

Acoustic wipeouts over the Continental Margins off Krishna, Godavari and Mahanadi River Basins, East Coast of India

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Abstract. Loss of seismic reflections, termed as acoustic wipeouts, are observed in the high resolution sparker seismic records over the continental shelf and slope of Krishna, Godavari and Mahanadi river mouths, east coast of India. The wipeouts observed in the sub-surface layers beneath the outer shelf off these basins (150 to 250 m water depth) result in a chaotic appearance, probably indicating the presence of gas mixed sediments, while those observed over the continental slope (beyond 500 m water depth) are mostly associated with faulted contacts and uplifts and represent an abrupt weakening of seismic energy or break in the pattern of surface and/or sub-surface reflectors. Though acoustic wipeouts result due to a variety of reasons, their association with vertical faults and location at depth off major river basins suggest that some of these might be due to migration of oil/gas along the faulted contacts from increased depths.

Keywords. Geophysics (Seismology), Marine Geology, Continental margin, East coast of India, Krishna Basin, Godavari Basin, Mahanadi Basin.

INTRODUCTION

An acoustic wipeout resulting in a weakening or loss of reflections in the seismic records is caused due to several causes like (1) attenuation of seismic energy (2) lack of continuity in the surface or sub-surface layers (3) presence of thick sand and reefs and (4) vertical migration of oil/gas from deeper depths below. These are apart from wipeouts caused due to instrumental breakdowns, changes in gain settings and other types of noise. In petroleum exploration, acoustic wipeouts of type four are very important since presence of an oil/gas seep is an indication of the hydrocarbon potential of the area (Behrens, 1988).

High resolution sparker seismic records over the continental shelf and slope of Krishna, Godavari and Mahanadi river basins indicated the presence of several acoustic wipeouts, particularly over the continental slope. A preliminary attempt is made in this paper to study the nature of these wipeouts.

MATERIALS AND METHODS

Seismic data presented in this paper was collected on board R. V. Gaveshani, during 1987 and 1988, using an EG & G, 9-electrode sparker profiler, with the transmitting energy varying from 1000 joules near the shelf to 8000 joules towards the slope. A depth penetration of nearly 100 m below the sea-bottom was obtained from the seismic records, though at shallow depths, multiple reflections cause

problems in the identification of sub-surface layers. The traverses are confined to water depths of nearly 30–2500 m spaced at an interval of nearly 20 km off Krishna and Godavari river basins and nearly 40 km off Mahanadi basin (Fig. 1). The shorter sections off the Krishna and Godavari basins are shown in dashed lines. Bathymetric data using a SIMARAD EK-12 deep-sea echosounder were also collected along these traverses, run perpendicular to the coast at a ship speed of nearly 5 knots. The stratigraphy of the continental shelf of this area from Ongole (south of Nizampatnam) to Paradip (Fig. 1) is presented elsewhere (Murthy, 1989). The present paper presents only the shallow seismic data off the major river basins, with particular reference to the occurrence of acoustic wipeouts.

BATHYMETRY

Bathymetric sections off Krishna, Godavari and Mahanadi river mouths (Fig. 2) indicate that the shelf is very narrow off Krishna and Godavari rivers (Profiles 3 to 15) whereas it is wide off Mahanadi river (Profiles 18 to 23). The shelf-break off Krishna and Godavari rivers occurs at a depth of nearly 130 metres and the topography of the shelf is irregular at some places (Profile 3, Fig. 2), particularly off Krishna river. The continental slope is very steep and a marginal rise (marked as M.R.) is recorded at the foot of the slope along almost all the traverses at depth varying from 1000 to 1200 m. The relief of this rise varies from 50 to 250 metres.

Off Mahanadi river, the shelf width is nearly 70 km and the shelf-break occurs around 200 m (Profiles 19 to 23, Fig. 2). The continental slope is highly rugged and is associated with several valleys and rises (Profile 19, Fig. 2). Marginal rise (MR) is recorded in all the profiles at depths varying from 800 to 1500 m.

ANALYSIS OF SEISMIC DATA

High resolution sparker seismic records indicate a number of acoustic wipeouts, most of them located over the continental slope of the Krishna, Godavari and Mahanadi river basins. The wipeouts (marked as 'W' in all the seismic records, Figs. 3 to 5) are mainly of two types, those observed over the outershell (150–250 m water depth) and over the slope (500–1500 m depth). Care is however taken in the identification of the wipeouts, so as to eliminate these wipeouts caused due to instrumental breakdowns, recorder gain settings and other types of noise.

Krishna Basin

Seismic records over the continental slope of this river basin indicate acoustic wipeouts in surface and sub-surface layers (Fig. 3a and b), most of them located at increased depths beyond 500 m (see Fig. 1 for location of the profiles).

In the seismic sections north of Nizampatnam (Profile 2, Fig. 3a); the wipeouts located at depths of 750 to 1800 m result in the weakening of the acoustic character of the surface and sub-surface layers. The surface layer with a high acoustic impedance is cut at several places by a hummocky type of light reflections (marked as G.S. in Fig. 3a) which appear to originate from sub-surface layers and rise above the surface layer. However, at some places the wipeouts in the sub-surface layers are

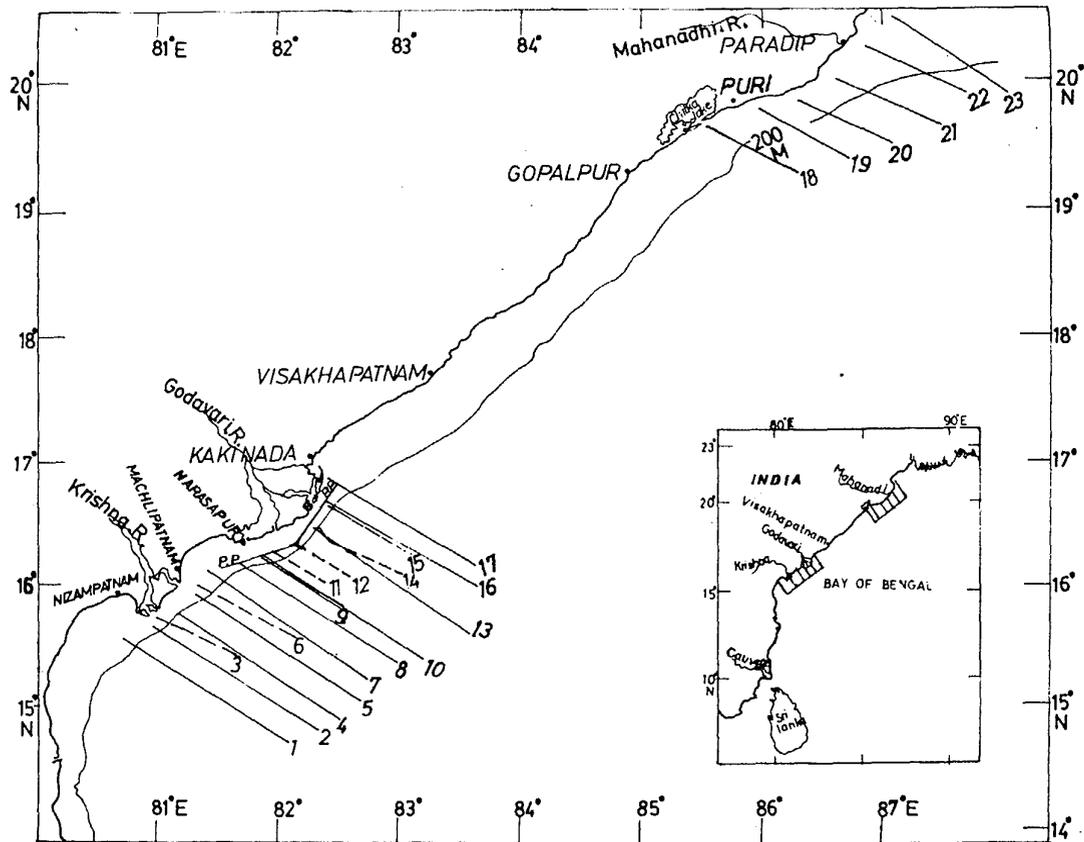


Figure 1. Location map showing seismic traverses off the Krishna, Godavari (Profiles 1 to 17) and Mahanadi (Profiles 18 to 23) river basins.

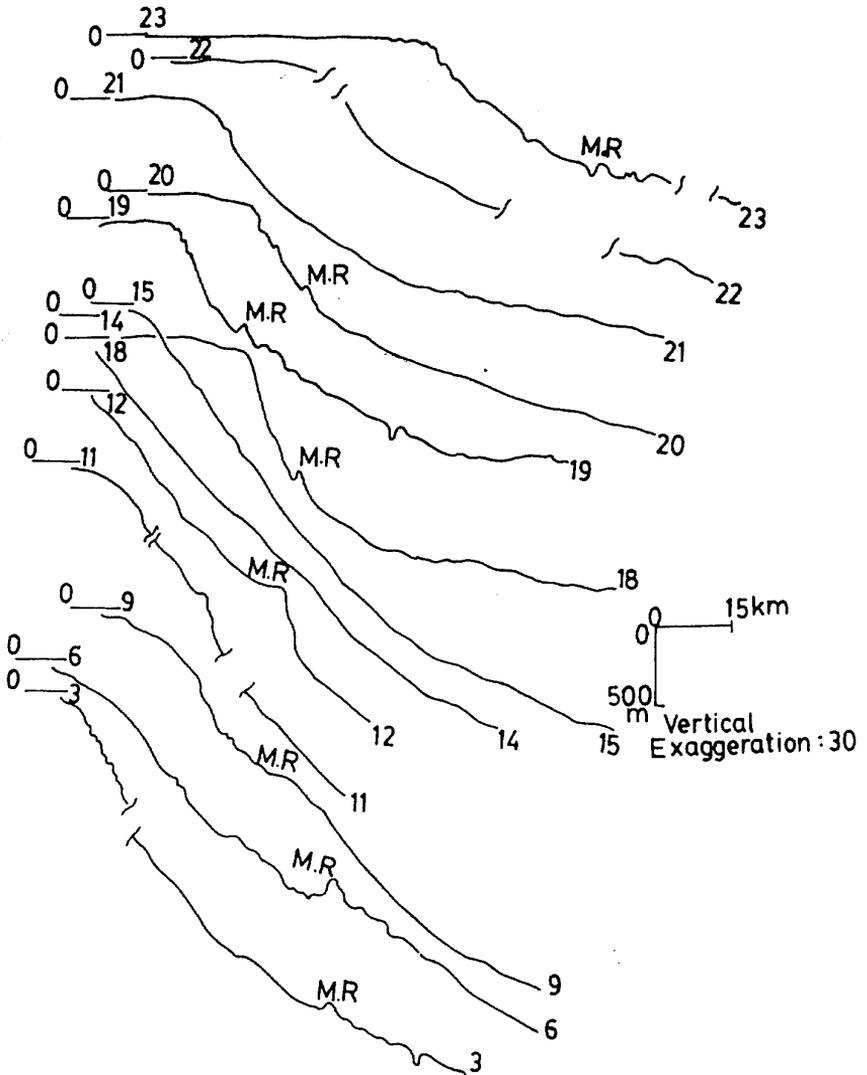


Figure 2. Bathymetric sections off Krishna, Godavari (Profiles 3 to 15) and Mahanadi (18 to 23) river basins.

not reflected in the surface layer which is acoustically strong. In the section off Machilipatnam (Profile 5) wipeouts in the sub-surface layers are observed beneath a faulted and uplifted ridge having a width of more than 5 km over the continental slope at a relatively shallow depth of about 500 m (Fig. 3b). Such uplifts are

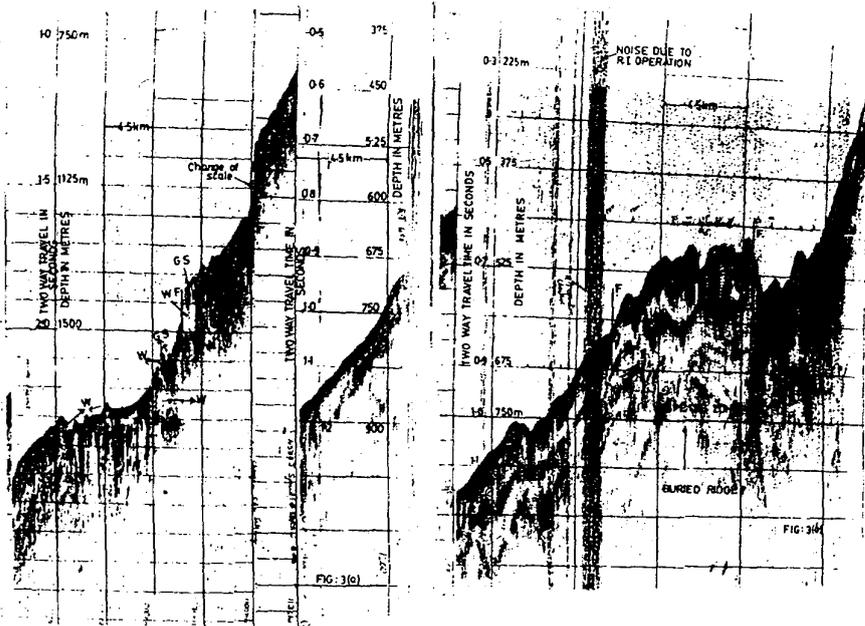


Figure 3. Seismic records off Krishna basin: (a) Profile 2 and (b) Profile 5 (see Fig. 1 for location of Profiles). W = acoustic wipeout; G.S. = Gas seep; F = Fault.

sometimes caused due to an underlying deeper structure like a salt diapir which could only be confirmed by a multichannel seismic survey over this area.

Though the top surface of this ridge is acoustically strong, the sub-surface layers appear to be discontinuous due to acoustic wipeouts. Behrens (1988) reported occurrence of gas/oil seepages beneath such ridges associated with underlying salt diapir off Gulf of Mexico. Acoustic wipeouts in the sub-surface layers due to a faulted continental slope are also observed off Machilipatnam resulting in a break in the continuity of these layers.

Godavari Basin

Sparker seismic record off Narasapur (Profile 9, Fig. 4a) is a typical cross section of the continental slope off Godavari basin over which two types of acoustic wipeouts are observed. In the first type, observed at shallow depths (150–250 m) below the outerslope (marked as GMS, Fig. 4a), the acoustic wipeouts in the sub-surface layer result in a chaotic appearance of the sediments, consisting of dark columns of high acoustic impedance. A transparent layer separates these chaotic sediments from the top surface of stratified sediments. The surface layer is also disturbed and reflects a wavy nature above these chaotic sediments.

Sidner *et al.* (1977) reported such chaotic sediments off Texas continental slope, North America, which from core samples are found to be gas mixed sediments. The

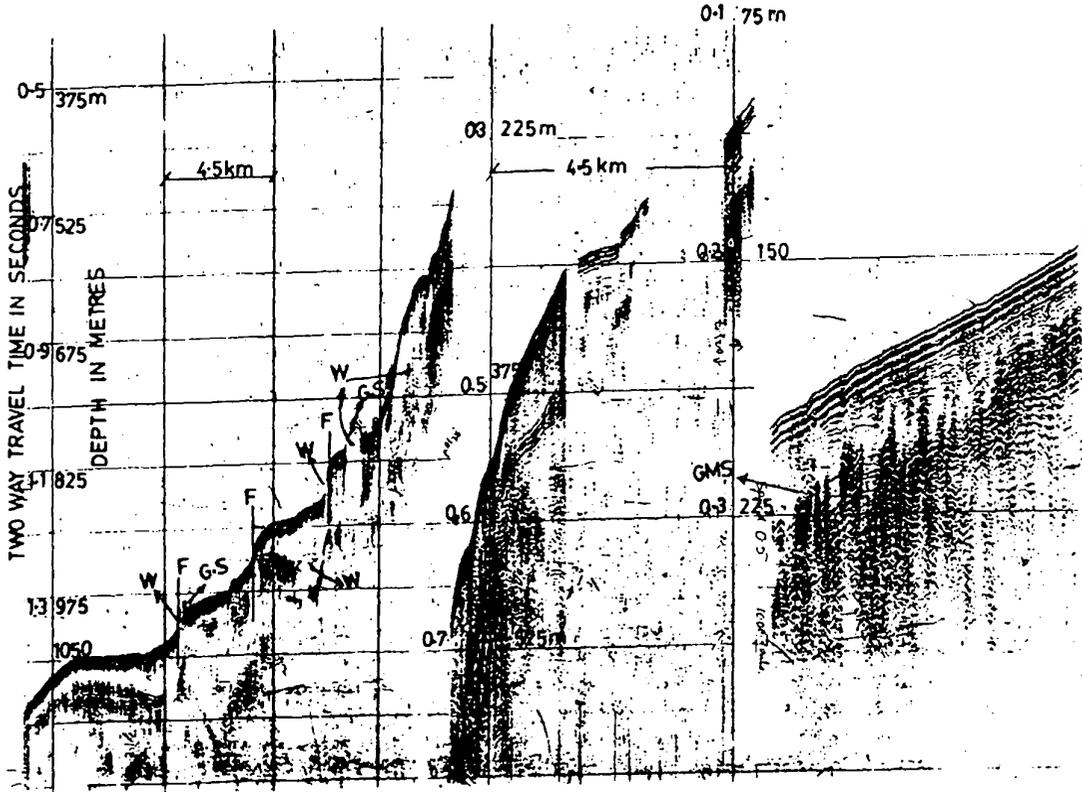


Figure 4a. Seismic records off Godavari basin: Profile 9 (Notation Same as in Fig. 3; GMS = Gas mixed sediments.

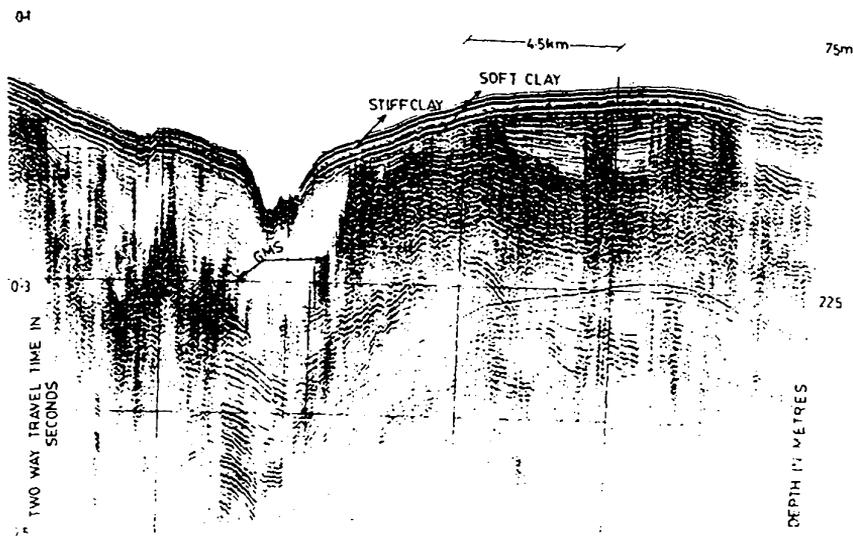


Figure 4b. Seismic record off Godavari basin Parallel profile P.P. Notations as Fig. 3; GMS = Gas mixed sediments.

chaotic appearance varies according to the degree of gas present in these sediments. Higher concentration of gas results in a complete wipeout zone. However, not all acoustic wipeouts are due to gas-charged sediments. Thick sand bodies and reefs also cause acoustic wipeouts (Bryant and Roomer, 1983).

The second type of acoustic wipeouts are observed over the continental slope off Narasapur (beyond 500 m, Fig. 4a), which indicate a definite association with recent faults over the continental slope. At several places, there is a down-throw of nearly 40 to 50 m in the top layer along these faults and the wipeouts appear to originate from deeper depths and reach above the top layer along these faulted contacts, indicating probably the migration of gases. However, wipeouts at faulted contacts are also caused sometimes due to diffraction effect (Sylwester, 1983). Such diffractions generally smoothen the faulted structures. In the present case, the wipeouts appear to be more due to the sub-surface material cutting the top surface.

Seismic record along a parallel profile (Fig. 4b) taken across the Godavari basin (marked as PP in Fig. 1) following a depth of nearly 150 metres shows the extensive nature of the chaotic/gaseous sediments off Godavari basin. The dark bands of the top layer might represent the stiff grey clay reported in this area (Naidu, 1968) whereas the intermediate layer of acoustically transparent nature might represent unconsolidated clay. The gas mixed sediments underlying these two layers are chaotic and in some places resemble dark vertical columns (Fig. 4b).

Mahanadi Basin

The continental margin off this river basin is not covered in much detail. The seismic traverses spaced at a wide interval of 40 km are mostly confined to the

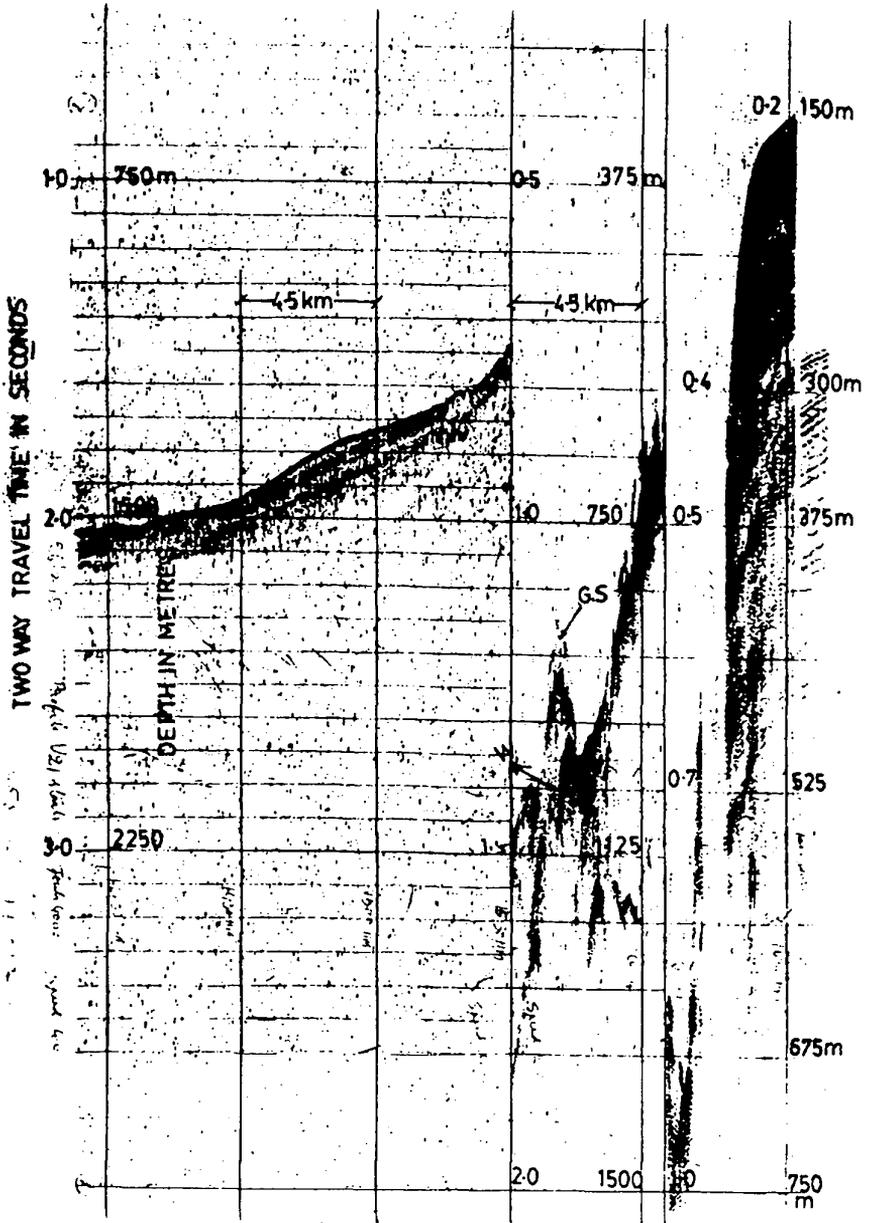


Figure 5. Seismic record off Mahanadi basin (Profile 18). Notations same as in Fig. 3.

southern part of the basin between Chilka Lake and Paradip (Profiles 18 to 23, Fig. 1).

Seismic section off Chilka Lake (Profile 18, Fig. 5) indicates an acoustic wipeout in the surface layer over the continental slope at a depth of around 900 m. The surface layer of high acoustic impedance appears to be cut by a huge heap of light material which rises nearly 150 to 200 m above the top surface. However, bathymetric section along this profile indicates this feature as a topographic rise (marked as M.R. in Profile 18, Fig. 2), and is probably due to lack of penetration. It is also possible that the weakening of the seismic reflection might have resulted due to the shorter time taken to traverse this feature. Acoustic wipeouts, resulting in the weakening of the surface layer are also found to be associated with vertical faults over the continental slope off Paradip.

CONCLUSIONS

High resolution sparker seismic records over the continental slope of Krishna, Godavari and Mahanadi river basins indicate acoustic wipeouts in the seismic signals. In general, two types of such wipeouts are observed. In the first type, located generally at shallow depths (150–250 m water depth), the wipeouts represent chaotic nature of sediments below the top layer, probably due to the presence of gas/oil. These gas mixed sediments are found extensively off Godavari basin at water depths of 150–250 metres (Fig. 4). The surface layer is also disturbed because of these gas mixed sediments which might indicate the migration of gases through to the top surface. In the second type, the wipeouts are mostly located over the faulted continental slope beyond water depths of 500 m. In most cases it appears that the wipeouts are caused at the faulted contacts, probably due to the escape of gases from sub-surface layers, thereby forming a hummock type topography (Fig. 3). However, off Machilipatnam (Krishna river basin), the wipeouts are observed only in the sub-surface layers beneath a faulted and uplifted ridge, the top layer being acoustically strong.

Though acoustic wipeouts are caused due to several reasons, other than due to the presence of gas/oil, their occurrence at deeper depths, along faulted contacts of the continental slopes and the fact that they are observed mostly off the river basins, point to the need for detailed geophysical surveys over these faulted slopes. Collection of core samples over these features as well as gas liquid chromatography analysis of sediments would reveal the cause of the observed wipeouts.

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