

RESEARCH COMMUNICATIONS

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Gas-charged sediments in shallow waters off Redi along the central west coast of India

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This study reports the occurrence of gas-charged sediments in the nearshore areas of the west coast of India. High resolution shallow seismic reflection profiles on the nearshore area along central west coast of India, at water depths of 11-18 m are characterized by anomalous seismic subbottom signatures in the form of acoustic turbidity which extends from the underlying reflector and reach within 4-5 m of the seafloor. Fine grained sediments apparently contain appreciable quantities of interstitial gas bubbles which are responsible for the anomalous seismic sig-

natures. This could be due to shallow hydrocarbon gases, mostly methane, which might have been derived due to the biogenic degradation of organic matter accumulated under palaeo-estuarine conditions. These gas-charged sediments pose a potential hazard for the offshore engineering constructions. Hence, the detection of these sediments forms an essential part of any offshore site investigation programmes.

The western continental shelf is widest off Cambay (345 km) and it narrows down (60 km) off Quilon. It is characterized by gently dipping seafloor, with an average gradient of 1:400-1:3000, and the shelf break occurs at 80 to 140 m water depths. The inner shelf up to 50-60 m water depths is marked by even topography and is carpeted by silts and clays while middle and the outer shelf show uneven to rough topography with a thin layer of calcareous sands.

Recent developments in marine geophysical techniques have made it easier to identify gases in shallow marine sediments. Based on shallow seismic, side scan sonar and echogram results, gas-charged sediments have been reported from most of the world's continental shelves¹⁻⁵. The addition of gaseous phase compounds to the otherwise fluid saturated seafloor sediments significantly alters the acoustic properties of the seafloor^{6,7}. These effects produce readily identifiable anomalies in high resolution subbottom reflection profiles of the shallow seafloor⁸⁻¹⁰. Though the occurrence of shallow gas-charged sediments is documented on the western continental margin of India using seismic signatures¹¹⁻¹⁴, little or no similar information is available so far regarding these in nearshore areas. Here we report the occurrence of gas-charged sediments in the nearshore areas of the west coast of India.

The study area lies in the shallow waters off Redi,

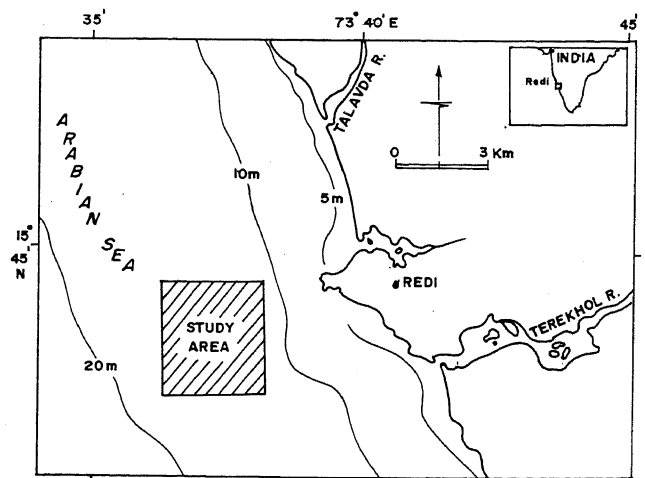


Figure 1. Map showing the survey area off Redi. Inset shows the location of Redi along the west coast of India.

about 400 km south of Cambay (Figure 1). Our data base comprises echosounding (Atlas Deso-10, 210 and 30 kHz), side scan sonar (EG&G, Mark IB, dual channel recorder 259-3 and tow fish 272) and high resolution shallow seismic profiling (300 joules and 400-5000 Hz). The survey tracks are approximately spaced 25 m apart in north-south and east-west grid fashion (Figure 2). The positions of the tracks were fixed by Mini Ranger MRS III system and a total of 500 line kms were covered.

In the study area, water depth ranges from 11 to 18 m and is dominated by gently westward sloping seafloor and it lies off the mouths of the rivers Talavda and Terekhol. The area is essentially featureless with the seafloor formed by silty clays. Shallow seismic records indicate that acoustically transparent clays with an assumed velocity of 1.5 km/sec range in thickness from 10 to 15 m cover the seabed. These clays are underlain by sandy reflectors. These acoustically transparent clays are marked by a sudden appearance of extensive patches of shallow gas-charged sediments in the form of 'acoustic turbidity', at places resembling inverted U-like features, where the reflections are chaotic caused by the scattering of the acoustic energy (Figure 3 a, b, c). The velocity in the gas-charged sediments is generally decreased depending upon the degree to which gas bubbles in

sediments act as a resonant system and the relation of acoustic frequency to the bubble-sediment resonance frequency¹⁵.

Acoustic turbidity is the term generally used to refer to those parts of the seismic studies where subbottom details are lost due to the effects of gas bubbles within the sediment pore spaces⁴. These acoustic turbid masses reach within 4-5 m of the seafloor. The sides of the turbid zones are nearly vertical. Their top edges are either flat or rounded. The records are similar to some of the published records of gas-charged sediments reported earlier^{1,11,13,14} in the outer shelf. The area covered by the present study is roughly 12 km² and it is estimated that 10-15% of the area is characterized by gas-charged sediments.

The anomalous features are confined only to the shallow seismic records and are not seen either in the corresponding echograms or in the sonographs. This reveals that the anomalous features due to gas are localized within the sediments but not surfacing out of the seabed, though upward migration of gases by either molecular diffusion or bubble formation from the sediments into the overlying waters could be possible¹⁶.

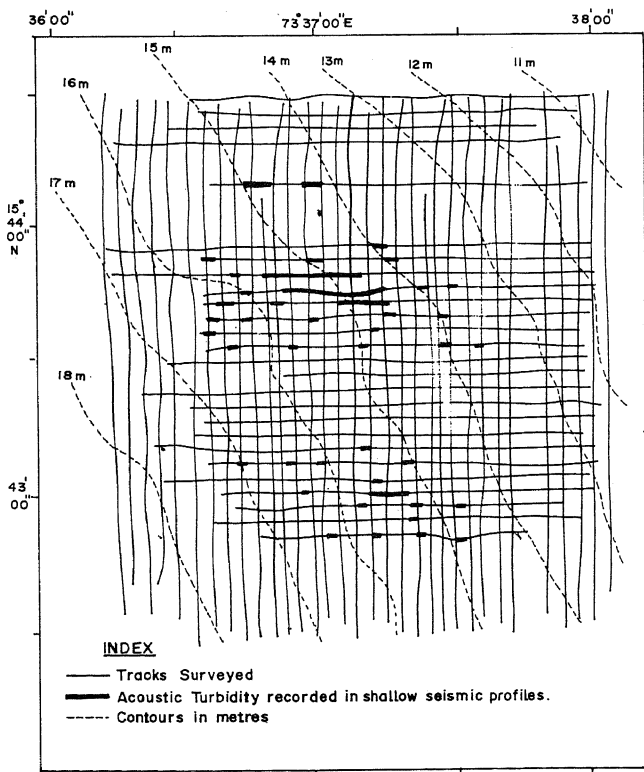


Figure 2. Survey tracks along which bathymetric, side scan sonar and shallow subbottom seismic profiling were carried out.

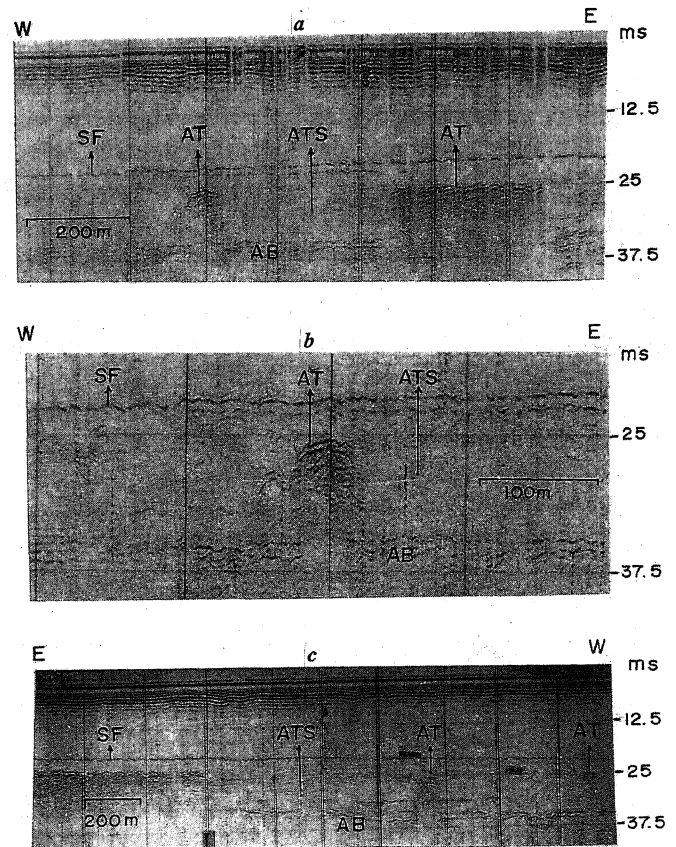


Figure 3 a-c. Seismic records showing examples of acoustic turbidity on high resolution seismic reflection profiles (300 J and 400-5000 Hz).

Shallow hydrocarbon gas, mostly methane has been reported from the western continental margin of India^{11-14,17} and from Amazon submarine deltaic regions¹⁸ elsewhere. According to Kaplan¹⁹, gases in the marine sediments could be from four different sources, viz. atmospheric, biogenic degradation of organic matter, upward diffusion by thermocatalytic cracking of more complex compounds and submarine volcanic or geothermal processes. Siddiquie *et al.*¹¹ indicated two probable possibilities for the gas on the western shelf, i.e. biodegradation of organic matter or thermocatalytic cracking of more complex compounds. Similarly Karisiddaiah *et al.*¹³ believed that these gases could be from biogenic sources or geothermal processes or both. Karisiddaiah and Veerayya¹⁴ emphasized the role of vegetation as the source for the accumulation of methane gas. Paropkari *et al.*²⁰ reported high organic carbon content in the western shelf of India. Mascarenhas *et al.*²¹ reported peat deposits intercalated in sediments from the inner shelf.

It is known that bacterial methane formation is common in more rapidly accumulating marine sediments with higher organic matter contents once the dissolved sulphate has been utilized²². Obviously, the primary requirement for the existence of such gases is the availability of sufficient organic matter below the seafloor and appropriate time for generation of sufficient gas molecules and enough permeability of the sediments required for gas to collect as bubbles²³.

The proximity of the study area to the mouths of the Talavda and Terekhol rivers, gives the high possibility that the offshore sediments may be sufficiently organic-rich to generate sufficient quantities of biogenic gas and to produce the observed seismic signatures. High rate of sedimentation at the river mouths which results in rapid burial of organic matter must have also triggered the gas formation. Since the occurrence of methane gas in the outer shelf sediments is reported earlier¹¹⁻¹⁴, this gas is also believed to be methane and of bacterial origin. As mentioned earlier, similar occurrences of shallow gas formations from deltaic sediments and from nearshore sediment containing organic-rich layer have been reported from the world's continental shelves²⁴⁻²⁸.

Methane is a powerful greenhouse gas^{29,30} which plays an important role in atmospheric chemistry by influencing both the ozone concentration and the infrared radioactive flux³¹. Similarly, the various effects of gas on the geotechnical behaviour of fine grained soils create the potential hazard for offshore construction and development. When the gas gets trapped and accumulates under an impermeable layer, the resulting gas pressure goes up to such a level that a blowout can occur during drilling. Similarly, gas escaping naturally to the surface in extreme cases causes the collapse of structures due to undermining of the foundation⁴. Hence, the gas

detection studies now form an essential part of any marine site investigation programmes.

Undoubtedly, there could be similar shallow sedimentary methane reservoirs in the Indian shelves associated with major buried palaeo-deltas of the rivers, buried fluvial systems, infilled palaeo-river channels, nearshore bays, estuaries, etc. More detailed and systematic studies of these areas, incorporating high resolution seismic subbottom profiling, will certainly unravel the reservoirs of natural gas accumulation.

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MEETINGS/SYMPOSIUMS/SEMINARS

Workshop on Fundamentals of Photosciences: Application to Basic Research

Date: 7-12 October 1996

Place: Calcutta

Topics include: Spectroscopic processes, viz. absorption, emission, NMR, ESR, etc. and their instrumentation; photodynamics using lasers and conventional flash lamps; photosynthesis, photomedicine, application of chiro-optical methods, synthetic photochemistry, etc.

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National Conference on Moriculture: Physiological, Biochemical and Molecular Aspects of Stress Tolerance in Mulberry

Date: Second half of October

Place: Tiruchirapalli

Topics include: Molecular aspects of stress tolerance; *In vitro* induction of stress tolerance; Physiology and biochemistry of mulberry in stressed environment; Environment of rhizosphere microflora (VAMF, ecto, microbes of extreme environment) in ferment of stress tolerance.

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National Seminar on Neotectonic Movements and their Geo-environmental Impacts (NETMOGEL)

Date: 27-29 November 1996

Place: Mysore

Themes include; Tectonic framework and deformational behaviour of Peninsular shield (Deep continental crust, Deccan volcanic province, BGC, Coastal boundaries); Geomorphological, hydrological and sedimentological signatures of tectonically formed/active zones; Geophysical signatures of crustal blocks (Conductivity, velocity models, deep reflection, magnetotellurics, and allied aspects); Petrological, structural and geochemical signatures of tectonic zones (Pressure, temperature, fluid flux history, dating, emission of helium and radon, and allied aspects); Modelling of tectonic processes, boundaries, earthquake expectancy, simulation strategies and constraints; Hazard zone mapping, distribution of epicentres, palaeoseismic sites and drainage reversals; Remotesensing applications to neotectonics and structural fabrics; Impact assessments of neotectonic activities and damage; Modernization and strengthening of monitoring networks.

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