Palynology and palynofacies of Recent marine sediments of the western flank of the Andaman Islands, Bay of Bengal

Arun Kumar

Department of Earth Sciences, Carleton University, Ottawa, Ontario, Canada KIS 5B6

Kumar, A. 1996. Palynology and palynofacies of Recent marine sediments of the western flank of the Andaman Island, Bay of Bengal. *Geophytology* **26(1)**:119-123.

Fifteen samples of Recent carbonate sands, silt and clays deposited at the bottom of the western flank of the Andaman Islands in Bay of Bengal have been studied with the objective to characterise the type, amount and source of organic matter. The total organic matter (TOM) ranges from 5-10 percent in most of the sediments. However, in few of the sediment samples TOM is as low as 1 percent and in few others as high as 15 percent. Mostly the organic matter is of autochthonous origin and derived from predominantly algal sources. These sediments contain a large number of both allochthonous and autochthonous palynomorphs and other microscopic remains of marine life like annelid jaws, foraminifera, silicoflagellates and diatoms. Such sediments would eventually produce sapropelic kerogen and would be oil prone in a favourable geothermal regime.

Key-words—Palynology, Marine sediments, Andaman Islands.

INTRODUCTION

THE organic matter in marine sediments is supplied by both allochthonous and autuochthonous sources. Muller's (1959) work on the palynology of the Orinieo delta and shelf sediments was a pioneering work on marine palynology. Since then Holocene and Recent sediments of various environments have been studied all over the world (Hooghiemstra 1986, 1988 a, b, 1989; Edwards 1992; Matsuoka 1992; Mudie 1992). Several papers defining the principles, objectives and methods for studying Recent palynomorphs and palynofacies appeared in the volume 4 of *Marine Geology* in 1966.

Williams (1971 a,b) published on the physical and chemical condition responsible for the distribution of dinoflagellate cysts in the Recent marine sediments. Hooghiemstra *et al.* (1986) and Hooghiemstra (1989) have published on the palynological study of Recent marine sediments of West African coastal areas and adjacent Atlantic ocean. The major emphasis of these studies have been to understand the relationship between modern pollen source areas, their transport mechanism to the site of deposition and distribution pattern in the marine sediments. Their studies have used palynological data of Pleistocene-Holocene marine sediments to demonstrate a relationship between the vegetation zones, seasonal wind pattern and atmospheric circulation to the pollen distribution in various marine enviornments (Hooghiemstra & Agwu 1986; Dupont & Hooghiemstra 1989). Van Waveren (1992) and Edwards and Andrle (1992) provide useful reviews on various factors responsible for the distribution of dinoflagellate cysts and copepod eggs in the marine sediments. Palynological studies of Recent marine sediments from Indian subcontinent are few, example are Ratan and Chandra (1983, 1984) and Saxena *et al.* (1982) covering parts of the Gulf of Kutch and the Arabian Sea.

The significance of such studies are manifold. Primarily they help to define the different physical, chemical and biological processes which are relevant for the distribution of organic matter in sediments accumulated in different environments. Thus an accurate interpretation of fossil palynomorph assemblages in marine sediments in terms of source areas, transport and environmental conditions during sedimentation can be achieved (Kumar 1980). The present study is undertaken to determine the amount and type of organic matter and various groups of palynomorphs present in the bottom sediments of the western flank of the Andaman Islands and to identify their possible source.

Area Investigated: The study area is located on the western flank of the Andaman Islands. These islands are fringed by coral reefs forming the insular shelves of 10 to 50 km width on the western side and less than 10 km on the eastern side. The area covers a variety of depositional enviornments like algal ridges, reef ridges and fore reefs (Rodolfo 1969). Vigorous reef growth and limited terrigenous source make the Andaman insular shelves and banks as areas of high $CaCO_3$ production. These areas are of low rates of sediment deposition.

This region goes through northeast monsoon during January and February when northeasterly winds 15 to 20 km/h blow and the region gets around 30 mm rain and relative humidity is lowest. The southwest monsoon is active during summer from May to September when wind blows averaging 30 km/h and relative humidity reaches maximum (average 85%) by June and cause heavy rains in the region. This account for 90 percent of the annual rain fall. The temperature and salinity relationship in these waters is as follows : 70-100 m depth is low salinity and high temperature. Surface salinities are variable owing to dilution by monsoonal rains and runoff, however, maximum annual salinities of dry winter season range between 33 to 34 part per thousand. The temperatures of the sea surface remain quite uniform throughout the year, ranging between 27°C and 30°C.

MATERIALS AND METHODS

This study is based on 15 samples collected by Geological Survey of India's marine cruise SM 69. The samples are predominantly clays and clacareous clays. The depth of each sample and brief lithological description is given in table 1. Dried samples (50-100g) were macerated using standard palynological techniques with objective of isolating all the acid insoluble organic matter present in the sediments. Two sets of slides were made, one for the study of organic matter type which was not humified, and the other for examination of palynomorphs which was both humified and filtered to isolate palynomorphs within the 10 to 80 µm size range. Indentification and grouping of the type of organic matter are based on the definition and description of Masran and Pocock (1981) and Pocock (1982). The total organic matter in each slide and the type of organic matter were visually estimated. Estimates are approximate and are based on the comparison chart for visual percentage estimation of Terry and Chillingerian (1955). The data obtained is presented in table 2.

Table 1- Sample depth and lithology

SAMPLE NO.	DEPTH	LITHOLOGY
11	3445	Clay
20	512	Silty sand
23	1625	Clay with foraminifera
32	651	Sandy silt with foraminifera
34	78	Calcareous sand
35	277	Fine boigenic sand
36	727	Silty clay with foraminifera
45	824	Sticky clay with foraminifera
46	148	Sticky clay with foraminifera
47	362	Sticky clay
48	286	Silty clay with-shell fragments
49	1516	Clay with foraminifera
60	593	Sandy clay with foraminifera
63	57	Sandy silt
64	844	Clay with foraminifera

RESULTS AND DISCUSSION

The TOM in slides generally range from 5 to 10 percent. However, in samples 20, 32 and 46 the TOM is as high as 15 percent and in sample 49 and 63 approximately 1 percent.

The organic matter are predominantly structured algal matter (SAM) and amorphous organic matter (AOM) alongwith dinoflagellate cysts and acritarchs of marine origin indicating autochthonous deposition. Allochthonous elements, such as pollen, spores, woody tissues and fungal remains are less than 2 percent of TOM. Evidently, terrestrial organic matter is of minor importance and palynomorphs are transported into marine realm mainly by wind during cyclones and storms. Transportation by streams probably is not very significant because there are fewer streams on these islands.

The depth of the study area and its distance from the Andaman islands are important factors controlling the distribution of the type of organic matter. Generally the samples of shallower depths and closer to the islands have abundant structured algal matter mainly derived from green and red algae. Samples from deeper depths and relatively farther from islands are generally rich in amorphous organic matter. Sample no. 11 is an exception to this trend. This sample is from the deepest and farthest location from the islands and its 22 percent

Table 2-Palynological data of Recent marine sediments from western flank of Andaman Islands.

Sample No.	Slide No.	Marine OM (MOM)					Continental OM (COM)			MOM/COM Ratio
		TOM %	SAM %	AOM%	DFC & AT%	AJFD & SF%	FR%	PS%	WT%	
11	A	10	60	15	1	2	5	2	15	78/22
	B	10	60	22	1	1	5	1	10	84/16
20	A	15	2	95	T	2	-	1	-	99/1
	B	15	2	95	T	2	-	1	-	99/1
23	A	3	-	98	-	T	-	1	1	98/2
	B	5	T	100	T	T	-	T	T	100
32	A	15	2	98	T	T	-	T	-	100
	B	15	2	97	-	T	-	1	-	99/1
34	A	7	10	80	4	5	-	1	-	99/1
	B	5	10	82	3	5	-	T	-	100
35	A	5	90	5	T	5	T	T	-	100
	B	5	95	3	T	2	T	T	-	100
36	A	10	15	80	2	3	T	T	T	100
	B	10	15	80	2	3	T	T	T	100
45	A	10	15	80	2	5	T	T	-	100
	B	10	35	60	T	5	-	T	-	100
46	A	15	90	5	1	2	2	T	T	98/2
	B	15	90	2	2	2	3	1	T	96/4
47	A	7	25	70	T	4	-	1	-	99/1
	B	7	25	70	T	4	T	1	-	99/1
48	A	10	2	95	1	2	T	T	-	100
	B	7	1	98	1	1	1	T	-	99/1
49	A	1	70	28	-	2	-	-	-	100
	B	1	70	30	-	-	T	-	-	100
60	A	5	7	90	-	3	T	T	-	100
	B	5	5	90	-	5	T	T	-	100
63	A	1	-	100	-	-	-	-	-	100
	B	1	-	100	-	-	-	-	-	100
64	A	10	15	80	1	2	1	1	-	98/2
	B	10	15	80	1	2	1	1	-	98/2

TOM% - Total organic matter%

SAM % - Structured algal matter%

AOM% - Amorphous organic matter%

DFC & AT% - Dinoflagellate cysts and Acritarchs%

AJFD & SF% - Annelid jaws, Foraminifera, Diatoms and Silicoflagellates%

FR% - Fungal remains%

PS% - Pollen and Spores%

WT% - Woody Tissues%

TOM is allochthonous comprising mainly woody tissues and pollen-spores. This sample, probably represents the clastic sediments of the Bengal Fan which is seaward progradation of Ganga-Brahmaputra delta. This suggestion is also supported by the presence of *Verrualetes assamicus* a typical Neogene pollen grain of northeast India (Rao *et al.* 1985; Kumar 1994).

The common presence of microscopic marine floral (diatoms, silicoflagellates, dinoflagellates, acritarchs and other algal remains) and faunal (foraminiferal linings and annelid jaws) remains is an interesting feature of these sediments and their percentage reaches to a maximum of 5 percent of TOM. It has been observed that the samples containing a very high percentage of amorphous organic matter contain such microscopic remains only in traces (sample nos. 23, 32 and 49) or none (sample no. 63) at all.

Generally it is expected to observe a fair to good proportion of dinoflagellate cysts in such marine environments since they are known to occur in shallow warm seas (Edwards & Andrle 1992). Surprisingly their representation is lower than expected. Both total number of individuals within a species and species diversity are low. The species observed are *Spiniferites* spp., *Polysphaeridium zoharyi*, *Lingulodinium machaerophorum*, *Operculodinium israelianum* and *O. centrocarpum*. The contribution of dinoflagellate cysts in the TOM varies from traces to 2 percent except for sample no. 34 which contains 4 percent of dinoflagellate cysts. It appears that, in the environments under study, the contribution of dinoflagellate cysts in the TOM is quite insignificant. The lower abundance could also be due to lack of required nutrients. The study area is devoid of any river mouth, where nutrients could come from terrestrial source. In addition there is no upwelling in the sea in this area (Rodolfo 1969) which could bring nutrients from bottom waters. The dinoflagellate cysts observed in this study occur in warmer (20° to 30°C sea surface waters and at shallower depths (Edwards & Andrle, 1992).

The TOM observed in this study will eventually lead to the formation of sapropelic kerogens. Such sediments are prone to generate hydrocarbons if they go through a favourable geothermal regime. Thus such sediments are interpreted to be oil prone.

ACKNOWLEDGEMENT

The views expressed here are of the author only. I am grateful to Dr. H. Hooghiemstra of Amsterdam and Dr. M. Smelror of Trondheim for their critical reviews and valuable suggestions.

REFERENCES

Dupont, L.M. & Hooghiemstra H. 1989. The Saharan-Sahelian boundary during the Brunhes chron. *Acta. Bot. neerl. Dec. 1989: 405 115.*

Edwrds, L.E. 1992. New semiquantitative (paleo) temperature estimates using dinoflagellate cysts, an example from North Atlantic Ocean. *In* : Head, M.J. & Wrenn, J.H. (eds)- *Neogene and Quaternary dinoflagellate cysts and acritarchs.* ASSP Foundation, pp. 69-88.

Edwards, I.E. & Andrle, V.A.S. 1992. Distribution of selected dinoflagellate cysts in modern marine sediments. *In* : Head, M.J. & Wrenn, J. H. (eds)- *Neogene and Quaternary dinoflagellate cysts and acritarchs.* AASP Foundation, pp. 159-188.

Hooghiemstra, H. 1986. Distribution patterns of pollen in marine sediments form a record for the seasonal wind patterns over NW Africa. *In.*: Faure, H. *et al.* (eds)- *Changements globaux en Afrique durant Quaternaire, passe-present-futur. Trav. Doc. ORSTOM, 197:191-194.*

Hooghiemstra, H. 1988 a. Palynological record from NW Atlantic marine sediments. A general outline of the interpretation of the pollen signal. *Philos. Trans. R. Soc. London* **B 318 : 431-449.**

Hooghiemstra, H. 1988b. Changes of major wind belts and vegetation zone in NW Africa 20,000-5,000 yr B.P., as deduced from a marine pollen record near Cap Blanc. *Rev. Palaeobot. Palynol.* **55** : 101-140.

Hooghiemstra, H. 1989. Variations in the NW African trade wind regime during the last 140,000 years : Changes in pollen flux evidenced by marine sediment record. *In:* Leinen, M. & Sornthein, M. (eds)- *Palaeoclimatology and Palaeometeorology : Modern and past patterns of Global Atmospheric Transport*, pp. 733-770.

Hooghiemstra, H., Agwu, C.O.C. 1986. Distribution of palynomorphs in marine sediments: a record for seasonal wind patterns over NW Africa and adjacent Atlantic. *Geol. Rdsh* **75**(1) : 81-95.

Hooghiemstra, H., Agwu, C.O.C. & Beug, H.J. 1986. Pollen and spores distribution in recent marine sediments : A record of NW African seasonal patterns and vegetation belts. *Meteor Forsch - Ergeb.*, C **40** : 87-135.

Kumar, A. 1980. Fossil dinophyceae and its uses in petroleum exploration with special reference to India. *J. palaeontol. Soc. India* **23** & **24** : 4-15.

Kumar, A. 1994. Palynology of the Tertiary sediments exposed along the Silchar Halflong road section, southern Assam. *Palaeontographica indica* No. 2, *KDM Institute of Petroleum Exploration, ONGC Ltd., Dehradun*, p-241.

Masran, Th.C. & Pocock, S.A.J. 1981. The classification of plant derived particulate organic matter in sedimentary rocks. *In* : Brooks, J. (Ed)-*Organic Maturation Studies and Fossil Fuel Exploration.* Academic Press, NY, pp. 111-144.

Matsuoka, K. 1992. Species diversity of modern dinoflagellate cysts in surface sediments around the Japanese islands. *In*: Head, M.J. & Wrenn, J.H. *(eds): Neogene and Quaternary dinoflagellate cysts and acritarchs.* AASP Foundation, pp. 33-54.

Mudie, P.J. 1992. Circum-Arctic Quaternary and Neogene marine palynofossils : palaeoecology and statistical analysis. *In* : Head, M.J. & Wrenn, J.H. (eds)-*Neogene and Quaternary dinoflagellate cysts and acritarchs.* AASP Foundation, pp. 347-390.

Muller, J. Palynology of Recent Orinoco delta and shelf sediments. *Micropalaeontology* **5** : 1-32.

Pocock, S.A.J. 1982. Identification and recording of particulate sedimentary organic matter. *SEPM Short Course* 7 pp. 13-133.

Rao, M.R., Saxena, R.K. & Singh, H.P. 1985. Palynology of the Brail (Oligocene) and Surma (Lower Miocene) sediments exposed along Sonapur-Badarpur road section, Jaintia Hills (Meghalaya) and Cachar (Assam). Part V. Angiospermous pollen grains. *Geophytology* 15(1): 7-23.

Ratan, R. & Chandra, A. 1983. Palynological investigation of the Araban Sea : Pollen/spores from recent sediments of the Gulf of Kutch, India. *Palacobotanist* 31(2) : 165-175.

Ratan, R. & Chandra, A. 1984. Palynological investigation of the Arabian Sea: Pollen/spores from recent sediments of the continental shelf off Bombay, India. *Palaeobotanist* 31(3) : 218-233.

Rodolfo, K.S. 1969. Sediments of the Andaman Basin, Northeastern Indian Ocean. *Marine Geol.* 7: 371-402.

Saxena, R.K., Chandra, A. & Setty, M.G.A.P. 1982. Palynological investigation of the sediment cores from the Arabian Sea. 2. Dinoflagellate cysts and acritarchs. *Geophytology* 12 : 81- 94.

Terry, R.D. & Chillingerian, G.V. 1995. Summary of "Concerning some additional aids in studying sedimentary formations. *Sed. Petrol.* 25 : 229-234.

Van Waveren, I.M. 1992. Morphology of probable planktonic crustacean eggs from the Holocene of the Banda Sea (Indonesia). *In* : Head, M.J. & Wrenn, J.H. (eds) : *Neogene and Quaternary dinoflagellate cysts and acritarchs.* AASP Foundation, pp. 89-120.

Williams, B.D. 1971a. The distribution of marine dinoflagellates in relation to physical and chemical conditions. *In* : Funnel, B.M. & Reidel, W.R. (eds): *The Micropalaeontology of Oceans.* Cambridge Univ. Press, pp. 91-96.

Williams, B.D. 1971 b. The occurrence of dinoflagellates in marine sediments. *In* : Funnel, B.M. & Reidel, W.R. (eds): *The Micropalaeontology of Oceans.* Cambridge Univ. Press, pp. 231-244.

(Received : 1. 12. 1994; Accepted : 19. 6. 1996)