TABLE 3 — CHEMISTRY OF SEDIMENTS OF THE ADJACENT SHELF

Sl No.	Stn No.	Water depth m	Texture	Al_2O_3%		Fe%		TiO_2%		Mn in ppm		$CaCO_3$%
				A	B	A	B	A	B	A	B	
SECTION I: NORTH OF GULF OF KUTCH												
1	1	20	Clay	13·42	14·91	3·45	3·83	0·42	0·47	1024	1138	10
2	2	27	Silty clay	13·06	14·35	3·56	3·91	0·43	0·47	791	869	9
3	3	41	Clay	12·95	14·23	5·62	6·71	0·41	0·45	558	613	9
4	4	94	Silty clay	12·36	15·45	5·53	6·91	0·41	0·51	268	335	20
SECTION II: NORTH OF GULF OF KUTCH												
5	1	—	do	13·64	15·15	5·53	6·14	0·45	0·5	529	588	10
6	2	60	Clayey sand	8·46	14·1	2·96	4·93	0·3	0·5	442	737	40
7	3	85	Silty sand	6·3	13·4	1·37	3·19	0·26	0·55	529	1125	53
8	4	100	do	7·51	12·11	3·23	5·21	0·42	0·67	1059	1708	38
SECTION III: SOUTH OF GULF OF KUTCH												
9	1	30	Silty clay	12·62	14·24	6·19	6·87	0·55	0·61	709	788	10
10	2	54	Clayey silt	10·73	12·77	5·54	6·59	0·64	0·76	709	844	16
11	3	65	Silty clay	9·17	12·23	3·62	4·83	0·61	0·81	721	961	25
12	4	90	do	8·99	12·31	3·56	4·88	0·59	0·81	669	916	27
SECTION IV: SOUTH OF GULF OF KUTCH												
13	1	29	do	12·27	13·34	5·61	6·09	0·57	0·62	686	746	8
14	2	42	do	12·63	13·88	6·42	7·06	0·69	0·76	768	844	9
15	3	69	do	5·74	9·26	3·01	4·85	0·44	0·71	593	956	38

A = concentrations in the bulk sample; B = concentrations on carbonate-free basis.

data with data from the Gulf sediments shows greater similarity with the sediments of the northern region than with those of the southern region. It is very well marked in the case of titanium, but it is not so in the case of iron; actually the behaviour of both aluminium and iron are similar. This implies that the sediments of the shelf region coming from the north are not transported up to the southern part of the Gulf to a great extent but are deflected into the Gulf as a result of some physical processes and this may be the reason for the sediments in the shelf region north of Gulf of Kutch being chemically different from those found south of the Gulf of Kutch. It may be mentioned here that the similarity observed between the Gulf sediments and the sediments of the northern region of the adjacent shelf could not be due to sediments coming from adjacent land masses to the Gulf because the supply from the streams opening into the Gulf is probably negligible in view of the fact that they are small, estuarine in nature and running through the surrounding land mass which is an arid zone.

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Sandstones in the Coastal Area Between Visakhapatnam & Bhimunipatnam, East Coast of India

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The 2 highly ferruginous sandstone units found are elongate, parallel to the coast line and are unfossiliferous. The sandstones are coarse grained, well sorted and negatively skewed. Textural characters, areal pattern and mineralogical composition suggest that the sandstones have been derived from the eolian red sands and deposited during one of the sea level fluctuations on the east coast of India. The sandstones are considered to be post-Pleistocene in age in view of their position above the late Pleistocene red sandy sediments.

TERTIARY sandstones are known from the coastal tracts of West and East Godavari Districts of Andhra Pradesh[1,2]. However, their extension further north has not been reported except the occurrence of sandstones in Ranasthalam area of Srikakulam District[3]. This patch of sandstones is considered to be an equivalent of Rajahmundry sandstones of Miocene age. During a study on the red sandy sediments in the coastal area between Visakhapatnam and Bhimunipatnam, 2 sandstone patches overlying the red sands have been observed near Vadapalem (Fig. 1). No outcrops of such rocks are found in other parts of the basin or in the adjacent areas. The 1st sandstone (S_1) is located at

300 m from the present coast line and the 2nd unit (S_2) lies further 300 m inland (Fig. 1). The first unit is at a lower level and the lower contact of the formation is not exposed and the outcrop is seen on either side of a channel cutting. The 2nd unit is a linear body 2 to 5 m wide, maximum of about 2 m thick and extends in the NE-SW direction for 200 m. A stream has greatly dissected the NE part of the formation reducing the length of the sandstone body. The sandstone units are almost parallel to each other and in turn parallel to the present coastline.

The sandstones are highly compacted, ferruginous, structureless and unfossiliferous. Therefore, in this paper an attempt is made to describe and interpret the depositional environment of the sandstones, basing mainly on textural characters, mineralogical composition and physiographical factors of the formations.

Two samples were collected from the sandstone unit I (S_1) on either side of the channel cutting. In the sandstone unit II (S_2) 3 samples were collected along its length. Two samples from the underlying red sandy sediments of S_2 and 2 from the inland red sands were also collected.

Sandstone samples were soaked in water for 24 hr and then gently crushed in a mortar until the individual grains were completely separated. These samples and the red sandy sediment samples were treated with stannous chloride to remove the iron oxide coatings. The clean sands thus obtained were subjected to granulometric analysis using $\frac{1}{4}$ ϕ sieves. Grain size parameters[4] were calculated from the statistical data. Heavy minerals were separated using bromoform and studied under microscope.

Grain size characters of sandstones and red sands (Table 1) show that the sandstone unit S_2 is relatively coarse grained and well sorted compared to the red sands and sandstone unit S_1. Both the sandstone units are better sorted than the red sands. While the red sands are positively skewed, the sandstones are negatively skewed. No systematic trend is apparent in the kurtosis values of the red sands and sandstones. Sandstones are characterized by quartz content in excess of 95% and are enriched in total heavy mineral per cent compared to the red sands. Heavy minerals present in decreasing order of abundance are sillimanite, opaques, kyanite, pyroxenes, rutile, tourmaline and zircon. However, the type of minerals present are same in both.

Highest quartz content, well sorted nature, high degree of rounding and restricted heavy mineral suite indicate a multicyclic origin of the sands constituting the sandstones. Pettijohn *et al.*[5] state that the above type of sands will have an eolian episode sometimes in the history, not necessarily in the last stage represented by the present accumulation. Therefore, it may be inferred that the sands of the sandstones under present study have been derived from the underlying as well as inland red sands that were considered to have an eolian deposit[6,7].

From the physiographic arrangement of the sandstone and the nature of the grain size parameters, the sandstones are considered to have been formed during one of the marine transgressive phases. Such a conclusion is strongly supported by the sea level fluctuations recorded on the east coast of India[8] and location of ancient shore lines farther inland to the present coast line in the Godavari Delta area[9]. Further, from the log data, from bores in the tidal basin of Visakhapatnam and features reported[10], it has been inferred that during the commencement of Holocene (since 10000 B.C.), the sea level at Visakhapatnam might have been about 7 m higher than the present. During this transgressive period, the red sands might have remained under sea for certain period and considerable reworking of the sediments took place. In the reworking process, finer particles of the red sands might have been winnowed out by the waves and carried offshore. Further, it improved the sorting of the sediments and resulted in the concentration of heavy minerals. Such a process by waves is evidenced by increase in the mean size, better sorting and negative skewness of the sands of the sandstones compared to the mean size, moderate sorting and positive skewness of the red sands. In addition, higher concentration of the

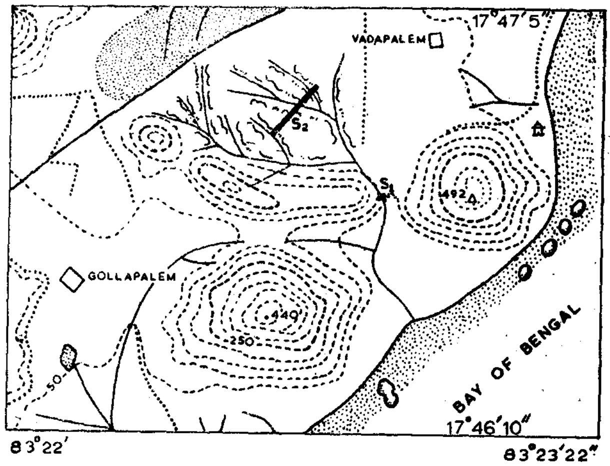

Fig. 1 — Physiography of the area and locations of sandstone units

TABLE 1 — GRAIN SIZE PARAMETERS AND HEAVY MINERAL PER CENT OF SANDSTONES AND RED SANDY SEDIMENTS

[Data from Folk and Ward[4]]

Sample No.	M_z	σ	Sk_1	K_g	Heavy mineral %
$S_1$1	1·51	0·556	−0·065	0·9224	13
$S_1$2	1·33	0·54	−0·096	1·071	15·5
$S_2$1	1·47	0·46	−0·012	1·526	9
$S_2$2	1·5	0·412	−0·071	1·49	11·3
$S_2$3	1·27	0·5	−0·069	1·039	15·3
RL_1	1·84	0·577	0·023	1·071	2·7
RL_2	1·9	0·574	0·036	0·99	2·8
RL_3	1·72	0·587	0·029	1·5	3·7
RL_4	1·94	0·646	0·274	1·544	4·5

S_1 = sandstone unit 1, S_2 = sandstone unit 2, RL = red sandy sediments.

total heavy mineral per cent of the sandstones relative to the red sands (Table 1) substantiates the inference that the red sands were considerably reworked by the waves before being deposited as sandstones. Mason and Folk[11], Friedman[12] and Duane[13] observed that to a greater extent dune sands are positively skewed and beach sands are negatively skewed. Martins[14] has suggested 2 possible causes for negative skewness: (i) addition of material to the coarser terminal, and (ii) subtraction of fines from a normal population. In the present area, the removal of the fines from the red sands by the waves might have resulted in the negative skewness of the sandstones.

Physiography of the area (Fig. 1) suggests that the sea might have entered the area of deposition of sandstones as a tidal inlet in between the 2 hills. Therefore, all the reworked sediments and the sediment load derived from the inland red sands could not be transported to the sea freely and probably resulted in the formation of a sand barrier. Such a development of sand barrier in the tidal inlets and also in the regressive and transgressive sedimentary cycles have been reported earlier[15,16]. The field relationship of the sandstones suggests that the sandstones were deposited in 2 phases of marine transgression. Perhaps the sea stood at the first unit (S_1) level long enough to form a barrier to be established and moved further inland. Later this barrier had been submerged and a new barrier has become established at the second sandstone unit (S_2) level. During the formation of the second barrier, the submerged barrier had been covered with the reworked red sands transported seaward from the new strand line and also with some pebbles derived from the wave attack on surrounding rocks. The 3 m overburden on the 1st sandstone unit S_1 constituting bands of uniform red sands and well rounded pebbles support the above conclusion.

There is no direct evidence on the stratigraphic position of the sandstones. However, the sandstones may be considered as Holocene, as they overlie the late Pleistocene[6] red sands.

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Spectral Characteristics of Sounds Produced by Toad Fish & Shrimps

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Sounds produced by toad fish and shrimps, collected from the Cochin backwaters, were recorded in the laboratory and the records analysed using an audio frequency spectrometer and an oscilloscope. The records of burst-pulsed sounds produced by toad fish showed at least 3 harmonically related frequencies. The fundamental frequency varied from about 125 Hz to 160 Hz depending on the size of the animal. The pulse type sound produced by the snapping shrimps had maximum energy in the frequency range 1500 Hz to 2500 Hz and appreciable energy was found even at 16 kHz. No difference in the structure of the sound was found to exist with the size of the shrimp.

SUCCESSFUL application of underwater acoustic techniques in naval operations, fathometry, fish finding and telemetry requires an understanding of sounds contributed by various component sources to the ambient noise level. Acoustic ambient noise in the sea has 3 major component sources, viz. water motion, man made sources and marine life. In coastal waters and harbour areas, a predominant component of ambient noise is due to marine life. Identification and localization of soniferous marine organisms from the sounds at sea is possible only if we know the characteristics of the sounds produced by individual contributors.

Significance of sounds produced by toad fishes and shrimps in the ambient noise level in the sea has been conclusively demonstrated. Fange and Wittenberg[1] have studied the structure of the swim bladder of the toad fish in relation to production of sound and Fish *et al.*[2] have shown that the frequency characteristics of sound produced by individual toad fishes are constant. Spectral distribution of energy of the sounds produced by snapping shrimps has been reported[3-5]. Johnson *et al.*[6] and Knudsen *et al.*[7] have described the snapping habits and the mechanism of sound production in shrimps. Acoustic characteristics of the sounds produced by toad fish (family Batrachoidae) and snapping shrimp (family Alpheidae) have been studied and the results presented in this paper.

The animals were collected from the Cochin backwaters and the individuals were kept in the laboratory in a tank (3×2×2 ft). The tank was lined inside with 2 in. thick foam rubber cushion, to prevent the animals from striking the sides and bottom, and was mounted on a 2 in. thick