

CONTINENTAL MARGIN OF ANDHRA PRADESH: SOME NEW PROBLEMS AND PERSPECTIVES

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The continental margin of Andhra Pradesh from Nellore (14°N) in the south to Baruva (around 19°N) in the north can be classified into two major parts, *viz.*, the non-basinal, Baruva - Visakhapatnam - Kakinada margin and the basinal part comprising the Krishna - Godavari basin and the Nizampatnam Bay. Extensive bathymetric, magnetic, high resolution seismic reflection and gravity data were collected over the margin by the National Institute of Oceanography for the last one decade. Analysis of the data provided significant results on offshore resources and geodynamics and neotectonics of the margin.

Geophysical and geological data revealed heavy mineral placer concentrations in the innershelf of Visakhapatnam - Bhimuniapatnam shelf, palaeochannels beneath the innershelf of Pudimadaka, Gangavaram, Visakhapatnam and Bhimuniapatnam, with probable association of heavy minerals, relict carbonates in the outershelf of Visakhapatnam and Kalingapatnam. In the K-G offshore basin, zones of gaseous sediments and gas seepages were located in the shelf and slope regions.

Interpretation of geophysical data brought out clear evidence of neotectonic activity associated with the structural lineaments extending into the innershelf of Visakhapatnam - Vizianagaram region of the non-basinal part, and also delineated Pranhita- Godavari Gondwana graben and two other oldest Pre-Cambrian Chintalapudi and Avanigadda cross trends into the offshore K-G basin. An isolated volcanic source of limited lateral extent is also located off Machilipatnam in the K-G basin at the foot of the continental slope, at around 3000 m water depth.

These preliminary findings suggest that the exploration of the Andhra Pradesh margin should be followed up more vigorously to infer its neotectonics and geodynamics and to identify targets for exploitation of non-living resources.

Introduction

The continental margin of Andhra Pradesh between Nellore and Baruva (14°N to 19°N, 80°E to 84°E) stretches to about 300 nm in length (Fig 1) and covers a distance of about 50 kms into the sea (0 to 3000 m water depth). The southern part between Nellore and Kakinada comprises of the Krishna - Godavari (K-G) offshore basin and the Nizampatnam Bay. The northern part between Kakinada and Baruva is devoid of any major rivers joining the sea, except small rivulets like Gosthani, Nellimarla, Kandivalasa, Nagavali and Vamsadhara. The coastal region of the northern part is associated with NE-SW and NW-SE trending hills of the Eastern Ghat Complex.

Oceanographic studies over the continental shelf of Andhra Pradesh were initiated in 1950's under the leadership of Prof. E.G Lafond, a renowned Oceanographer

from Scripps Institute of Oceanography USA. Under his guidance, scientists from Andhra University, Visakhapatnam have collected significant preliminary information on waves, tides, currents, shelf topography, water chemistry and biology of the Visakhapatnam shelf. Subsequently, the Oil and Natural Gas Corporation (ONGC) has become the leading organisation for geophysical studies in the K-G basin as a part of their hydrocarbon exploration. The K-G basin in Andhra Pradesh has now become an important target next only to the Bombay High. Geological Survey of India, Marine Wing, National Institute of Oceanography (NIO), and so many other organisations as well as several Departments of Andhra University accelerated their research work over this margin during the last decade.

In this paper, significant results obtained from detailed analysis of bathymetric, magnetic, high resolution seismic and gravity surveys over the Andhra Pradesh margin are reviewed and vital aspects are identified on which immediate attention should be focussed in planning geophysical surveys.

Shelf Topography

The shelf- slope characteristics of the eastern continental margin of India (ECMI) were summarized by Murthy, et al. (1993) from bathymetric data collected at 10 n.m. interval traverses (Fig. 1). The shelf - break in the northern part of the non - basinal area occurs at about 200 m of water depth, with a shelf width of about 50 km, whereas in the southern part the width is only 25 km with shelf break at about 70 m water depth (Fig. 2). The shelf gradient is relatively gentle in the north. The foot of the continental slope occurs at about 2000 m in the north and at 2500 m in the south. The transition from continental to oceanic crust, the Continent - Ocean - Boundary (COB) occurs at the foot of the continental slope (Murthy et al., 1993, Gopala Rao et al., 1997). Location of this slope helps in the palaeo-reconstruction of the Indian plate since its break-up from Antarctica in Early Cretaceous (126 Ma). The surface sediments in the northern

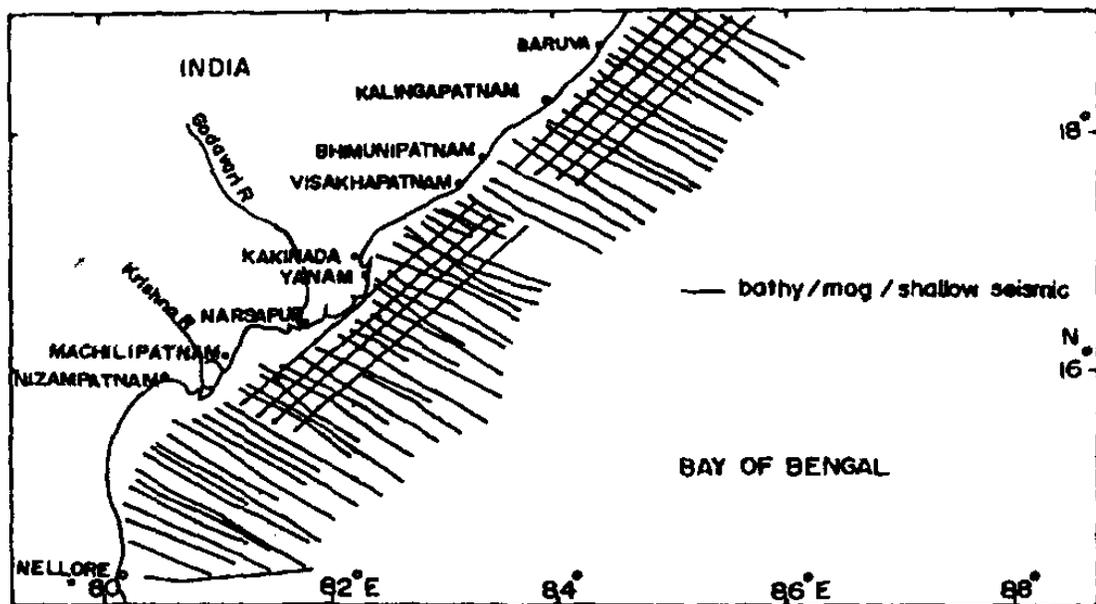


Fig. 1 : Geophysical Survey tracks over the Andhra Pradesh Margin

part are divided into four zones, viz., sandy (0-30m), clay (30 - 60 m), shell zone (60 - 100 m) and concretion zone (100 - 200 m) (Mahadevan and Poornachandra Rao, 1954). Subba Rao (1964) reported a zone of calcareous rich sediments off Visakhapatnam at 90 to 140 m water depth. The surface sediments of the K-G basin are mostly recent deltaic sediments and predominantly clayey in nature.

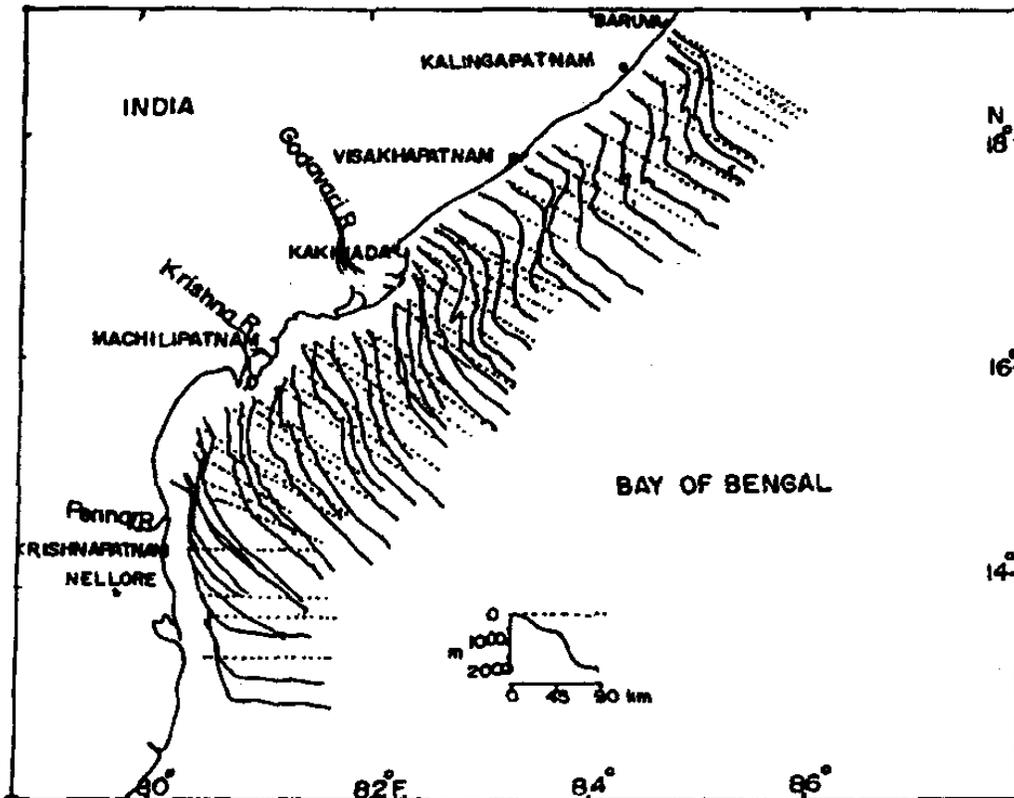


Fig. 2 : Bathymetry sections over the Andhra Pradesh Margin

Inferences from geological and geophysical data

Baruva - Visakhapatnam - Kakinada margin :

Placer deposits are located in the innershelf of Visakhapatnam - Bhimunipatnam (Fig. 3) mainly at Ramakrishna Beach and Lawson's Bay in Visakhapatnam City, at Bhimunipatnam Bay (see Fig. 1 for location) and at Uppada Bay in between. Sediment samples from these areas revealed that the heavy mineral concentration varied from 20 to 40%, and contains magnetite, ilmenite, zircon, garnet, sillimanite, rutile and kaonite. Magnetic anomalies and sediment samples in these shallow water bays also indicated an inter-relationship between heavy minerals, structural lineaments like fracture zones and the drainage channels reported on land (Subrahmanyam et al., 1991). Three palaeochannels were located from shallow seismic records off Bhimunipatnam, Gangavaram and Pudimadaka below the seabed, nearly 40m beneath the innershelf. These palaeo channels are economically important since they were active carriers of heavy minerals in the Late Holocene (5000 yrs B.P.).

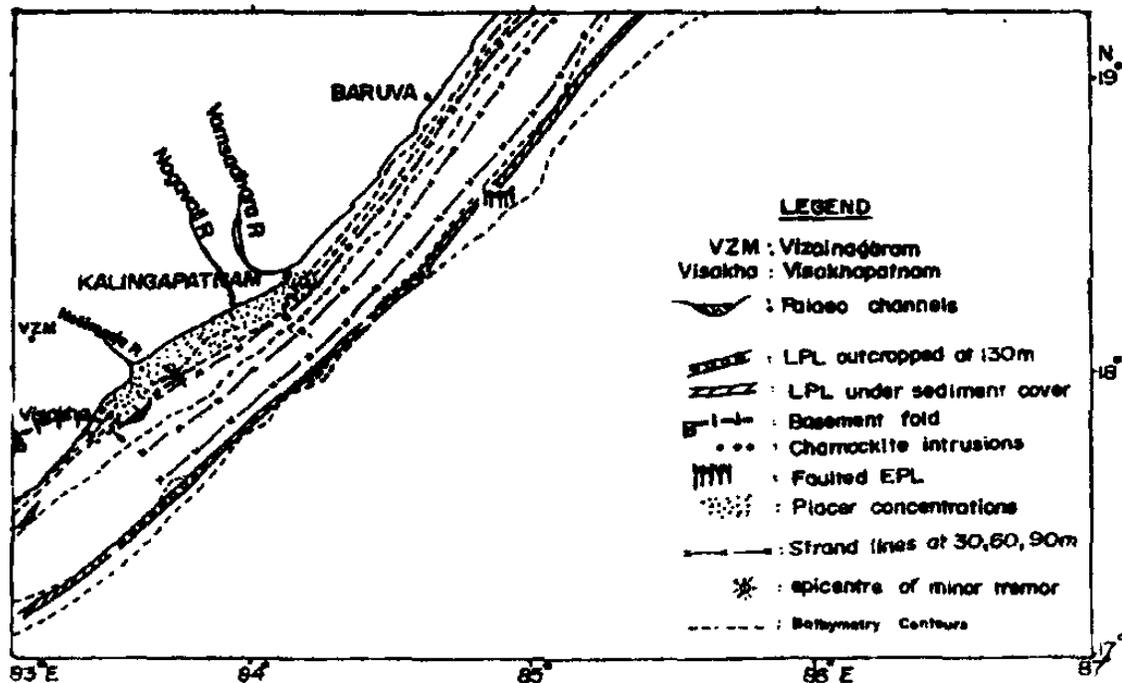


Fig. 3 : Summary of salient features observed from the geophysical data of the Kakinada - Baruva part of Andhra Pradesh margin.

Four relict strandlines at 130, 80, 60 and 30 m water depths (Fig 3), representing different phases of the sea level transgression since late Pleistocene glaciation (18000 yrs to the present) were identified from shallow seismic data of the outer shelf (30 to 200 m water depth) of Visakhapatnam -Kalingapatnam Shelf (Mohana Rao and Rao, 1994). The strandlines were identified from the seismic records as linear trends of relict features like terraces, reefs, pinnacles etc, running parallel to the coast. They are generally associated with strong seismic reflections with high acoustic impedance, thereby suggesting hard and compact nature of these features. The Early and Late Pleistocene layers, EPL and LPL (Fig. 3) are palaeoshelves related to different sea level transgressions and regressions. The relict features were sampled at different places along the shelf width and radio carbon dating was carried out from the relict samples. Thus an estimation of age vs. sea level change was established for the Visakhapatnam shelf (Mohana Rao and Rao, 1994). The outer shelf (50 - 200m w.d) off Visakhapatnam to Kalingapatnam thus forms an area of extensive relict carbonates.

Magnetic and gravity data along coast parallel transects indicate offshore extension of several coastal cross trends of basement rocks. A major fold axis, the Tuni ~ Visakhapatnam fold axis reported onshore (Sriramdas and Rao, 1979), was delineated upto 30m into the innershelf off Lawsons Bay in Visakhapatnam City from magnetic anomalies. Analysis of magnetic data also revealed offshore extension of charnockitic intrusions into innershelf on either side of the fold axis (Fig 3). Marine magnetic anomalies off Vizianagaram shelf also revealed offshore extension of fracture zones associated with Kandivalasa and Nellimarla rivers joining the sea at Vizianagaram coast. Modelling of magnetic data also suggested a faulted basement beneath the innershelf off Vizianagaram. It is significant to note that the epicenter of a

minor tremor observed on 18th Dec., 1995 was located off Vizianagaram in the Bay of Bengal at about 15m water depth, coinciding with the rock outcrops (Santapalle rocks) at this water depth. This epicenter falls in line with the offshore extension of the structural lineaments associated with the Kandivalasa and Nellimarla rivers (Murthy et. al 1998), thereby suggesting neotectonic activity associated with these lineaments.

Krishna - Godavari Basin :

The significant results from the southern part of the Andhra Pradesh margin (mainly the K-G basin) are summarized in Figs 4 and 5.

Analysis of marine magnetic anomalies of the K-G basin delineated five major tectonic trends (I to V, Fig 5). Trends I and II corresponds to the offshore extension of the old Pre-Cambrian trends in the K - G basin viz., the Avanigadda (ACT) and Chintalapudi (CCT) cross trends respectively. Trend III corresponds to the Ocean - Continent Boundary (OCB) located at the foot of the continental slope, at 3000 m water depth. Demarcation of OCB is important both for hydrocarbon exploration in deep sea part of the basin and in positioning the Indian Plate with respect to the Enderby Land of east Antarctica in the geodynamic studies of eastern Gondwana land (Murthy et al 1995). Trends IV and V correspond to the offshore extension of Bapla - Kaza ridge and Yanam cross trend respectively (Fig 5).

Marine magnetic and gravity data as well as SEASAT geoid data revealed an isolated source off Machilipatnam located at the OCB near the foot of the continental slope (marked as W, Fig5). The limited lateral extent of the source was suggested from

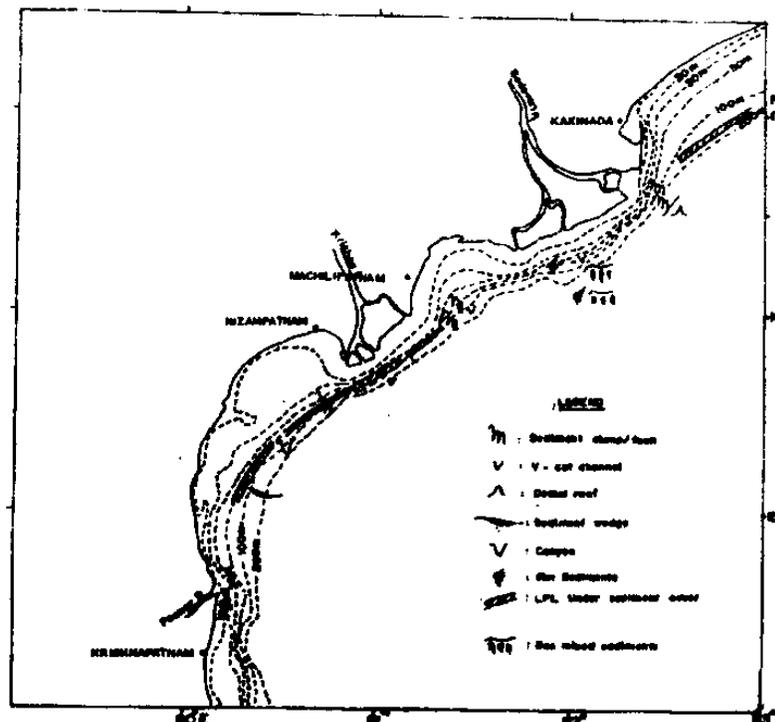


Fig. 4 : Summary of the salient features observed from the geophysical data of the K-G basin and Nizampatnam Bay of Andhra Pradesh margin.

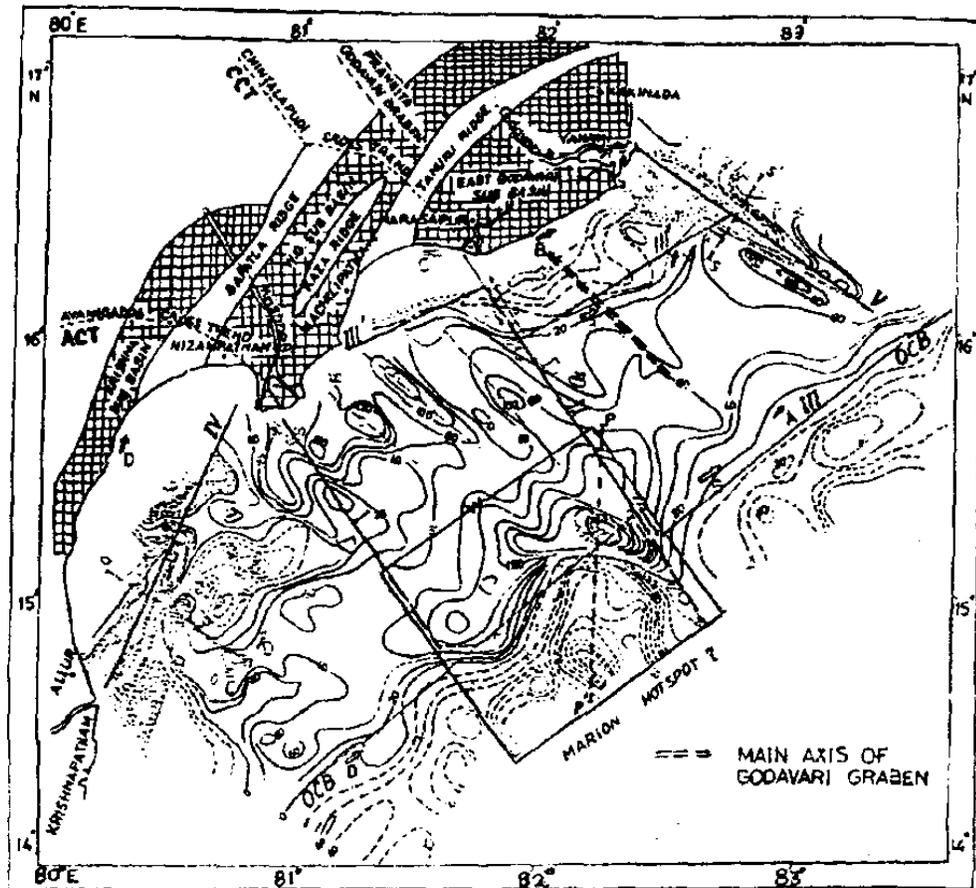


Fig. 5 : Total intensity magnetic anomaly map of K-G basin with significant tectonic lineaments. Contour interval 20 nT.

the gravity and magnetic anomaly contours (Murthy et al, 1995), whereas multi-channel seismic reflection data (Gopal Rao et al, 1997) over this feature indicated a hump of oceanic crust, having contrasting seismic character with the surrounding basement. These geophysical signatures when correlated with the geodynamic history of the K-G basin lead to the view that this anomaly off Machilipatnam might either represent a submerged volcano (Venkateswarlu et al, 1992) or a hot spot trace (Murthy et al, 1995).

High resolution seismic reflection (Sparker) data of the K - G basin revealed extensive zones of gaseous sediments, particularly off Narsapur and Machilipatnam. Seismic signatures associated with gas seepages generally are of chaotic nature and columnar in appearance, suggesting escape of gases from underlying sediments to the sea surface. Sparker records of the K - G basin indicate two types of such gas mixed sediments (GMS, Fig 4), apart from the general geomorphic features like sediment slumps, v-cut channels, canyons, fan shaped sediments, Late Pleistocene layers (LPL), etc., (Fig 4). In the first type, observed over the continental shelf, gas mixed sediments are columnar in nature with chaotic seismic signature, while in the second type gas seepages associated with the faulted contacts of the continental slope are common phenomenon. Though quantitative estimates of these shallow gases have not been made, this region is an ideal target for exploration of shallow gases.

Discussion :

Considerable new data with significant results were obtained over the continental margin of Andhra Pradesh ever since the initial work of Andhra University in 1950's, initiated by Prof. E.C Lafond. It appears from these results, that the future plan of R&D and exploration work over this margin might be of two fold nature: (1) exploration for the non-living resources and (2) research related to the geodynamics and neotectonics of the region.

Exploration : As far as the exploration part is concerned, a systematic work on heavy minerals of the beaches and innershelf is quite essential. Recent studies by the Atomic Minerals Directorate for Exploration and Research, Visakhapatnam and Hyderabad and the Atomic Minerals Division, Bangalore indicate vast areal extent of placer deposits in the north Andhra Coast, with considerable high percentages of ilmenite, garnet, Siilimanite, rutile, zircon and Monazite. On the Bhavanapadu coast of Srikakulam District, for example, the estimated reserves of total heavy minerals was worked out to be of the order of 29.78 million tons (Rao et. al 1998). In contrast, not much quantitative work has been attempted on the innersheif placers, though there is a clear indication of heavy mineral concentrations in the offshore region of north Andhra coast.

The relict carbonates (calcium and magnesium) of the outershelf of Visakhapatnam - Kalingapatnam margin are a potential source of building material, though it is too early to estimate the economics involved in the exploitation of these deposits located at about 50 - 200 m water depth.

The other source of economic importance is the shallow gases associated with the offshore basin. A quantitative estimate of the amount of methane available in the shallow gases of the K-C basin should be attempted and their utility as an alternative fuel source for coast based small scale industries must be assessed. Only some zones of shallow gas accumulations have been identified so far from high resolution seismic reflection data and it is quite essential to extend these studies at least in some selected places of Godavari basin (off Narsapur for example), where seismic data indicate considerable gas seepages and gaseous sediments.

Geodynamics and neotectonics : On the research front related to geodynamics and neotectonics, the immediate task is to generate a tectonic lineament map of the continental margin of the Andhra Pradesh including the mapping of marine geohazards. Recent studies indicate several cross trends extending into the sea. The nature of these trends must be substantiated with additional geophysical data, particularly the Avanigadda and Chintalapudi cross trends, the Pranhita - Godavari graben trend, the Continent - Ocean crustal Boundary (COB) and several minor trends off Visakhapatnam and Vizianagaram, identified from only a single parameter like magnetic or gravity. The neotectonic activity associated with these trends should be studied, in view of the recent views on the stability of the south Indian shield (Murthy, 1994, Murthy et. al., 1997.) One significant feature observed from almost every geophysical parameter (shipborne gravity, sea-sat, magnetic, multichannel seismics) is the probable volcanic source off Machilipatnam in the K-G basin which needs a detailed study. Magnetic, gravity and multi-channel seismic data over a rectangular grid of 100 x100km might

be planned over this isolated source. The data must be analysed with 2-D and 3-D models and the lateral and vertical boundaries of the source might be estimated. Its origin must be analysed in relation with the movement of the Indian plate since Early Cretaceous (126Ma). Its origin and nature will have a significant role both on the geodynamics of the Indian Plate and also the hydrocarbon accumulation of the deep sea basin.

In recent times, the State of Andhra Pradesh has shown rapid progress in the field of Information Technology. However, it might be, remembered that the state has a vast resources of non-living resources as well, in the coastal and offshore regions, which when tapped properly might lead to an equal revolution in the industrial front as well.

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