Journal of Advances and Scholarly Researches in Allied Education
Vol. XV, Issue No. 1, April-2018, ISSN 2230-7540

Palynofacies Analysis of Subathu Sediments of Dogadda Area, Pauri-Garhwal District, Uttarakhand: Implications for Depositional Environment

Rashmi Panwar[1]* O. P. Thakur[2]

[1,2] Kurukshetra University, Kurukshetra, Haryana, India

Abstract – Palynofacies analysis has been carried out on samples collected from Subathu Formation exposed along Umreila-Aeta road near Aeta village, Dogadda, Pauri- Garhwal District, Uttarakhand, India. Palynofacies analysis shows overall dominance of Grey amorphous organic matter followed by Fungal debris, Opaque phytoclasts, Cuticles, Spores/Pollen and Resin. The present lithological investigated section is made up of alternate layers of Purple and Green shales. The frequency variation pattern of dispersed organic matter and lithology indicates fluctuations from Fluvial to Shallow open marine environment for the deposition of the Subathu Formation in the area.

Keywords: Subathu Formation, Palynofacies, Dogadda, Depositional Environment.

----------X----------

INTRODUCTION

During the past few years there has been an upsurge of interest in the field of palynofacies study and its implications to aid the interpretation of depositional environment, organic maturation studies and hydrocarbon source rock potential in sedimentary terrain at global level. These studies are used by several institutions and oil companies for documentation of organic facies patterns. Palynofacies is described as: "a body of sediment containing a distinctive assemblage of dispersed organic matter thought to reflect a specific set of environmental conditions or to be associated with a characteristic range of hydrocarbon-generating potential"

The term palynofacies was introduced by Combaz in 1984. Since then many terminologies have been used by different researchers viz., "Organic matter" used by Gehmann and Lorente in 1962 and 1991, "Palynodebris" by Alpern in 1970, Boulter in 1994. and "Kerogen" used by Tyson in 1995, Filho *et. al.*, 2002, and Carvalho et.al., 2002. Many workers have given various classifications of sedimentary organic matter (Staplin 1969, Correia 1971, Burgess 1974, Bujak *et. al.* 1977, Combaz 1980, Claret 1981, Pocock 1982 and Pocock *et al.* 1988). However, classification adopted for the present study is of Tyson 1995, that provides detailed information regarding classification of thermally immature to mature palynofacies material for palaeoenvironmental studies. A detailed study of literature reveals that the published palynofacies documentation from the study area is almost negligible. The present palynofacies study will eventually help in understanding the depositional environment during Palaeogene time in the region and will provide important clues regarding depositional environment.

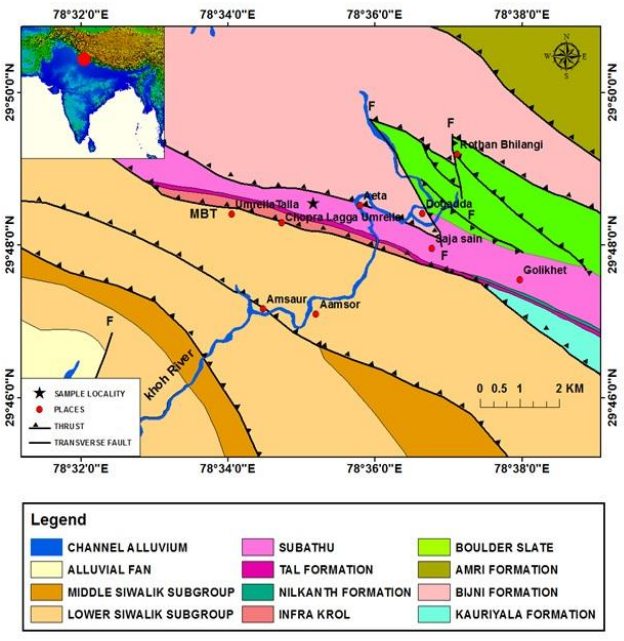

Figure 1. Geological map of Dogadda area, District Pauri Garhwal, Uttarakhand showing sampled locality.

GEOLOGICAL SETTING:

Tectonically, Subathu Formation has thrusted contact with the crystalline rocks of Bijni tectonic unit to the northwest (Shanker and Ganeshan 1973) and to the south, it is delimited by Krol Thrust. Lithologically, the entire Subathu succession of the area is comprised of splintery carbonaceous shale, ooidal ironstone, grey, red and green shales, limestone and sandstone.

The basal part of Subathu Formation is comprised of dark grey, non-calcareous & poorly consolidated carbonaceous shale with coaly bands & ooidal iron stone. The berthierine rich ooidal iron stone has sharp lower contact with sediments of Kakara Formation. The ooidal iron stone is overlain by the grey shale, siltstone with minor bands of green & red shales with packstone containing foraminiferas. The top most part of the succession is comprised of thick sandstone. The stratigraphy of the present area is given in Table no.1

Table 1. The Tectonic succession in the study area, Dogadda, Garhwal Himalaya.

FORMATION	LITHOLOGY	AGE
Amri	Schistose phyllites with granite	Lower Palaeozoic to Precambrian?
..... Amri Thrust		
Lower Bijni	Quartzites, boulder slate, gritty quartzites and sandy limestones	Permian to Late Carboniferous
..... Garhwal Thrust		
Subathu	Intercalated bands of grey, green and purple shales, grey sandstones, and lenses of limestones and brownish shell marls	Early Eocene to Upper Palaeocene
Tal	Interbedded greenish, reddish shales and compact sandy limestones becoming oolitic and shelly near top	Early Palaeocene to Cretaceous
Krol	Dolomitic grey limestones and grey, green and red shales	Cretaceous? Jurrasic to Early Paleozoic
..... Krol Thrust		
Siwalik Group	Compact micaceous sandstones and interbedded greenish and reddish shales	Pliocene to Middle miocene

METHODOLOGY

The present investigations for palynofacies study have been carried out on 11 representative samples collected from 20 meter thick lithosection (fig.2) of Subathu Formation at the Aeta-Umreila village road located on the left bank of river Khoh in Dogadda, Pauri Garhwal Dist., Uttarakhand, India. Out of 11, only 10 samples were found productive for the palynofacies study. Standard maceration technique was used for the recovery of sedimentary organic matter. For slide preparation of organic matter, about 5 to 10 gram of each sample was taken and crushed to peanuts size. these peanuts size samples were then treated with hydrochloric acid for about 24 hrs for the digestion of carbonates. After thorough washing, the sieved residue was further treated with hydrofluoric acid for 48 hrs for the removal of silica. Finally the residue was sieved using 40 ASTM mesh size sieve for the removal of remaining clay particles. The residue was then mounted on glass slide using polyvinyl alcohol and Canada balsam. Thereafter permanent slides were prepared and used for the counting of organic matter particle under transmitted mode using Olympus light microscope for calculation of percentage of each type. These percentage count were used fot the preparation of frequency variation diagram given in fig.2 based on classification of sedimentary organic matter given by Tyson in 1995.

RESULTS:

Characteristics of sedimentary organic matter:

In the present study, the palynofacies components are classified based on the classification of sedimentary organic matter given by Tyson in 1995. He has classified dispersed organic matter into two major categories, ie, structureless and structured organic matter.

Structureless organic matter:

Structureless organic matter may contain organic matter that lacks a distinct outline or fails to infer any botanical affinity while observing under the light microscope. This matter includes amorphous organic matter, resin and humid gel. In the present study, we observed amorphous organic matter and resin category of structureless organic matter.

Table 2. Classification of partiulate Organic Matter (after Tyson 1995) .

	CATEGORY	SOURCE	CONSTITUENT
STRUCTURED	Phytoclasts	Macrophyte plant Debris	Cuticle
			Cortex Tissue
			wood
			Opaque Semi-opaque
		Fungal Debris	Hyphae
	Zooclasts	Zooplankton and Zoobenthos	Graptolite debris
			Arthopod debris
	Palynomorphs	Sporomorphs	Miospore: microspore pollen
			Macrospores
		Organic -walled Phytoplankton (including meroplankton)	Chlorococcales Algae
			Dinocysts
			Acritarchs
			Prasinophyte
		Zoomorphs	Foraminiferal Test- Linings
			Scolecodonts
			Chitinozoa
STRUCTURELESS	Amorphous Organic Matter	Amorphous Organic Matter	Grey Amorphous Organic Matter
			Yellow Amorphous Organic Matter
		Resin	
		Humic gel	

Amorphous organic matter:

It consists of all particulate organic components that appear structureless while observed under light microscope. It may be phytoplankton or bacterially derived. It varies from yellow to grey coloured material and identified as grey amorphous organic matter or yellow amorphous organic matter. In the present study grey amorphous organic matter (41-84%) is found in abundance while yellow amorphous organic matter (1-3%) is scarce. Such type of organic matter is derived from phytoplankton, bacterial degradation or by degradation of fresh water algae gathered in oxygen exhausted while yellow amorphous organic matter is derived by microbial digestion on terrestrial fragments. The frequency of Amophous organic matter in the present section is quite high 41-84%.

Resin:

Resin, earlier know as Amber is defined as highly resistant; yellow, red and orange coloured structureless material derived from coniferous gymnosperms and angiosperm trees. The present study contains low frequency of Resin i.e 0-1%. The resin found is of orange colour and is of smaller size with rounded shape which indicates longer duration of transportation.

Structured organic matter:

Structured organic matter may be defined as individuals that have definite or recognizable entities or plant & animal fragments that can infer their affinities. This category includes phytoclasts and palynomorphs.

***Phytoclasts*:**

Phyloclasts are derived from the land plants. They may be opaque or show some internal structures.

Opaque phytoclast:

Opaque phytoclast is subjected to the phytoclast and that have undergone sufficient alternation or maturation to become opaque when observed under the transmitted light. It may be equant, lath or corroded. The present study shows low frequency of opaque phytoclasts. The frequency of Opaque ranging from 2-13% in the present section.

Cuticle:

Cuticle is subjected to the outermost part of the epidermal layer of leaves of higher plants. Good percentage of cuticles indicates lower energy, onshore fluvio-deltaic and lacustrine palaeo environment. Cuticle is present in minute quantity i.e. 1-5% throughout the section which indicates probability of the deposition in near terrestrial source.

Fungal Debris:

Fungal Debris may be described as fragments of hyphae, filaments of mycelium of higher fungi. Although, it has little or no potential for hydrocarbon generation but is useful for the palaeoenvironmental interpretation. The present study reveals sub-dominance of fungal hyphae which indicates oxygenated environment during deposition. The frequency of the fungal hyphae in the present section is 15-45%.

Palynomorph:

According the Tyson 1995, palynormorph are represented by terrestrial pollen and spores, marine phytoplanktons (Dynoflagellates, Acritarchs, Prasinophytes and Chlorococcalean algae) and zooplanktons (Microforaminiferal linings, Scolecodonts and Chitinozoans).

Spore and Pollen:

Spores and Pollen are the reproductive structures that are produced sexually or asexually by Cryptogams while pollen are produced by vesicular, non-flowering gymnospermous plants. In the present study, minute quantity i.e 1-4% of pollen and spores are present which infers terrestrial influence during their deposition.

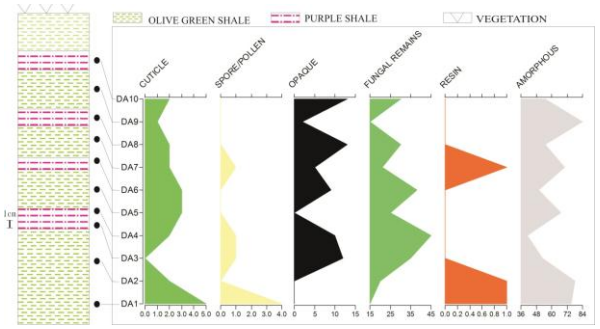

Figure 2. Quantitative representation of various types of sedimentary organic matter in the Stratigraphic section of Subathu Formation at Umreila-Aeta road section, Dogadda, Uttarakhand.

DISCUSSIONS:

The overall dominance of different types of organic matter in the Umreila-Aeta section is:

Grey amorphous organic matter> Fungal Debris> Opaque phytoclasts> Cuticle> Spore/Pollen> Resin. The frequency pattern of dispersed organic matter reveals variation in the distribution in accordance with the alternate lithology of purple and grey shales present in the area. The palynofacies data from Purple shales show dominance of Fungal Debris followed by Grey amorphous organic matter and Opaque phytoclasts. Dominance of fungal remains suggests low salinity due to the close proximity to the active fluvio-deltaic source. Presence of Opaque phytoclasts depicts oxygenated environment during deposition of sediments. The palynofacies studies from the Green olive shale reveals dominance of Grey amorphous organic matter. Some amount of Fungal debris is also present. Presence of Cuticle and Spore/Pollen alongwith Resin is very scarce. Dominant amount of Grey amorphous organic matter in the section represents deposition in low energy, oxygen deficient environment. Fungal Debris is found in fluvial-deltaic high energy environment. Presence of Cuticle and Spore/pollen infers the proximity of the depositional site to the terrestrial input source. Presence of dark colored Resin indicates higher maturation or distant deposition. The alternation of lithology in the present section containing purple and green shales indicates

occurrence of fluctuation in the sea, red facies is derivatives of red parent rock of warm humid uplands in oxidizing continental environment while green shale is deposited in reducing environment (Raiverman, 1964). The red and green shale is stacked close together in alternation is probable green shale to be deposited in quiet environment over which flooded streams deposited the enormous amount of ferruginous material (Bhandari and Agarwal,1967) So, it indicates Fluvial- shallow open marine environment.

CONCLUSION:

1. Based on the palynofacies data recovered from the studied section using classification of sedimentary organic matter by Tyson1995; the pattern of dominance of dispersed organic matter is as follows: Grey amorphous organic matter> Fungal Debris> Opaque phytoclasts> Cuticle> Spore/Pollen> Resin.

2. The present section shows fluctuating depositional environment based on the variation in the palynofacies distribution pattern is inferred which is also in accordance with the lithology present in the section. The palynofacies frequency shows Purple shales having been deposited in oxidizing environment while Green shale deposited in reducing environment. Thus, the study reveals presence of Fluvial-Shallow open marine environment for the deposition of Subathu Formation in the area.

REFERENCES:

Alpern, B. (1970) Classification petrographique des constituants organiques fossiles des roches sedimentaires. *Revue de l'Institut Franrais du Petrole,* 25, pp. 1233-66.

Batten, D.J. (1981). Palynofacies, organic maturation and source potential for petroleum. In:

Organic Maturation Studies and Fossil Fuel Exploration Brooks, J. (Ed.), Academic Press, London, pp. 201-224.

Bhandari, L.L and Agarwal, G.C. (1967). Eocene (Subathu) of the Himalayan foothills of north india. *Pub. Cent. Adv. Stud. Geol. Punjab. Univ. Chandigarh*, 1, pp. 57-78.

Boulter, M.C. (1994). An approach to a standard terminology for palynodebris, in Sedimentation of Organic Particles, edited by Travers, A., Cambridge, Cambridge University Press, pp. 199-216.

Bujak, J.P. et. al. (1977). Offshore east Canada's organic type and color and hydrocarbon potential. *The Oil and Gas Journal,* 75, pp. 198—201.

Burgess, J.D. (1974) Microscopic examination of kerogen (dispersed organic matter) in petroleum exploration. *Geological Society of America Special Paper,* 153, pp. 19-30.

Gehman, H.M. (1962). Organic matter in limestones. *Geochimica et Cosmochimica Acta,* 26, pp. 885-97.

Carvalho, M.A., Mendonça Filho, J.G., Menezes, T.R. (2002). Palynofacies analysis of the upper Aptian–Albian succession of the Sergipe Basin, Brazil. Boletim do 6° Simpósio sobre o Cretáceo do Brasil, São Pedro-SP, pp. 209–214

Carvalho, M.A. et. al. (2002). Palynofacies analysis of upper Aptian-Albian succession of the Sergipe basin, Brazil, 2099-214.

Claret, J. et. al. (1981). La diversite des roches meres petrolieres: aspects geologiques et implications economiques a partir de quatre exemples. *Bulletin des Centres Recherche Exploration-Production Elf-Aquitaine,* 5, pp. 383-417.

Combaz, A. (1980). Les kerogenes vus au microscope, in *Kerogen: Insoluble Organic Matter From Sedimentary Rocks* (ed. B. Durand), Editions Technip, Paris, pp. 55-111.

Correia, M. (1971). Diagenesis of sporopollenin and other comparable organic substances: application to hydrocarbon research, in *Sporopollenin,* (eds J. Brooks, P. Grant, M.D. Muir, G. Shaw and P. Van Gijzel), Academic Press, London, pp. 569-620.

Lorente, M.A. (1991). Open workshop on organic matter classification, Amsterdam. Hugo de Vries Laboratory, pp. 73.

Mendonça,F. et. al. (2002). Palinofácies. In: *Técnicas e Procedimentos para o Trabalho com Fósseis e Formas Modernas Comparativas*, Dutra, T.L. (Ed.), Unisinos, São Leopoldo, pp. 20-24.

Pocock, S.A.J. (1982). Identification and recording of particulate sedimentary organic matter, in *How to Assess Maturation and Paleotemperatures* (eds D.J. Staplin, W.G. Dow, C.W.O. Milner, D.I. O'Connor, S.A.J. Pocock, P. Van Gijzel, D.H. Welte and M.A. Yukler), *Society of Economic Paleontologists and Mineralogists, Short Course,* 7, pp. 13-131.

Pocock, S.A.J. et. al. (1988). Introduction to the study of particulate organic materials and

ecological perspectives. *Journal of Palynology,* 23-24 (1987-1988), pp. 167-88.

Raiverman, V. (1964). Clay sedimentation in Subathu-Dharamshala Group of rocks in the foothills of nothwestern Himalayas, *Bull. O.N.G.C.*, 1, pp. 27-37.

Shanker, R. and Ganeshan, T. M., (1973). A note on the Garhwal Nappe. *Him. Geol.,* 3, pp. 72-2.

Staplin, F.L. (1969). Sedimentary organic matter, organic metamorphism and oil and gas occurence. *Bulletin of Canadian Petroleum Geology*, 17: pp. 47-66.

Tyson, R.V. (1993). Palynofacies analysis In: *Applied Micropaleontology*, Jenkins, D.G. (Ed.), Kluwer Academic Publishers. The Netherlands, Amsterdam, pp. 153–191.

Tyson, R.V. (1995). Sedimentary Organic Matter. Organic facies and palynofacies. *Chapman and Hall, Londons*, pp. 615.

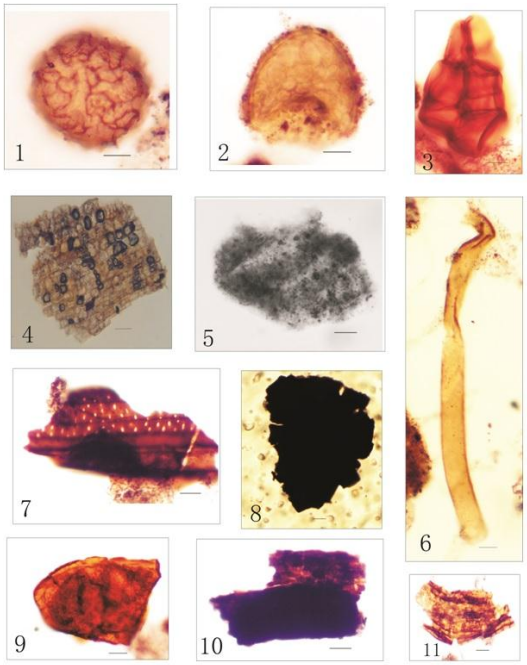

Plate 1. (1,2,3) Spore/Pollen 4) Cuticle 5) Grey amorphous 6) Fungal Hypha 7) Wood 8) Opaque phytoclasts 9) Resin 10,11) Semi-opaque phytoclasts.

Corresponding Author

Rashmi Panwar*

Kurukshetra University, Kurukshetra, Haryana, India

rashmipanwar2009@gmail.com