

Wave refraction pattern and its role in the redistribution of sediment along southern coast of Tamilnadu, India

N Angusamy, P Udayaganesan & G Victor Rajamanickam
Department of Earth Sciences, Tamil University, Thanjavur - 613 005, India

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Wave convergent zones are identified at Manappad, Tiruchendur, Tamirabarani river mouth, Tuticorin, Kallar, Vaippar, Vembar and Valinokkam beaches. Wave divergent zones especially from Mandapam to Chinna Ervadi are marked by strong progradational activities in the prevailing low energy environment. Textural parameters of the sediments show a characteristic variation in mean size and sorting in the zones of wave divergence and convergence. At wave divergent zones, sediments are of fine, moderately sorted, negatively skewed and mesokurtic in nature. Coarse sediments of well sorted, negatively skewed and mesokurtic nature are the characteristic of sediments in convergent zones.

Wave refraction phenomenon is an important process responsible for effecting changes in coastal configuration. Along the east coast of India, studies are few on wave refraction and its role in the redistribution of sediments¹⁻⁴. In southern coast of Tamil Nadu from Mandapam to Kanyakumari, wave parameters are controlled by the change in monsoonal cycle. Waves approach the coast⁵ in SE, NW directions with wave period varying from 5 sec - 15 sec. In NE monsoon, wave heights exceeding 2 m are observed especially in Kuttankuli and Manappad. In the present study region, an attempt is made to examine the impact of waves in modulating coastal sediment texture along the southern coast of Tamilnadu.

Materials and Methods

The predominant wave directions prevailing in the study region (Fig.1), from Mandapam to Kanyakumari, are referred in the wave atlas as south east (SE), during south west (SW) monsoon, north west (NW) and during the north east (NE) monsoon⁶. The wave refraction study has been done using Naval Hydrographic charts by using a wave refraction model⁷. Various parameters like wave incidence angle, dominant wave period, first orthogonal origin and maximum orthogonal limit were given as inputs in the wave refraction model. Depth contours were drawn for 5,10,25, 50, 100 m water depths and using gridded format depth

values were uniformly extrapolated horizontally up to 100 m water depth. About 356 sediment samples were collected from low, mid, high tides and berm regions from 14 different stations, during pre-south west monsoon period in May from the coastal region of Mandapam - Kanyakumari. All the samples were sieved at 1/4 ϕ interval. The textural parameters were calculated using Schlee & Websters⁸ programme.

Results and Discussion

In the refraction pattern of 6 sec (Fig.2) of SE direction, convergent zones are noticed in Pudumadam, and P.S.Puram, areas. The refraction pattern for 8 sec. (Fig. 3) shows many zones of wave convergence while the Vembar region is represented as a strong divergent zone. In the refraction pattern of 10 sec (Fig. 4) the stretch of Mandapam - Chinna Ervadi is characterised by a zone of divergence except at Pudumadam. Convergent zones are also noticed at Valinokkam, Vaippar, Sippikulam, Kallar, Tuticorin and Tamirabarani river mouth region, Tiruchendur, Manappad, Periyathalai, Vattakkottai. The characteristic shift in Vembar in the different wave periods of SE direction clearly attests the presence of both deposition and erosion.

In the wave period of 8 sec of NW wave direction (Fig.5) Punnakayal, Kilakkarai, Kayalpattinam and Kilmundal regions depict zone

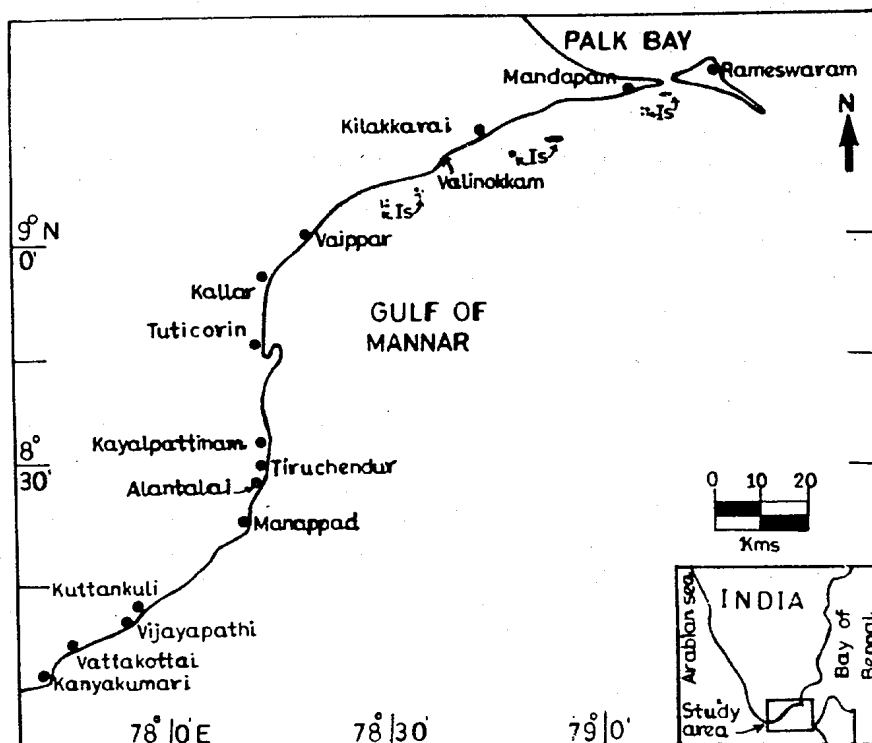


Fig. 1—Location map

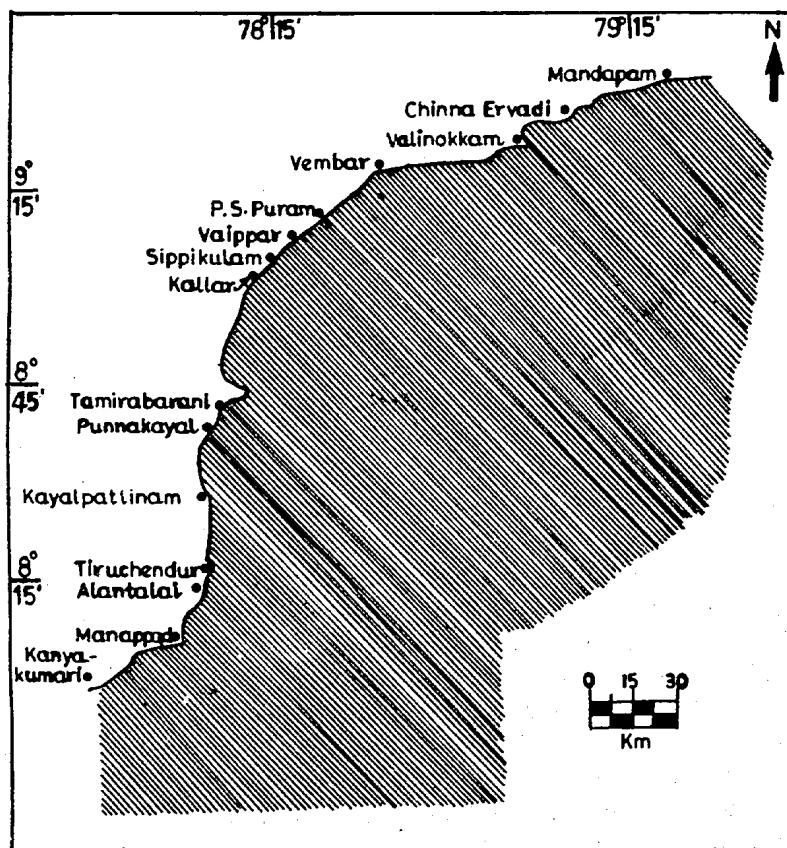


Fig. 2—Wave refraction pattern for SE in 6 seconds

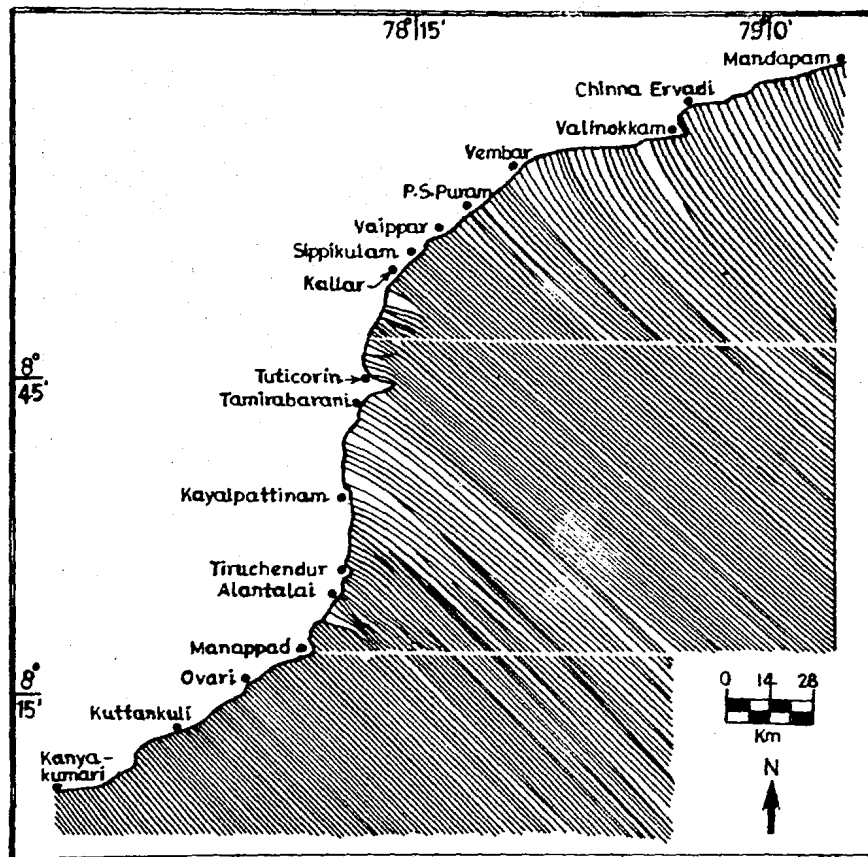


Fig. 3—Wave refraction pattern for SE direction in 8 seconds

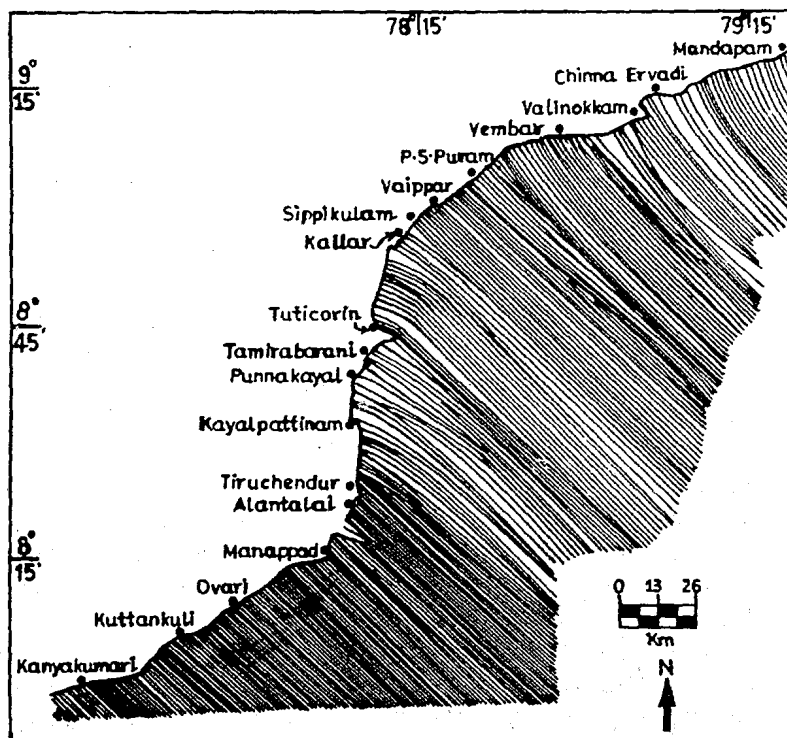


Fig. 4—Wave refraction pattern for SE direction in 10 seconds

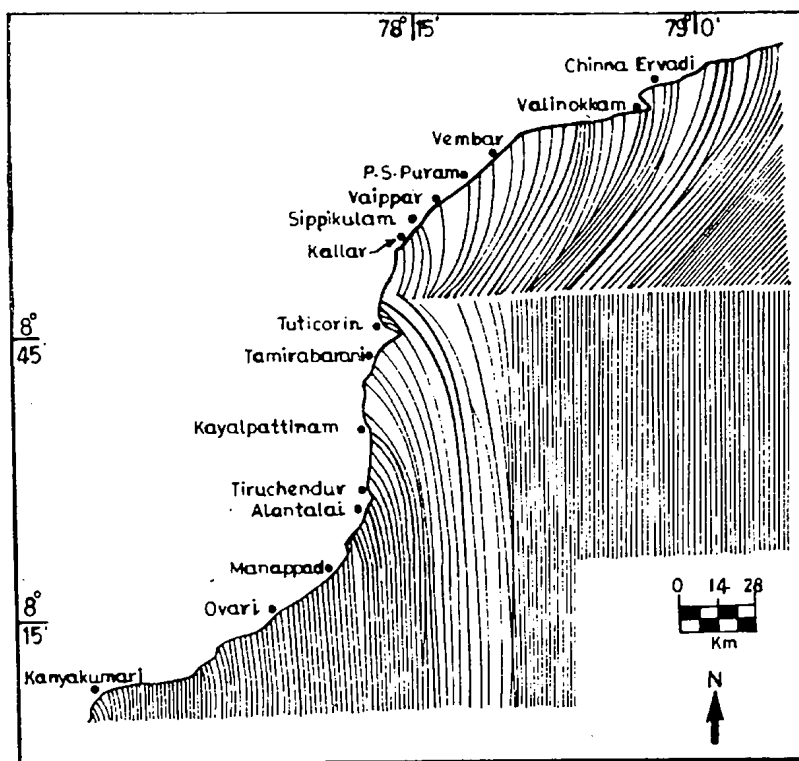


Fig. 5—Wave refraction pattern for NW wave direction for 8 seconds

of divergence, while the shoreline beyond south of Kayalpattinam is characterised by neither convergence nor divergence but in an inept condition.

For the same direction the pattern of 10 sec period (Fig. 6) indicates a strong divergence at Punnakayal, Vaippar and Vembar, while a strong convergence is present at Pudumadam, Valinokkam and Tamirabarani river mouth.

From the wave refraction pattern of SSW for the period of 8 sec (Fig. 7), it is clearly discernible that Pudumadam, Valinokkam, P.S.Puram regions depict convergences while the other places like Chinna Ervadi, Kilakkarai, Vaippar are found to be influenced by divergence.

The overall pattern of the wave refraction of the study region of SE direction displays strong convergence in number of places like, Manappad, Tiruchendur, Tamirabarani river mouth, Tuticorin, Kallar, Vaippar, Vembar and Valinokkam. Tamirabarani river mouth region shows convergence in SE and NW, while the same zone becomes a clear divergence in SSW direction. The other river mouths like Vaippar, Vembar and

Kodaggadi river (Sethukkarai) also display similar pattern. Denudational activities take place in front of these river mouths. The change of wave energy from convergence to divergence, in a particular station in different wave periods, has been attributed to the increasing bedload of sediments movement⁹.

South of Tuticorin registers broadly a low energy condition leading to accretion. Region from Tuticorin to Manappad can be treated as a zone of accretion. Loveson & Rajamanickam¹⁰ have well-documented the prograding nature of this coast from geomorphic indicators as inferred from satellite imagery and aerial photographs.

In Tuticorin a high energy environment is indicated by strong convergence in the north as well as in the south of spit formation. In places of strong wave convergence conditions more amount of northerly drift is observed. In the perennial river mouth of Tamirabarani, i.e. at Punnakayal littoral is minimum in both northerly and southerly direction. Since this region is under strong divergent condition depositional processes are maximum, hence littoral drift is restricted in the

river mouth. In Tiruchendur, Manappad, due to the disposition of promontories abutting the coastline, a more convergence of orthogonals is observed. The nature of eroded, cliffed coastline from Kuttankuli to Vattakkottai indicates a zone of high energy environment.

Mandapam sediments are fine in nature (Table 1) and this is in line with the predominance of wave divergent conditions which favours more of depositional activities. The coarser nature of

sediments at Vaippar (1.20ϕ), Kallar (1.20ϕ), Tuticorin (1.40ϕ) and Tiruchendur (1.60ϕ) indicates the winnowing action of waves. Further, down south, at Kayalpattinam, Alantalai, Kuttankuli and Kanyakumari regions, the distribution of fine sediments indicates a calm depositional conditions.

In Mandapam, the sorting value is shown by 0.60ϕ with the mean of 2.75ϕ , indicating the moderately sorted nature of sediments. In Kallar

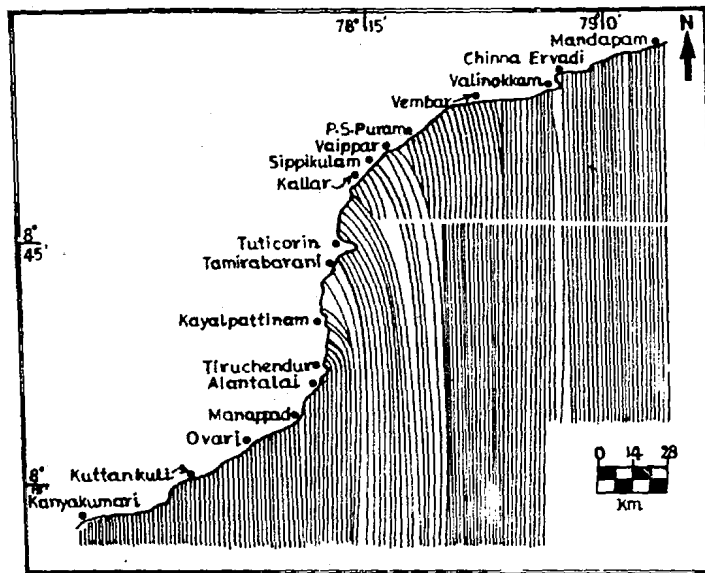


Fig. 6—Wave refraction pattern for NW wave direction for 10 seconds

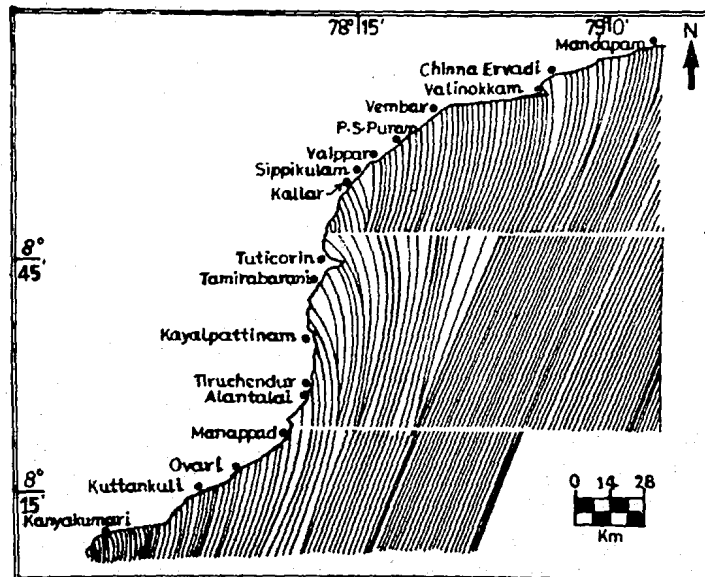


Fig. 7—Wave refraction pattern for SSW wave direction for 8 seconds

Table 1—Distribution of textural parameters

Station	Mean ϕ	Standard deviation ϕ	Skewness	Kurtosis
Mandapam	2.75	0.60	-0.31	1.24
Kilakkarai	2.00	0.78	-0.21	1.10
Valinokkam	2.75	0.60	-0.06	1.76
Vaippar	1.20	0.58	-0.19	1.41
Kallar	1.20	0.68	-0.23	1.14
Tuticorin	1.40	1.40	0.10	1.50
Kayalpattinam	2.90	0.68	-0.15	1.25
Tiruchendur	1.60	0.60	0.10	1.10
Alantalai	1.90	0.56	0.90	1.05
Manappad	2.15	0.68	-0.05	1.03
Kuttankuli	2.80	0.60	-0.19	1.21
Vijayapathi	1.75	0.56	-0.17	1.28
Vattakkottai	2.35	0.48	-0.16	1.08
Kanyakumari	2.70	0.44	-0.26	1.18

and Vaippar, the moderately well sorted nature of sediments is attributed to the prevalence of strong convergence of waves. From Kuttankuli to Kanyakumari, sediments show moderately sorted to well sorted nature (0.52 to 0.68 ϕ) and this can be ascribed to the prevalence of strong northerly drift. The skewness values vary from -0.01 to 0.90. Most of the samples display negative skewness except Tuticorin, Alantalai and Tiruchendur regions.

Mandapam to Valinokkam sediments are characterised by mesokurtic nature. It confirms well with the nature of fine sediments being deposited here. The kurtosis values show a spurt at Valinokkam due to the well sorted sediment nature with poor mixing of the tails. This distribution is envisaged to the strong convergence and the prevalence of high energy conditions in most part of the year. From Tiruchendur to Kuttankuli no significant change in the kurtosis values is observed. In Manappad, the kurtosis value hardly shows any variation in spite of the presence of promontory and wave convergence.

From the present study it is concluded that at wave divergent zones, sediments are of fine, moderately sorted, negatively fine skewed and mesokurtic in nature whereas coarse sediments of well sorted, negatively coarse skewed and mesokurtic nature are the characteristic of samples from convergent zones.

Acknowledgement

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References

- 1 Anbarasu K, *Geomorphology of the northern Tamilnadu coast using remote sensing Techniques*, Ph.D. thesis, Bharathidasan University, India, 1994.
- 2 Chandrasekar N, *Beach placer mineral exploration along the central Tamilnadu coast*, Ph.D. thesis, Madurai Kamaraj University, India 1992.
- 3 Rajamanickam G V, Vethamony P & Gujar A R, *Proc Indian Acad Sci (Earth Planet Sci)*, 95 (1986) 237.
- 4 Vecrayya M & Pankajakshan T, *Indian J Mar Sci*, 17 (1988) 102.
- 5 Anon, *West coast of India Pilot* (Chief Hydrographer, Govt. of India) 1981 pp.227.
- 6 Chandramohan P, Sanilkumar V, Nayak B U & Anand N M, *Wave atlas of Indian Ocean region*, (NIO, Goa, India) 1990, pp.312.
- 7 Chandramohan P, *Longshore sediment transport model with particular reference to Indian coast*, Ph.D. thesis, Indian Institute of Technology, Madras, India 1988.
- 8 Schlee J & Webster J, *Sedimentology*, 8 (1967) 45.
- 9 Hanamgond P T, *Morphological and sedimentological studies within Kwada bay and Belekeri bay beaches, Uttara Kannada District, Karnataka, West coast, India*, Ph.D. thesis, Karnatak University, Dharwad, India, 1993.
- 10 Loveson V J & Rajamanickam G V, *Indian J Land Sys Ecol Studies*, 12 (1988) 94.