

Paleoenvironmental Analysis of Benthic Foraminifera and Radiolarians in Middle Eocene Tabyin Formation, Mindon-Taing Da Area, Magway Region, Myanmar*

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Abstract

The study area is situated about 8 km north of Mindon, Mindon Township, Thayet District, Magway Region. It lies between North Latitude 19°25' and 19°35' and East longitude 94°37' and 94°45'. The study area regionally lies on the southern part of the Salin Sub-Basin in the Central lowland of Myanmar. It is situated near the eastern foothills of Rakhine Yoma where the entire area is covered by the Eocene rocks. The stratigraphic succession of Eocene formations, Paunggyi Formation, Longshe Formation, Tilin Formation and Tabyin Formation, are well exposed from the eastern foothills of Rakhine Yoma to the Pathine - Monywa highway. The western part of the study area is bounded by highlands, where arenaceous formations of the Paunggyi Formation and Tilin Formation are well exposed in the form of highlands and cliffs. The argillaceous formations, Longshe Formation and Tabyin Formation, are well exposed in the form of rough plain. Lithologically these formations are made up of conglomerate, sandstone, muddy sandstone, shale and claystone.

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Paleoenvironmental Analysis Of Benthic Foraminifera and Radiolarians in Middle Eocene Tabyin Formation, Mindon-Taing Da Area, Magway Region, Myanmar

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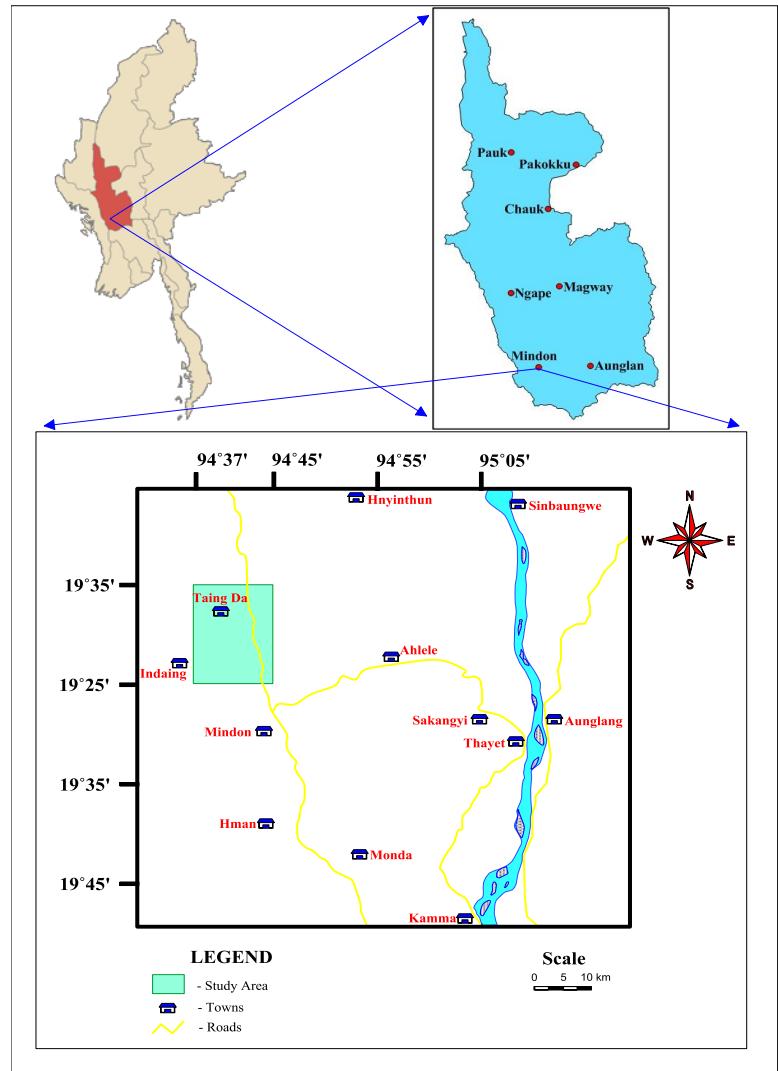
Outline

1. INTRODUCTION
2. STRATIGRAPHY
3. MICROPALAEONTOLOGY

Objective

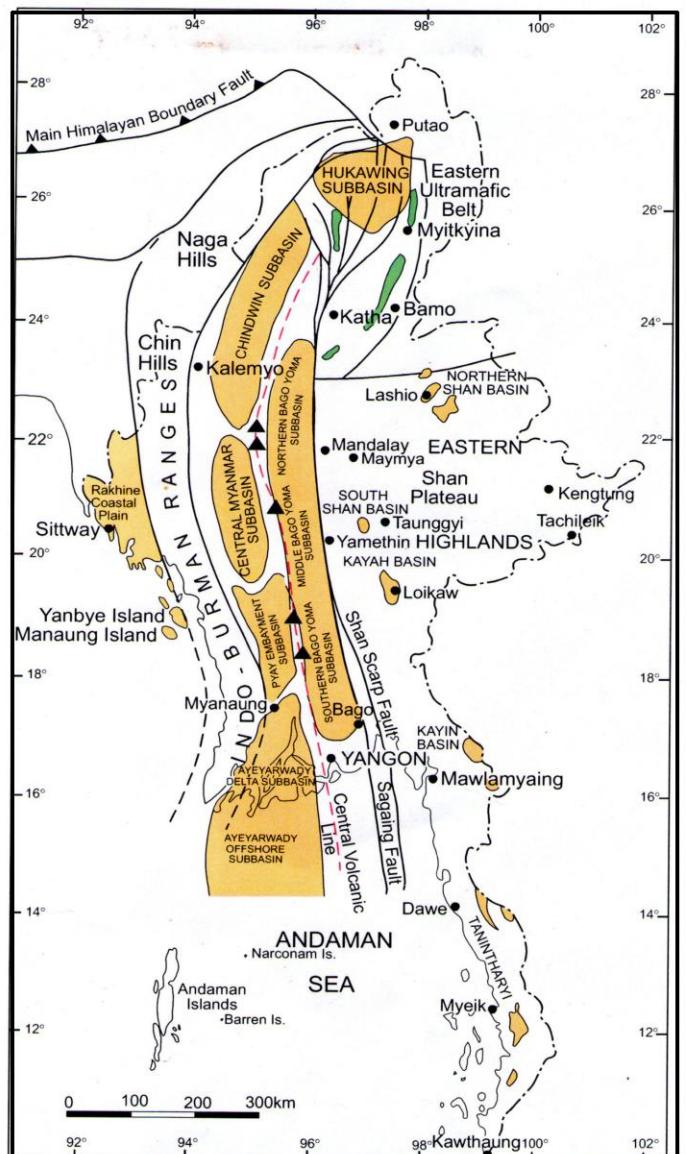
- To find out the paleoenvironmental and paleoecological conditions of the study area during middle Eocene with the help of common Foraminifera and Radiolarians.
- To compare depositional conditions of the sediments during Eocene, Oligocene and Miocene times based on microfauna.

Location of the study area



- The present study area is situated about 8 kms northern part of the Mindon , Mindon Township, Thayet District,
- Magway Region, Myanmar.
- It lies between Latitude 19°25' N and 19°35' N and Longitude 94°37'E and 94°45' E.

Regional Geological Setting



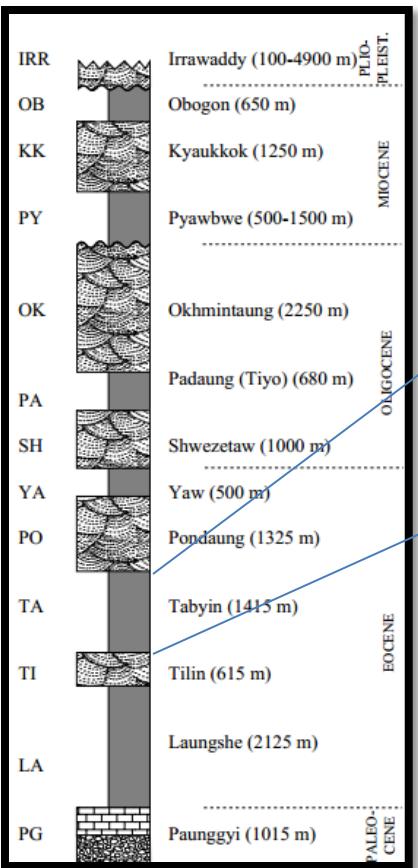
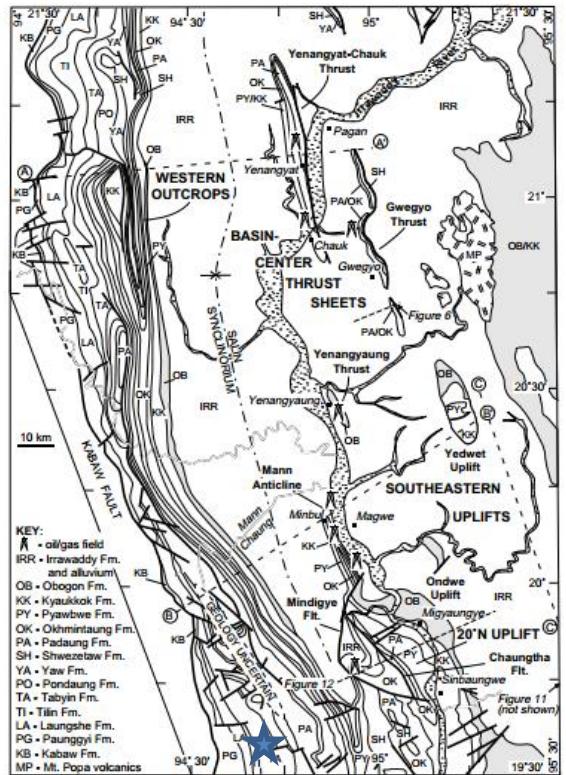
- ❖ Myanmar is divided into four north- south linear geotectonic provinces, namely (from east to west)-

 1. The eastern Highland (Shan-Tanasserian Highland)
 2. The Central Low Land
 3. The western Ranges and
 4. The Rakhine Southern and Northern coastal area (Maung Thein 1983)

- ❖ The study area is regionally lies on the central Cenozoic belt of Central lowland of Myanmar.
 - lies on the southern part of the Salin subbasin in the Central lowland of Myanmar.
 - near the eastern foot hills of Rakhine Yoma where the whole area is covered by the Eocene, Oligocene and Miocene Formations.

STRATIGRAPHY

The stratigraphic sequence of the study area

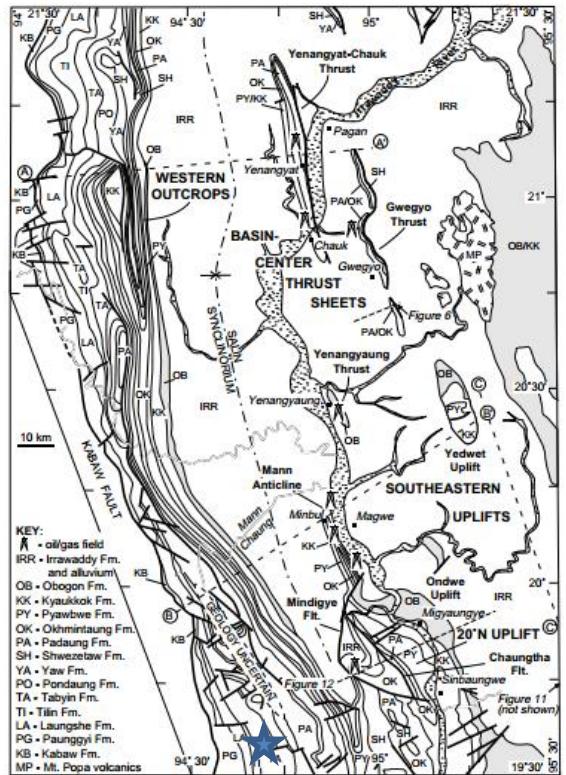


(Simplified geologic map of the Salin subbasin D.
A. Pivnik, J. Nahm, R. S. Tucker, G. O. Smith, K. Nyein, M. Nyunt, and P. H. Maung, 1988)

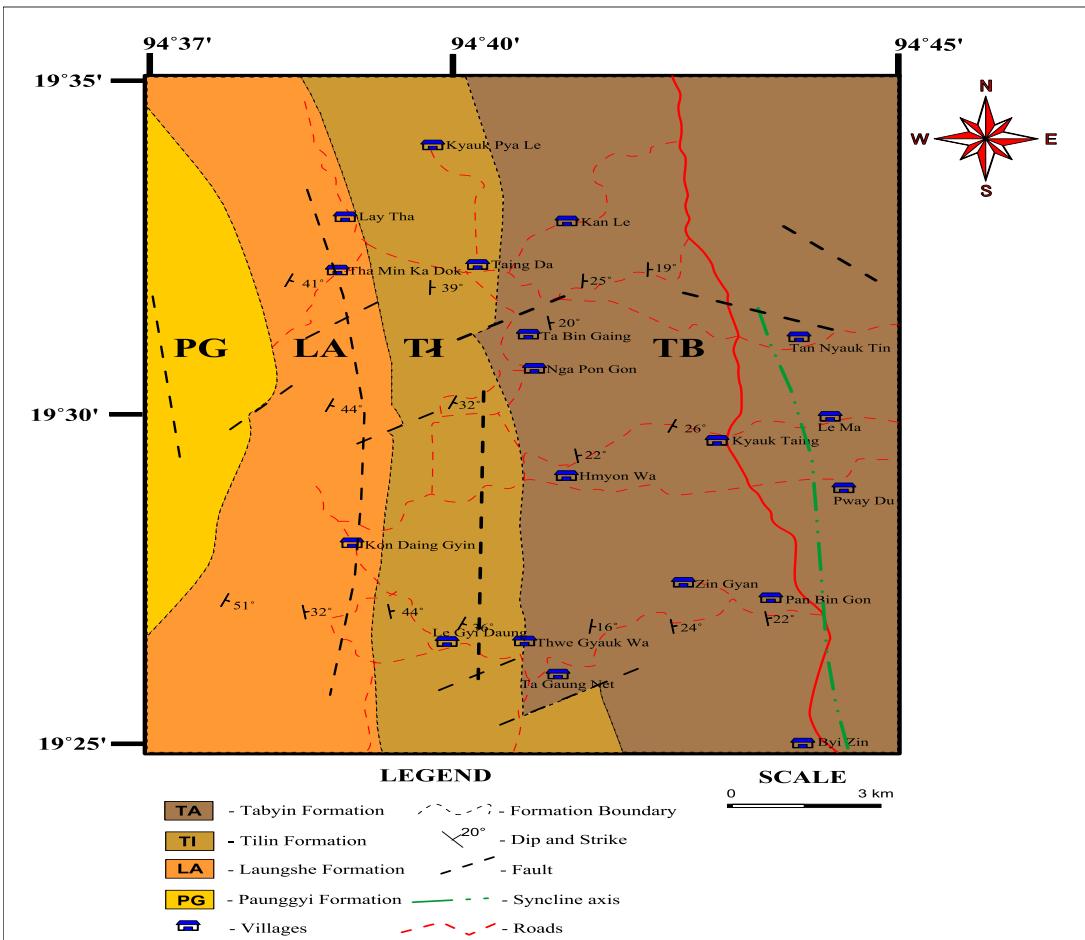
Formation	Thickness (Central Myanmar Basin)	Thickness (Present Study Area)	Geological Age (Chit Saing, 2004)
Older Alluvial	--	--	--
Tabyin Formation	2031 m	2870 m	Middle Eocene
Tilin Formation	1625 m	-	Lower Eocene
Longshe Formation	1875 m	-	Lower Eocene
Paunggyi Formation	1843 m	-	Paleocene

STRATIGRAPHY

The stratigraphic sequence of the study area



(Simplified geologic map of the Salin subbasin D.
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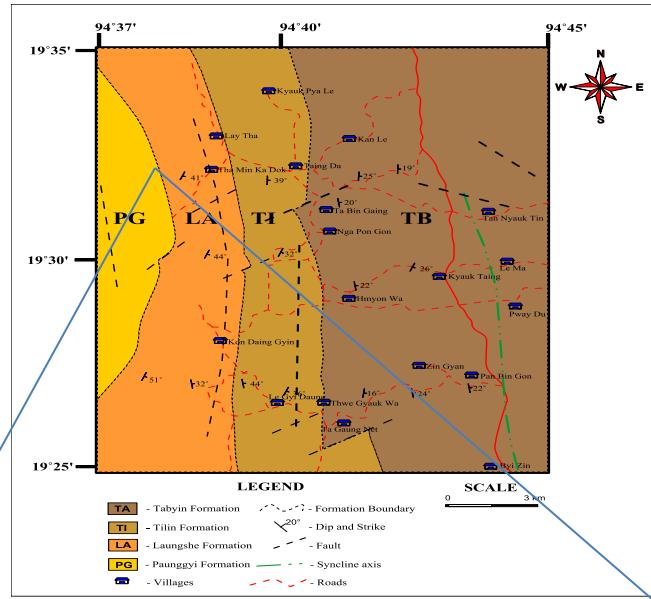


Geological Map of Study Area (After MOGE, 2012)

Paunggyi Formation

Lithology:

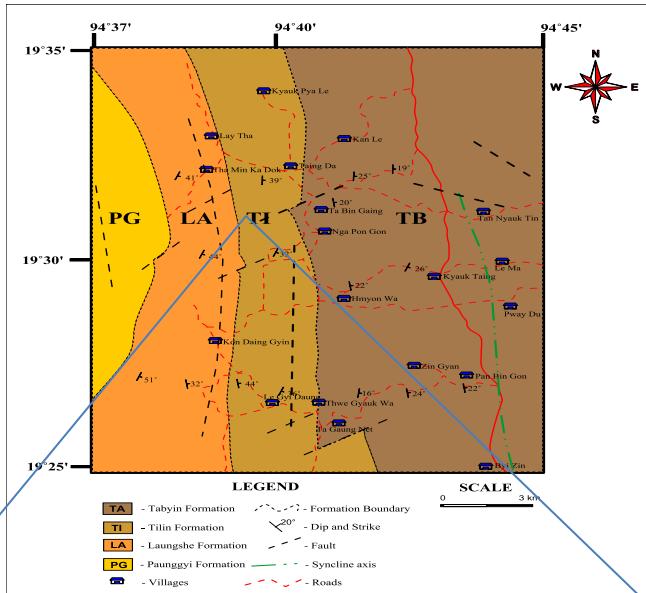
- ❖ sandstone interbedded with gritty to conglomeratic beds.
- ❖ light grey to yellowish brown, fair hard, massive - bedded, fine to coarse grained



Loungshe Formation

Lithology:

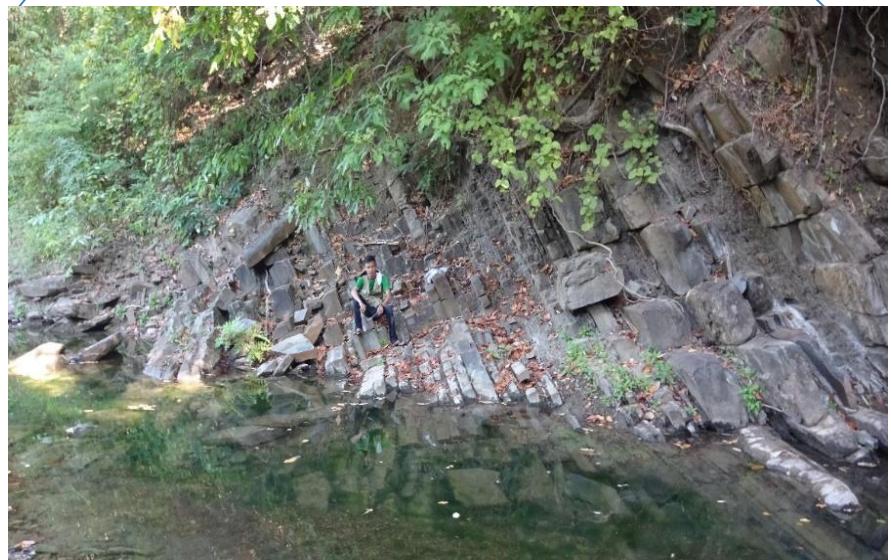
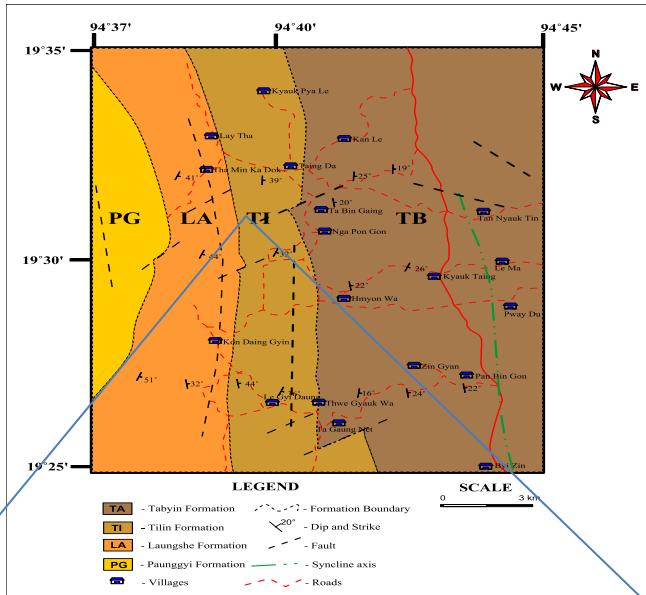
- ❖ shales interbedded with fossiliferous limestone.
- ❖ dark to light grey colour, laminated to nodular, carbonaceous and interbedded with argillaceous sandstone.
- ❖ Limestone are dark to light grey colour and thick bedded to massive.



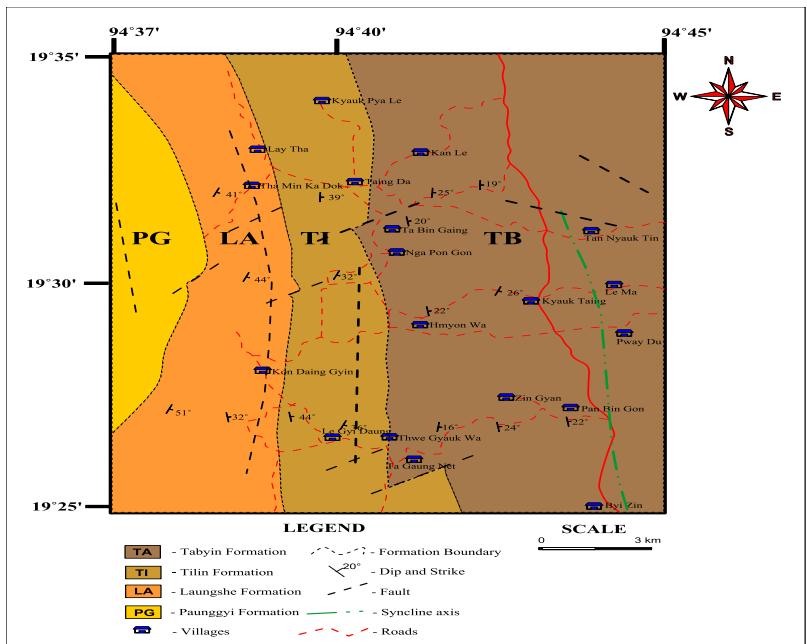
Tilin Formation

Lithology:

- ❖ sandstone interbedded with argillaceous shales.
- ❖ buff colour, yellowish brown to light grey, massive to thick bedded, fine to medium grained, fairly sorted and composed of carbonaceous material.
- ❖ Shale are light grey and moderately hard, thinly laminated and sometime ferriogenius.



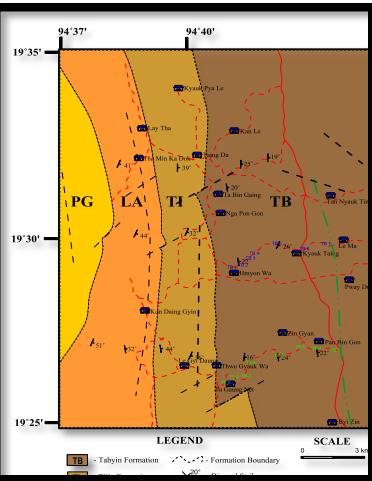
Tabyin Formation



Lithology:

- shales interbedded with argillaceous sandstones.
- dark grey to grey, thinly laminated, fairly carbonaceous and fossiliferous.
- In the upper part, the shale colour is yellowish brown.
- Sandstone are grey to buff colour, moderately hard and thin to medium badded.

Columnar section of the Tabyin Formation
in Section 1(19° 26' 30" to 19° 27' 06"
N/1(94°40'30" to 94°42'49" N)



Units	Thickness (meter)	Litho-stratigraphic Units	Sample No.	Lithologic Description
		19°27'06.6" N 94°42'49.1" E	TB 8	Shale; It is made up fairly soft, thin to medium bedded, fine to medium grained, and buff colour shale.
	2800 m		TB 7	Shale; It is made up fairly soft, thin to medium bedded, fine to medium grained, and light gray shale.
	2600 m		TB 6	Shale; fairly hard, thin to medium bedded, fine to medium grained, and dark gray shale.
	2400 m		TB 5	Shale; medium to fine grain, bluish grey colour massive concretionary shale.
	2200 m		TB 4	
	2000 m		TB 3	Sandstone and shale alteration; It is composed of thin to medium bedded sandstone with light -gray shales. The interbedded sandstone are calcareous, fairly hard , thick-bedded to massive, fine to medium grain and buff in colour
	1800 m		TB 2	Shale; It is made up massive, light to bluish grey, highly weather, slightly mottled shale.
	1600 m		TB 1	
	1400 m			
	1200 m			
	1000 m			
	800 m			
	600 m			
	400 m			
	200 m			
		Soil Shale Sand		
		19°26'30.1" N 94°40'00.1" E		

Columnar section of the Tabyin Formation in
Section 2(19° 28' 04 " to 19° 29' 45 " N/1(94°
39' 06 " to 94° 42' 55 " N.

Units	Thickness (meter)	Litho-stratigraphic Units	Sample No.	Lithologic Description
		19°29'45.4" N 94°42'55.2" E	TB 7b	Shale; It is made up fairly soft, thin to medium bedded, fine to medium grained, and buff colour shale.
	2400 m		TB 6b	Shale; It is made up fairly soft, thin to medium bedded, fine to medium grained, and light gray shale.
	2200 m		TB 5b	Shale; medium to fine grain, bluish grey colour massive concretionary shale.
	2000 m		TB 4b	
	1800 m		TB 3b	
	1600 m		TB 2b	Sandstone and shale alteration; It is composed of thin to medium bedded sandstone with light -gray shales. The interbedded sandstone are calcareous, fairly hard , thick-bedded to massive, fine to medium grain and buff in colour
	1400 m		TB 1b	Shale; It is made up massive, light to bluish grey, highly weather, slightly mottled shale.
	1200 m			
	1000 m			
	800 m			
	600 m			
	400 m			
	200 m			
		Soil Shale Sand		
		19°28'04.8" N 94°39'36.6" E		



- Photograph showing fairly soft, thin to medium bedded, and buff colour shale found in the upper part of Tabyin Formation.
- Photograph showing fairly soft, thin to medium bedded, and light gray shales found in the upper part of Tabyin Formation.
- Photograph showing fairly hard, thin bedded, dark gray shale found in the middle part of Tabyin Formation.
- Photograph showing massive, light to bluish grey, highly weather, slightly mottled shale exposed in the Lower part of the Tabyin formation.

The Distribution of Foraminiferal and Radiolarian species present in section 1

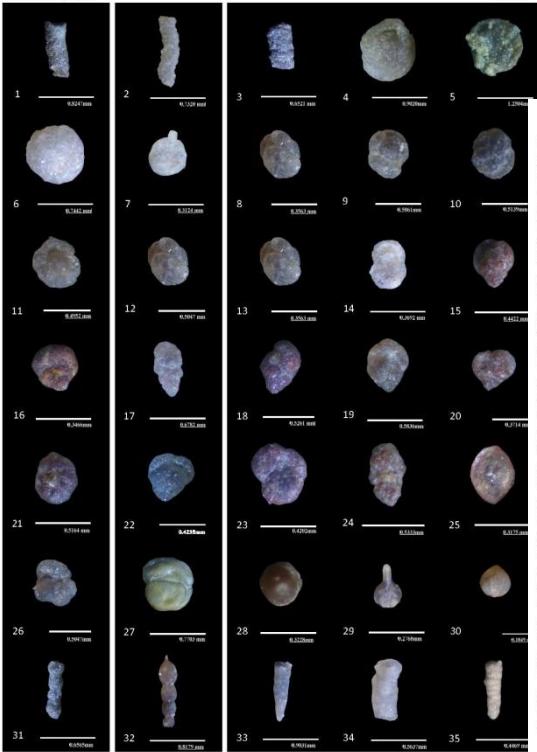
Table - The distribution of Benthonic and Planktonic species along the Zaw Gyi Chaung Section

The Distribution of Foraminiferal species present in section 2

Table - The distribution of Benthonic and Planktonic species along Kon Daing Gyn – Hmon Wa Section

Eocene Foraminifera in Myanmar

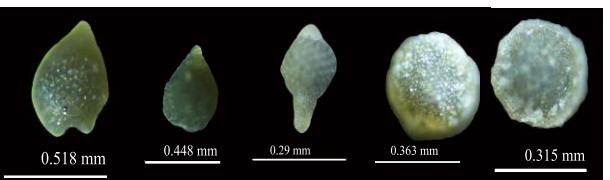
Benthonic Species



Planktonic Species



Radiolaria species in the study area



1. *Calocyclus castum*
2. *Theocotyle ficus*
3. *Cenosphaera eocenica*
4. *Acanthosphaera* sp.
5. *Phacodiscus* sp.

Biostratigraphic Zone

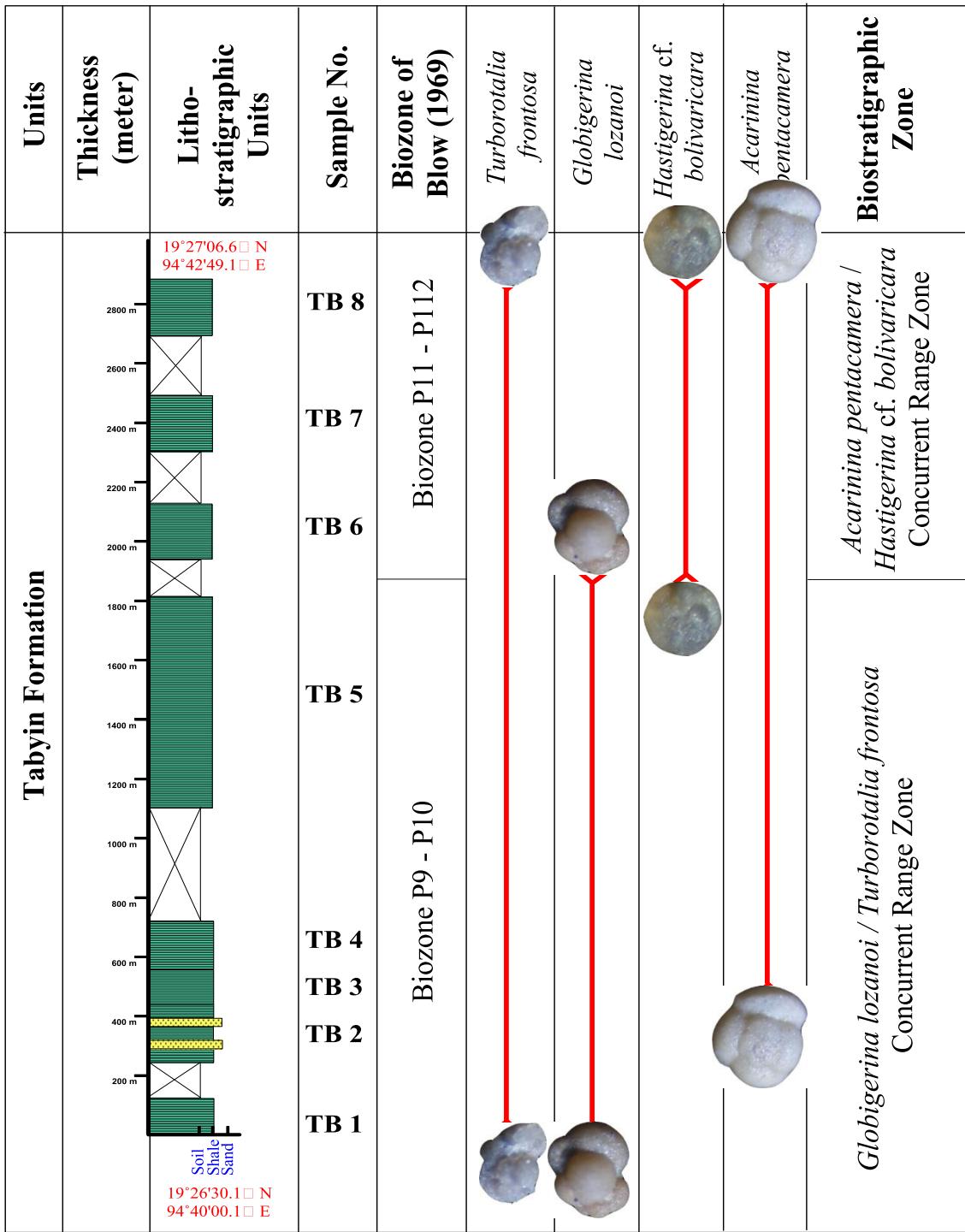
Formation

*Acarinina pentacamera -
Hastigerina cf.
bolivaricara
(Concurrent range Zone)*

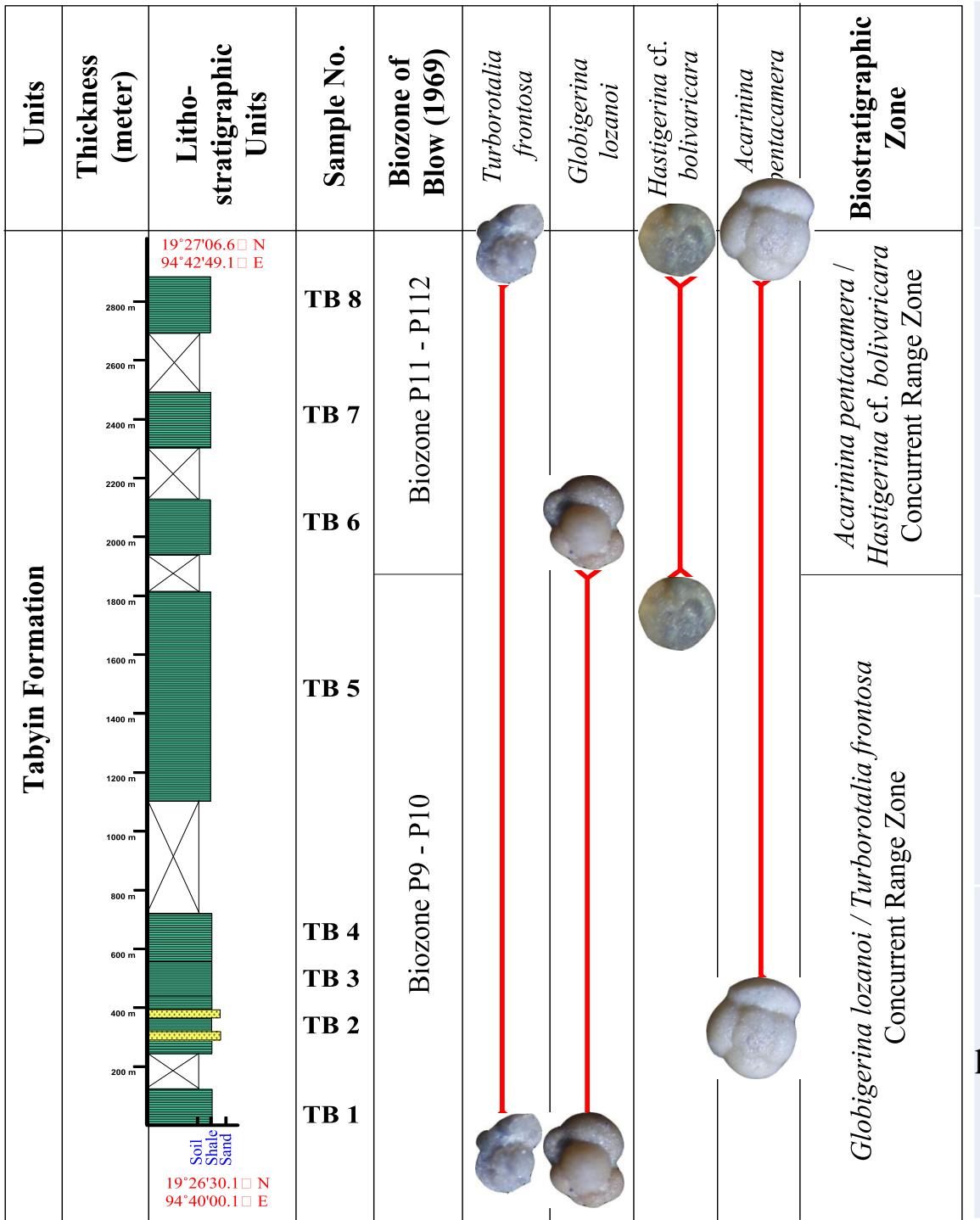
Upper part of the
Tabyin
Formation

Middle part of
the Tabyin
Formation

Basal/Lower
part of the Tabyin
Formation



19°26'30.1 N
94°40'00.1 E



Biostratigraphic Zone

Formation

Acarinina pentacamera -
Hastigerina cf.
bolivaricara
(Concurrent range Zone)

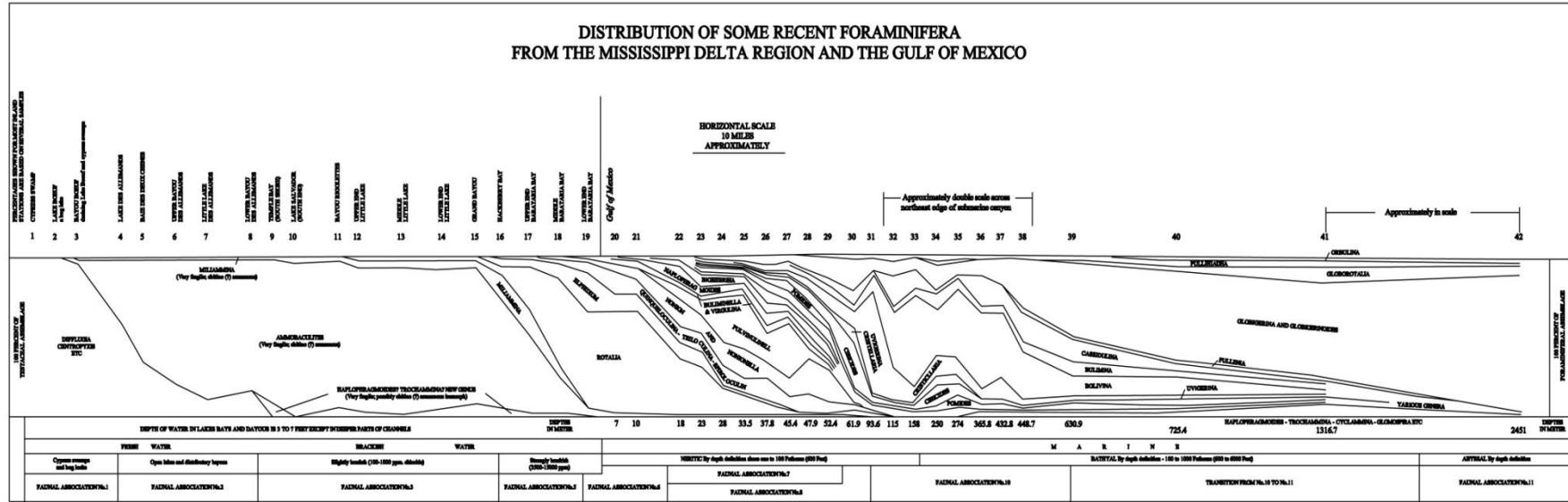
Lutetian

Middle part of the Tabyin Formation

Globigerina lozanoi -
Turborotalia frontosa
(Concurrent range Zone)

Basal/Lower part of the Tabyin Formation

Bathymetry range



(Lowman, 1949)

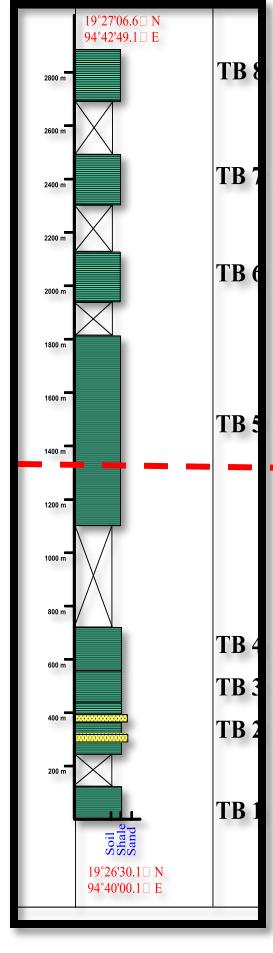
(Kaminski, 2008)

Bathymetry range

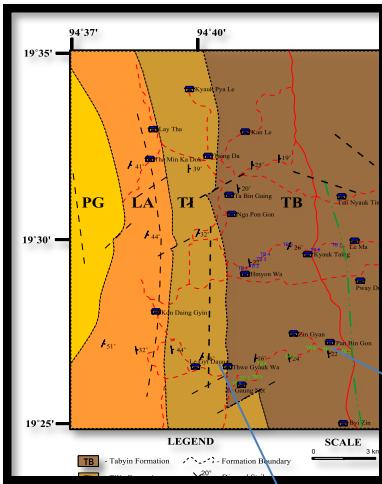
No.	Species	Brackish Zone	Inner Neritic	Middle Neritic	Outer Neritic	Upper Bathyal	Middle Bathyal	Lower Bathyal	Upper Abyssal	Lower Abyssal
1	<i>Trochammina</i>									
2	<i>Ammobaculite</i>									
3	<i>Cibrostommooides</i>									
4	<i>Gaudryina</i>									
5	<i>Gaudryinopsis</i>									
6	<i>Dorothia</i>									
7	<i>Plectina</i>									
8	<i>Dentalina</i>									
9	<i>Robulus</i>									
10	<i>Cushmanella</i>									
11	<i>Cibicides</i>									
12	<i>Gyroidina</i>									
13	<i>Eponides</i>									
14	<i>Cancris</i>									
15	<i>Subreophax</i>									
16	<i>Hormosinella</i>									
17	<i>Haplophragmoides</i>									
18	<i>Texularia flintii</i>									
19	<i>Siphonodosaria quadrulata</i>									
20	<i>Chrysalogonium cretaceum</i>									
21	<i>Amphimorphina amchitkaensis</i>									
22	<i>Buliminella subfusiformis</i>									
23	<i>Bulimina cf. B. hebespinata</i>									
24	<i>Spiroplectammina</i>									
25	<i>Uvigerina bifurcata</i>									
26	<i>Nonion elongatum</i>									
27	<i>Nodosaria irregularis</i>									
28	<i>Nodogenerina sagrinensis</i>									
29	<i>Gumbelina cubensis</i>									
31	<i>Saccammina</i>									
32	<i>Bathysiphon</i>									
33	<i>Nothia</i> sp.									
34	<i>Spirolocutita taddae</i>									

(Lowman, 1949)

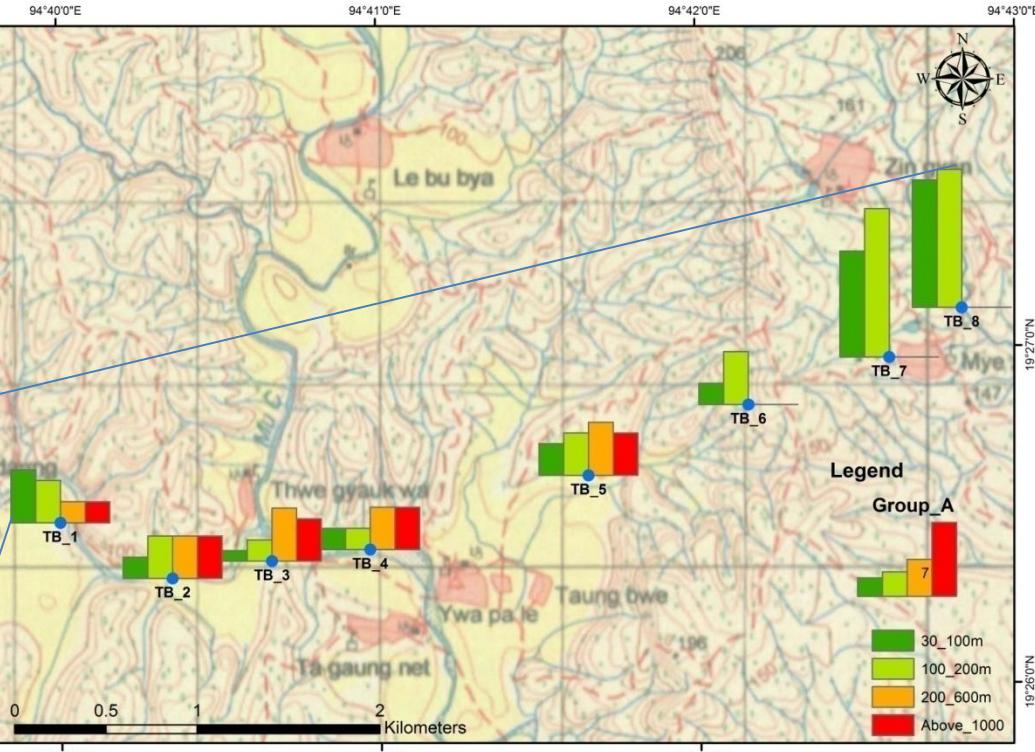
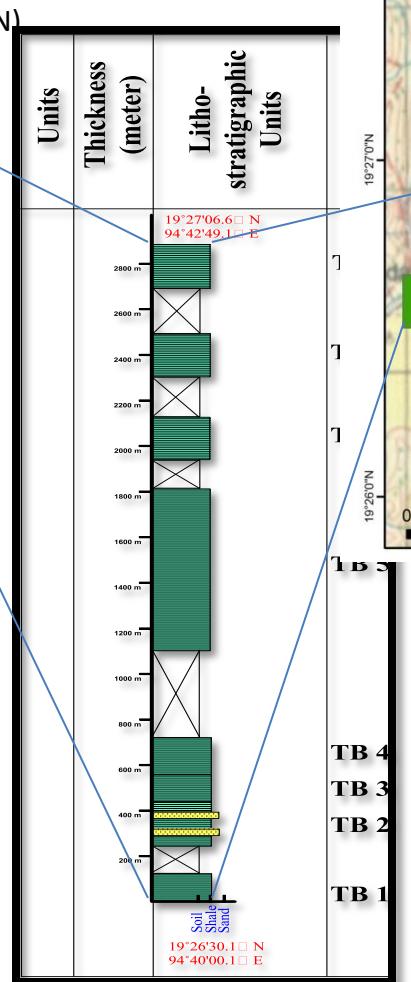
(Kaminski, 2008)



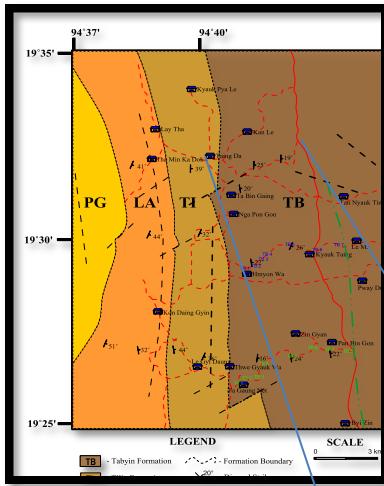
Bathysiphon eocenicus
Nothia sp.
Hormosinella ovulum
Subreophax pseudoscalarius
Saccammina globosa
Gaudryina triangularis
Haplophragmoides emaciatum
Ammobaculite sp.1
Dorothia altacamerata
Trochammina trincherasensis
Plectina dalmatina
Textularia flintii
Nodosaria irregularis
Siphonodosaria quadrulata
Bulimina subacuminata
Chrysalogonium cretaceum
Phacodiscus sp.
Cenosphaera sp.
Calocyclus eocenica
Thecocotyle castum
Thecocotyle ficus



Columnar section of the
Tabyn Formation in Section
1(19° 26` 30" to 19° 27`06"
N/1(94°40`30" to 94°42`49"



Distribution of fauna in the Tabyn Formation in Section 1(19° 26` 30"
to 19° 27`06" N/1(94°40`30" to 94°42`49" N)

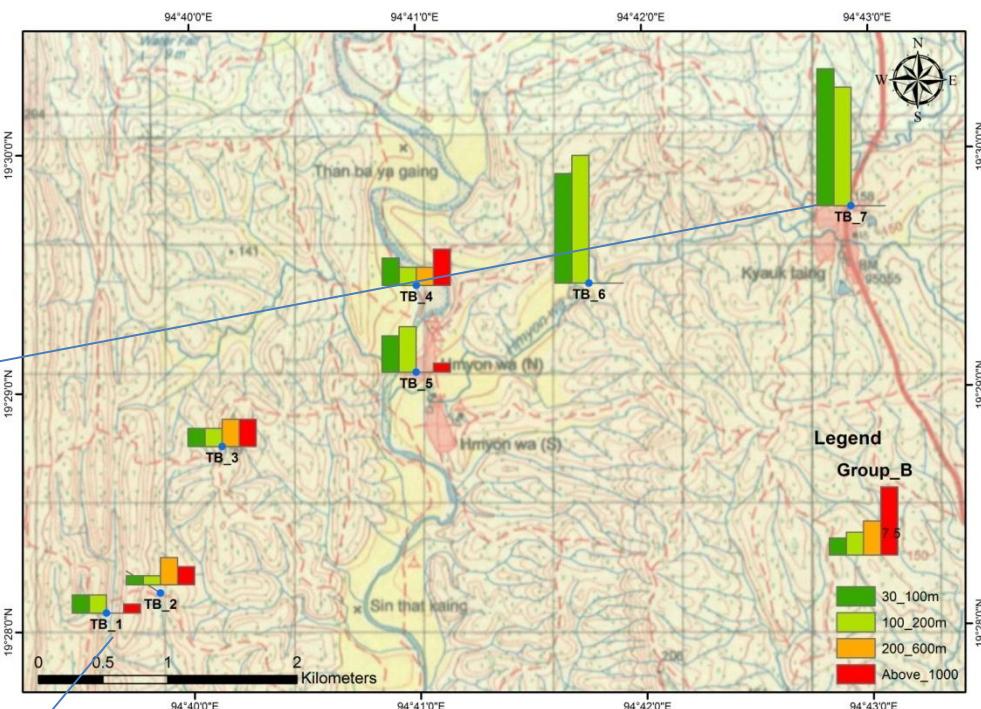
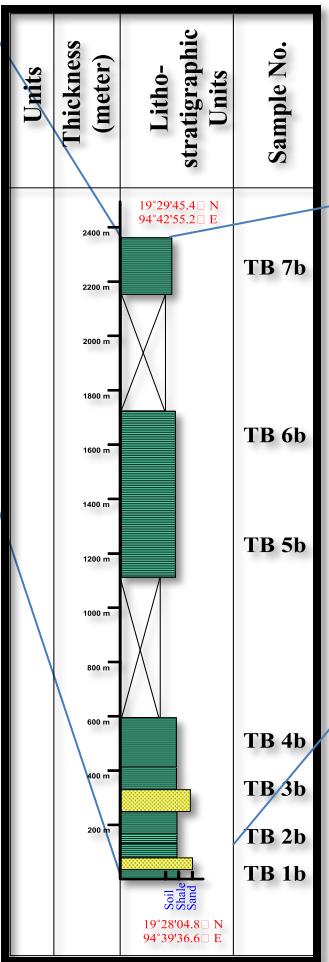


Columnar section of the
Tabyin Formation in Section

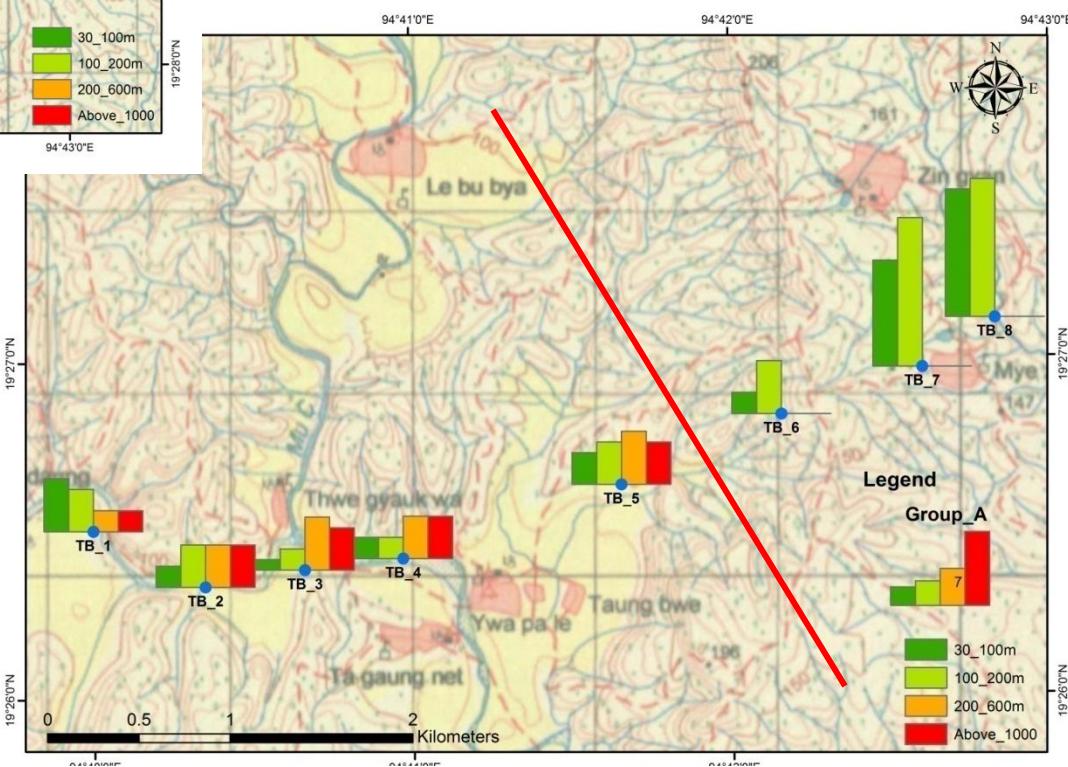
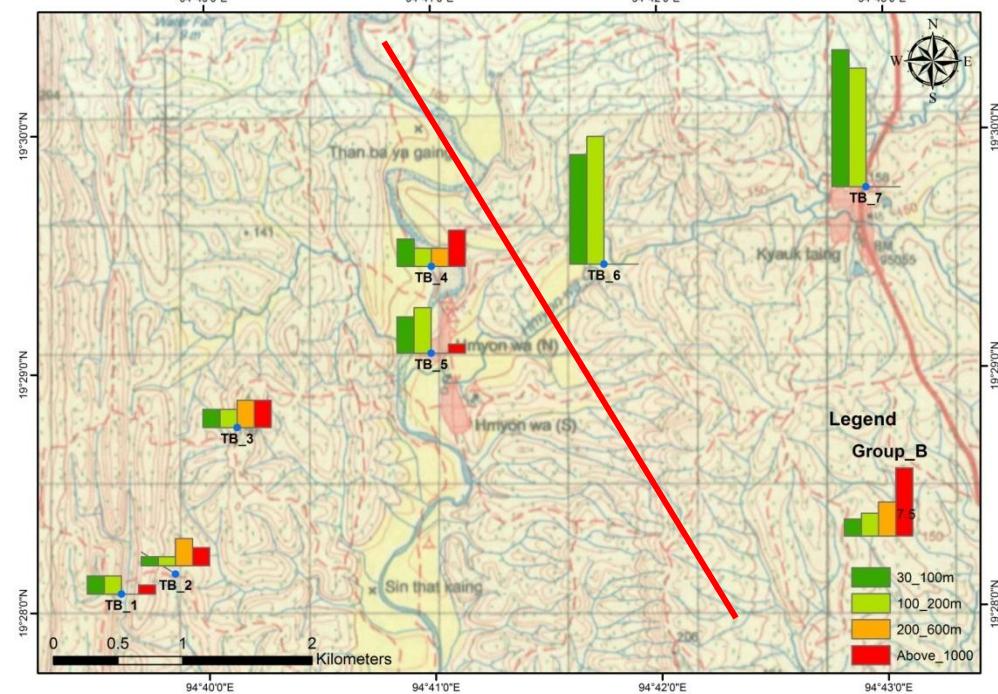
1(19° 26` 30" to 19° 27`06"

N/1(94°40`30" to 94°42`49"

N)



Distribution of fauna in the Tabyin Formation in Section 1(19° 26` 30"
to 19° 27`06" N/1(94°40`30" to 94°42`49" N)

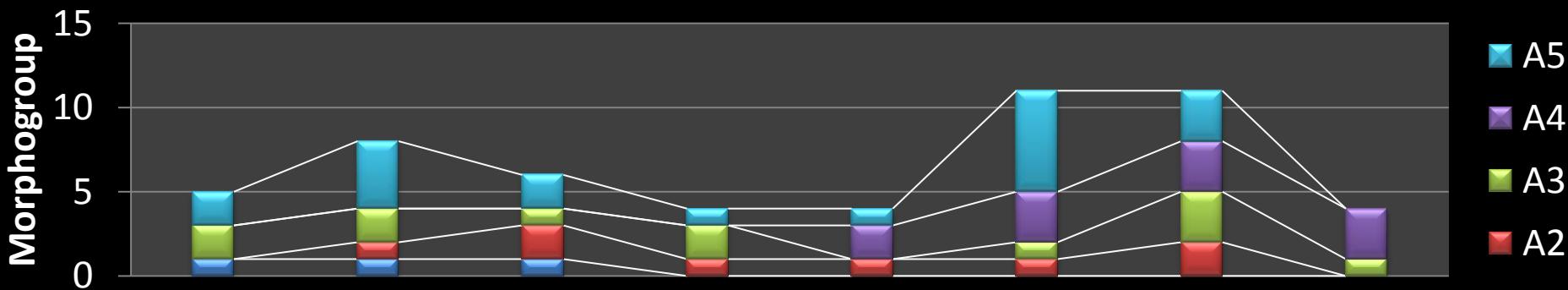


Agglutinated foraminifera morphogroups and their inferred life position as well as feeding habits(Bak,K *et al.*,1997, Kaminiski *et al.*,1988, Nagy *et al.*,1995)

Morphogroup	Test Type	Position within sediments	Feeding Strategy	Main genera
A1	Tabular or branched	Epifaunal erect	Suspension feeders	<i>Bathysiphon</i>
A2	Flattened	Epifaunal	Deposit feeders	<i>Hormosinella</i> <i>Saccammina</i> <i>Ammobaculite</i> <i>Gaudryina</i>
A3	Plano-convex, concavo-convex	Epifaunal	Herbivores Detritivores	<i>Textularia</i> <i>Trochamminoides</i> <i>Trochammina</i>
A4	Rounded or biconvex	Epifaunal/shallow infaunal	Detritivores	<i>Haplophragmoides</i>
A5	Elongate Subcylindrical tapered	Shallow to deep infaunal	Detritivores	<i>Nothia</i> <i>Subreophax</i> <i>Dorothia</i> <i>Plectina</i>

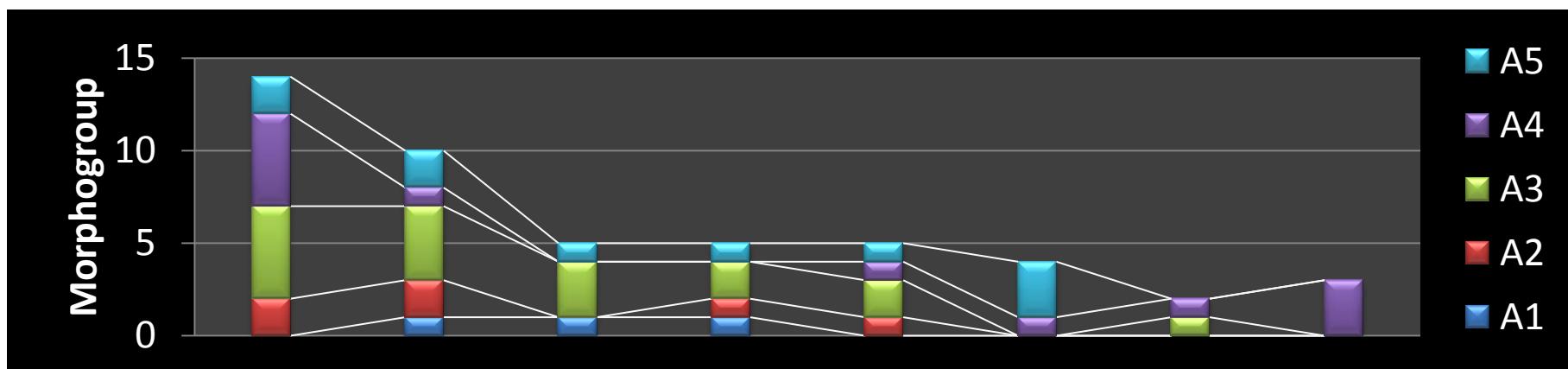
Agglutinated foraminifera morphogroups and their inferred life position as well as feeding habits in Section 1

	A1(Epi-Sup-feeder)	A2(Epi-Dep-feeder)	A3(Epi-her/detivore)	A4(Sh/de-In – detrivore)	A5(Sh/de-In – detrivore)		
TB8	0%	0%	25%	75%	0%	Epifaunal < Infaunal	<ul style="list-style-type: none"> ➤ Medium to high energy condition. ➤ Lower rate of sedimentation with less common gravitational currents ➤ Amount of nutrient in the sediments was very restricted.
TB7	0%	18.18%	27.27%	27.27%	27.27%	Epifaunal < Infaunal	
TB6	0%	9.09%	9.09%	27.27%	54.54%	Epifaunal < Infaunal	
TB5	0%	25%	0%	50%	25%	Epifaunal < Infaunal	
TB4	0%	25%	50%	0%	25%	Epifaunal > Infaunal	<ul style="list-style-type: none"> ➤ low to Medium energy condition. ➤ Lower rate of sedimentation with less common gravitational currents ➤ Amount of nutrient in the sediments was fair.
TB3	16.6%	33.33%	16.6%	0%	3.33%	Epifaunal > Infaunal	
TB2	12.5%	12.5%	25%	0%	50%	Epifaunal = Infaunal	
TB1	20%	0%	40%	0%	40%	Epifaunal > Infaunal	

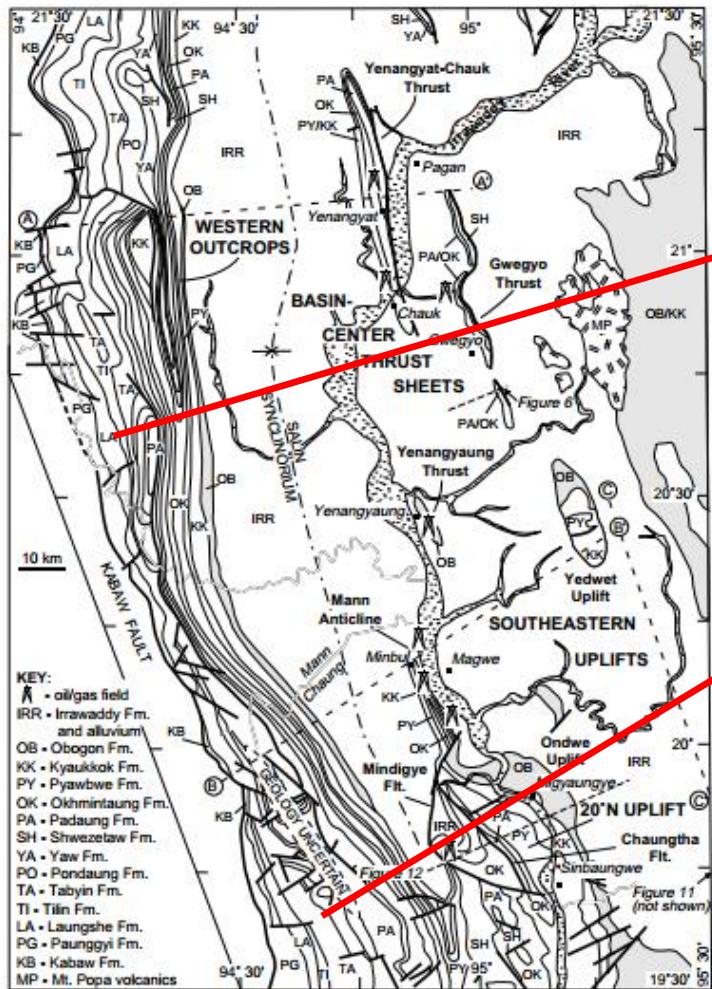


Agglutinated foraminifera morphogroups and their inferred life position as well as feeding habits in Section 2

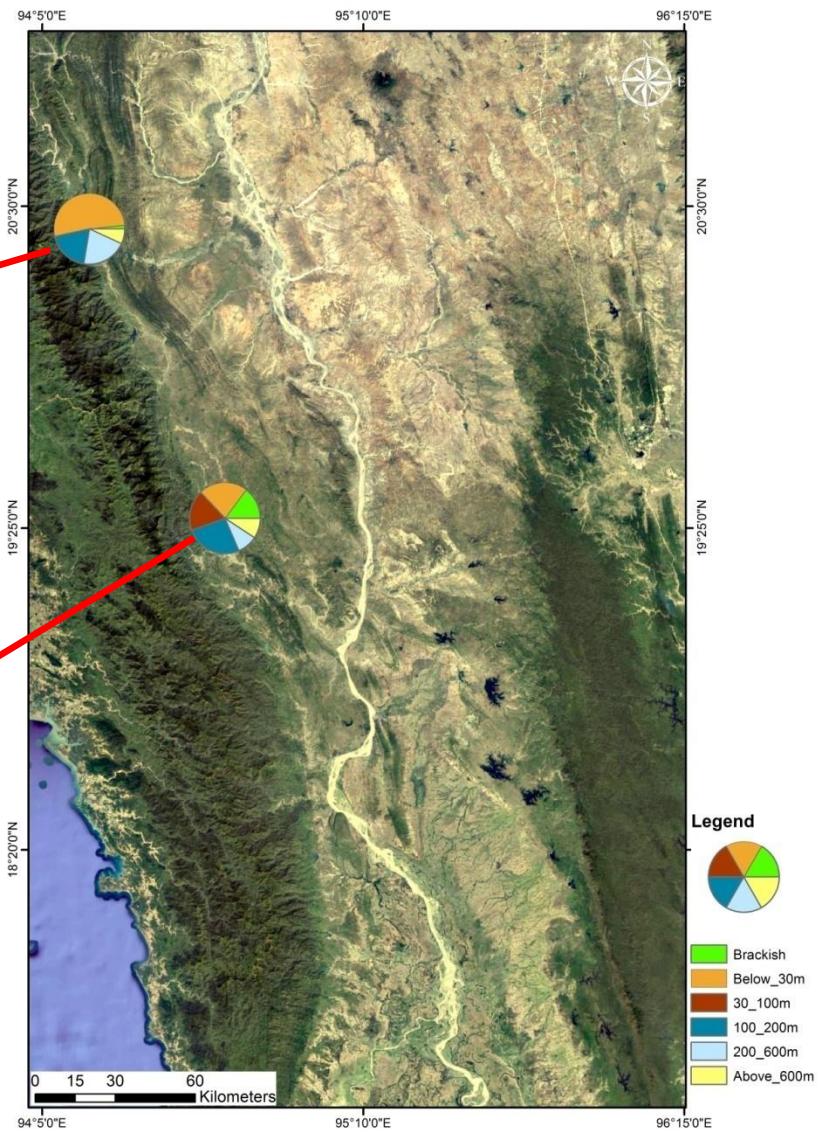
	A1	A2	A3	A4	A5		
TB8	0%	0%	0%	100%	0%	Epifaunal < Infaunal	<ul style="list-style-type: none"> ➤ high energy condition. ➤ Lower rate of sedimentation with less common gravitational currents ➤ Amount of nutrient in the sediments was very restricted.
TB7	0%	0%	50%	50%	50%	Epifaunal < Infaunal	
TB6	0%	0%	0%	25%	75%	Epifaunal < Infaunal	
TB5	0%	20%	40%	20%	20%	Epifaunal > Infaunal	
TB4	20%	20%	40%	0%	20%	Epifaunal > Infaunal	<ul style="list-style-type: none"> ➤ Medium to high energy condition. ➤ Lower rate of sedimentation with less common gravitational currents ➤ Amount of nutrient in the sediments was fair.
TB3	20%	0%	60%	0%	3.33%	Epifaunal > Infaunal	
TB2	10%	20%	40%	10%	20%	Epifaunal > Infaunal	
TB1	0%	14.28%	35.71%	35.71%	14.28%	Epifaunal = Infaunal	



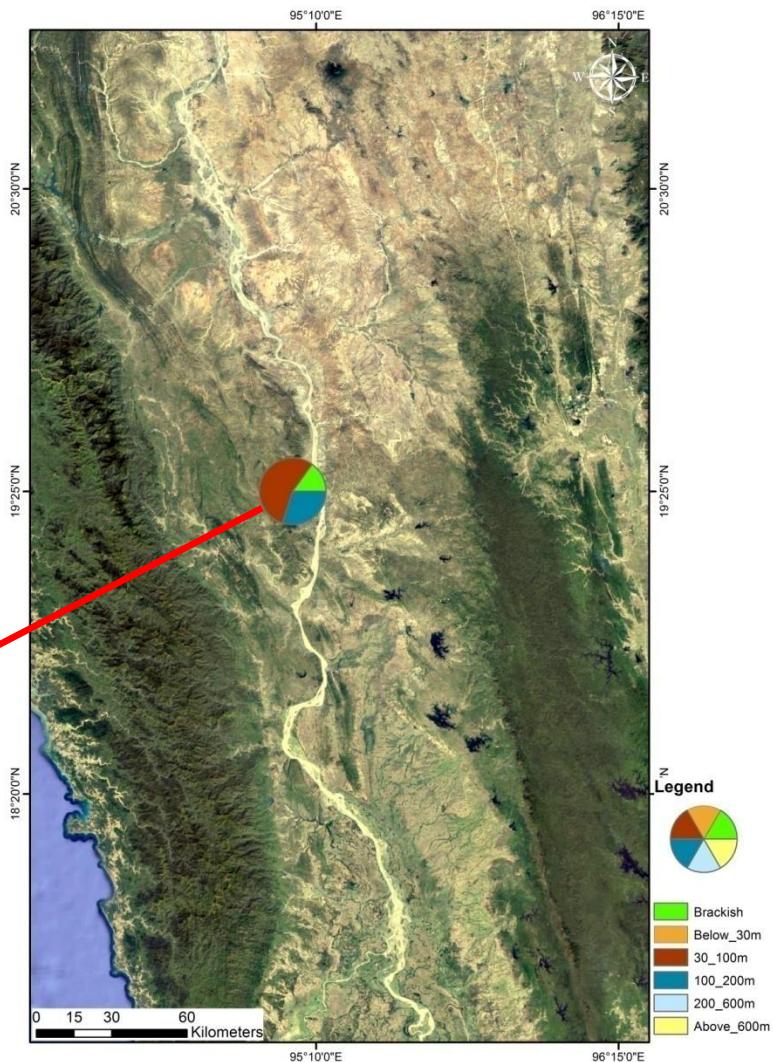
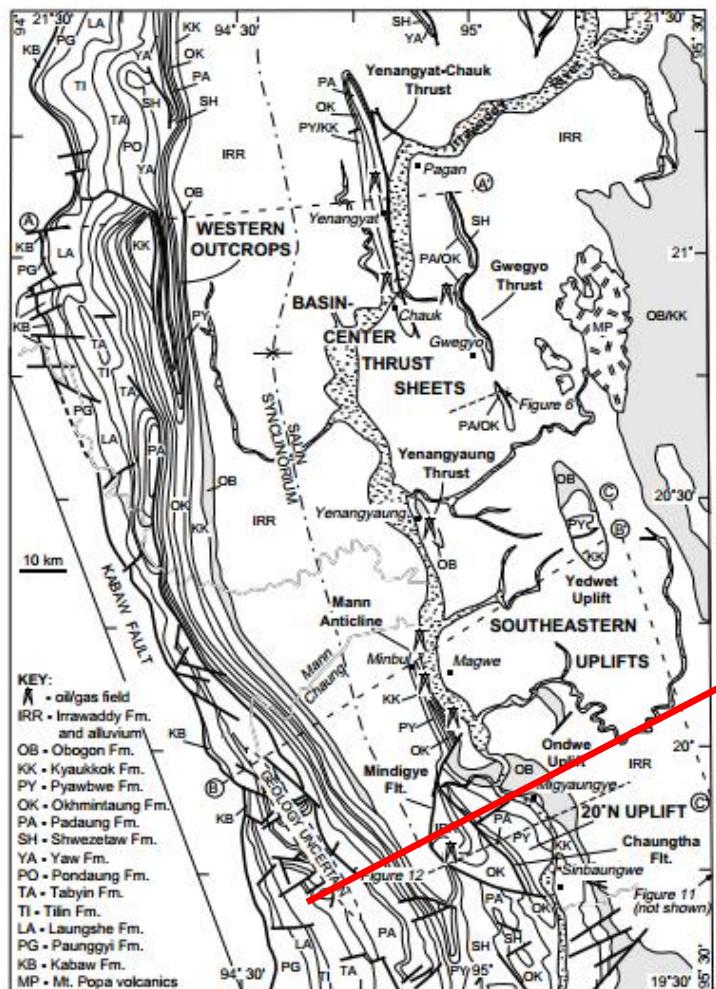
Eocene



It
is
very



Oligocene



Oligocene Foraminifera in Salin subbasin

Benthonic Species

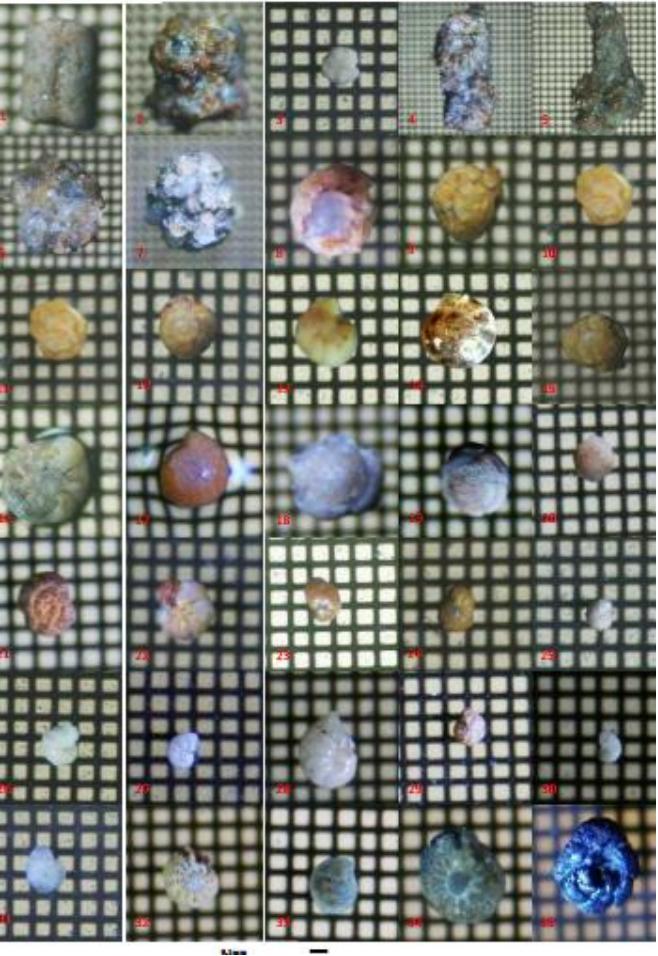


Plate- I

Benthonic Species

- Fig 1. *Barrycypion arenaceum*, Le Roy-1944, Sample no. B4
- Fig 2. *Ammobaculites fragmenarius*, Cushman-1927, Sample no. A1, B1
- Fig 3. *Ammobaculites* sp.1, Sample no. A5
- Fig 4. *Ammobaculites* sp.2, Sample no. A1, B1
- Fig 5. *Ammonarginalita* sp cf. *expansa*, Plummer-1933, Sample no. A1, B1
- Fig 6. *Haplophragmoides calculus*, D'Orbigny-1839, Sample no. A1, B1, B2
- Fig 7. *Reticularia* sp.1, Sample no. A2, B1, B2
- Fig 8. *Retzia beccarii*, Ucs- 2001, Sample no. A9, B4
- Fig 9. *Rotalia ozawa*, Asano-1951, Sample no. A3, A9, B4
- Fig 10. *Rotalia indica*, Le Roy-1939, Sample no. A9, B4
- Fig 11. *Rotalia ameaveae*, Huang-1964, Sample no. A9, B4
- Fig 12. *Rotalia* sp.1, Sample no. A8, B4
- Fig 13. *Rotalia* sp.2, Sample no. A9, B3
- Fig 14. *Rotalia* sp.3, Sample no. A9, B3
- Fig 15. *Rotalia* sp.4, Sample no. A1, B4
- Fig 16. *Reticularia tholus*, Galloway and Hemley-1945, Sample no. B2
- Fig 17. *Robulus* sp.1, Le Roy-1944, Sample no. A9, B3
- Fig 18. *Eponides kirbyi*, Bermudez-1936, Sample no. A4, B2
- Fig 19. *Eponides abdolutensis*, Bermudez-1936, Sample no. A4, B3
- Fig 20. *Eponides umbonatus*, Reuss & Le Roy-1944, Sample no. A4, B3
- Fig 21. *Eponides compressus*, Palmer and Bermudez-1936, Sample no. A14, B9
- Fig 22. *Eponides praeclara*, Karrer-1884, Sample no. A12, B5
- Fig 23. *Cilioides koevenyi*, LeRoy- 1944, Sample no. A12, B5
- Fig 24. *Cilioides dorosoptilosis*, Le Roy-1944, Sample no. A1, B4
- Fig 25. *Cilioides soondensis*, LeRoy- 1941, Sample no. A9, B3
- Fig 26. *Cilioides fusa*, Le Roy- 1939, Sample no. A2, B2
- Fig 27. *Cilioides malayensis*, LeRoy- 1941, Sample no. A1, B4
- Fig 28. *Cilioides koevenyi*, LeRoy- 1944, Sample no. A12, B5
- Fig 29. *Cilioides azanum*, Bermudez-1936, Sample no. A12, B5
- Fig 30. *Cilioides (Anomalina?) domoileensis*, Le Roy-1944, Sample no. A12, B5
- Fig 31. *Cilioides kantamensis*, Le Roy, Sample no. A6, B5
- Fig 32. *Elphidium carnicolum*, Le Roy-1944, Sample no. A12, B5
- Fig 33. *Pulvininella hardyi*, LeRoy-1944, Sample no. A10
- Fig 34. *Gyrina cushmani*, , Sample no. A4, A10, B4
- Fig 35. *Retzia rohnseni*, Cushman and Bermudez-1946, Sample no. A8, A10, AB12

Explanation of Plate I

Benthonic & Planktonic Species

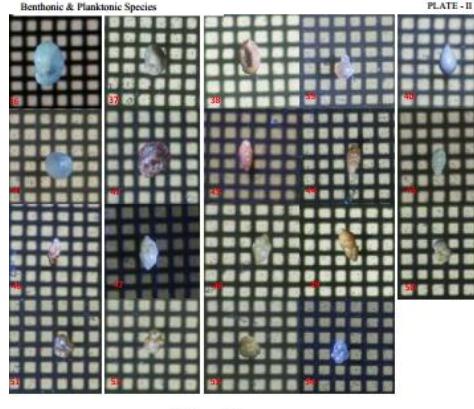
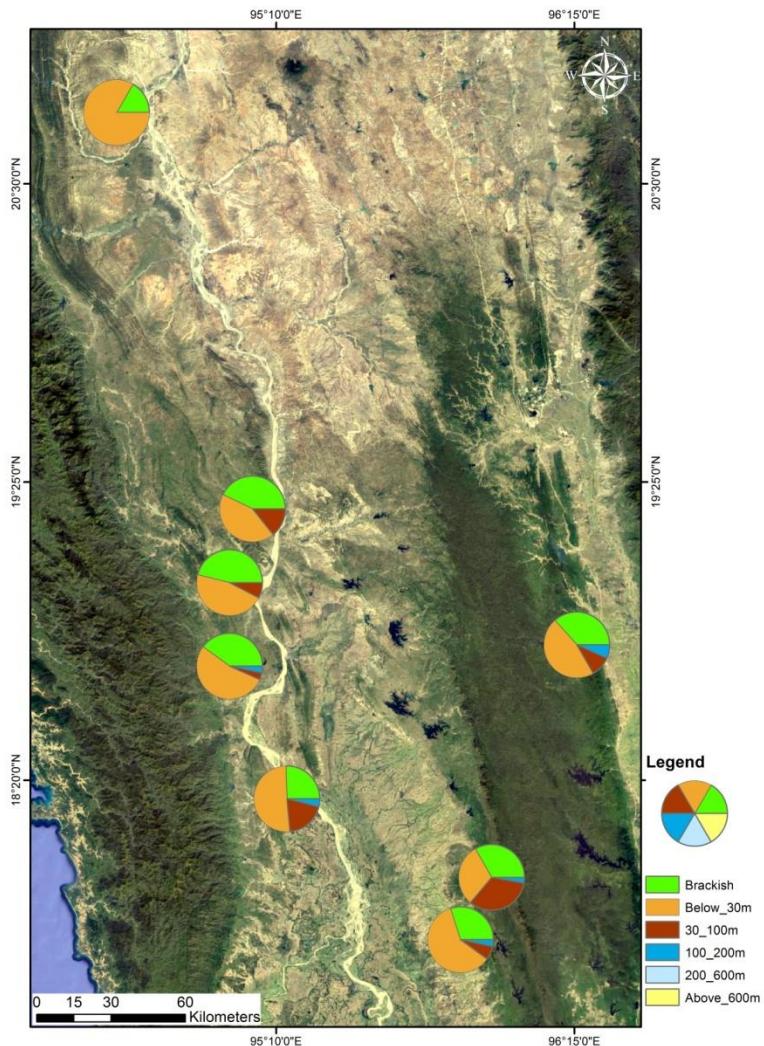
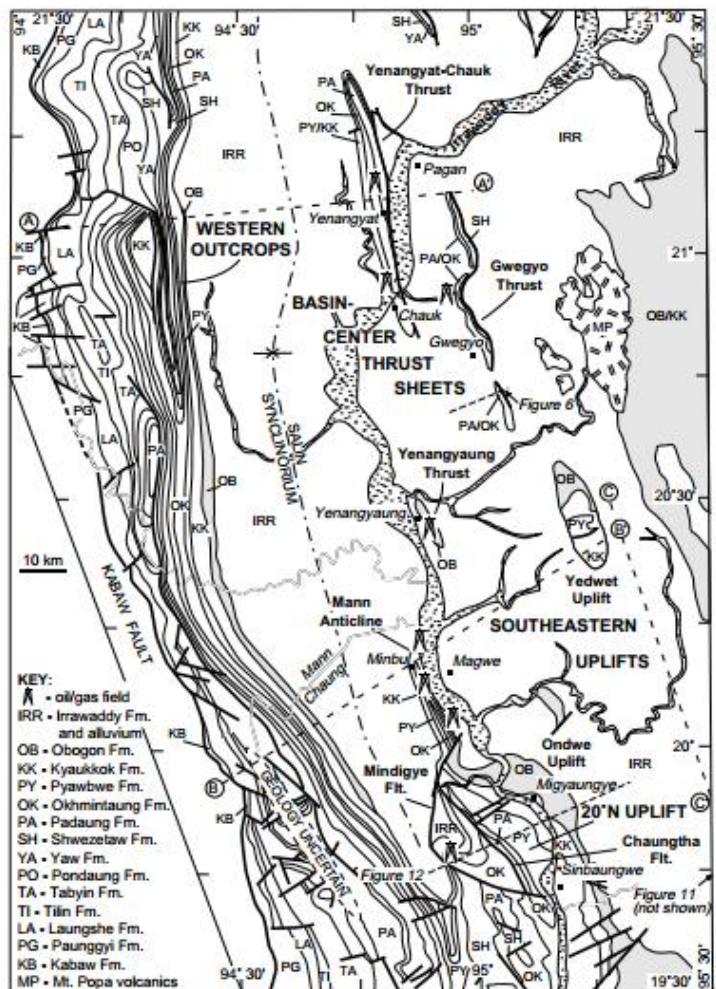


PLATE - II

Explanation of Plate- II

- Fig 36. *Nodosaria microumbilicata*, Le Roy- 1944, Sample no. A2, B2
- Fig 37. *Sigmoilina mucronata*, Bermudez-1836, Sample no. A14, B9
- Fig 38. *Anomalinoides cicutaricus*, Brozzi-1942, Sample no. A12, B5
- Fig 39. *Lagenula* globosa, Le Roy-1944, Sample no. A5, B2, B5, B9
- Fig 40. *Lagenula semiritaria*, Williamson Brady-1884, Sample no. A6, A14, B5
- Fig 41. *Gypsina globulus*, Brady- 1884, Sample no. A4, A5, A10, A12, A14, B3
- Fig 42. *Pseudoglandulina glauca*, d' Orbigny- 1826, Sample no. A5, B5
- Fig 43. *Bolivina sombreensis*, Le Roy-1944, Sample no. A12, B5
- Fig 44. *Bolivina gestriai*, Le Roy-1944, Sample no. A12, B5
- Fig 45. *Bolivina* sp.1, Sample no. A12, B5
- Fig 46. *Pleurostomella alternans*, Schwager- 1866, Sample no. A12, B5
- Fig 47. *Uvigerina hispida*, Schwager- 1866, Sample no. A10, B5
- Fig 48. *Uvigerina carpentiana*, Orbigny, var. Cushman and Renz-1941, Sample no. B5
- Fig 49. *Uvigerina auberti*, Bermudez-1949, Sample no. A12, B5
- Fig 50. *Globigerina ampliapertura*, Böhl-1957, Sample no. A1, A2, A3, A4, A6, A7, B1, B2, B6
- Fig 51. *Globigerina compressa*, Plummer-1926, Sample no. A1, A6, A9, A10, B1, B5, B6
- Fig 52. *Globigerina* sp., Sample no. A1, A6, B9
- Fig 53. *Globorotalia opima opima*, Böhl-1957, Sample no. A1, A2, A6, A10, B1, B2, B5, B6
- Fig 54. *Globorotalia absus*, Böhl, 1957 Sample no. B1, B2, B3, B5

Miocene





Miocene Foraminifera in Salin subbasin



Explanation of Plate I

- Fig.1: *Bathyphymus abutilonensis* Bermudez, sample no. 3, 4, 8, 10, Thayet Township
 Fig.2: *Bathyphymus abutilonensis* (Side View) Bermudez, sample no. 3, 4, 8, 10, Thayet Township
 Fig.3: *Bathyphymus* sp. sample no. 3, 8, 9, 10, Thayet Township
 Fig.4: *Harmonia* sp. sample no. 8, Thayet Township
 Fig.5: *Ammobaculitesveneris* Bermudez, sample no. 8, Thayet Township
 Fig.6: *Ammobaculites* sp. 1 sample no. 8, Thayet Township
 Fig.7: *Ammobaculites* sp. 2 sample no. 8, 9, Thayet Township
 Fig.8: *Ammofususdominicensis* Bermudez, sample no. 15, Thayet Township
 Fig.9: *Ammofususconicus* Bermudez, sample no. 15, Thayet Township
 Fig.10: *Textularia simplex* Cushman, sample no. 8, 10, Thayet Township
 Fig.11: *Karrerella mexicana* Nuttall, sample no. 8, Thayet Township
 Fig.12: *Karrerella*, *clitostoma* Reuss, sample no. 8, Thayet Township
 Fig.13: *Haplophragmoidescompressus* Le Roy, sample no. 5, 9, 10, 12, Thayet Township
 Fig.14: *Haplophragmoidescompressus* Le Roy, sample no. 5, 9, 10, 12, Thayet Township
 Fig.15: *Haplophragmoidescompressus* Cushman & Renz, sample no. 5, 9, 10, 12, Thayet Township
 Fig.16: *Haplophragmoidescompressus* Cushman & Renz, sample no. 3, 5, 8, 9, 10, 11, 12, Thayet Township
 Fig.17: *Haplophragmoidesdecoloratus* Cushman & Renz, sample no. 3, 5, 8, 9, 10, 11, 12, Thayet Township
 Fig.18: *Haplophragmoides* evanescens Brady, sample no. 5, 9, 12, Thayet Township
 Fig.19: *Haplophragmoides* evanescens Brady, sample no. 5, 9, 12, Thayet Township
 Fig.20: *Haplophragmoides* evanescens Bouyoumpart, sample no. 5, 8, 12, Thayet Township
 Fig.21: *Haplophragmoides* evanescens Kinder, Kaminski and Jones, sample no. 9, Thayet Township
 Fig.22: *Haplophragmoides* sp. sample no. 9, Thayet Township
 Fig.23: *Haplophragmoides* sp. 2 Michel et al., sample no. 5, 10, 12, Thayet Township
 Fig.24: *Haplophragmoides* sp. 2 Michel et al., sample no. 5, 10, 12, Thayet Township
 Fig.25: *Haplophragmoides* sp. 3, sample no. 5, 9, 12, Thayet Township
 Fig.26: *Haplophragmoides* sp. 3, sample no. 5, 9, 12, Thayet Township
 Fig.27: *Cyclammina gasparinis* Bermudez, sample no. 9, 12, Thayet Township
 Fig.28: *Cyclammina gasparinis* Bermudez, sample no. 9, 12, Thayet Township
 Fig.29: *Cyclammina cancellata* Riedel, sample no. 5, 9, 10, Thayet Township
 Fig.30: *Eratidesp.* Michel et al., sample no. 5, 12, Thayet Township
 Fig.31: *Gyroidinaeascoloidi* var. *arcuata* Bouyoumpart, sample no. 4, Thayet Township
 Fig.32: *Lageninaeaspirata* Orbigny - Graham & Millstone, sample no. 8, Thayet Township
 Fig.33: *Nodosariaverberbiata* BATTSCH, var. ASANO, sample no. 5, Thayet Township
 Fig.34: *Nodosarialongicostata* (Orbigny) - Cushman & Stainforth, sample no. 4, 5, 8, 11, Thayet Township
 Fig.35: *Nodosaria* sp. Schwager, sample no. 5, Thayet Township

Explanation of Plate II

- Fig.36: *Nodosariastreckeri* Schwager, Le Roy, sample no. 8, Thayet Township
 Fig.37: *Nodosariaspurulosa* d'Orbigny var. *semi-eugosha* d'Orbigny, sample no. 8, Thayet Township
 Fig.38: *Nodosariatokinoi* Schwager, sample no. 8, Thayet Township
 Fig.39: *Nodosariastornata* Schwager, sample no. 8, Thayet Township
 Fig.40: *Nodosariastriata* 1, sample no. 15, Thayet Township
 Fig.41: *Nodosariastriata* 2, sample no. 8, Thayet Township
 Fig.42: *Nodosariastriata* 3, sample no. 8, Thayet Township
 Fig.43: *Nodosariastriata* 4, sample no. 8, Thayet Township
 Fig.44: *Ellipsodonosariaunicostata* d'Orbigny, Cushman, sample no. 5, 8, Thayet Township
 Fig.45: *Ellipsodonosariaunivalveolata* d'Orbigny, Le Roy, sample no. 8, Thayet Township
 Fig.46: *Ellipsodonosaria recta* Cushman & Stainforth, sample no. 8, Thayet Township
 Fig.47: *Lagenodiscularis* (Le Roy) Schubert, sample no. 3, 7, 8, Thayet Township
 Fig.48: *Lagenodiscularis* sp., sample no. 8, Thayet Township
 Fig.49: *Nodogenerina* (Thalmann) Thalmann, sample no. 8, Thayet Township
 Fig.50: *Nodogenerina* (Thalmann) Bermudez, sample no. 7, 8, Thayet Township
 Fig.51: *Chrysalogena* (mucilacolum) Cushman & Jarvis, sample no. 8, Thayet Township
 Fig.52: *Chrysalogena* (mucilacolum) Cushman & Jarvis, sample no. 8, Thayet Township
 Fig.53: *Chrysologania* (mucilacolum) Cushman & Jarvis - Bermudez, sample no. 7, Thayet Township
 Fig.54: *Siliostrophus* Cushman, sample no. 8, Thayet Township
 Fig.55: *Pleustostomella*, sample no. 7, Thayet Township
 Fig.56: *Dentalinatuberculata* Schwager, sample no. 7, 8, Thayet Township
 Fig.57: *Dentalinatuberculata* Le Roy, sample no. 8, Thayet Township
 Fig.58: *Dentalinatuberculata* Neugeboren, sample no. 8, Thayet Township
 Fig.59: *Dentalinatuberculata* d'Orbigny, sample no. 8, Thayet Township
 Fig.60: *Dentalinatuberculata* d'Orbigny, sample no. 8, Thayet Township
 Fig.61: *Dentalinatuberculata* Cushman & Stainforth, sample no. 7, 8, Thayet Township
 Fig.62: *Dentalinatuberculata* d'Orbigny, sample no. 7, 8, Thayet Township
 Fig.63: *Dentalinatuberculata* Le Roy, sample no. 8, Thayet Township
 Fig.64: *Virginalinatuberculata* Galloway & Morey, Le Roy, sample no. 7, Thayet Township
 Fig.65: *Virginalinat*, sample no. 7, Thayet Township
 Fig.66: *Lenticulina* (nancycordata) Cushman, sample no. 8, Thayet Township
 Fig.67: *Lenticulina* (nancycordata) Orbigny, sample no. 8, Thayet Township
 Fig.68: *Robulus* (robulus) Bermudez, sample no. 4, 8, Thayet Township
 Fig.69: *Robulus* (convergens) Bermudez, sample no. 4, 5, 8, Thayet Township
 Fig.70: *Robulus* (echinatus) d'Orbigny, sample no. 15, Thayet Township

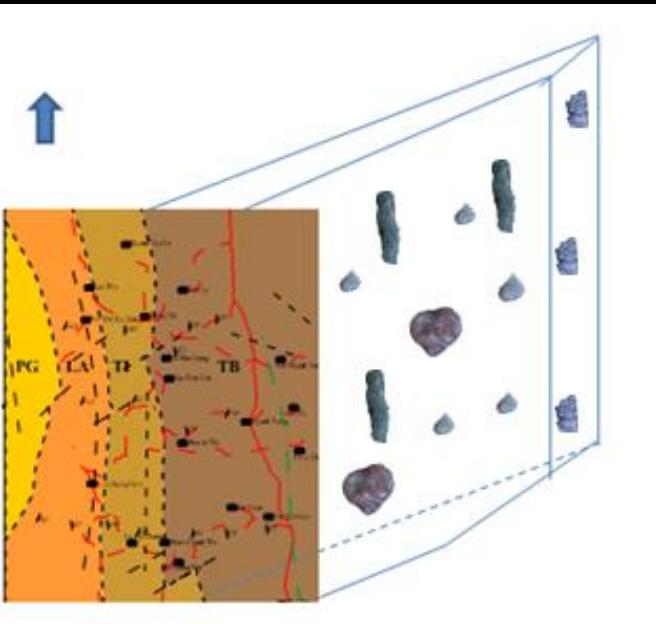
Explanation of Plate III

- Fig.71: *Robulus* sp. H, Le Roy, sample no. 8, Thayet Township
 Fig.72: *Cibicides hamatus* Le Roy, sample no. 2, 3, 4, 8, 10, 11, Thayet Township
 Fig.73: *Cibicideshamatus* Le Roy, sample no. 5, Thayet Township
 Fig.74: *Cibicidesforbesi* d'Orbigny, sample no. 15, Thayet Township
 Fig.75: *Cibicidesconcolor* Le Roy, sample no. 5, 9, 11, 12, Thayet Township
 Fig.76: *Cibicides* sp., sample no. 8, Thayet Township
 Fig.77: *Epistrephus* (epistrephus) Carter - Le Roy, sample no. 4, 5, 10, 11, Thayet Township
 Fig.78: *Baggiusinflatus* Le Roy, sample no. 2, 4, 8, 11, 15, Thayet Township
 Fig.79: *Baggiusinflatus* 1, sample no. 8, Thayet Township
 Fig.80: *Baggiusinflatus* 2 sample no. 7, Thayet Township
 Fig.81: *Conularia* (fischeli) Moll, sample no. 8, Thayet Township
 Fig.82: *Conularia* (fischeli) d'Orbigny - Le Roy, sample no. 8, Thayet Township
 Fig.83: *Nonionia* (mucilaculum) Le Roy, sample no. 2, 3, 8, Thayet Township
 Fig.84: *Bolivinavaccini* Schubert, sample no. 2, 4, 7, 8, 11, 15, Thayet Township
 Fig.85: *Bolivinavaccini* Cushman, sample no. 2, 4, 5, 7, 11, Thayet Township
 Fig.86: *Bolivina marginata* Cushman, sample no. 2, 4, 7, 8, Thayet Township
 Fig.87: *Bolivina marginata* Le Roy, sample no. 5, 7, Thayet Township
 Fig.88: *Bolivinablaesi* Le Roy, sample no. 7, Thayet Township
 Fig.89: *Bolivinaster* Le Roy, sample no. 5, 8, Thayet Township
 Fig.90: *Bolivinaster* Cushman & Renz, sample no. 7, Thayet Township
 Fig.91: *Bolivina caudata* Cushman & Renz, sample no. 7, 8, 11, Thayet Township
 Fig.92: *Bolivina* sp. 1, sample no. 8, Thayet Township
 Fig.93: *Bolivina* sp. 2, sample no. 7, Thayet Township
 Fig.94: *Bulinimina* (cylindriglobulus) Le Roy, sample no. 8, Thayet Township
 Fig.95: *Bulinimina* (cylindriglobulus) Bermudez, sample no. 8, Thayet Township
 Fig.96: *Bulinimina* (quadriglobulus) d'Orbigny, sample no. 8, Thayet Township
 Fig.97: *Bulinimina* (quadriglobulus) d'Orbigny, sample no. 8, Thayet Township
 Fig.98: *Bulinimina* (quadriglobulus) d'Orbigny, sample no. 8, Thayet Township
 Fig.99: *Bulinimina* (subfusiformis) Cushman, sample no. 7, Thayet Township
 Fig.100: *Anomalinamammilla* Reuss, sample no. 10, Thayet Township
 Fig.101: *Planimina* (armatum) d'Orbigny, sample no. 3, 7, Thayet Township
 Fig.102: *Planimina* (armatum) Bermudez, sample no. 8, Thayet Township
 Fig.103: *Rotaliabuccarii* (Linné) var. *annectens* Parker & Jones, sample no. 2, 4, 5, 10, 15, Thayet Township
 Fig.104: *Rotaliabuccarii* (Linné) var. *annectens* Parker & Jones, sample no. 2, 4, 5, 15, Thayet Township
 Fig.105: *Rotaliabuccarii* (Linné), sample no. 2, 4, 5, 15, Thayet Township

Explanation of Plate IV

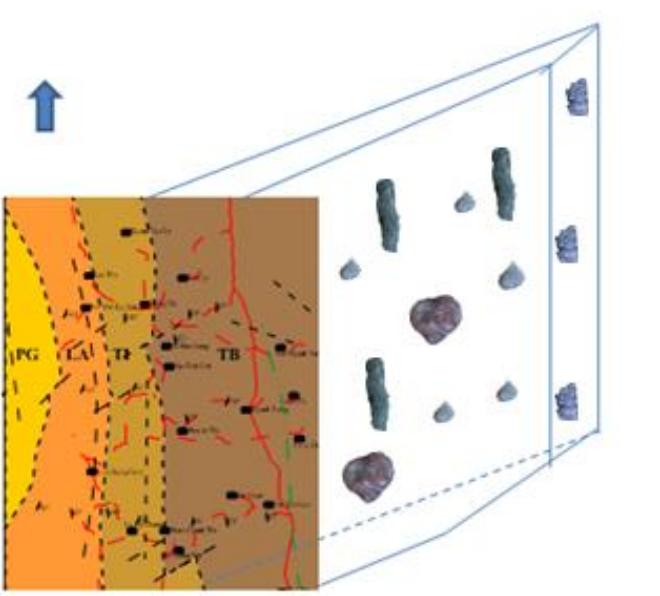
- Fig.106: *Rotaliabuccarii* (Linné) var. *koehoensis* Le Roy - Huang, sample no. 2, 8, Thayet Township
 Fig.107: *Uvigerina* (multicostata) Le Roy, sample no. 2, 4, 8, 15, Thayet Township
 Fig.108: *Uvigerina* (parisicostata) Le Roy, sample no. 2, 8, 15, Thayet Township
 Fig.109: *Uvigerina* (parisicostata) Le Roy, sample no. 2, 8, 15, Thayet Township
 Fig.110: *Uvigerina* (Mexicananatalia), sample no. 2, 5, 8, Thayet Township
 Fig.111: *Uvigerina* (c. mediterranea) Hofer, sample no. 8, Thayet Township
 Fig.112: *Uvigerina* (galloianaweyi) Cushman - Stainforth, sample no. 4, Thayet Township
 Fig.113: *Uvigerina* (interrupta) locusta Boomgaard, sample no. 2, 15, Thayet Township
 Fig.114: *Uvigerina* (carpathica) Bermudez, sample no. 4, 8, Thayet Township
 Fig.115: *Angulogerina* (carinata) Cushman, var. *Bradyana* Cushman, sample no. 8, Thayet Township
 Fig.116: *Bradyana* (bradyana) Cushman, sample no. 8, Thayet Township
 Fig.117: *Globigerina* (cerponensis) ottangensis Eogi, sample no. 8, 11, Thayet Township
 Fig.118: *Globigerina* (cerponensis) (cerponensis) Bolli, sample no. 8, Thayet Township
 Fig.119: *Globigerina* (cerponensis) Bolli, sample no. 4, 8, Thayet Township
 Fig.120: *Globigerina* (praebulbula) (praebulbula) Blow, sample no. 2, 4, 5, 8, 10, 11, 12, Thayet Township
 Fig.121: *Globigerina* (praebulbula) Blow & Banner, sample no. 8, Thayet Township
 Fig.122: *Globigerina* (rostrata) Bolli, sample no. 8, Thayet Township
 Fig.123: *Globigerina* (multicostata) Bolli, sample no. 2, 8, Thayet Township
 Fig.124: *Globigerina* (primordia) Blow & Banner, sample no. 2, 4, 7, 8, Thayet Township
 Fig.125: *Globigerina* (nodosulcata) Todd & Blow, sample no. 8, 10, 11, Thayet Township
 Fig.126: *Globigerina* (nodosulcata) d'Orbigny - Le Roy, sample no. 2, 4, 8, Thayet Township
 Fig.127: *Globigerina* (nodosulcata) MDCP, FT, sample no. 8, 10, 11, Thayet Township
 Fig.128: *Globigerina* (nodosulcata) (quadriglobulus) d'Orbigny - Blow, sample no. 8, Thayet Township
 Fig.129: *Globigerina* (nodosulcata) (quadriglobulus) d'Orbigny - Bolli, sample no. 2, 8, Thayet Township
 Fig.130: *Globigerina* (globularis) Cushman, sample no. 8, 10, 11, Thayet Township
 Fig.131: *Globigerinatamayeri* (Bolli), sample no. 5, 7, 8, 11, Thayet Township
 Fig.132: *Globigerinatamayeri* (Bolli), sample no. 2, 8, 15, Thayet Township
 Fig.133: *Globigerinoides* (sulcatus) (sulcatus) Bolli, sample no. 8, Thayet Township
 Fig.134: *Globigerinoides* (quadriglobulus) (quadriglobulus) d'Orbigny - Blow, sample no. 8, Thayet Township
 Fig.135: *Globigerinoides* (quadriglobulus) (quadriglobulus) d'Orbigny - Bolli, sample no. 8, 11, Thayet Township
 Fig.136: *Globigerinoides* (sulcatus) (sulcatus) Bolli, sample no. 2, 8, 15, Thayet Township
 Fig.137: *Hastigerina* (infraspinifera) (infraspinifera) Blow, sample no. 8, 15, Thayet Township

Lower Part of the Tabyin Formation



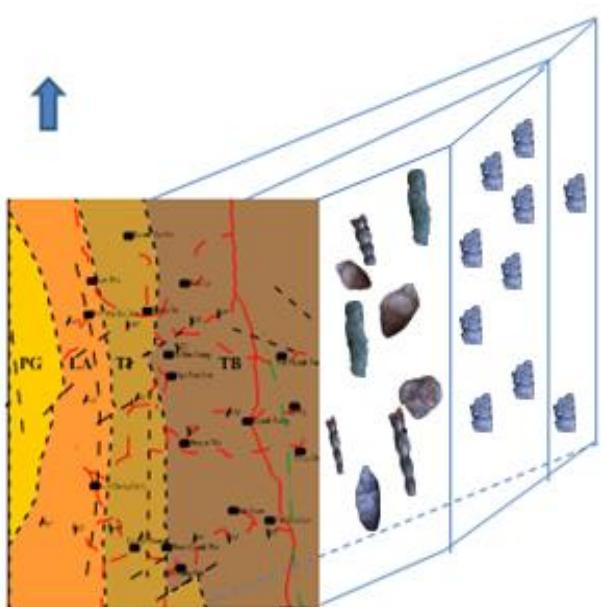
Lower
Part of the Tabyin
Formation

Upper
Part of the
Tabyin Formation



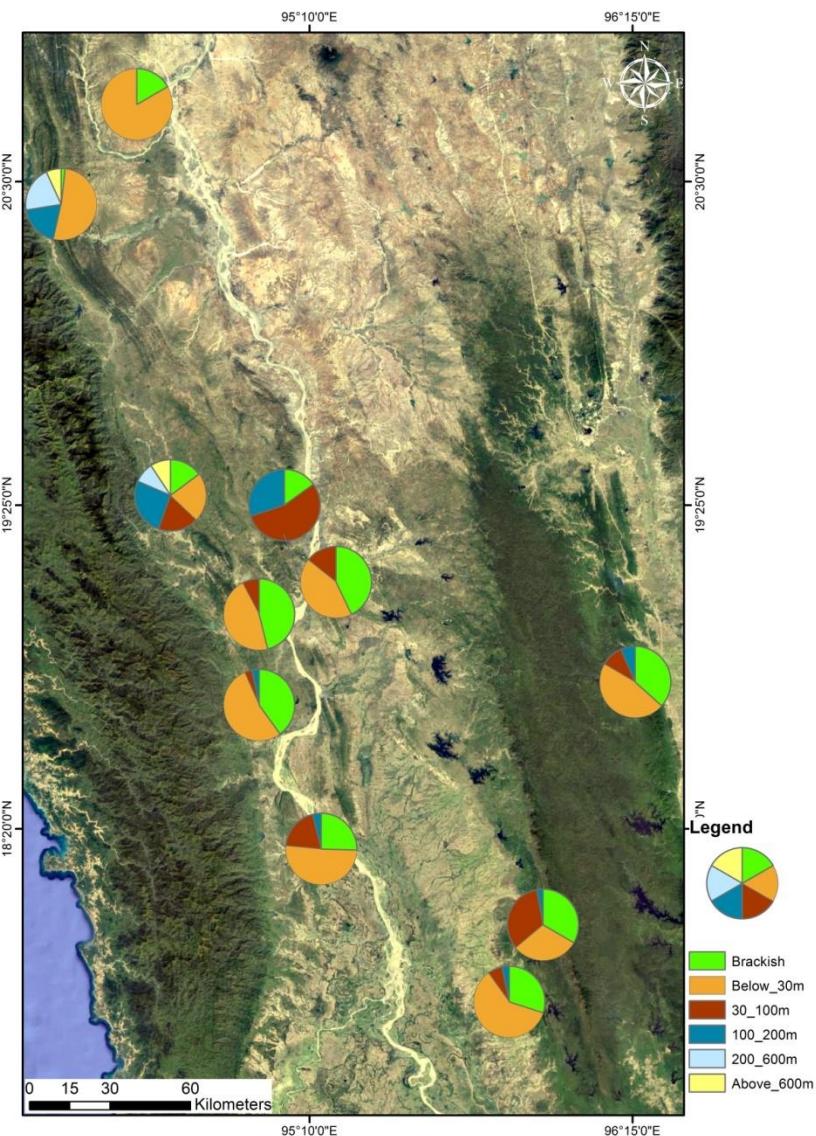
- Low to medium energy condition.
- Lower rate of sedimentation with less common gravitational currents
- Normal marine salinity/sluggish circulation in the marine.
- Near the edge of the shelf (in much deeper water)

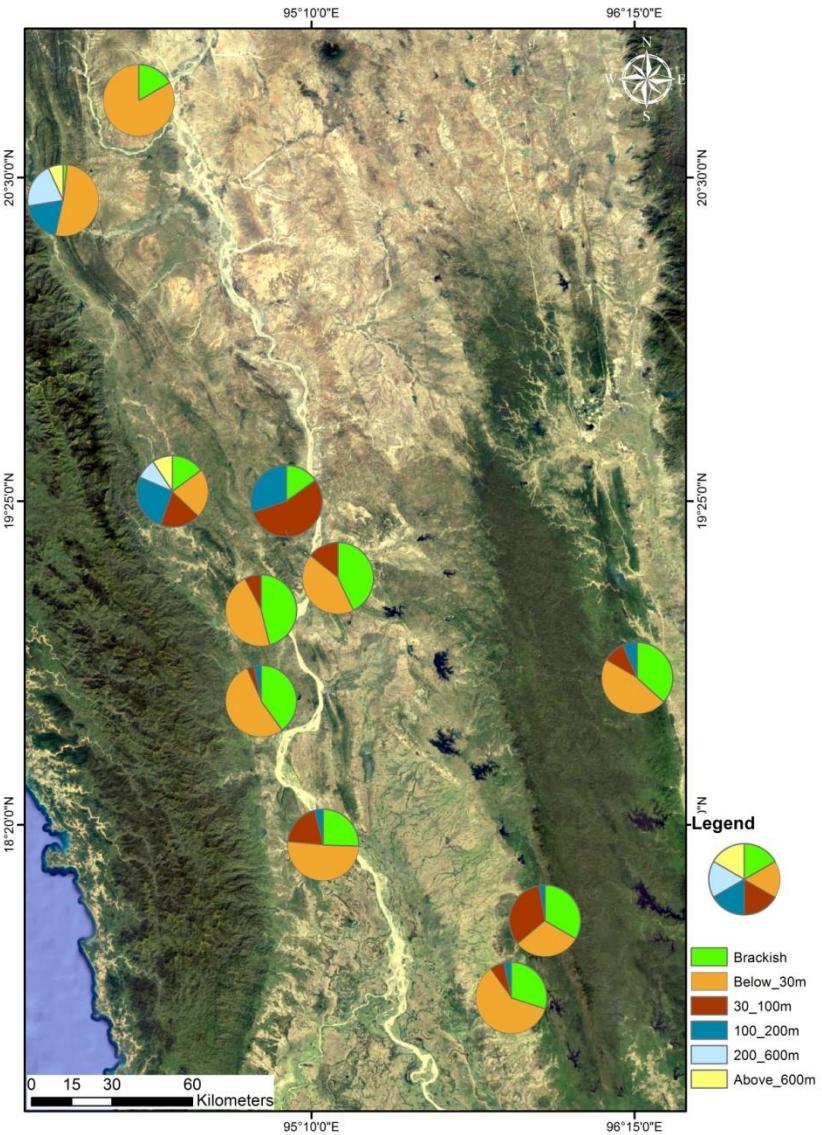
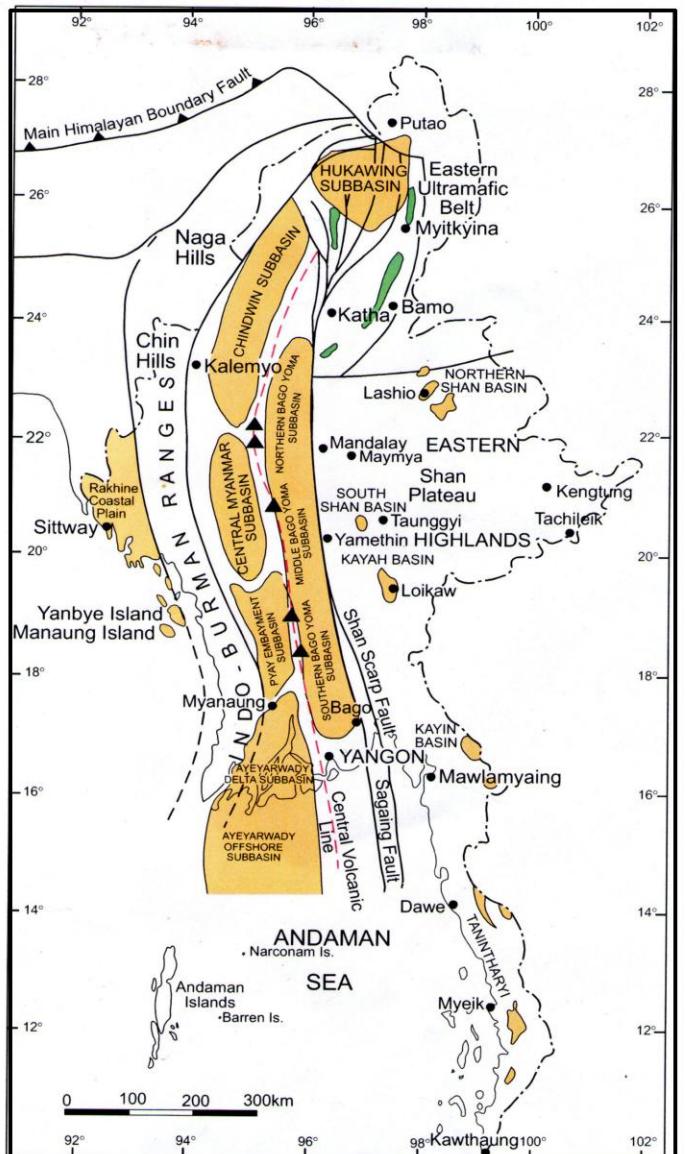
Lower
Part of the Tabyin
Formation



Upper
Part of the
Tabyin Formation

- medium to high energy condition.
- Lower rate of sedimentation.
- **Amount of nutrient in the sediments was very restricted.**
- Shallow marine or deeper condition (Middle to Outer Neritic).

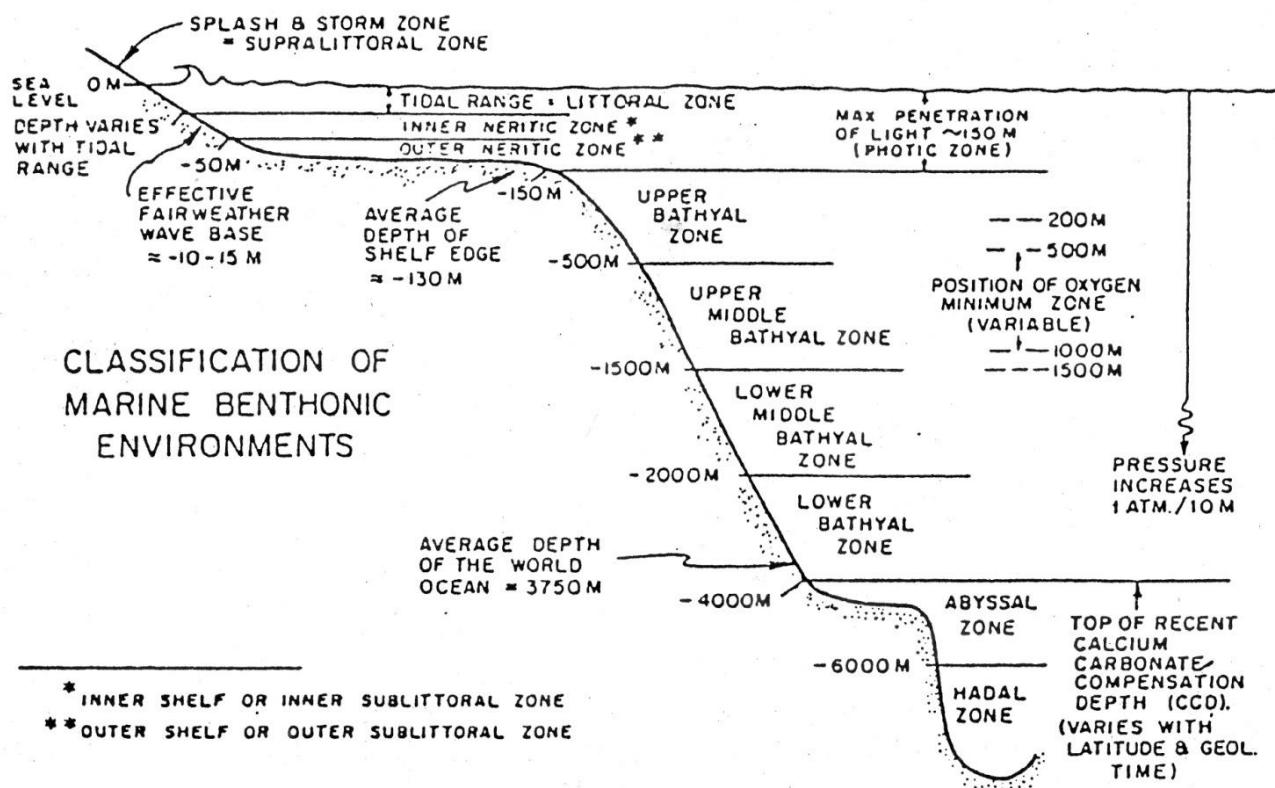






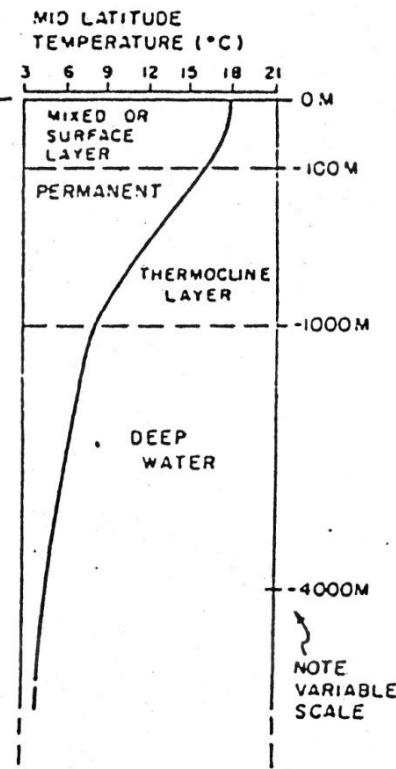
THANK YOU VERY MUCH

CLASSIFICATION OF MARINE BENTHONIC ENVIRONMENTS



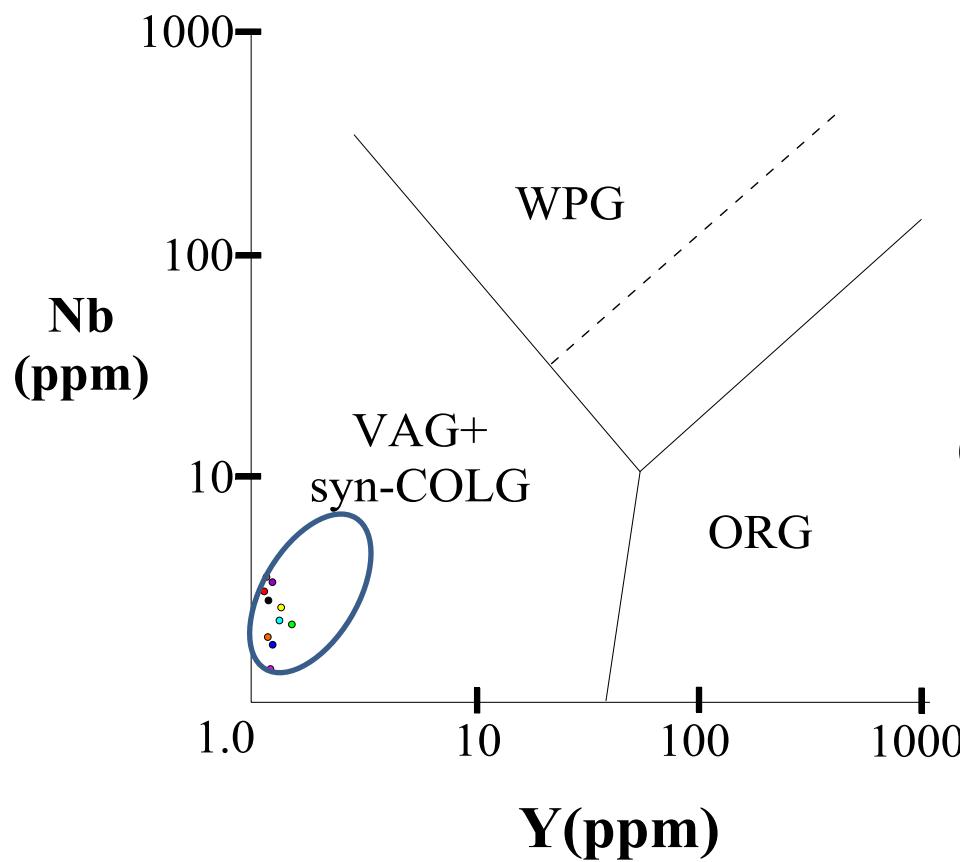
* INNER SHELF OR INNER SUBLITTORAL ZONE

** OUTER SHELF OR OUTER SUBLITTORAL ZONE

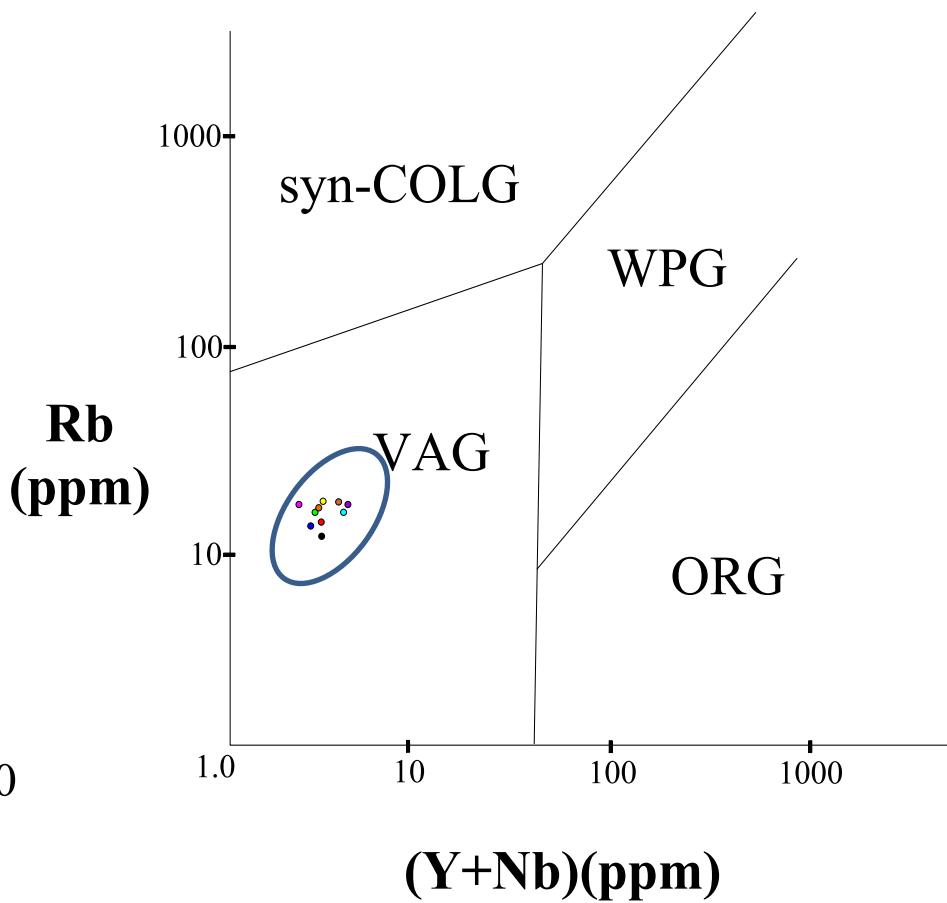


Classification of benthonic marine environments in terms of depth and positions of critical oceanographic boundaries or transitional zones in the modern world ocean. Note that water depths are given in meters. This classification is a modification of that presented by Hedgpeth (1957); from Ingle (1975a).

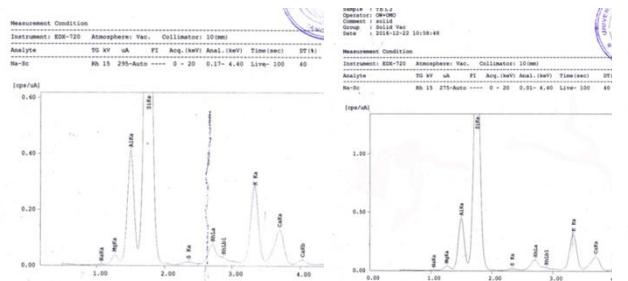
Sample No. Elements	1	2	3	4	5	6	7	Present study	Oligocene	Miocene
V	29.07	15.6	29.17	33.33	27.05	28.21	28.5	27.27	150.00	130.00
Cr	126.96	92.77	122.17	153.6	113.46	128.1	128.54	123.65	110.00	125.00
Ni	168.95	129.51	114.23	180.43	144.27	69.93	85.62	127.56	55.00	58.00
Cu	43.65	45.51	49.41	41.64	29.67	32.46	46.39	41.25	67	74
Zn	273.43	155.8	229.75	226.71	176.81	184.66	182.42	204.23	85	86
Rb	79.01	78.68	84.17	75.74	67.88	64.36	76	75.11	160.00	125.00
Sr	66.34	63.35	63.91	71.46	90.35	77.61	83.79	73.83	200.00	142.00
Nb	12.39	14.56	14.76	13.63	12.23	13.47	14.63	13.67	19.00	13.00
Pb	46.58	39.74	43.96	47.85	37.03	34.65	35.38	40.74	20.00	20.00
Th	20.99	20.9	15.42	6.63	16.56	17.1	19.53	18.16	14.60	12.30
U	18.54	24.64	19.7	13.37	12.27	14.55	11.36	16.35	3.10	2.70
Zr	173.35	187.71	171.78	168.88	161.88	160.6	171.96	170.88	210.00	200.00
Y	3.01	3.44	2.79	4.28	3.88	2.58	2.47	3.21	27.00	27.00



The Nb-Y discrimination diagrams for granites (after Pearce *et al.*, 1984), showing the fields of volcanic-arc granites (VAG), syn-collisional granites (syn-COLG), within-plate granites (WPG) and ocean-ridge granites (ORG).The broken line is the field boundary for ORG from anomalous ridges.

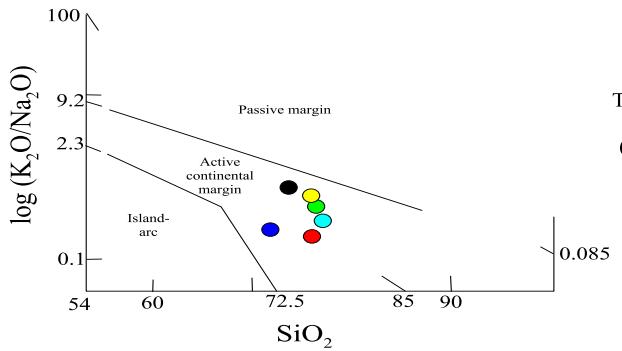


The Rb-(Y+Nb) discrimination diagrams for granites (after Pearce *et al.*, 1984), showing the fields of syn-collisional granites (syn-COLG), within-plate granites (WPG), volcanic-arc granites (VAG) and ocean-ridge granites (ORG).

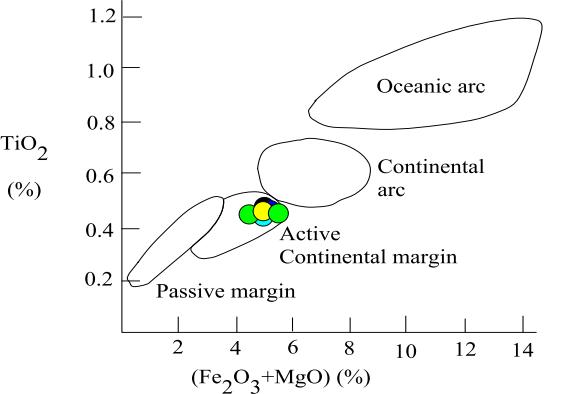


Quantitative Result

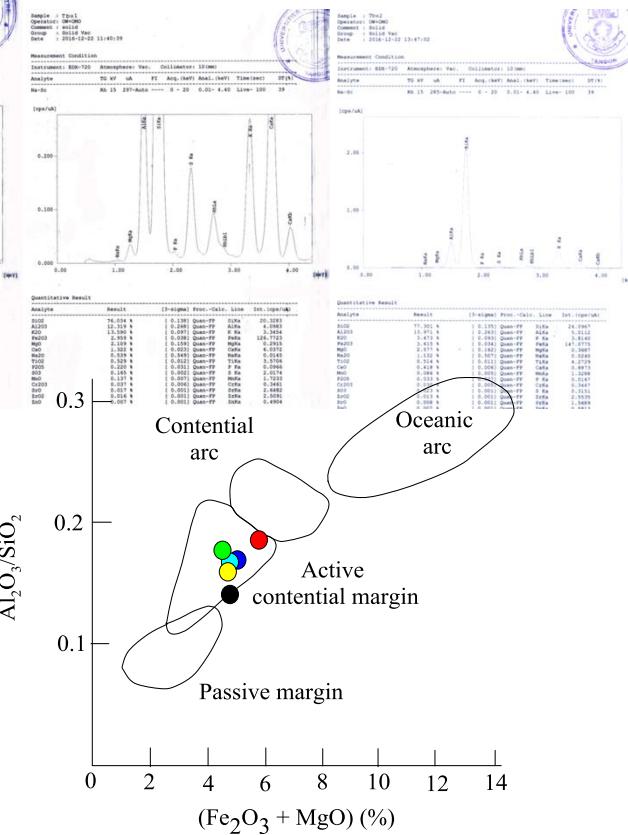
Analyte	Result	(%+ve) Poco-Calc. Line	Int. (cps/ku)
Al2O3	10.143 %	10.144 %	10.143
SiO2	72.500 %	72.541 %	72.500
TiO2	0.143 %	0.144 %	0.143
Po2O5	1.039 %	1.039 %	1.039
Fe2O3	4.589 %	4.589 %	4.589
MnO	1.144 %	1.144 %	1.144
CaO	0.194 %	0.194 %	0.194
MgO	0.020 %	0.020 %	0.020
Na2O	0.000 %	0.000 %	0.000
K2O	0.000 %	0.000 %	0.000
Cr2O3	0.000 %	0.000 %	0.000
La2O3	0.000 %	0.000 %	0.000
Y2O3	0.000 %	0.000 %	0.000
Th2O	0.000 %	0.000 %	0.000
U3O8	0.000 %	0.000 %	0.000
Sc2O3	0.000 %	0.000 %	0.000
Eu2O3	0.000 %	0.000 %	0.000
Gd2O3	0.000 %	0.000 %	0.000
Dy2O3	0.000 %	0.000 %	0.000
Tb2O3	0.000 %	0.000 %	0.000



The log (K_2O/Na_2O) vs SiO_2 discrimination diagram of Roser and Korsch (1986) for sandstone-mudstone suites and showing the fields for a passive continental margin, an active continental margin and an island-arc. The plotting coordinates for the field boundaries have been extracted from Roser and Korsch (1986)



Discrimination diagrams for sandstone-mudstone (after Bhatia, 1983), based upon a bivariate plot of TiO_2 vs $(Fe_2O_{3(tot)} + MgO)$. The fields are oceanic island-arc, continental island-arc, active continental margin and passive margin.



Discrimination diagrams for sandstone-mudstone (after Bhatia, 1983), based upon a bivariate plot of Al_2O_3/SiO_2 vs $(Fe_2O_{3(tot)} + MgO)$. The fields are oceanic island-arc, continental island-arc, active continental margin and passive margin.

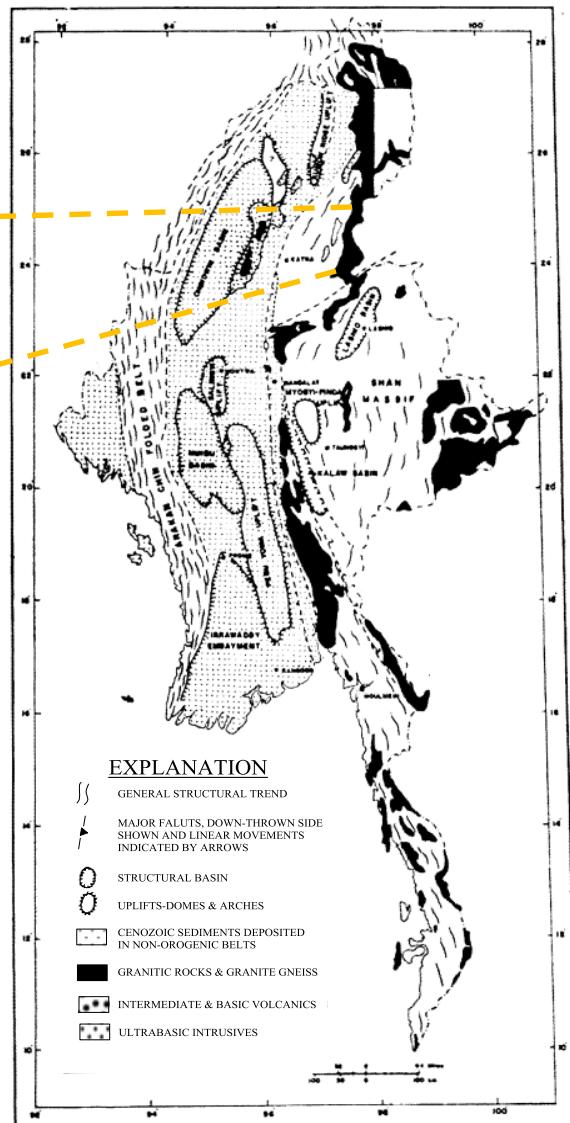
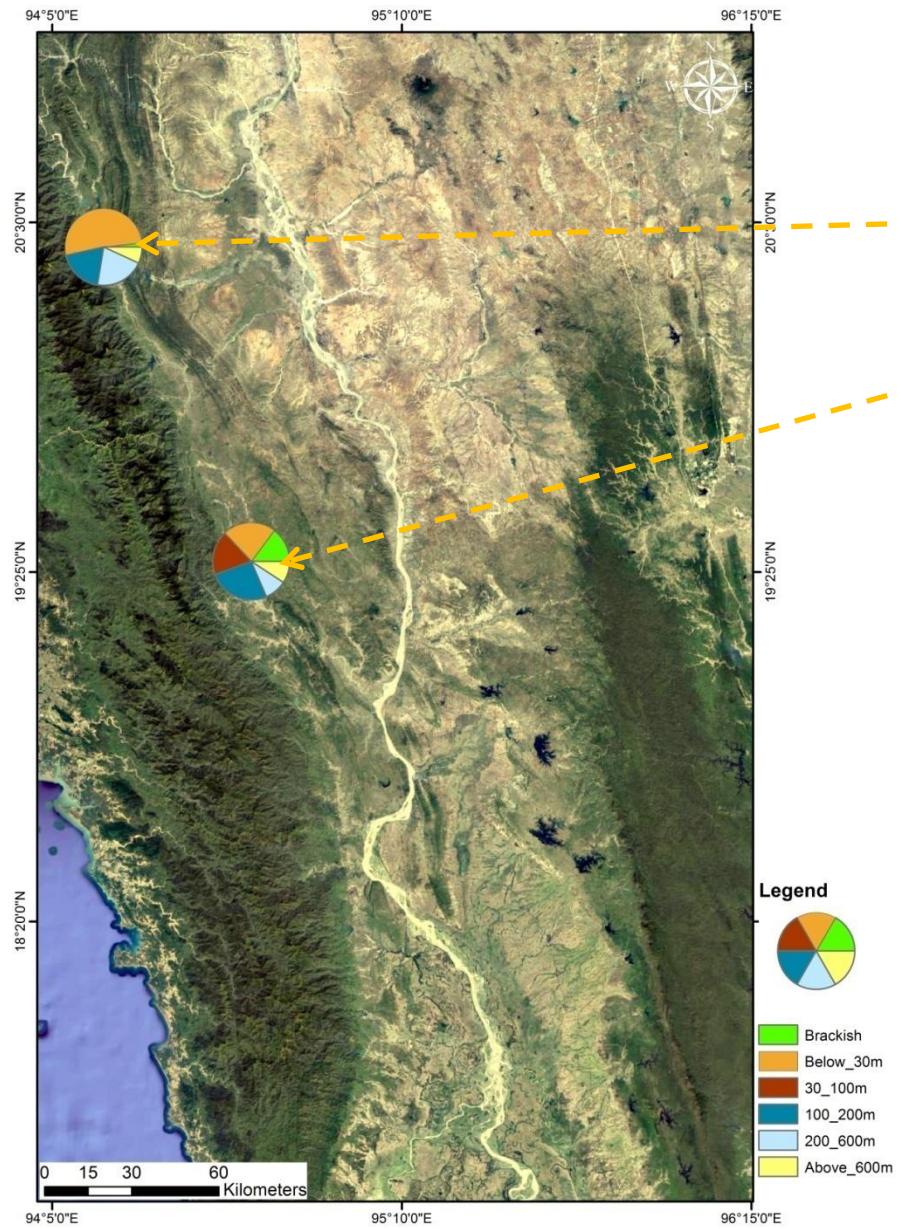


Fig 2. Generalized Tectonic Map of Burma.