Geochemical Characteristics Of Shale Of Disang Group, Tirap District, Arunachal Pradesh

B.K. Gogoi, R. K. Sarmah

Abstract: This paper aims to study the geochemical characteristics of shale of Disang group of Eocene age. Geochemical study and the data reported indicate that Shales are deposited under the marine condition. Tectonic setting was active continental margin to passive continental margin and sediments were derived from volcanic and/or granitic source area. Study reveals that Source-rating of studied shale is found to be poor and its hydrocarbon source proclivity towards gas. Further, shale of the Disang group is found to contain over-matured organic matters, represented by Kerogen Type-III and Type-IV.

Key words: Disang Group, Rock-Eval, T-max, TOC

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1 Introduction

The Disang Group of Eocene age represents the oldest rocks in the Tertiary sequence of the Assam-Arakan Basin. This paper presents findings of a study on shale of the Disang group in a part of the Assam-Arakan Basin, lying between latitudes $95^{0}20^{/}$-$95^{0}30^{/}$ E and latitude $27^{0}0^{/}$N-$27^{0}10^{/}$N. This part constitutes a portion of the Tirap District of Arunachal Pradesh. Fig 1A shows the position of Tirap district along with the tectonic elements of the eastern Himalayas and Indo-Burman Ranges [1]. In the said region, shale samples were collected from Deomali-Khonsa road section and part of Tissa river section section (Fig 1B). Major and minor oxide element analysis was restricted for the samples collected form road section whereas Rock-eval analysis was done for the samples collected from river as well as road section. A thick sequence of shales, interbedded with thin sandstone and siltstone is found to be outcropped along these sections. The objective of the present study is to evaluate the tectonic settings and provenance of shale of Disang Group under study. Further, it is envisaged to assess the hydrocarbon potential of the shale of Disang Group based on geochemical data generated.

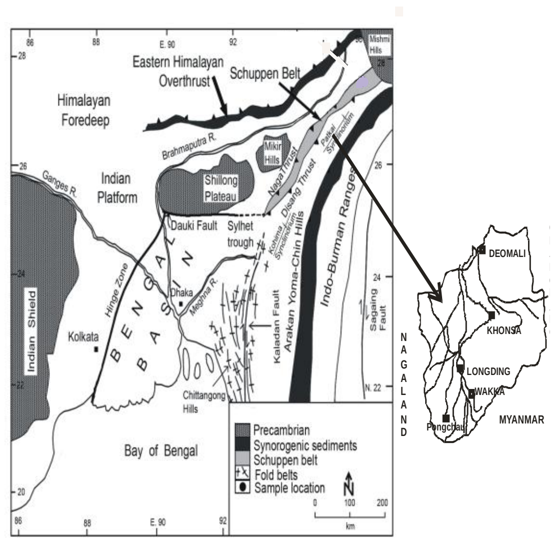

Fig 1A: Map showing the tectonic elements of the eastern Himalayas and Indo-Burman Ranges. Samples were collected from the south eastern part of the Schuppen belt as shown in figure (after Hutchison, 1989).

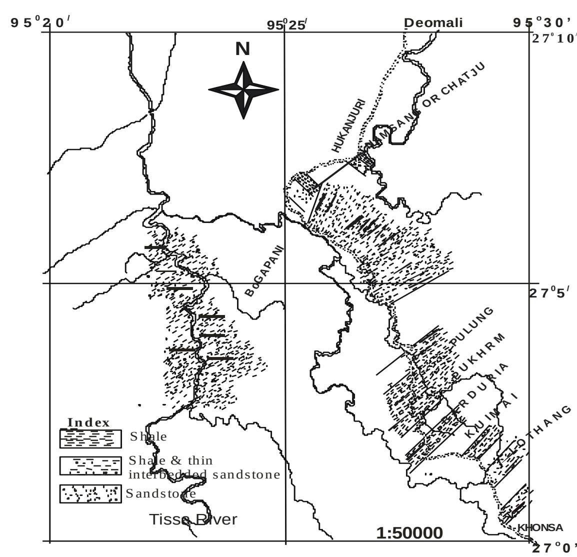

Fig1B. Location map showing Sampling position along the Deomali- Khonsa Road section and a part of Tissa river section, Tirap District, Arunachal Pradesh

- *Bijit Kumar Gogoi, Research scholar, Department of Applied Geology, Dibrugarh University, Dibrugarh-786004, Assam.* bijitgogoi@gmail.com
- *Ranjan kumar Sarmah,* Associate Professor, *Department of Applied Geology Dibrugarh University, Dibrugarh-786004, Assam.* ranjanksharmah@yahoo.co.in

2 Methodology

Major oxides are determine by using philips PW 1480 sequential x-ray fluorescence spectrometer in Guhati University, ASSAM, for this purpose 1-2 gms of powdered shale samples (ASTM 250 mesh) are mixed with 0.5 gm. of grade E Merck boric acid (H_3BNO_3) and pressed in a steel mould under a pressure of 25 to 30 tons to made pellet. A known sample of silicate rock is taken for reference. Two types of radiation detector were used; a gas flow proportional detector for long wavelength and a scintillation detector for short wave length radiation .X40 software is used to calculate concentrations of oxide in wt percent. Rock-Eval analysis is carried Oil India Ltd Duliajan, for this 100 gm of shale sample was first heated to 300°C for three minutes in an inert atmosphere (helium). During this period "free hydrocarbons" were thermally desorbed from the sample. The abundance of free hydrocarbons was measured using a flame ionisation detector (FID) and recorded as the S1 peak. The sample is then pyrolysed by increasing the temperature of the furnace from 300° to 550° C or 600°C at the rate of 25°C min^{-1}. The amount of hydrocarbons generated during this period was measured using a FID and reported as the S2 peak. The T_{max} was measured in °C at which the maximum rate of hydrocarbon generation occurs.

3 Geological setup:

During middle Eocene, collision of Indian plate with the Tibetan and central Burmese plates took place and as a result strong compressional forces were generated and Assam-Arakan Basin came into existence. In this basin, the flysch type of sediments of Disang Group was deposited in a shallow but rapidly sinking basin during Eocene period. The sub-flysch Barail sediments were accumulated in this basin under coastal to fluvio-deltaic basin set-up in Oligocene age [2]. The stratigraphic succession covering Tirap District of Arunachal Pradesh is shown in Table-1 [3]. The Disang Group occupies a vast area in the Tirap and Tissa valleys of the Naga-Patkai Ranges occurring at the core of a Nampong anticline due to folding and faulting. In Plio-Pleistocene due to continuing thrust of the Asian and Burmese plates compressional force acted from two directions, one from north and the other from SE. As a result of SE directional compressional force the development of Naga Schuppen belt was taking place. On the basis of structural elements the Naga-Patkai Ranges are subdivided in to two zone belts, viz., the Schuppen belt and the Kohima Patkai synnclinorium [4]. The Disang thrust is the dividing line between these two structural zone, the area lying to its southeast forms Patkai Synclinorium, here the rocks of the Disang, Barail Groups and post-Barail sediments have been folded into a number of north-easterly plunging folds which swerve to east-west and then to NW-SE trend. Of these the folds, the Patkai anticline exposes the Disang Group of rocks which occupy large area of Tirap Vally.

4 Results

XRF analysis shows that major and minor oxides which are present in the Disang Shale include SiO_2, Al_2O_3, Fe_2O_3, MnO, TiO_2, Na_2O, K_2O, CaO, MgO and P_2O_5. Concentration of different oxide minerals in wt % is given in Table-2. SiO_2 (58.98-65.15 wt%) Constitute the major portion of the oxide minerals followed by Al_2O_3 (16.05-20.28wt %) and Fe_2O_3 (5.55-9.44wt %). Exceed of K_2O (0.8-3.69%) over Na_2O (0.75-2.09 wt%) and CaO (0.56-2.02 wt%) is an indication of granitic source. Data obtained from Rock-eval analyses of studied shale show high T-max values and lower values of TOC and S_2 (Table 5)

Table 1. Stratigraphic succession covering Tirap District, Arunachal Pradesh (after Jhanwar et al. 1999)

Group (Age)	Formation	Lithology
Recent	Alluvium	Loose sand, pebbles and boulders of sandstone and gneissic rocks, clay and silt
………………………………..unconformity…………………………………………		
Dihing Group (Plio-Pliestocene)	Dihing Formation (+3500 m)	Boulder of sandstone, gneisses, schist and basic rocks set in sandy and clay matrix ,Bluish grey, medium to coarse, gritty sandstone with sandy clay lenses
	Namsang Formation	Bluish to green, loose, unconsolidated sand beds with pebbles of quartzite and lignite fragments, carbonized and silicified wood
………………………………..unconformity…………………………………………		
Tipam group (Mio- pliocene)	Girujan Formation (+ 1250 m)	Mottled, grey, bluish grey clays with greenish Sandstone beds and chert nodules
	Tipam Formation (+1500m)	Bluish to green, medium to coarse, friable to well indurated sandstone intercalated with mottled clay, grit and conglomerate beds
Barail group (Oilgocene)	Tikak parbat Formation (+1000 m)	white to grey , sandy clay- shale intercalated with brown, argillious sandstone and coal seams in the basal part
	Baragoloi Formation (+2000 m)	Grey to brownish red, thickly bedded, micaceous to argillaceous sandstone with pellets, Carbonaceous shale and coal stringers/lenses
	Naogaon Formation (+2250 m)	Grey hard flaggy thin bedded sandstone with intercalation of dark grey splintery shale and sandy shale
……………………………..unconformity…………………………………………		
Disang group (Eocene- Lr Oilgocene)	Disang Formation (+3500 m)	Dark grey to black splintery shale interbedded with fine to medium , gray, flaggy to massive sandstone and siltstone
………………………………..unconformity…………………………………………		
Metamorphic (Precambrian)		quartz-mica schist, quartzties, slate

5 Discussion

5.1 Provenance & tectonic setting:

From the XRF analysis it is evident that TiO_2 concentration increases with Al_2O_3, this suggested that TiO_2 is probably associated with phyllosilicate especially with illite [5]. The ratio of SiO_2/Al_2O_3 is low (between 2.9 and 3.8) in all the samples indicating a lower silt content and therefore a tendency towards marine condition [6] . As compared with that of the average shale composition ([7] , [8]) shows that it is enriched in SiO_2, Al_2O_3, Fe2O3 and Na_2O content and poor in the content of MgO, CaO and P_2O_5 oxides. The Chemical composition of early published average shale of different part of world is given in Table 3. Roaldest [9] used the ratio of K_2O/Al_2O_3 Vs log MgO/Al_2O_3 (Fig.3) to demarcated the marine and non marine clay and this ration is used for the present study and it shows that studied samples fall in the marine part. Roser and Korsch [10] used the ratio of K_2O/Na_2O Vs SiO_2 and SiO_2/Al_2O_3 Vs K_2O/Na_2O (Fig 4A & 4B) to discriminate the tectonic setting. In both the diagrams studied sample plot in the active margin as well as passive margin field .Active margin (fore arc, continental arc, back arc, strike slip) sediments are characterized by mixture of arc derived material and old upper crustal sources, Whereas passive margin sediments are generally dominated by old upper crustal sources [11]. Amajor [12] suggested the ratio of TiO_2/Al_2O_3 as a province indicator, Appling this ratio for the present sediments suggest different sources region (Fig 5). Discrimination diagram by Roser and Korsch [13] (Fig 6) for sedimentary province indicate towards mafic igneous province igneous province.

Table2. Major element composition of studied shale samples

Sample No	SiO_2	Al_2O_3	Fe_2O_3	MnO	MgO	CaO	Na_2O	K_2O	TiO_2	P_2O_5	LOI
KS-01	65.15	20.28	5.55	0.01	1.35	0.56	0.97	3.27	0.82	0.05	-
KT-03	59.33	17.78	9.44	0.08	2.93	0.68	0.75	0.8	1.1	0.12	6.69
KS-05	63.49	18.27	6.95	0.05	2.45	2.02	1.13	3.46	0.86	0.07	-
KS-09	62.33	19.67	6.86	0.9	1.86	1.23	1.21	3.18	0.84	0.09	-
KS-13	59.95	20.1	8.69	0.04	2.5	1.31	1.47	3.69	0.82	0.15	-
KS-16	62.11	17.02	7.45	0.05	2.03	0.68	1.89	2.12	0.31	0.1	6.21
KS-20	63.12	16.05	7.19	0.07	1.99	0.66	2.09	2.82	0.52	0.14	6.11
KS-25	62.32	17.05	8.2	0.11	1.16	0.86	1.19	2.42	0.42	0.17	6.21
KS-29	60.44	18.1	8.12	0.03	1.78	0.87	1.25	3.14	0.39	0.03	6.2
KS-35	58.98	17.77	6.7	0.07	2.21	1.02	1.91	2.76	0.69	0.13	7.62
KS-38	60.11	18.28	8.16	0.12	2.23	0.87	1.18	2.11	0.87	0.19	6.11
KS-43	61.93	16.21	8.06	0.11	2.01	0.64	1.47	3.12	0.38	0.04	6.22

Table3. Comparison of chemical composition of the studied shales with published average shales and regional average composition

Composition	Present studied shale	Average shale (Pettijohn 1975);	Average shales (Turekian and Wedepohl 1961);
SiO_2	61.61	58.1	58.5
Al_2O_3	18.05	15.4	15
TiO_2	0.668	n.a.	0.77
Fe_2O_3	7.614	4.02	4.72
MgO	2.042	2.44	2.5
MnO	0.137	-	-
CaO	0.95	3.11	3.1
Na_2O	2.741	1.3	1.3
K_2O	3.49	3.24	3.1
P_2O_5	0.107	n.a.	0.16

Fig3. Depositional environment of the studied samples based on the relation between log MgO/Al_2O_3 and log K_2O/Al_2O_3 (Roaldest,1978).

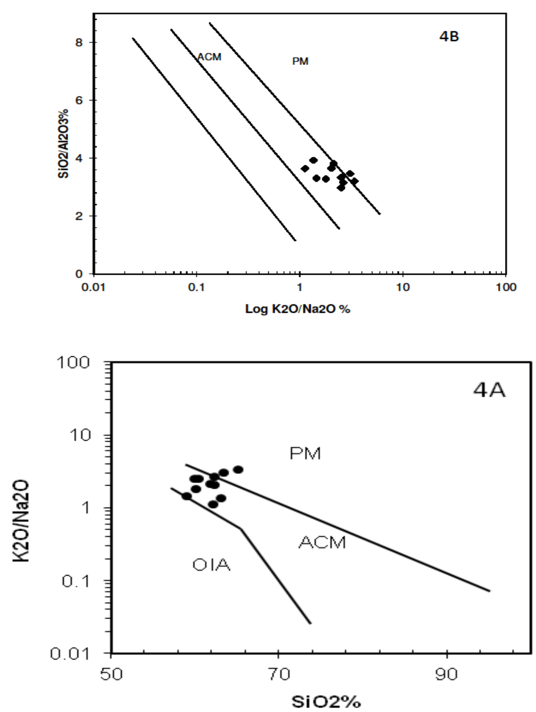

Fig4. (A) K_2O/Na_2O Vs SiO_2 and (B) SiO_2/Al_2O_3 Vs K_2O/Na_2O tectonic discrimination plots for the analyzed shale samples(after Roser and Korsch,1986) OAI= oceanic island arc; ACM=active continental margin; PM=passive margin

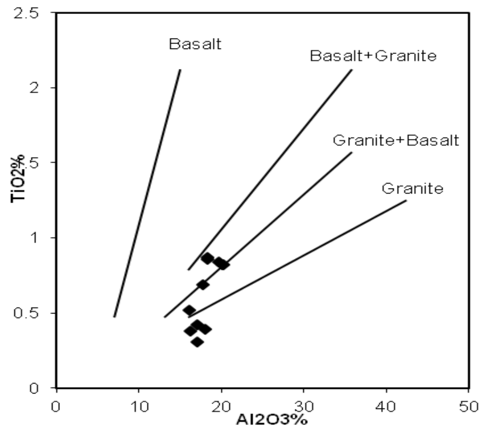

Fig5. TiO_2/Al_2O_3 binary plot (Amajor,1987)

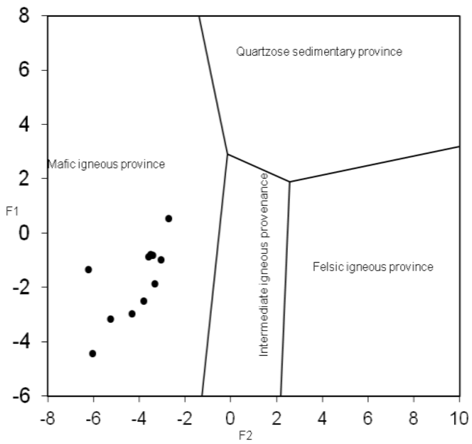

Fig6. Discrimination diagram for sedimentary provenance (Roser and Korsch,1988)

5.2 Rock -eval analyses:

Data generated from Rock-eval analysis shows that the S_2 values are found to range from 0.0 % to 0.13%. TOC values vary from 0.09% to 0.46%. This imply that studied shale have TOC value below the threshold limit of 0.5wt % TOC reported for the generation of organic matter from clastic sediments [14]. This suggests an insufficient organic matter constituent for the generation of hydrocarbon. The S_2 (0-0.13) value of shale in the investigated area indicate poor source rating and their source proclivity is towards gas [15].T-max value normally increases with the increase in the maturation level of organic matter [16]. The high T-max value (462-545) in the studied shale samples indicates that the organic matters in them are over-matured. The low Hydrogen Index (0-40) indicates that oil potential of the studied shale samples is poor and the organic matter type in them is Type- IV [15]. Plotting of HI versus T-max values (Fig 7 and Fig 8) and S_2 versus TOC (Figs.9) shows that majority of the studied shale samples fall in the 'gas zone' [17] and Kerogen Type-III field [18].

Table4. Representative Rock-eval analysis data of studied sample collected from Deomali- Khonsa road section and a part of Tissa river section.

Sample ID	Oil (mg/g rock)	Gas(mg /g rock)	S2 (mg/g rock)	T max(0C)	TOC(%)	HI((mg/g TOC)
KS1	0	0	0	***	0.21	0
KS2	0	0	0.04	544	0.3	10
KS4	0	0	0	***	0.2	0
KS5	0	0	0.01	482	0.37	2
KS7	0	0	0	***	0.22	0
KS8	0	0	0	***	0.27	0
KS9	0	0	0	***	0.33	0
KS13	0.02	0	0.07	491	0.46	15
KS16	0	0	0	***	0.09	0
KS18	0	0	0	***	0.13	0
KS19	0	0	0	***	0.15	0
DS4	0.04	0	0.08	510	0.23	34
DS5	0.07	0	0.13	499	0.33	39
DS6	0.07	0	0.1	503	0.25	40
DS10	0.01	0	0.02	464	0.22	9
DS14	0	0	0.02	532	0.3	6
DS15	0.03	0	0.11	545	0.38	29
DS21	0	0	0.04	535	0.37	10
DS22	0	0	0.01	476	0.35	2
DS23	0	0	0	***	0.4	0
DS24	0	0	0.02	501	0.37	5
DS25	0	0	0.02	499	0.41	4

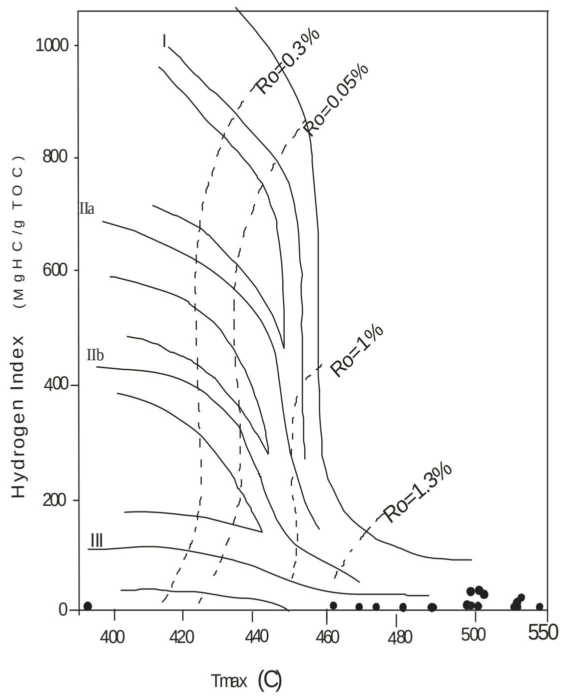

Fig7. Hydrocarbon Index Vs T-max diagram for the rocks of Disang shales under study (Field After Devaux et al 1990)

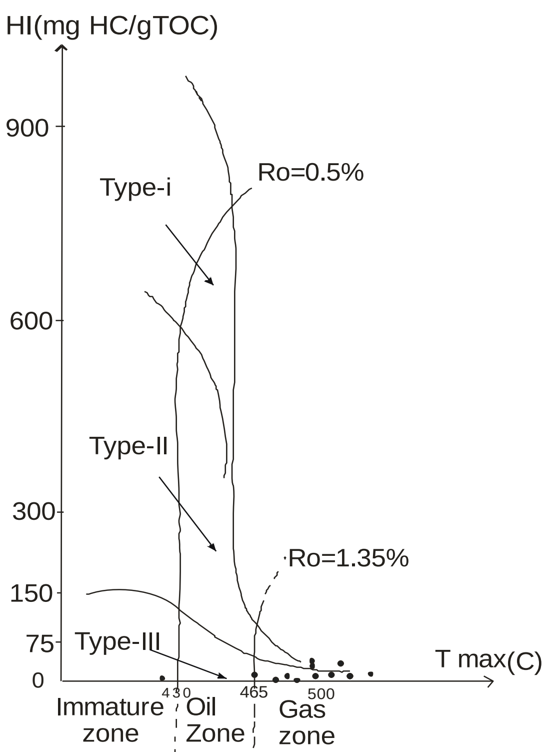

Fig8. Estimation of organic matter type and degree of maturation for the rocks of Disang shale (Espitalie et al 1985)

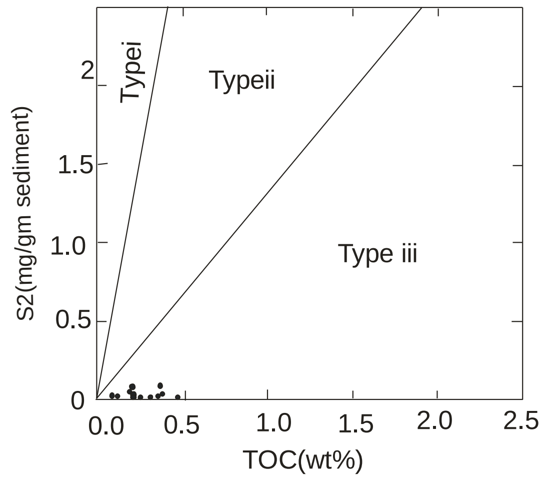

Fig9. Plot of S2 Vs Total organic carbon (TOC) for the selected samples of Disang Shale, fields are taken from Lengford and Blanc-Valleron (1990)

6 Conclusions

Geochemical study and the data reported indicate that shale of Disang Group deposited under the marine condition when tectonic setting was active continental margin to passive continental margin. Different plots adopted for provenance study suggest mafic source this indicate sediment contribution from the eastern ophiolite belt of the Indo-Burman Ranges, but felsic source for the studied samples cannot be cannot be ruled out. Regarding the hydrocarbon potential, source rating of studied shale of Disang Group in the study area is very poor, it only bears minor gas potential. From T-max values, it is found that organic matters present in the shale samples are over matured and they represent type Type-III and Type IV kerogen.

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