Study of the Pattern of Neogene Sedimentation in the Western Part of Siwalik Foredeep of Arunachal Pradesh (India)

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Abstract — *The Upper Tertiary rocks of Arunachal Pradesh are represented by Dafla, Subansiri and Kimin Formations. The Dafla Formation is characterized by bedding. The distinctness and the degree of preservation of bedding indicate quietness of water during sediment accumulation. The middle and upper part of this Formation consist of silty sandston containing coal streaks whereas the overlying Subansiri Formation shows poor development of the bedding character. Poor stratification is due to relatively higher velocity of transport and lack of opportunity for local sorting. This Formation mainly consists of medium to fine grained sediment with salt and pepper texture. The Kimin Formation is conglomeratic in nature and consists of sand and gravel deposits. This reflects increase in intensity of turbulance and velocity of current during its deposition.*

The study of size and shape parameters of Dafla and Subansiri sediments suggests that these sediments are medium to fine grained and deposited in fluviatile environment. The Mean size (Mz) of Dafla and Subansiri sandstones indicates a fine sand type deposited by moderate to low velocity current. Moreover the standard deviation (δ) values of both the sandstone suggest moderately sorted character of the sediments indicating same level of fluctuation in kinetic energy condition for the depositing agent. Positive skewness character is dominant in both Dafla and Subansiri Sandstones shows the presence of more material in the fine tail. Higher values of the average kurtosis (Kg) in Dafla and Subansiri sediments suggest that the major part of the sediments achieved good sorting elsewhere and deposited finally in an environment of low sorting efficiency.

Sphericity and roundness study of the grains of both the sandstones have shown high sphericity and moderate roundness suggesting a texturally submature character for these sediments. Further it reveals that the velocity of the current and the degree of turbulance in the depositing medium was moderate and the transportation of the sediment took place for a short distance from the source area before deposition.

From the sedimentological evidences deduced from field and laboratory investigations it could be inferred that sediment of both Dafla and Subansiri Formations were deposited under fluviatile condition by river during the Upper Tertiary period. The conglomeratic character of the Kimin Formation and gradual coarsening of the sediments upward, indicate shallowing up of the basin of deposition towards the later part of Upper Tertiary period.

Keywords — *Upper Tertiary, Kurtosis, Texturally submature, source area, Fluviatile.*

I. INTRODUCTION:

The area under investigation is situated between Bhalukpung of Sonit pur District of Assam on the south and Elephant of West Kameng District of Arunachal Pradesh on the north. The area falls between the longitude 92°33′ E and 92°40′E and latitude27°00′N and 27°07′ N and represents a very rugged terrain with steep dissected valleys .The Kameng River flows through the area and emerges into Assam plains. The foothill (Lesser Himalayas) region is marked by a thick belt of Tertiary Formation, which is succeeded by Gondwanas. (Fig 1 and Fig 2).

Ranga Rao and Babu (1974) on the basis of lithological characters divided the Upper Tertiary sediments into three units viz. Dafla, Subansiri and Kimin Formations in ascending order. These sediments were deposited in a foredeep known as Siwalik foredeep.Verma and Tandon (1976) considered the Upper Tertiary rocks of Kameng district as Siwalic Group on the basis of the lithological resemblance with the Middle Siwalik sediments of south western Himalayas and divided into three units – unit A, unit B and unit C. The unit A is characterized by a fine-grained, pale brown sandstone with salt and pepper appearance. Unit B is made up of medium grained calcareous sandstone with clast and the unit C is a medium grained sandstone and silt in association with coaly matter. Ramachandran and mallik (1976) reviewed the works on the geology of Kameng district and suggested that the broad geological framework is more or less similar in the Eastern Himalaya. However opinions differ amongst different workers about the stratigraphic position of the Siwalik beds in contact with Gondwana.

Karunakaran and Ranga Rao (1976) correlated the three stratigraphic units viz. Dafla Subansiri and Kimin with the Bokabil, Tipam and Dihing sediments of Upper Assam. These terminologies have been used by the ONGCL and the GSI in their recent publications (Sp. Pub. No.23. GSI, 1985). Dutta and Singh (1980) have divided these rock units into four divisions on the basis of palynological studies. Srinivasan (2003) studied the stratigraphy and structure of the siwaliks in

Arunachal Pradesh through remote sensing technique and he proposed a techtonostratigraphic model across the Siwalik Belt in Arunachal Pradesh.

In the present study, the nomenclature put forwarded by Ranga Rao and Babu (1974) has been used to avoid confusion regarding terminology put forwarded by different authors at different times for the Upper Tertiary rocks of Arunachal Pradesh.

II. STRATIGRAPHY:

The following stratigraphical succession has been observed in the area under discussion.

Time Unit		Stratigraphic Unit	Lithology
	Pliocene	Kimin Formation	Pebble-Cobble beds, with occasional red clays.
Upper Tertiary		Subansiri Formation	Fine to medium grained sand stone, Salt and pepper sandstone with occasional thin coaly layers and pebbles.
---------------------------------- Tippi Thrust ----------------------			
	Miocene	Dafla Formation	Brown to grey colored well bedded sandstone with grey shale bands.
——————————Main Boundary Thrust ——————			
	Permian	Bhareli Formation	Micaceous and coarse-Grained sand stone, siltstone, coal and carbonaceous shale.

To get an overall picture of the depositional environment of these sandstones an attempt has been made by considering the sedimentological evidences deduced from field and laboratory investigations. The sedimentologic properties represent changes of a sedimentary deposit both vertically and laterally, which help in deciphering the depositional environment.

III. FIELD OBSERVATION AND INTERPRETATION.

A. Dafla Formation

The Dafla Formation was named after the Dafla tribe of Arunachal Pradesh. This Formation forming the base of the Neogene sediments and exposed between about 1 km. north of Tippi and stretches upto the Main Boundary Fault about 74 km. stone on the Tezpur- Bomdila Road where they are thrust over by the Bhareli Formation (Gondwana). It consists of alternating sandstone, shale and clay.

The sandstones are hard as compared to the overlying Subansiri sandstones, brown to grey in colour, and well bedded, but towards north gray to dark gray sandstones alternating with shale bands are found. In the area between 73- 74 km stone of the Tezpur- Bomdila Road micaceous laminations are seen within the sandstone. Sporadic distributions of pebbles are found in Dafla Sandstone near the contact with Subansiri Formation. Because of presence of the Tippi thrust and the M. B.F. these rocks are highly disturbed and exhibit tectonic effect as a result of which the highly dipping well-bedded sediments are completely distorted. Highly dipping beds (20^o – 42^o) are seen toward north and northwest. Beds are almost vertical near the M.B.F.

In the field, the Dafla Formation is showing bedding, which are separated by thin mica partings and shale laminations. The deposition of mica with their flat surface parallel to bedding and their concentration in thin partings indicate transportation in suspension by currents. The distinctness and degree of preservation of parallel layering in the Dafla sandstone indicate quietness of the waters in which sediments were accumulated. Presence of alternation of fine sand and shale in Dafla sandstone near the contact of Subansiri sandstones suggest that sedimentation took place in a fluviatile environment under low to moderate energy conditions. Because such stratification is known from in the absence of bed load transport and by deposition from suspension.

The fine-grained silty sandstones in the middle and upper part of the Dafla Formation contain streaks of coal and carbonaceous matter here and there. This suggests stagnation of depositional area during the later phase of sedimentation of Dafla sediments, allowing accumulation of vegetal matter. Another feature that is observed in the Dafla sandstones is the presence of alternate layers of fine sand and silt. According to Bouma (1968) such layers are the result of longer period of constant rate of sedimentation. In the light of this observation it can be stated that towards the later part of Dafla period, the rate of sedimentation was uniform. This suggests uniformity in the prevailing energy conditions in the area of sedimentation. Moreover, the finer nature of the sediments and presence of coal streaks indicate a low energy condition and stagnation of depositional area.

The age of the Dafla Formation is Miocene, which is equated with the Bokabil Formation of Upper Assam.

B. Subansiri Formation

The Dafla Formation is conformably overlain by the Subansiri Formation and is exposed between Bhalukpung on the south to about 1 km. north of the Tippi thrust on the Tezpur- Bomdila road. This is named as Subansiri Formation by Ranga Rao and Babu (1972) possibly after the river Subansiri.

The Formation comprises medium to coarse grained, massive to poorly bedded, soft, micaceous sandstone and silty sandstone, generally brown to grey in colour showing salt and pepper texture (a characteristic shown by the Tipams of Upper Assam). On the north of Tippi river these sandstones contain thin coaly layer at Tippi. The dip of the beds varies between 30^o to 48^o towards north. The maximum dip being seen near the Tippi thrust.

In the field, the middle and upper part of Subansiri sandstone shows poor development of bedded character. Poor stratification is probably due to relatively high velocity of transport and lack of opportunity for local sorting. The middle and upper part of Subansiri sandstone mainly consists of medium to fine grained sediments with salt and pepper appreance. In the middle part of the Subansiri sandstone, clasts of different sizes are occasionally observed. Near Bhalukpung, the Subansiri sandstones are thick bedded, blocky and compact. In few places current beddings are also observed. All these characters suggest that current of high velocity transported the sediments of middle and upper part. Moreover, the presence of clast and medium grained character of the sandstone implies deposition by both traction and saltation. But the basal part of the Subansiri sandstone shows presence of appreciable amount of fine and medium grained sediments. This indicates that the initial stage of deposition of Subansiri sandstone is marked by suspension under low energy condition. The presence of coal streaks within the basal part of the Subansiri sandstone suggest that there was stagnation of the depositional area during the early phase of sedimentation of Subansiri sandstone allowing vegetal accumulation. The occasional occurrence of cross stratification in the middle part of Subansiri sandstone suggest shallowing of basin of deposition during middle Subansiri times. Allen (1966) was of the opinion that cross stratification in fluviatile sediment is generated by migrating dunes or large scale ripples within the sand body created during the process of migration or realignment of aggrading streams. But small-scale occurrence of this feature inhabits to draw any conclusion with certainity.

The age of the Subansiri Formation is regarded as Upper Miocene and is correlated with the Tipams of Upper Assam.

C. Kimin Formation

The Kimin Formation uncomformably overlies the Subansiri Formation. Ranga Rao and Babu (1974) have named these lithotype as Kimin Formation, perhaps after Kimin a place of Arunachal Pradesh. In the area reviewed this Formation is exposed in a very limited area (upto 2 kms north of Bhalukpung and at few places as patches on the east bank of the river Kameng). Pebbles and cobbles with occasional thin partings of clay are characteristics of this formation.

With the advent of Kimin time, the conditions in the basin of deposition were changed. This is indicated by the conglomeratic nature of this formation. The Kimin Formation consists of sand and gravel deposits. This characteristic reflects rough water environment and suggests further increase in the intensity of turbulance and velocity of the current in the basin of deposition during the Kimin period. The Kimin Formation therefore represents a unit of fluviatile origin. The increase in turbulance and velocity of current toward the upper Subansiri and Kimin times may be due to increase in gradient of numerous sediments carrying streams flowing down the mountains towards south because of rising of the mountain range of Himalayas lying on the north.

The age of the Kimin Formation is regarded as Pliocene and is correlated with the Dihing Group of Upper Assam.

IV. LABORATORY INVESTIGATION AND INTERPRETATION

A. Textural Parameters Size

Texture deals with the size, shape and arrangement of the component minerals of a rock (Pettijhon, 1984). A study of the textural parameters of the size and shape distribution of clastic sediments helps to understand the mechanism of transportation and deposition of clastic sediments. The study therefore is undertaken to know the textural attribution of the grains and to predict related depositional processes.

The textural parameters of grain size frequency distributions of Dafla and Subansiri Sandstones are computed graphically following formulae prepared by Folk and Ward (1957), (Table 1 and Table 2). In practice the different percentiles of cumulative curves are used in the formulae to calculate the graphic measures.

1. Graphic Mean Size (Mz): The following features of the Graphic Mean are observed in the Dafla and Subansiri Sandstones. The clustering of the Graphic Mean (Mz) values for the sands of Dafla sandstone is observed between 2.25ϕ and 2.55ϕ representing fine sand texture. The average Mean Size (Mz) for this sandstone is 2.37ϕ. In the Subansiri sandstones the Graphic Mean (Mz) varies between 1.60ϕ and 2.65ϕ and the average is 2.40ϕ, which indicate fine to very fine sand texture for the sandstone.

2. Inclusive Graphic Standard Deviation (δ_1): The Inclusive Graphic Standard Deviation (δ_1) of the sediments of Dafla sandstone ranges from 0.66 – 1.00ϕ and in Subansiri sandstone from 0.57 – 0.91ϕ. The values of Standard Deviation of Dafla Sandstone indicate that the sediments are moderately sorted while in the Subansiri sandstone the Standard Deviation values indicate moderately sorted to moderately well sorted character of the sediments. In both the sandstones no distinct pattern of variation in the sorting character is observed. However, the comparison of the individual Standard Deviation values of both the sandstones show that the Subansiri sandstones are slightly better sorted than the Dafla sandstones. Slightly better sorting character of the sediments of the Subansiri sandstone express in a general way that at the time of deposition of these sediments the effects of waves and current action were slightly more so as to bring a comparatively better sorting in them.

3. ***Inclusive Graphic Skewness (Ski):*** The Inclusive Graphic Skewness (Ski) values of Dafla sandstones are +ve and ranges between + 0.04 and + 0.34 which indicate that the sediments are near symmetrical to strongly fine skewed. In Subansiri sandstones the Inclusive Graphic Skewness (Ski) values vary

between – 0.25 and + 0.29 and the samples are mostly +vely skewed. This may be attributed to increasing velocity of the current during the deposition of Subansiri sandstones, which helped in sudden increase of coarser fraction material.

*4. **Graphic Kurtosis (Kg):*** The Kurtosis (Kg) values range between 1.16 and 1.60 in Dafla sandstones heance belongs to leptokurtic class. In Subansiri sandstones it varies between 0.55 and 1.92 and majority of the samples are found to be leptokurtic. However isolated samples of mesokurtic and platykurtic class are also present within the sediment. The Kurtosis (Kg) values in Dafla sandstones vary within a small limit but in the Subansiri sandstones the limit is wide. This may be due to the fluctuation in the energy conditions during the deposition of sediments.

5. Interpretation: The computed Mean size (Mz) of the Dafla and Subansiri sandstones are characterized by fine to very fine sand texture. It is found from the comparision of the average Mean size (Mz) and average median (Md) values of both the sandstones (average Mz and Md of Dafla and Subansiri sandstones are 2.37, 2.26 and 2.40, 2.29) that the difference between Mean and Median is small and nowhere found to be coinciding. This comparison of Mean and Median indicate non-normal grain size distribution of both Dafla and Subansiri sandstones (Pettijhon, Potter and Seiver, 1972). Moreover, the Mean size values of these sandstones indicate a moderate to low velocity of the depositing medium. Nearly indentical values of average Mean size in both these sandstones indicate that the velocity of the current with the depositing medium during the deposition of both the sandstones were same.

The Standerd Deviation values (δ_1) (ave δ_1 of Dafla and Subansiri sandstones are 0.84ϕ and 0.75ϕ) indicates that both the sandstones are moderately sorted and these sandstones were subjected to almost same level of fluctuation in the kinetic energy condition of the depositing agent and may therefore have been deposited in environments of identical nature. The Standard Deviation values (δ_1) of Dafla and Subansiri sandstones further suggest that these sandstones were deposited in fluvial environment (river).

Positively skewed nature of both Dafla and Subansiri sandstones indicate presence of more material in the fine tail during deposition a characteristic of river deposition. The difference in the variation of the skewness values of both these sandstones (variation is small in dafla sandstones and wide in Subansiri sandstones) may be attributed to the differences in the velocity fluctuation of the current to different limits at the time of deposition of these two sandstones.

Dominance of leptokurtic class in the samples of both Dafla and Subansiri sandstones indicate mixing of a predominant F.S. population with a very minor amount of coarser material (Mason and Folk, 1958). The average kurtosis values of Dafla and Subansiri (1.35 and 1.24) sandstones being greater than 0.65 are more peaked and are bimodal.

B. Shape

Sphericity and Roundness (shape) are important textural elements of clastic sediments of sand size. Sphericity largely reflects the condition of deposition during accumulation of sediment and to a limited extent is modified by abrasion processes. The roundness indicates maturity and abrasion history of sediments. Pettijhon, (1957) concluded that the shapes reflect degree and intensity of the processes of selective sorting and may be used to different depositional environment.

Samples from the Dafla and Subansiri Formations were selected for sphericity and roundness study. These were disaggregated and separated in size classes of quarter ϕ interval. From each size fraction, grains are mounted on glass slides for examination and projection under microscope with the help of camera lucida. In determining the sphericity the Riley's (1953) projection sphericity formula was adopted and roundness of the grains were determined following Wadell's (1935) Roundness Formula. For each size class the sphericity and roundness values were grouped into different spherical and roundness class with interval limits 0.05 and then frequency percentages were determined. From the frequency data the cumulative curves were constructed and the values of different percentiles of each curve were used to calculate the graphical parameters of Folk & Ward (1957) Table 3 & 4.

1. Interpretation: The sphericity and roundness frequency percentages for each size class of Dafla and Subansiri sandstone samples are given in Tables 3 & 4 respectively. The average sphericity value of different sieve fractions in each sample of Dafla Formation varies between 0.68 and 0.71 and in Subansiri Formation between 0.67 and 0.73. The sand grains of the Dafla and Subansiri Formations do not show any systematic variation in the sphericity with decrease or increase in size. In Dafla Formation the average roundness values of grains of different sieve fraction varies between 0.62 and 0.67 and Subansiri Formation between 0.64 and 0.70. Larger grains of both the sandstones show greater rounding than the smaller ones. The average roundness of the grains of the Dafla sandstones is less than the average roundness of the grains of Subansiri sandstones.

The values for different graphical parameters like mean (Mz), standard deviation (δ_1), inclusive graphic skewness (Ski) and graphic kurtosis (Kg) are given in Table – 3 (Sphericity) and 4 (Roundness). It is observed that in case of both sphericity and roundness the different graphical parameters calculated for different classes for both the formations show a close similarity.

The mean sphericity for different size classes lies between 0.63 & 0.71 in Dafla Formation and between 0.67 & 0.73 in Subansiri Formation. The standard deviation is between 0.05 and 0.06 in Dafla Formation and between 0.04 and 0.08 in Subansiri Formation. The skewness values vary between – 0.23 and + 0.12 in Dafla Formation and between – 0.47 and +0.14 in Subansiri Formation. Kurtosis varies between 1.15 and 1.32 in Dafla Formation and between 0.77 and 1.93 in Subansiri Formation.

The mean roundness for different size classes lies between 0.62 and 0.67 in Dafla Formation and between 0.64 and 0.70 in Subansiri Formation. The standard deviation is between 0.05 and 0.08 in Dafla formation and between 0.03 and 0.08 in Subansiri Formation. The skewness values vary between – 0.26 and - 0.03 in Dafla Formation and between – 0.61 and + 0.17 in Subansiri formation. Symmertical curves have Ski value 0.00. These with excess of fine material are positively skewed, while negative Ski is shown with excess of coarse material. The more Ski value departs from 0.00, the greater is the degree of asymmetry. Kurtosis varies between 1.32 and 1.70 in Dafla Formation and between 1.03 and 1.89 in Subansiri Formation.

C. *Conclusion*

Synthesis of evidences offered by field characters of Dafla, Subansiri and Kimin Formations has shown that these sandstones were deposited in a basin characterized by fluviatile conditions. The depositional conditions were fluctuated and the depositional surface was subjected to change of depth with time.

The size textural parameters of the samples of both the Dafla and Subansiri sandstones indicate that these sandstones are medium to fine grained, moderately sorted, bimodal, fine skewed and leptokurtic suggesting fluviatile environment of deposition

The low values of standard deviation, sphericity and roundness for both formations suggest good sorting. The Skewness values exhibit near symmetrical distribution. The kurtosis values indicate mesokurtic to leptokurtic distribution for sphericity and roundness of both the formations.

High sphericity values of the grains indicate that the velocity of current and degree of turbulence at the time of deposition were moderately high. No definite relationship is observed between sphericity and roundness of the sand grains. Subangular and subrounded charater of sand grains indicates textural immaturity.

Increase in percentage of subangular sand grains in Dafla Formation indicate that the sediments were either transported for a short period or passed through not more than one cycle of transportation. However, according to Russel and Taylor (1937) sometimes progressive fracturing accompanying abrasion may cause a decrease in roundness i.e. increase in angularity.

From the study of the overall characteristics of these sandstones it can be inferred that identical processes of deposition in a fluviatile environment deposited these sandstones. The basin of deposition was dominated by low to moderate turbulance and current activity during the period of deposition of Dafla sandstone. But toward the middle and later part of period of deposition of Subansiri sandstone, the intensity of current activity and turbulance increased and reached their peak during the deposition of Kimin Formation.

D. *Figures and Tables*

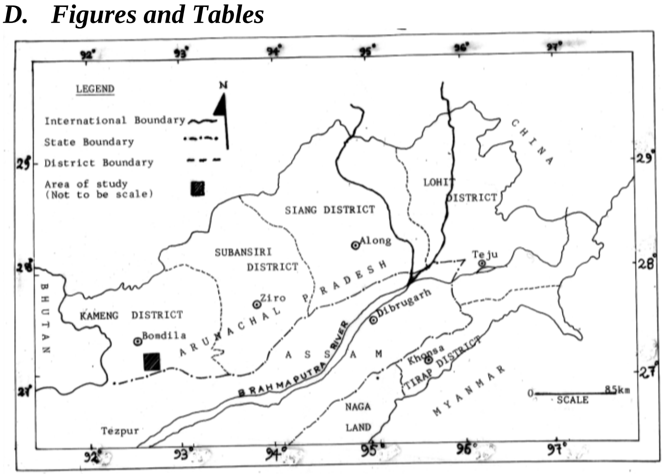

Fig 1 Location Map of the Study Area

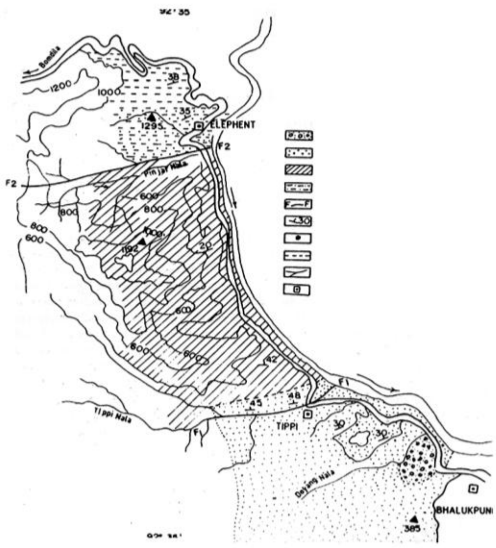

Fig 2 Geological Map of the Area around Tippi.

Table – 1
Graphic Size Parameters of Dafla Sandstones

Sample No.	Median Md	Value of				Class of			
		Graphic Mean size M_z	Incl. Graphic Standard Deviation δ_1	Incl. Graphic Skew ness Sk_i	Graphic Kurtosis K_g	Grain size	Standard Deviation	Skewness	Kurtosis
D1	2.25	2.31	0.84	0.11	1.46	F.S.	M.S.	FSR	L
D2	2.25	2.31	0.81	0.09	1.32	F.S.	M.S.	N.S.	L
D3	2.25	2.31	0.83	0.09	1.42	F.S.	M.S.	N.S.	L
D4	2.25	2.38	0.92	0.19	0.40	F.S.	M.S.	F.Sk	L
D5	2.25	2.55	1.00	0.29	1.36	F.S.	M.S.	F.Sk	L
D6	2.25	2.55	0.68	0.18	1.36	F.S.	M.S.	F.Sk	L
D7	2.25	2.37	0.68	0.18	1.31	F.S.	M.W.S	F.Sk	L
D8	2.25	2.40	0.74	0.23	1.38	F.S.	M.S.	F.Sk	L
D9	2.25	2.38	0.87	0.14	1.25	F.S.	M.S.	F.Sk	L
D10	2.25	2.37	0.84	0.12	1.30	F.S.	M.S.	F.Sk	L
D11	2.30	2.35	0.82	0.04	1.23	F.S.	M.S.	N.S.	L
D12	2.25	2.35	0.89	0.11	1.19	F.S.	M.S.	F.Sk	L
D13	2.35	2.42	0.78	0.25	1.42	F.S.	M.S.	F.Sk	L
D14	2.25	2.35	0.66	0.15	1.16	F.S.	M.W.S	F.Sk	L
D15	2.30	2.36	0.84	0.08	1.54	F.S.	M.S.	F.Sk	L
D16	2.30	2.50	1.10	0.34	1.60	F.S.	P.S.	F.Sk	L
D17	2.25	2.33	0.88	0.11	1.27	F.S.	M.S.	F.Sk	L
D18	2.25	2.26	0.80	0.06	1.37	F.S.	M.S.	F.Sk	L
D19	2.20	2.25	0.85	0.07	1.32	F.S.	M.S.	F.Sk	L
D20	2.25	2.30	0.84	0.10	1.37	F.S.	M.S.	F.Sk	L
Ava rage	2.26	2.37	0.84	0.15	1.35				

Table – 2

Grain size parameters of Subansiri Sandstone.

Sample No.	Median Md	Value of				Class of			
		Graphic Mean size M_z	Incl. Graphic Standard Deviation δ_1	Incl. Graphic Skewness Sk_i	Graphic Kurtosis K_g	Grain size	Standard Deviation	Skewness	Kurtosis
S_1	2.40	2.48	0.65	0.15	1.18	F.S	M.W.S	F.Sk	L.
S_2	2.15	2.18	0.72	0.11	1.76	F.S	M.S.	F.Sk	VL
S_3	1.90	1.60	0.82	-0.25	1.00	MS	M.S.	C.Sk	M.
S_4	2.25	2.65	0.57	0.25	0.55	F.S	M.W.S	F.Sk	PK
S_5	2.25	2.35	0.70	0.18	1.40	F.S	M.W.S	F.Sk	L.
S_6	2.35	2.50	0.64	0.24	1.20	F.S	M.W.S	F.Sk	L.
S_7	2.15	2.21	0.74	0.14	1.80	F.S	M.S.	F.Sk	VL
S8	2.25	2.05	0.82	-0.25	1.15	F.S	M.S.	C.Sk	L.
S9	2.25	2.30	0.79	0.06	1.37	F.S	M.S.	M.S	L.
S10	2.25	2.38	0.71	0.22	1.41	F.S	M.S.	F.Sk	L.
S11	2.35	2.48	0.66	0.24	1.09	F.S	M.W.S	F.Sk	M.
S12	2.40	2.55	0.84	0.22	1.92	F.S	M.S.	F.Sk	VL
S13	2.40	2.45	0.72	0.06	1.52	F.S	M.S.	N.S.	VL
S14	2.35	2.51	0.83	0.21	1.27	F.S	M.S.	F.Sk	L.
S15	2.15	2.20	0.72	0.08	1.36	F.S	M.S.	N.S.	L.
S16	2.35	2.53	0.81	0.23	1.25	F.S	M.S.	F.Sk	L.
S17	2.30	2.50	0.81	0.26	1.40	F.S	M.S.	F.Sk	L.
S18	2.35	2.48	0.66	0.24	1.23	F.S	M.W.S	F.Sk	L.
S19	2.40	2.50	0.68	0.19	1.13	F.S	M.W.S	F.Sk	L.
S20	2.20	2.36	0.73	0.29	1.46	F.S	M.S.	F.Sk	L.
S21	2.40	2.49	0.94	0.12	1.30	F.S	M.S.	F.Sk	L.
S22	2.30	2.40	0.88	0.08	1.43	F.S	M.S.	N.S.	L.
S23	2.25	2.30	0.91	0.03	0.89	F.S	M.S.	N.S.	P.K
S24	2.40	2.50	0.81	0.12	1.32	F.S	M.S.	F.Sk	L.
S25	2.30	2.50	0.84	0.08	1.40	F.S	M.S.	N.S.	L.
S26	2.30	2.40	0.80	0.09	1.33	F.S	M.S.	N.S.	L.
S27	2.15	2.45	0.69	0.24	1.28	F.S	M.W.S	F.Sk	L.
S28	2.15	2.33	0.75	0.27	1.23	F.S	M.S.	F.Sk	L.
S29	2.40	2.53	0.66	0.25	1.16	F.S	M.W.S	F.Sk	L.
S30	2.30	2.37	0.62	0.12	1.42	F.S	M.W.S	F.Sk	L.
Ava rage	2.29	2.38	0.75	0.14	1.31	F.S			

Table – 3
Graphic Shape Parameters (Sphericity) of Subansiri and Dafla Formation

Sample No.	Class interval (in ϕ)	Mean (Mz)	Standard Deviation (δ_1)	Skewness (Sk_i)	Kurtosis (K_g)
S1	0.75-1.0	0.59	0.02	0.17	1.0
	1.25-1.50	0.70	0.05	0.22	0.76
	1.75-2.0	0.65	0.05	0	0.92
	2.25-2.52	0.69	0.06	-0.17	1.0
S5	0.75-1.0	0.60	0.03	-0.1	1.00
	1.25-1.50	0.65	0.06	-0.19	1.18
	1.75-2.0	0.65	0.05	0.33	1.0
	2.25-2.52	0.74	0.04	0.34	1.43
S15	0.75-1.0	0.65	0.05	0.35	1.71
	1.25-1.50	0.75	0.03	0.33	1.59
	1.75-2.0	0.64	0.03	-0.36	1.46
	2.25-2.52	0.76	0.06	0.25	1.52
S20	0.75-1.0	0.54	0.05	-0.22	1.29
	1.25-1.50	0.73	0.07	-0.23	1.10
	1.75-2.0	0.62	0.07	0.17	1.15
	2.25-2.52	0.65	0.06	0.15	1.25
D1	0.75-1.0	0.57	0.06	-0.42	1.20
	1.25-1.50	0.74	0.06	0.23	1.0
	1.75-2.0	0.69	0.06	-0.31	2.1
	2.25-2.52	0.65	0.07	-0.22	1.41
D5	0.75-1.0	0.56	0.04	-0.13	1.35
	1.25-1.50	0.72	0.04	-0.11	1.76
	1.75-2.0	0.68	0.06	0.23	1.65
	2.25-2.52	0.64	0.06	0.25	1.10
D10	0.75-1.0	0.54	0.04	-0.28	1.30
	1.25-1.50	0.78	0.04	0.30	1.68
	1.75-2.0	0.67	0.05	0.31	1.10
	2.25-2.52	0.69	0.08	-0.27	1.13

Table –4
Graphic Shape Parameters (Roundness) of Subansiri and Dafla Formation

Sample No.	Class interval (in ϕ)	Mean (Mz)	Standard Deviation (δ_1)	Skewness (Sk_i)	Kurtosis (K_g)
S1	0.75-1.0	0.60	0.02	-0.06	1.40
	1.25-1.50	0.69	0.05	0.24	0.82
	1.75-2.0	0.66	0.06	0.19	1.06
	2.25-2.52	0.69	0.06	0.08	0.85
S5	0.75-1.0	0.62	0.05	0.21	1.20
	1.25-1.50	0.71	0.05	-0.11	1.31
	1.75-2.0	0.68	0.04	0.09	1.30
	2.25-2.52	0.69	0.06	0.10	1.25
S15	0.75-1.0	0.60	0.05	-0.26	0.99
	1.25-1.50	0.72	0.03	-0.22	1.21
	1.75-2.0	0.68	0.04	0.21	1.32
	2.25-2.52	0.74	0.04	0.17	1.41
S20	0.75-1.0	0.56	0.11	-0.78	1.54
	1.25-1.50	0.72	0.09	1.12	1.59
	1.75-2.0	0.65	0.05	-0.22	1.70
	2.25-2.52	0.70	0.05	-0.24	1.51
D1	0.75-1.0	0.57	0.05	-0.42	1.50
	1.25-1.50	0.74	0.05	0.14	1.13
	1.75-2.0	0.69	0.06	-0.35	1.64
	2.25-2.52	0.65	0.06	-0.31	1.29
D5	0.75-1.0	0.50	0.04	-0.27	1.53
	1.25-1.50	0.72	0.06	0.25	1.52
	1.75-2.0	0.61	0.06	0.14	1.62
	2.25-2.52	0.63	0.07	-0.25	1.73
D10	0.75-1.0	0.59	0.07	-0.20	1.65
	1.25-1.50	0.79	0.05	-0.25	1.73
	1.75-2.0	0.63	0.05	0.23	1.85
	2.25-2.52	0.65	0.05	-0.22	1.55

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