Heavy Mineral Assemblages of the Langpar Formation from the Subsurface of parts of Dibrugarh and Tinsukia Districts, Upper Assam Shelf

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The Langpar Formation of Upper Assam Shelf of Dibrugarh and Tinsukia districts contains heavy mineral assemblage comprising zircon, tourmaline, rutile, hornblende, hypersthene, garnet, epidote, augite, enstatite, apatite and opaque minerals such as magnetite, hematite, ilmanite and pyrite. There is a distinct trend in distribution of some species of these minerals. The occurrence of hypersthene in the Early Tertiary rocks is significant. These heavy minerals show wide range in the maturity index value that suggest that these sediments have varying compositional maturity. The mineralogical maturity on the NE and SW of the Rajali Well is distinctly different, indicates derivation from different sources. It is concluded that these sediments were derived from igneous, metamorphic and reworked sediments.

Key-words–Heavy minerals, ZTR maturity index, Reworked sediments, Provenance, Assam-Arakan Region, India.

INTRODUCTION

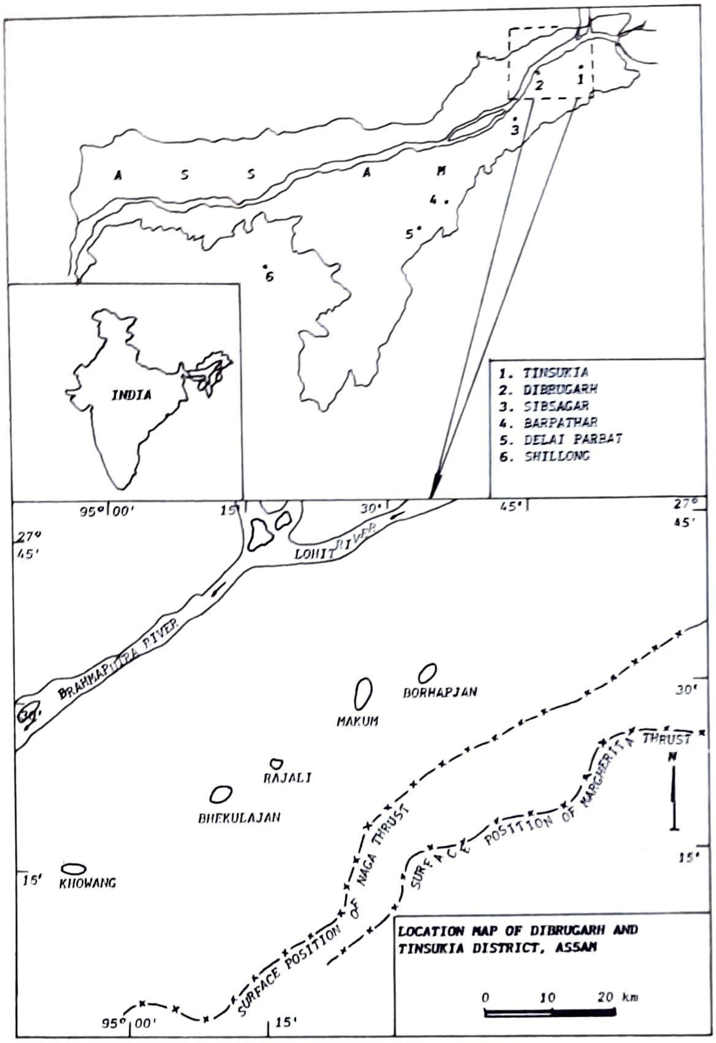
THE basal part of the Tertiary sequence in the subsurface of Dibrugarh and Tinsukia districts is regarded as Langpar Formation of Lower Palaeocene age by Oil India Limited (OIL) on the basis of lithological characters. The Oil and Natural Gas Commission Limited (ONGCL) has named the formation which forms the base of the Tertiary sequence in the Sibsagar district (undivided) as Basal Sandstone and based on fossil evidence fixed Early Eocene age for the sediments.

Till about two decades back, oil and gas fields in the shelf zone of the north-eastern part of Upper Assam were restricted to Barail Group of Oligocene age and Tipam and Girujan Clay Formations of Miocene age. The study of the basal unit is gaining importance after the recent discovery of oil and gas in Paleocene – Eocene in some of the oil fields of Dibrugarh, Tinsukia and undivided Sibsagar districts.

Medlicott (1869) named the sediments which conformably overlie the Mahadek Formation as Langpar Formation and regarded Mahadek, Langpar and overlying Therria (former "Cherra Sandstone Stage") as Upper Cretaceous in the southern part of the Shillong Plateau around Mahadek Village (25° 13' N, 91° 45' E). In the type area, the Langpar Formation comprises mainly sand, sandy calcareous shale with thin limestone partings towards base. In the subsurface of Dibrugarh and Tinsukia, the formation consists mainly of fine to very coarse grained sandstone, shaley sandstone and bluish gray shale with hard carbonaceous shale. There is occasional occurrence of glauconitic sugary white sandstone, sandstone with off white feldspars and poorly sorted very coarse grained sandstone with angular to sub-angular quartz.

MATERIAL AND METHOD

The samples for heavy mineral studies of the Langpar Formation were collected from different oil wells at various depths by OIL during their drilling operations. These drill cutting samples were subjected to heavy mineral separation following the funnel separation method of Milner (1962). The different size grades of each sample ranging from 60 mesh (ASTM) were first mixed up thoroughly. It has been done so as to get a better result from the average percentage of the heavies in different size grades (Russel 1936). The sediments taken for the study were treated with dilute



HCl of 1:10 strength. The materials were heated gently in HCl and then added $SnCl_2$ to the mixture to remove any cementing material adhering to the grains. After 24 hrs the grains were washed carefully with distilled water to dilute out the last traces of HCl and then dried in an oven at low temperature. The heavy residues were then separated from the lighter fraction with the help of bromoform (sp gr. 2.89). After separation, the heavy minerals were washed with acetone and air dried. Microslides were prepared from the heavy minerals for the detailed petographic studies and statistical analysis. The percentage frequency distributions of the heavy minerals were tabulated and their vertical distributions were represented by polygonal graphs. To obtain the ZTR maturity index, the recalculated ZTR were plotted in triangular graphs. Spatial percentage frequency distributions for particular minerals were plotted to obtain their horizontal distribution.

In order to show the relative predominance amongst the zircon, tourmaline and rutile, the individual percentage of zircon, tourmaline and rutile within the ZTR maturity index were recalculated. The recalculated values of ZTR were then plotted in a triangular diagram (Hazarika 1984).

The triangular diagram is divided into three main blocks *viz.* A, B and C by joining the mid-points M on the ZT with R, N on the ZR with T and O on the TR with Z, respectively. These three medians meet at a common point X producing two tiers in each block such as A_1 and A_2 in A, B_1 and B_2 in B and C_1 and C_2 in C block. Each tier represents the dominance of zircon, tourmaline and rutile as follows:

(i) Tier A_1 (XMZ) having Z>T>R;
(ii) Tier A_2 (XNZ) having Z>R>T;
(iii) Tier B_1 (XNR) having R>Z>T;
(iv) Tier B_2 (XOR) having R>T>Z;
(v) Tier C_2 (XMT) having T>Z>R;
(vi) Tier C_2 (XOT) having T>R>Z.

DESCRIPTION OF HEAVY MINERALS

The heavy mineral assemblage of the Langpar Formation comprises zircon, tourmaline, rutile, hypersthene, hornblende, garnet, titanite, epidote, enstatite and opaque minerals. Besides these, apatite and kyanite are recorded from Makum area and augite from the Rajali area.

The salient morphological characters of the heavy minerals of the Langpar Formation are described below:

1. *Zircon* (Pl.1, figs 1 & 2) : Zircon grains are mostly euhedral but subhedral grains are also present.

PLATE 1

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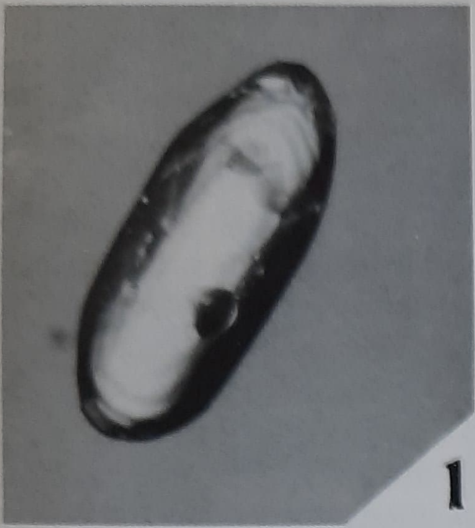
1. Zircon under crossed nicols x 150
2. Fractured zircon under plane polarised light x 100
3. Tourmaline under plane polarised light x 100
4. Rutile under plane polarised light x 150
5. Subrounded hornblende under plane polarised light x 100
6. Prismatic hornblende under crossed nicols x 100
7. Field view of hornblende under crossed nicols x 100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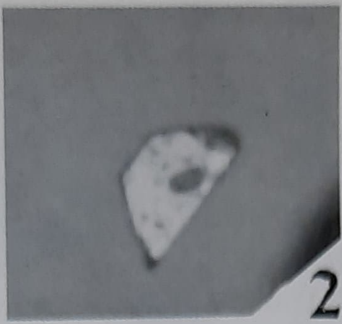
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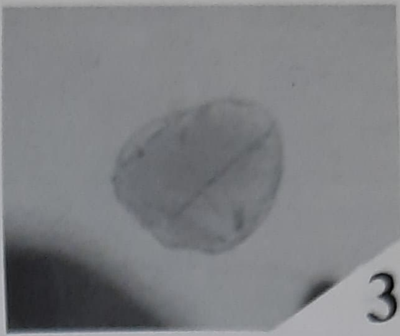
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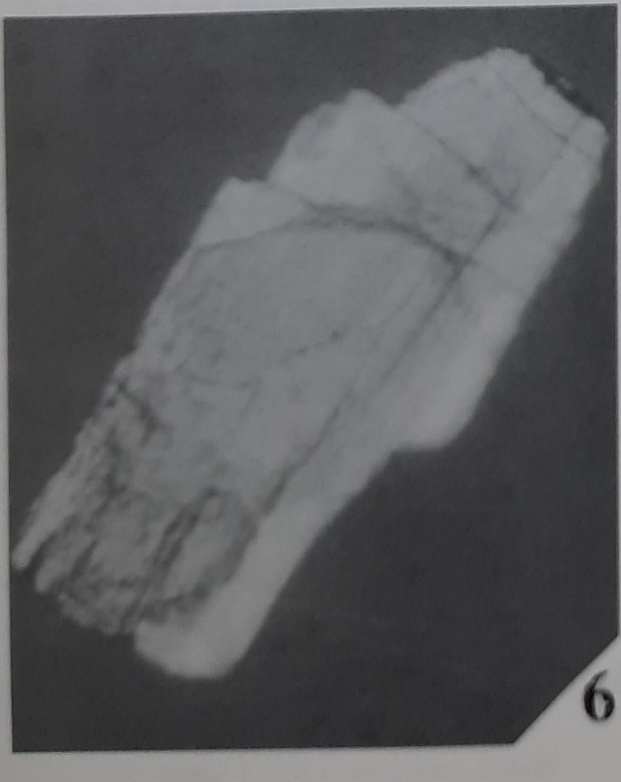
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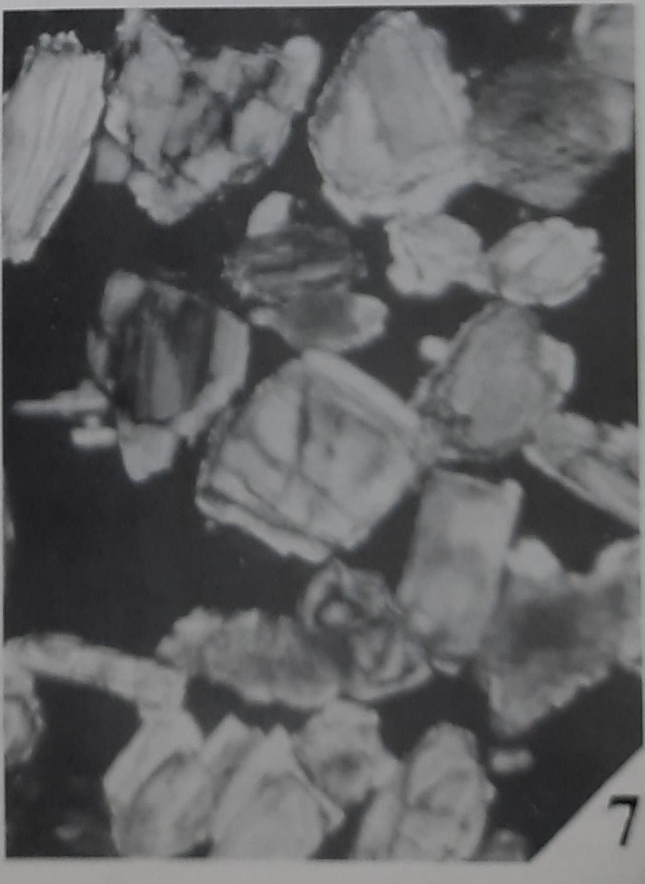
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PLATE I

Some are even rounded. Both long and short and prismatic grains are abundant. Grains are usually colourless but some are also pinkish in colour. Overgrowths are observed in some grains. Broken grains are fequently seen. Though extinction is parallel in most of the grains, some show strain effect. Some zircons exhibit zoning.

2. *Tourmaline* (Pl.1, fig. 3): Tourmaline grains are light brown in colour. Pleochroism is distinct. Grains are subhedral to subrounded with prismatic faces. Many grains are well rounded. Some grains also show overgrowth. Extinction is parallel.
3. *Rutile* (Pl.1, fig. 4): Rutile grains are generally brick red to dark red in colour. Dark red grains exhibit nearly opaque character under crossed polarized light. Most of the grains are subrounded. Extinction Parallel.
4. *Hypersthene* (Pl.2, fig.1) : Grains are light green to greenish brown in colour. Most of them are subangular prismatic. Some grains also show inclusions and overgrowth. Extinction parallel.
5. *Hornblende* (Pl. 1, figs 6 & 7): Grains are green to greenish brown in colour. Subangular prismatic in form. Distinctly pleochroic. Some grains show hacksaw and overgrowth. In the Khowang well, a good number of grains show twinning. Extinction varies from 4° to 24°.
6. *Garnet* (PL.2, figs. 2-5) : Both angular and subrounded varieties are common. Pink coloured grains are dominant over colourless. Minute inclusions are observed in the grains. Many grains show irregular cracks. Isotropic character of the mineral grains is distinct.
7. *Titanite* (PL.2, fig 6): Grains are colourless to pale yellow in pleochroic. Subangular to subrounded in shape. Some grains turn bluish at the extinction position. Extinction varies between 51° to 52°.
8. *Epidote* (Pl.2, fig.7): Grains are greenish yellow in colour and pleochroic. Colour appears same under crossed nicols. Subrounded to rounded in shape. Show minute inclusions. Extinction angle low.
9. *Augite* : Dark to light green in colour. Non-pleochroic. Grains are subrounded and prismatic. Extinction angle high (45° to 48°).
10. *Enstatite* : Colourless to light pink in colour. Prismatic in form with striations parallel to cleavage. Subangular to subrounded in shape. Inclusions common. Parallel extinction.
11. *Kyanite* : Grains are colourless. Elongated with marked rectangular outline. Conspicuous cross cleavage associated with step like changes in order of interference colour. Abundant black inclusions. Extinction varies from 28° to 31°.
12. *Apatite* : Apatite grains are less frequent and colourless. Grains are oval to nearly rounded. Inclusions often appear in rows. Extinction parallel.
13. *Opaque* : Due to the lack of characteristic optical properties the opaque minerals could not be described. However, with the help of colour and shape they could be grouped as brownish ilmanite and black hematite. Some globular bodies can be grouped as pyrite. Among these, most dominating are the magnetites.

STATISTICAL ANALYSIS

In the Langpar Formation the statistical data of the heavy mineral percentage frequency distribution (Table 1) reveals that rutile, hornblende and garnet are the dominating non-opaque heavy minerals. Rutile percentage varies from 0% to 95.56% whereas hornblende and garnet range from 0% to 92.90% and 0% to 97.73% respectively. Percentage of zircon ranges from 0% to 55.56% Tourmaline constitues 0% to 50.00% of the mineral assemblage. Hypersthene mainly dominates in the Borhapjan area and ranges from 0% to 74.26%.

PLATE 2

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1. Hypersthene under plane polarised light x 100
2. Pink garnet under plane polarised light x 00
3. Garnet with rows of inclusions under plane polarised light x 150
4. Subrounded and angular garnet under plane polarised light x 100
5. Field view of garnet under plane polarised light x 50
6. Titanite with inclusions under plane polarised light x 150
7. Epidote under plane polarised light x 100


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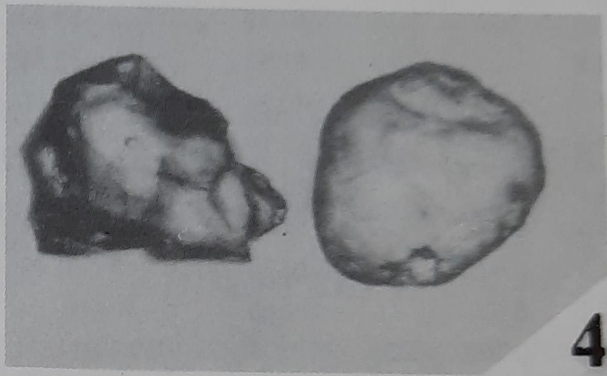
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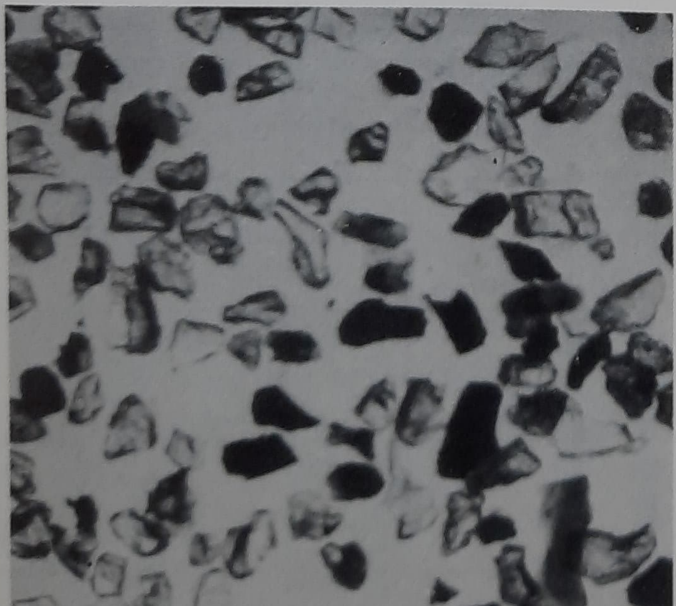
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PLATE 2

Table 1 : Heavy mineral percentage frequency distribution.

Sample No.	Zr	Tr	Rt	Hy	Hb	Ti	Ep	G(p)	G(cl)	Ky	En	Ap	Aug	Opq
SN/KH/1.3	-	-	-	9.11	90.89	-	-	-	-	-	-	-	-	0.26
SN/KH/1.2	44.15	12.50	28.30	-	4.16	0.83	-	4.17	3.33	-	2.50	-	-	69.23
SN/KH/1.1	-	-	-	-	92.90	-	-	5.14	1.97	-	-	-	-	6.63
SN/BK/1.3	-	-	75.00	-	-	-	-	25.00	-	-	-	-	-	73.00
SN/BK/1.2	25.00	50.00	25.00	-	-	-	-	-	-	-	-	-	-	55.00
SN/BK/1.1	-	8.70	4.35	4.35	17.39	-	8.70	47.83	-	-	8.70	-	-	67.00
SN/RJ/1.4	-	-	83.33	5.56	8.33	-	-	2.78	-	-	-	-	-	86.00
SN/RJ/1.3	27.01	7.30	23.36	-	2.19	-	2.19	1.46	-	-	-	-	1.46	58.00
SN/RJ/1.2	-	-	95.56	-	-	-	4.44	-	-	-	-	-	-	50.00
SN/RJ/1.1	1.04	1.04	88.54	-	4.17	1.04	2.08	2.08	-	-	-	-	-	43.00
SN/MK/1.11	0.52	-	92.19	-	2.60	-	0.52	3.13	-	-	1.04	-	-	38.48
SN/MK/1.10	-	-	69.04	-	4.76	-	7.14	19.05	-	-	-	-	-	82.12
SN/MK/1.9	3.16	-	67.47	-	10.84	3.61	1.20	10.84	-	1.20	-	1.20	-	70.03
SN/MK/1.8	-	-	61.54	-	15.38	-	7.69	15.38	-	-	-	-	-	85.39
SN/MK/1.7	-	4.55	40.91	-	18.18	-	9.09	22.73	-	-	4.55	-	-	92.02
SN/MK/1.6	1.82	-	38.18	-	16.36	1.82	-	18.18	-	-	20.00	-	-	86.25
SN/MK/1.5	-	-	46.88	-	3.13	1.56	-	48.43	-	-	-	-	-	81.39
SN/MK/1.4	0.59	-	14.85	-	0.79	0.20	-	83.56	-	-	-	-	-	41.95
SN/MK/1.3	0.40	-	19.35	-	0.40	-	-	79.84	-	-	-	-	-	56.89
SN/MK/1.2	0.62	-	1.65	-	-	-	-	97.73	-	-	-	-	-	36.44
SN/MK/1.1	0.16	1.26	-	-	-	-	0.16	94.47	3.63	-	00.32	-	-	18.52
SN/BH/1.5	55.56	13.33	16.67	-	7.78	-	1.11	-	-	-	-	-	-	44.00
SN/BH/1.4	9.09	-	-	9.09	27.27	-	-	18.18	-	-	36.36	-	-	43.00
SN/BH/1.3	9.47	3.16	-	63.16	23.16	-	1.05	-	-	-	-	-	-	35.00
SN/BH/1.2	10.62	-	-	56.42	3.91	-	1.12	27.93	-	-	-	-	-	18.00
SN/BH/1.1	0.50	-	-	74.26	2.48	-	-	22.77	-	-	-	-	-	36.00

Zr = zircon, Tr=tourmaline, Rt=rutile, Hy=hypersthene, Hb=hornblende, Ti=titanite, Ep=epidote, G(p)=pink garnet, G(cl)=colourless garnet, Ky=kyanite, En=enstatite, Ap=apatite, Aug=augite, Opq=opaque minerals

Titanite, epidote and enstatite are less abundant in the heavy mineral suit and vary from 0% - 3.61%, 0% - 9.09% and 0% - 36.36% respectively. Kyanite, augite, apatite are the rare constituent of the heavy mineral assemblage of the Langpar Formation. The opaque minerals are persistent throughout the formation and ranges from 0.26% to 92.02%. The non-opaque to opaque ratio in about 53% of the samples is less than one.

The average spatial distribution (Table 2) of zircon in different wells varies from 0% to 44.15%. Tourmaline and rutile vary from 0.53% to 19.57% and 16.67% to 72.77% respectively. Hypersthene ranges from 0% to 50.69%, hornblende from 4.90% to 62.65% and garnet from 2.11% to 45.18%. The

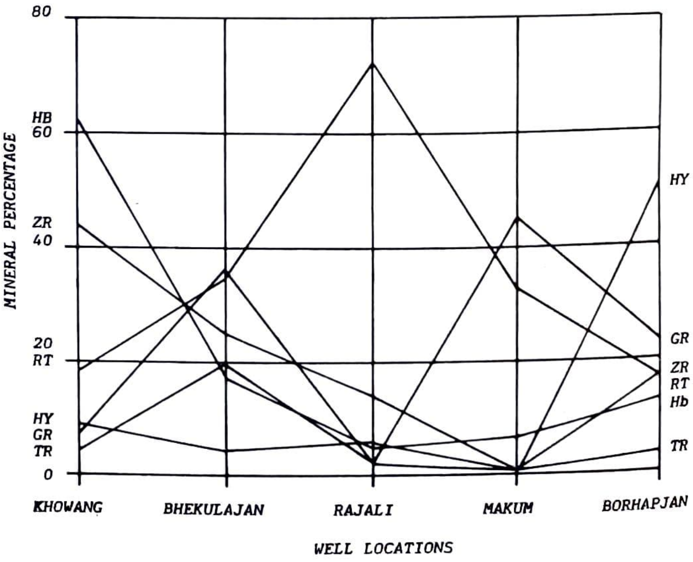

Fig. 1. Sapatial distribution of heavy minerals in Langpar Formation of Upper Assam shelf (subsurface)

Table 2 : Well wise spatial distribution heavy mineral frequency (%) and average spatial distribution heavy minerals in Langpar Formation

Mineral species	Khowang	Bhekulajan	Rajali	Makum	Borhapjan	Average
Zircon	44.15	25.00	14.02	0.70	17.05	20.38
Tourmaline	4.17	19.57	2.09	0.53	3.30	5.93
Rutile	18.30	34.78	72.77	32.68	16.67	35.04
Hypersthene	9.11	4.35	5.56	-	50.69	13.94
Hornblende	62.65	17.39	4.90	6.60	12.92	20.89
Titanite	0.82	-	0.26	-	-	0.27
Epidote	-	2.90	2.18	2.35	0.66	1.62
Garnet	7.31	36.42	2.11	45.18	22.96	22.80
Kyanite	-	-	-	0.11	-	0.02
Enstatite	0.83	2.90	-	2.36	7.27	2.68
Apatite	-	-	-	0.11	-	0.02
Augite	-	-	0.37	-	-	0.08
Opaques	25.37	65.00	59.26	62.68	35.20	49.50

graphical representation of these minerals is shown in Figure 1. Less abundant as epidote varies from 0% to 2.90% and enstatite from 0% to 7.27%. The opaque minerals spatially distributed from 25.37% to 65.00%.

STUDY OF ZTR MATURITY INDEX

The compositional maturity of sediments can be expressed in terms of ZTR index. The ZTR maturity index is the percentage of combined zircon, tourmaline and rutile grains in the total quantity of non-opaque (Hubert, 1962). The ZTR maturity indices of individual samples were calculated following Hubert (1962) and the results are shown in Table 3.

The ZTR maturity index varies widely in different wells and recorded as 84.95% in Khowang, 75% - 100% in Bhekulajan, 57.67% - 95.56% in Rajali, 15.44% - 92.71% in Makum and 10.62% - 85.56% in Borhapjan area (Table 4). The mean ZTR index as a whole is found to be 48.20%. Individually, zircon varies from 0% to 55.56%, tourmaline from 0% to 50% and rutile from 0% to 92.19%.

The recalculated zircon, tourmaline and rutile percentage vary as follows : zircon from 0% to 100%, tourmaline from 0% to 60.67% and rutile from 19.48% to 100% (Table 3).

The triangular plot (Fig. 2) shows the concentration of points in the A_2 tier of A block and B_1 tier of B block of the diagram which indicates the predominance of zircon and rutile in the ZTR assemblages of the Langpar sediments.

INTERPRETATION

The mineral assemblage in the heavy mineral suit of the Langpar Formation includes zircon, tourmaline, rutile, hypersthene, hornblende, garnet (both pink and colourless), titanite, epidote, enstatite, apatite, kyanite, augite and opaque minerals. Amongst these minerals, the first six minerals are dominating.

The dominance of zircon, tourmaline and rutile and

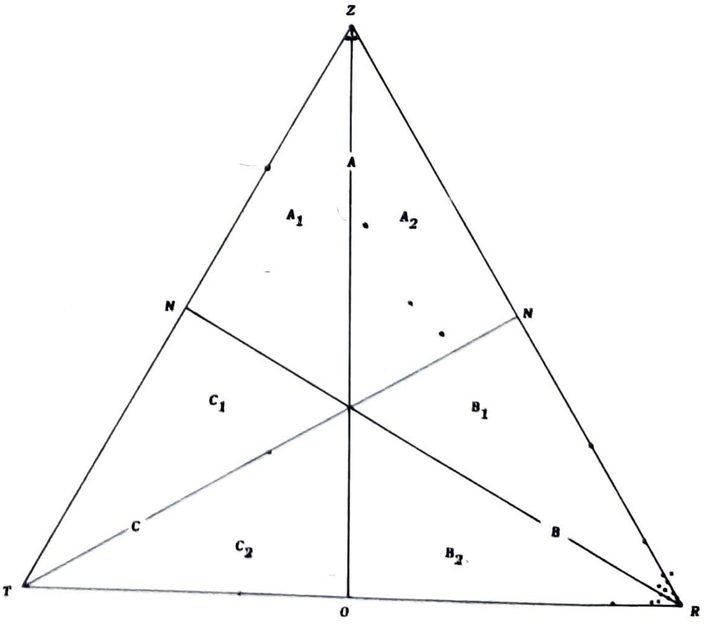

Fig. 2. Triangular plotting of ZTR.

Table 3 : Results of ZTR Analysis in Langpar Formation

Sample no. maturity	ZTR values within the Heavy mineral suit (excluding iron ore and micaceous minerals)				Zircon-Tourmaline-Rutile percentage within ZTR index.			
ZR (%)	Tr(%)	Rt(%)ZTR maturity index (%)Zr(%)			Tr(%)	Rt(%)	Total (%)	
SN/KH/1.3	-	-	-	-	-	-	-	-
SN/KH/1.1	44.15	12.50	28.30	84.95	52.00	14.70	33.30	100
SN/KH/1.1	-	-	-	-	-	-	-	-
SN/KH/1.3	-	-	75.00	75.00	-	-	100.00	100
SN/KH/1.2	25.00	50.00	25.00	100.00	25.00	50.00	25.00	100
SN/BK/1.1	-	8.70	4.35	13.05	-	66.67	33.33	100
SN/BK/1.4	-	-	83.33	83.33	-	-	100.00	100
SN/RJ/1.3	27.01	7.30	23.36	57.67	46.80	12.70	40.50	100
SN/RJ/1.2	-	-	95.56	95.56	-	-	100.00	100
SN/RJ/1.1	1.04	1.04	88.54	90.62	1.1	1.1	97.70	99.90
SN/MK/1/11	0.52	-	92.19	92.71	0.60	-	99.40	100
SN/MK/1.10	-	-	69.04	69.04	-	-	100	100
SN/MK/1.9	3.61	-	67.47	71.08	5.10	-	94.90	100
SN/MK/1.8	-	-	61.54	61.54	-	-	100	100
SN/MK/1.7	-	4.55	40.91	45.46	-	10.00	90.00	100
SN/MK/1.6	1.82	-	38.18	40.00	4.60	-	95.40	100
SN/MK/1.5	-	-	46.88	46.88	-	-	100	100
SN/MK/1.4	0.59	-	14.85	15.44	3.80	-	96.20	100
SN/MK/1.3	0.40	-	19.35	19.75	2.00	-	98.00	100
SN/MK/1.2	0.62	-	1.65	2.27	27.30	-	72.70	100
SN/MK/1.1	0.16	1.26	-	1.42	11.30	88.70	-	100
SN/BH/1.5	55.56	13.33	16.67	85.56	64.94	15.58	19.48	100
SN/BH/1.4	9.09	-	-	9.09	100.00	-	-	100
SN/BH/1.3	9.47	3.16	-	12.63	75.00	25.00	-	100
SN/BH/1.2	10.62	-	-	10.62	100.00	-	-	100
SN/BH/1.1	0.50	-	-	0.50	100.00	-	-	100

presence of ilmanite and magnetite in the assmblage suggests that a significant proportion of the sediments were derived from acid plutonic rocks. The presence of prismatic and long slender grains and also zoned grains of zircon support the above observation. However, presence of colourless zircon and zircons with opque inclusions suggest their derivation from igneous and metamorphic sources (Hazarika 1984). Some grains of zircon are broken which indicate their short distance transportation. From the above characteristics of zircon it may be concluded that the zircon grains were dervied from nearby igneous and metamorphic sources. As mentioned earlier, many grains of zircon are rounded which indicates that some of them might have been contributed by reworked sediments. The occurrence of grains of different derivatives in these sediments may be attributed to the sources of varied composition.

Higher percentage of tourmaline in the sediment indicates contribution from metamorphic rocks. Blatt *et al.* (1972) also made such observation.

The presence of hornblende in higher percentages suggests a metamorphic source for these sediments. The hornblende grains show hacksaw growth structure which may be due to the post-depositional intrastratal solutions (Edlman and Doegls, 1931, in Sedimentary Rocks, Pettijohn, 1975) or due to decomposition during diagenesis and epigenesis (Strawkhow, 1957, in S.K. Chanda, 1960). The

Table 4 : Range of ZTR Index of Langpar Formation

Area	Range of ZTR index	Compositional maturity
Khowang	84.95	Mature
Bhekulajan	75 - 100	Mature to highly mature
Rajali	57.67-95.56	Mature
Makum	15.44-92.71	Less mature
Borhapjan	10.62-85.56	Less mature

higher concentration of hornblende (92.90%) in the sediment is a characteristic of near shore sediments (Lindholm 1987, pp. 212). Moreover, dominance of unstable mineral like hornblende on the southwestern side of the area indicates that the sediments were not only derived from metamorphic rocks but also the source lies very near to the basin of deposition.

The presence of hypersthene in the heavy mineral assemblages of Lower Tertiary rocks of this region is observed for the first time. However, hypersthene have been recorded from the Upper Tertiary rocks of the region. The occurrence of this mineral in significant proportion in the Langpar sediments suggests contribution of sediments from metamorphic sources.

Both pink and colourless varieties of garnet suggest in general a metamorphic source for these sediments. However, the dominance of pink garnet with rows of inclusions in the sediments specifically suggests their derivation from peletic schist type of metamorphic rock (Williams, Turner & Gilbert, 1982, p. 549).

The presence of kyanite-epidote and garnet in the assemblage also definitely suggest a metamorphic provenance for some of these sediments.

In the assemblage, the non-opaque to opaque ratio is found to be low (47.17:52.83) and magnetite is the dominating constituent amongst the opaques. This suggests that one of the sources may be crystalline rock.

The ZTR maturity index of the Langpar sediments varies within a wide limit, ranging from 10.62% to 100%. The sediments of Khowang, Bhekulajan and Rajali areas show higher ZTR maturity index while sediments of Makum and Borhapjan areas indicate low to moderate ZTR maturity index values. This may be attributed to the presence of sediments derived from multiple sources, because many ZTR grains are rounded while some of the species of ZTR of the heavy mineral assemblage are normally subrounded to subangular. These rounded zircon, tourmaline and rutile grains might have been derived from reworked sediments while others having low roundness were the product of first cycle.

The above study in general, therefore, suggests that the heavy minerals of the Langpar Formation were derived from varied sources. However, the igneous and metamorphic sources have contributed the major portion of the sediments. The presence of rounded, subrounded grains suggest contribution from reworked sediments as well. The textural characteristics such as broken grains of zircon and subrounded outlines of various heavy mineral species suggest a short to moderate distance transport of the sediments. One significant characteristic in the spatial distribution of heavy minerals is that the hornblende concentration in the assemblage is very high in the southwestern side of the area of study while the concentration of the same decreases towards the northeast. The reverse is the case in the distribution of hypersthene which shows higher concentration on the northeastern side of the area. The contrast in the spatial distribution of these two minerals may be attributed to the contribution of hypersthene bearing sediments from the northeast and the hornblende bearing sediments from the south west. This suggest that some sediments were derived from the Himalayas and some others from Assam-Arakan region.

One significant feature of the distribution of garnet is its higher concentration in the basal part of the formation. This indicates that at the early stage of deposition, the sediments were derived from metamorphic sources.

From the overall studies of the heavy mineral content and their distribution in the Langpar Formation, it may be concluded that these sediments were derived from varied sources which lie on the northeast and the southwest of the area.

The last occurrence of Langpar outcrop on the northern side of the type area has been observed in the Umstew gorge section (1023' Falls Section, 25° 10'0" N, 91° 43' 30" E) at 29 milestone on the Shillong-Shella road, about 370 kms south of the present area. Another important outcrop section has been observed towards north in the Koilajan (26° 00'15"N, 93° 33' 30"E), Delai Parbat, Karbi Anglong (former Mikir Hills) where the Therria Formation rests directly on the Sylhet Trap of Pre-Upper Cretaceous.

The ONGCL has drilled deep oil wells at Dergaon, Borpathar, etc. in the Upper Assam Valley far away towards north of the type area where no Langpar Formation has been reported. The aerial distance between the type area and Dibrugarh is about 373 kms. Since, the present study reveals that the sediments were transported over short to moderate distance, it is possible that the Langpar Formation of the Dibrugarh and Tinsukia districts is not a continuation of the type area.

Although oil fields are occasionally encountered in continental beds, Hoffmeister (1960), the most reputed oil-palynologist feels "that the best location for oil-exploration lies in the areas where near shore to brackish sediments merge with brackish to marine sediments". Since the Langpar Formation was deposited in near shore conditions, as it is revealed from the present study, the determination of its age, correlation, etc. are very important for petroleum exploration and establishment of heavy minerals will play an important role for these studies.

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