indica*, *Robulus abuillotensis* and *Rotalia koeboensis*. Each of the above species appears upward one by one generally in their distribution pattern. It shows in the form of ladder steps, later occupying the whole of Middle Pyawbwe Formation. Among the benthonic species, *Rotalia beccarii* (Linne) var. *annectens*, *Rotalia beccarii* (Linne) var. 1, 2 and 3 of Su Su Win and Chit Saing (2000) constitute major part of the fauna, which forms a another high peak of the species diversity. The dominant occurrence of all *Rotalia* group indicates that they becomes a shallow marine influenced by the brackish water.

In the upper part of the Pyawbwe Formation, the abundant occurrences of *Rotalia beccarii* (Linne) var. 2 Su Su Win and Chit Saing (2000), and *Rotalia koeboensis* have been noted associated with a few planktonic foraminiferal species such as *Globigerinoides quadrilobatus*, *G. triloba sacculifera*, *G. sicanus* and *Globoquadrina dehiscans*. The common species recorded in the Upper Pyawbwe Formation are *Bathysiphon arenacea* and *Bathysiphon abuillotensis*. This indicates that the fauna is composed mainly of arenaceous species showing that the benthonic species are dominant over the planktonic, indicating that the fauna is considered to be brackish waters suddenly interrupted by marsh waters.

Paleo-environment of Pyay embayment subbasin

The Pyay Embayment subbasin, is situated between Latitudes 20° and 18° 30' and it is mainly composed of clastic sedimentary rock formations namely Paunggyi formation, Laungshe Formation, Tilin Formation, Tabyin Formation, Pondaung Formation and Yaw Formation which are in age of Paleocene to Eocene. Moreover, Oligocene – Miocene Formation of Shwezataw Formation, Padaung Formation, Okhmintaung Formation, Pyawbwe Formation, Kyaukkok Formation, Obogon Formation and Pliocene age of Irrawaddy Formation are also present. Lithologically these formations are made up of conglomerate, sandstone, muddy sandstone, shale, claystone of clastic rocks.

This formation is an argillaceous unit, which is mainly composed of thick clays and shales with sandstone interbeds. The clays and shales are fairly soft, bluish gray in colour and thin bedded, massive in the base of the formation. The interbedded sandstones are calcareous, fairly hard, and thick bedded to massive, fine to medium grained, and gray in colour. Generally, the sandstones are massive with trace fossil in the middle part.

In the middle part, the clays and shales are fairly soft, light to bluish gray in colour and thin bedded, to massive nodular shales. The shales and clays are structureless with sandstones geode and calcites crystal in the upper part of the formation. The shale and clays contain rich foraminiferal fossils, by means of which the formation can be differentiated from the overlying Kyaukkok Formation.

The benthonic species found in the lower part of the Pyawbwe Formation are- *Bathysiphon abuillotensis*, *B. sp.*, *Haplophragmoides compressa*, *H. carinatus*, *H. rediculatus*, *H. emaciates*, *H. giganteus*, *H. sp.1*, *H. sp.2*, *H. sp.3*, *Cyclammina cancellata*, *Eratidus sp*, *Gyroidina neosoldeni ocuta*, *Nodosaria cf. verlebralis*, *N. longiscata*, *N. tasta*, *Ellipsonodosaria multicostata*, *Lagenodosaria scalaris*, *Robulus abuillotensis*, *R. convergens*, *Cibicides bantamensis*, *C. tapanoeliensis*, *C. concenlla*, *Eponides praecintus*, *Baggina inflata*, *Nonion microumbilicatus*, *Bolivina vaceki*, *B. goesii*, *B. marginata*, *B. sumatrensis*, *B. gesteri*, *B. sp.1*, *Ammonia sp.*, *Planulina cf. arminensis*, *Rotalia anneatens*, *R. beccarii*, *R. beccarii var.3* (Su Su Win and Chit Saing, 2000), *R. koeboeensis*, *Uvigerina multicostata*, *U. sparsicostata*, *U. aff. mexicana*, *U. gallowayi*, *U. interrupta costata*, and *U. carapitana*.

The planktonic species found in the lower part of the Pyawbwe Formation are; *Globigerina praebuloides praebuloides*, *Globigerina cf. ciperoensis*, *Globigerinoides altiapturus*, *Globigerinoides primordius*, *Globigerinoides trilocularis*, *Globorotalia mayeri*, *Globorotaloides suteri*, *Globoquadrina dehiscens*, *Globoquadrina altispira altispira*, and *Catapsydrax dissimilis*.

A few number of species recorded in the Lower part of the Pyawbwe Formation are *Haplophragmoides sp.1*, *Haplophragmoides sp.2*, *Gyroidina neosoldeni ocuta*, *Nodosaria tasta*, *Ellipsonodosaria multicostata*, *Lagenodosaria scalaris*, *Robulus abuillotensis*, *Bolivina marginata multicostata*, *Bolivina sp.1*, *Rotalia beccarii var.3* (Su Su Win and Chit Saing, 2000), *Planulina cf. arminensis*, *Uvigerina gallowayi*, *U. carapitana*, and *U. sp* which formed the upward to low species diversity. The planktonic species, *Globigerinoides primordius* and *Globoquadrina altispira altispira* are well found in the lower part of the Pyawbwe Formation. *Globigerinoides altiapturus*, *Globorotalia mayeri* and *Globoquadrina dehiscens* occur rarely in the lower part of the Pyawbwe Formation.

Rotalia annectens and *Rotalia beccarii* occur very commonly in the lower part of the formation. The dominant occurrence of all *Rotalia* group indicates that they becomes a shallow marine influenced by the brackish water.

The middle part of the Pyawbwe formation is characterized by abundant to flooded occurrences of the following benthonic species: - *Haplophragmoides compressa*, *H. carinatus*, *H. rediculatus*, *H. nauticus*, *Ellipsonodosaria vurnleuli*, *Dentalina cf. consobrina*, *Robulus convergens*, *Cibicides bantamensis*, *Baggina inflata*, *Caneris saga*, *Bolivina vaceki*, *B. goesii*, *B. marginata*, *B. sumatrensis*, *B. bilaensis*, *B. caudria*, and *Planularia dominica*. However, the *Baggina inflata*, *Bolivina vaceki*, *B. goesii*, *B. sumatrensis*, *B. bilaensis*, *B. caudria*, *Planularia dominica* and some planktonic species occurs flooded. This condition indicates that they become shallow marine of a relatively a deeper water in marine conditions (Outer neritic).

In the upper part of the Pyawbwe Formation, the common occurrences of *Haplophragmoides rediculatus* and *Cibicides bantamensis* have been noted associated with a few planktonic foraminiferal species such as *Globigerinoides bisphericus*, *Globorotaloides suteri*, *Globoquadrina altispira altispira*, and *Hastigerina praesiphonifera*, showing that the benthonic species are dominant over the planktonic, indicating that the sediments is considered to be deposited under relatively a shallow marine condition.

Paleo-environment of Ayeyarwady Delta Subbasin

The Ayeyawady Delta Subbasin is the southernmost onshore subbasin, lying between the Rakhine Yoma in the west and the low-lying hills of the Bago Yoma in the east. The shape of the basin is triangular, and extends over the widest area in the southern part of Myanmar, covering about 2000 square miles (3200 square km). Most of the Tertiary strata are covered by alluvium, except for two areas located in the southwestern corner of the subbasin, namely: (i) the Ngaputaw, Yesaing and Myaungmya areas, and (ii) the Ngathainggyaung and Lemyethna areas which are located in the western and southwestern parts of Hinthada District.

The Tumyaung Formation is composed mainly of shales, clays, marls interbedded with fore-reefal limestones. They examined a total of thirty shale samples and eleven limestone samples. They recorded sixty-two smaller benthonic species and twenty-one planktonic species from argillaceous rocks.

The Tumyaung Formation is overlain by Kwingyaung Formation in the same area. This Formation is well-exposed on the track connecting Kwingyaung and Kathabaung villages. Kwingyaung village is situated at 16° 15'N: and 94° 48'E. This Formation is made up of about 80% of limestones and 20% of thin calcareous shales with thin similar sandstone beds.

Hnin Hnin Maung *et al.* (2006) studied the biostratigraphy of the foraminiferal species in the shales and limestones. A total of fifty-seven foraminiferal species (forty-six smaller benthonic species and eleven planktonic species) have been recorded from the Kwingyaung Formation. This formation is placed in the upper part of Early Miocene to the middle part of Middle Miocene, based on the stratigraphic ranges of some selected species such as *Globorotalia praefohsi* and *Globorotalia scitula praescitula*. Based on the foraminifera species, These formation is considered to have been deposited under nearshore marine.

Conclusions

The Central Belt of Myanmar occupies the full N-S trended central part of Myanmar, extending from 14°N to 26°30'N. The belt is divided into six subbasins, The Hukawng (24°N-26°N), Chindwin (22°N-24°N), Central Myanmar (20°-22°N), Pyay Embayment (20°N-18°N) Ayeyarwaddy Delta (20°N-18°N), Ayeyarwaddy Offshore (14°N-16°N) subbasins. Present stratigraphical knowledge is mainly confined to the south portion of the Hukaung and Chidwin Subbasin and very little geological fieldwork had been carried out in the Hukaung and Chidwin Subbasin. In the case of the Biostratigraphy of the Hukawng and Chindwin subbasins, most of the sediments are considered to have been deposited under nonmarine deltaic, and swampy conditions. Both of them are now land-locked basins, but were filled by marine sediments from the Triassic to the Middle Eocene and by terrestrial sediments from the Oligocene to the Pliocene. In the southern part of the Chindwin Subbasin and the Central Myanmar Subbasin, from the Paunggyi Formation

(Paleocene) to the Pyawbwe Formation, fossiliferous limestones are interbedded with sandstones, clays and shale beds. These fossiliferous beds are dominated by the larger foraminiferal species, used for zonation. In the areas south of latitude 22° North, typically in the Central Myanmar Subbasin, Pyay Embayment Subbasin, Ayeyarwaddy Delta Subbasin and Ayeyarwaddy Offshore Subbasin, faunal and floral zonation has been attempted, based on local foraminiferal numbered species, pollen and nannoplankton. All the sediments were deposited under shallow marine to fairly deep marine conditions.

The geology of the Chindwin Subbasin is not completely understood, since it has been described only from geological traverses along the motor road between Kalemmyo and Kalewa, and the whole area of the Wuntho Igneous massif. Many expatriate and Myanmar geologists have made geological traverses along this motor road, observing details of the geology and classifying the various types of rocks in this region. Reimann & Aye Thaug (1975) were the first palynologists to investigate the Tertiary sequence in the Chindwin Subbasin of northwestern Myanmar.

Paucity of the foraminiferal fauna in lowest part of the sediments (Pyawbwe Formation) between between Latitude 22° and 15° 00' during early Miocene time indicate that the sediments were deposited in very shallow water conditions which probably represent the initial phase of the Miocene transgression. This is also indicated by the development of conglomerates in the basal part of the Pyawbwe Formation. Gradual deepening and shallowing up of the subbasins during the period of deposition of the Pyawbwe Formation is indicated by the increase and decrease in deeper water marine and shallower water brackish fauna encountered in these sediments.

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