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# Very Shallow Gas Potential in Krishna-Godavari Basin

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## Summary

*In the scenario where Natural Gas is increasingly gaining credence all over the world as a clean eco-friendly fuel for various energy needs, it becomes imperative on the part of explorationists not to ignore the possibility of exploitation of gas from settings other than conventional, however small the potential may be. It is here that Krishna Godavari basin has been indicating, in the form of gas seepages and gas activity at very shallow depths (in boreholes) at various locations over the years, a possibility of commercial gas in unconventional settings. Looking at the successful exploitation of shallow gas elsewhere in the world, a need was felt to make an attempt to study the phenomena of gas seepage/activity at shallow depths in the KG Basin. ONGC is currently concentrating its efforts on shallow gas exploration ranging from 200- 600m, whereas the present study deals with very shallow occurrence of gas ranging from 10-200m.*

## Introduction

Krishna Godavari Basin hinted the presence of its hidden treasure of hydrocarbon potential through Gas seepages. In 1944 Geological Survey of India reported gas seepage near Tatipaka village of East Godavari district. It is said that a rice miller used the seeping Gas to boil rice for more than a year.

The relentless exploratory efforts by ONGC lead to a good number of oil and gas strikes in KG Basin ranging in age from the oldest Permo-Triassic Mandapeta sandstone to the youngest Pliocene reservoirs within Godavari clay. The depth range of the known hydrocarbon accumulations range from 4444m to 510m .

A good number of gas seepages have occurred at places covering a large part of the KG Basin reported at various times over the years by the local population during drilling of bore wells for water and, by other agencies like ONGC (during seismic shot hole drilling) and AMD (while exploring for heavy minerals) (fig:1). Some of these gas seepages have been investigated by ONGC

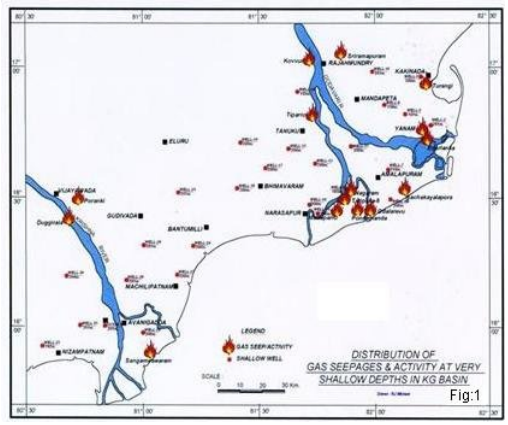


Fig:1

In the light of commercial viability of shallow/very shallow gas exploitation elsewhere in the world and our experiences of striking shallow gas reservoirs in Sitarampuram, Kesavadasupalem etc, it becomes necessary to put in perspective the relationship between the surface gas seepages vis-à-vis the commercial shallow gas occurrences in the basin so that a deliberate attempt may be made to explore for very shallow gas (10-200m)

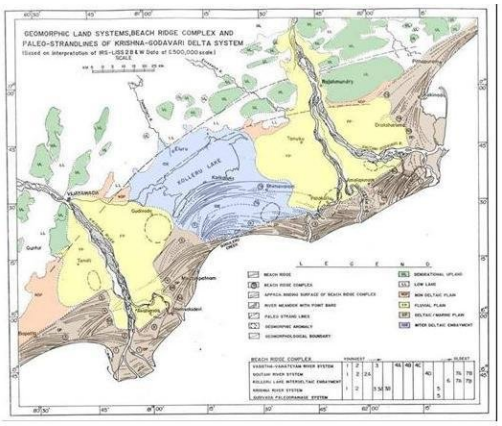



Fig:3

## The Approach

This study is an endeavor to document the surface gas seepages so far reported and their comparison with gas characteristics of various gas fields within the basin for genetic correlation. Subsurface structural influence/control if any is also analyzed. In addition, the anomalies of surface geochemical attributes wherever surveyed are studied in the light of these seepages/very-shallow gas occurrences.

The study documents the reported gas seepages/activity at shallow depths in KG basin and attempts to decipher its genesis. The top 200m section of Recent sediments is studied by utilizing all the available geological data of shallow bore wells drilled by ONGC. An attempt was also made to understand the relation of these near-surface gas occurrences/seepages to the subsurface, through available seismic data.

## Background

In eastern China Late Quaternary shallow biogenic gas reservoirs have been discovered and commercially exploited (Lin et al, 2004). The gas occurs in flood-plain sand bodies of thickness 3-10m and at depths of 30-60m. The main hydrocarbon sources are dark gray clays of flood-plain facies and gray muds of sublittoral-marine bay facies (fig.2)

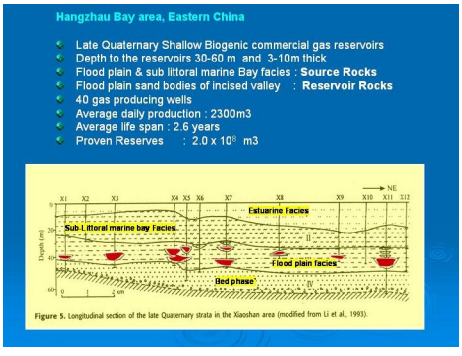
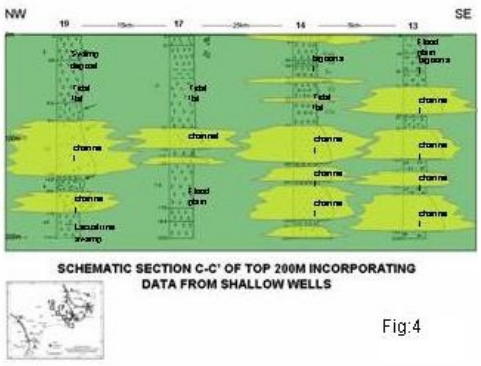



Fig: 2

## Geology of the top 200m section of recent sediments in KG Basin:

The outcrops of gently dipping older formations skirt the periphery of the basin. Further basin ward upto present-day strandline the area is draped by the alluvium, the flood plains, the deltaic and the marginal marine sediments of Recent age. The geomorphology of the area (fig.3, Feroze Dotiwala et al, 1993) based on the interpretation of satellite imagery indicates development of landforms ranging from abandoned channels, Oxbow lakes, Fluvial marsh, Swamps, Lagoon, mangrove swamps, Beach ridges, Spits, Barrier bars etc encompassing fluvial to fluvial-marine to open-marine environmental conditions.

ONGC drilled shallow wells to 200m at various points in the delta areas of Krishna and Godavari rivers to study and bring out sedimentation model for the recent delta sediments during 1976-84. Detailed laboratory studies (sedimentalogical, geochemical, paleontological and palynological) of the cores were carried out and integrated by K.Satyanarayana et al, 1985.




SCHEMATIC SECTION C-C' OF TOP 200M INCORPORATING DATA FROM SHALLOW WELLS

Fig:4

The lithofacies distribution within the top 200m section along the selected shallow wells indicates a good distribution of clay/claystone capping thin to thick reservoir sands. The environments of deposition ranges from fluvial to transitional to marine (based on study of cores by K.Satyanarayana, et al, 1985) and generally correspond to the overlying present day surface geomorphic features.

The section A-A' along various shallow wells indicates predominantly argillaceous facies with good development of arenaceous facies in the respective delta areas. (figs.4)

## Gas seepage/ shallow gas occurrence in Krishna Godavari basin:

Fig.1 shows the gas seepages so far reported within the geographical extent of the KG basin and brought to the notice of ONGC. The locations of the gas seeps are associated on the surface with a diverse set of present day geomorphic features like Beach ridge complex, flood plains, paleochannels, uplands etc. The following is an attempt to look at the geological setting and possible causatives for the unique occurrence of gas seepages.

**Tiparru village**:

Gas activity from shot hole at 10m. Gas composition - CH4:87.74% C2:0.29, C3:0.75%, C4:0.18%.The surface geomorphology indicates presence of flood plain deposits of Godavari River and in the subsurface the section in the nearby shallow well no.16 shows dominantly finer clastics of flood plain/Lacustrine deposits interspersed with channel sands indicating good reservoir and capping mechanism.

**Poranki village**:

Gas activity from bore well at 40m,Gas composition: $CH_4$: 87.03%,$N_2$ :6.7%, $CO_2$- 6.27%. The area has dominantly finer clastics of flood plain and mangrove

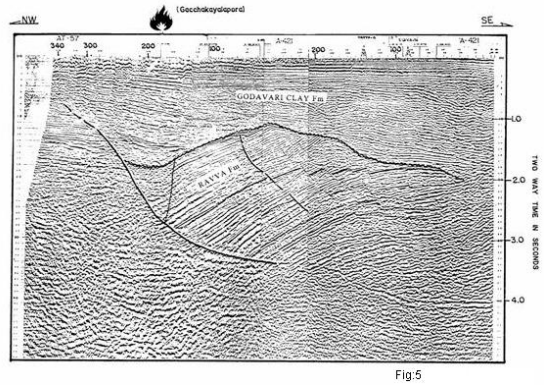


Fig:5

swamp interspersed with channel sands indicating good reservoir with capping mechanism

## Gachakayalapura coastal village:

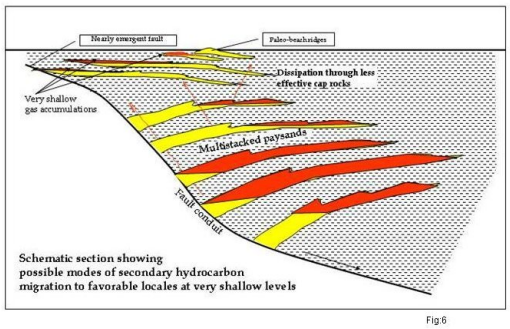


Fig:6

Gas activity in the Borewell - Inflammable Gas flowed for one year – Analysis is not available. The location falls on the downthrown side of the Mio-pliocene structure building fault close to coast. The seismic profile (fig.5) across the location depicts the major Mio-Pliocene growth fault responsible for Ravva structure. The present day lagoon in the area is a surface expression seen continuing in the subsurface as a subtle depression on the down side due to continued activity of the growth fault. It is possible for the gas to migrate from deeper reservoirs along the structure-building fault upto the Mio-Pliocene unconformity and then dissipate upwards to the surface across Godavari Clay Formation. In this case, a number of discrete distributions of gas accumulation near to surface may be expected along the structure-building fault depending upon the disposition of the paleo-beach ridge complexes at the surface along the coast (Fig: 6)

**Keasanapalli coastal area**:

Gas activity in the seismic shot holes at 45m(fig: 7). Inflammable gas along with water blew out to a height of 10m. The surface geomorphology around the area indicates paleochannels of
Vaineteyam-Godavari River along with beach-ridge complex. The 200m section in the nearby shallow well indicates exposed beach-ridge sand followed by prodelta deposits interspersed with delta front sands and distributary mouth bar sands (Fig: 7)

## Gas-characterization and Correlation studies pertaining to shallow gas shows in K.G. Basin.

A regional study carried out by ONGC suggests that the gas type generally correlates with the age of the Source-Reservoir rocks. The Thermogenic gas occur in the Pre-Tertiary rocks, a mix of Thermogenic-Biogenic gas in the Early-Middle Tertiaries and Biogenic gas in the late Tertiary and younger sequence.

Surface Geochemical surveys carried out by ONGC in the areas of Ponnamanda-Komarada, Vadaparru-Bandamurlanka, and Endamuru in East Godavari and Northern flank of Tanuku Horst and Mahadevapatnam-Bantumilli in West Godavari indicate the presence of Methane, Ethane and Propane in all samples and I-Butane and n-Butane in most of the samples and Iso-pentane in 60% of the total number of samples. Presence of hydrocarbon $C_1$ to $C_5$, in these samples is suggestive of upward migration of hydrocarbons from subsurface. The concentration ranges of hydrocarbons and their ratios like Bernard ratio ($C_1 / C_2 + C_3 < 10$) indicate that these gases are of catagenetic origin.

Fig:7

## Discussion:

The geomorphology (fig.2) of the onland area is manifest with many features that point towards **Neotectonic activity** within the basin (Biswas, 1993, and Feroze Dotiwala et.al, 1993, Prasad et al, 2003). This is further evidenced by occurrence of earthquakes (Brijesh K.Bansal, 1998). All of this is manifested in the form of a few active/reactivated emergent faults at places along the strike.

Studies carried out in Gulf of Mexico (Losh, 1998) indicate a major Growth fault acting as conduit for hydrocarbon migration from deep to shallower levels. However, the main controlling factor is the continued growth fault activity especially during hydrocarbon migration.

From the above analysis of the geological factors, in each of the gas seep phenomenon, it is evident that there exists a direct relation with the deeper commercial accumulations. The magnitude of upward migration and accumulation at very shallow depths may vary at different locations depending upon the required conditions of reservoir, cap, and trapping mechanism. The structural component in terms of a closure at very shallow levels is apparently negligible and any accumulations that are found are mainly due to stratigraphic features.

The lithofacies distribution within the top 200m section along the selected shallow wells indicate a good distribution of clay/claystone capping thin to thick reservoirs providing a good sealing mechanism for any hydrocarbon accumulations. Based on carbon dating of lignites samples in some shallow wells the sedimentation rate is inferred to be rapid in the deltaic areas compared to inter-deltaic areas.

**Suggested Strategy**: The shallow accumulations appear to have dispersed in the entire basin just like nectar in flowers. They can cater the needs of small consumers only. It is not wise to search for honey combs at such shallower depths. It is very much essential to assess the potential of these gas reservoirs by drilling a shallow well near the known occurrence. After identifying the pay zones it is worth going for shallow resistivity survey to chase the known gas sand to know its extension. In Alberta such reservoirs were tracked by air borne electromagnetic surveys (fig: 8). As

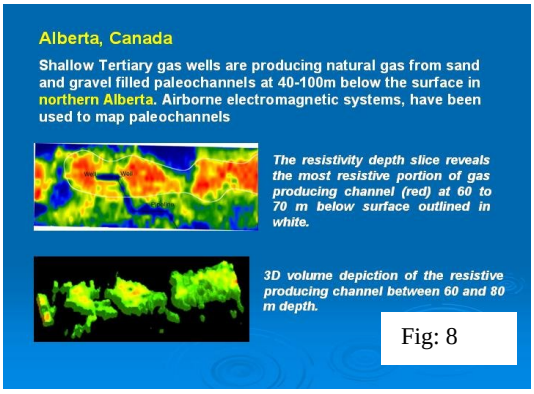



Fig: 8

evident from china example each well may contribute less than one million cubic meters of gas in total. In such a case one can not afford to drill such wells by deep rigs. A well equipped truck mounted mini rigs will be ideal to drill these wells. A well cost of not more than 1, 00,000 rupees ($2000) is viable. The bores can be cased with PVC pipes upto the top of the known reservoir to produce gas. Each shallow well in this regard can be assumed as one perforation into the reservoir.

## Conclusion:

- The gas seep/shallow gas accumulations so far reported are distributed all over the KG basin.
- The composition of most of these gas seep/shallow gases indicates dominantly Methane with less higher fractions.
- Broadly the gas seeps/very shallow gas occurring along the coast seems to be related to deeper accumulations.
- The presence of multitasked hydrocarbon pools in some of the fields in the coastal tract, distributed through deeper reservoirs to as shallow as 510m coupled with the surface gas seepage/activity at very shallow depths is a fair indication of active hydrocarbon redistribution/migration to shallower levels through mainly fault conduits and point towards existence of still shallower hydrocarbon pools, subject to favorable trapping mechanism.
- Neotectonic activity as evidenced by geomorphic features, emergent faults at places and seismicity within the basin is substantiation towards the inference relating the surface gas seeps/very-shallow gas accumulations to deeper accumulations.
- The gas seeps occurring at the basin margins and at the flanks of highs in West Godavari areas are inferred to be related to deeper accumulations, based only on their geological setting, as there is no data regarding isotopic composition.
- The gas seeps are associated on the surface with diverse geomorphic features like Paleo-beach ridge complex, flood-plains, uplands and mangrove-swamp/lagoonal complex. The lithofacies distribution within the top 200m section along the selected shallow wells indicate a fair distribution of clay/clay stone capping thin to thick reservoirs providing a good sealing mechanism for any hydrocarbon accumulations.
- In terms of a favorable setting for gas accumulations at very shallow depths in KG basin, the widely distributed paleo-beach ridge complex with an overlapping flood-plain offers the best conditions.
- The shallow bores can cater the needs of small consumers only They are viable only when their cost is around 1, 00,000 rupees ($2000) as their potential at very shallow depths can be less than a million cubic meters.

## Acknowledgement:

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