ID no- 2004548

Shale Gas – A Matter of Innovation: Potential of Shale Gas Exploration in Cambay – Tarapur Tectonic Block of Cambay Basin

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Abstract

Shale gas has the potential to fill the India's energy basket with rich Almonds, because it's abundant, cheap & burns cleaner than fossil fuels. Shale basins in India are highly prospective & the same time geologically highly complex, but innovative exploration techniques & highly technological approach can leads to change the future of unconventional energy. This paper is mainly containing 1) The method to assess the shale gas potential in an area 2) A unique study on future prospective of the shale formations of the Cambay – Tarapur tectonic block in Cambay basin. 3) The method to prepare well log profile for Shale Formation Assessment. The Shale Formation from the different fields of Cambay – Tarapur area have been analysed and the most prospective areas have been identified based on the Well logs, Depth, Shale thickness, Shale characteristic, Gas show while drilling, Core & Cutting data supported by Geo chemical data (VRo Value, Maturity value & TOC etc). The sophisticated well log profiles have been prepared & analysed with integration of the all above data, based on this well logs profiles along with all supportive geological & geochemical data, the most potential areas of Cambay – Tarapur block can be prognosticate for Shale Gas prospective.

Introduction

Unconventional sources of energy are one of the hot topics of debate in the international energy sector at the moment. Shale is a fine-grained, Clastic sedimentary rock composed of mud that is a mix of flakes of clay minerals and tiny fragments (silt-sized particles) of other minerals, especially quartz and calcite.

Shale has low matrix permeability, so gas production in commercial quantities requires fractures to provide permeability. Shale gas has been produced for years from shales with natural fractures; the shale gas boom in recent years has been due to modern technology in hydraulic fracturing to create extensive artificial fractures around well bores. Horizontal drilling is often used with shale gas wells, with lateral lengths up to 10,000 feet (3,000 m) within the shale, to create maximum borehole surface area in contact with the shale. The gas is produced by inducing fractures preferably by water from multilevel completions. The pressures are generally low but the length of production period compensates by volume.

Shale Gas in India

India has huge shale deposits across the Gangetic plain, Assam, Gujarat, Rajasthan, and many coastal areas. India contains a number of basins with organic-rich shales, mainly the Cambay, Krishna Godavari, Cauvery, and Damodar Valley basins. There are some other potential reserves such as the Upper Assam, Vindhyan, Parinhita- Godavari, and South Rewa, but it was found that either the shales were thermally too immature for gas or the data with which to conduct a resource assessment were not available.

Shale basins in India are geologically highly complex. Many of the basins, such as the Cambay and the Cauvery, have horst and graben structures and are extensively faulted. The prospective area for shale

gas in these basins is restricted to a series of isolated basin depressions (sub-basins). While the shales in these basins are thick, considerable uncertainty exists as to whether (and what interval) of the shale is sufficiently mature for gas generation.

The Study Area

The Cambay Basin is an elongated, intra-cratonic rift basin (graben) of Late Cretaceous to Tertiary located in the State of Gujarat in north-western India. The study area comprises of Cambay-Tarapur block in Cambay Basin, lying between the Mahisagar and vatrak rivers, the Cambay-Tarapur block is semi circular in shape with a large number of structures on its peripheries. The block is a comparatively shallow syncline containing about 3000m of Cenozoic sediments. Some of the fields in this block are Cambay, Akholjuni, Kathana, Siswa, Anklav, Chaklasi, Nadiad and Vadatal (Fig 1).

The focus of this study is to look for any hydrocarbon presence found in cambay shale. The cutting samples, conventional core, SWC and Laboratory data including geochemical analysis were studied. Also, any gas and hydrocarbon show encountered during drilling in mud and else way has also been given preference. The logs of studied wells are also studied and graphical presentation of any findings is given on logs.

Lithological Description of Cambay Shale in Cambay-Tarapur Block

The Cambay Shale formation is composed of dark grey to black fissile shale, non calcareous, often pyritic, and rich in organic matter with minor siltstone streaks. Prominent bands of carbonaceous matter and coal are present in the formation. Locally oolitic claystone are present. The sequence is inferred to have been deposited during lower Eocene marine transgression in comparatively deep water under highly reducing conditions, as suggested by the predominance of euxinic dark grey to black shales. The formation is restricted within the cambay graben and varies widely in thickness from 75m to more than 1000m. The Olpad formation underlies the cambay shale with unconformable and/or gradational contact. The cambay shale is unconformably overlain by Kalol formation. The earlier studies reveal that Cambay shale is the major source rock of Cambay Basin and can be considered as a very good candidate for the exploration of shale gas.

Data Constrain for Exploration in Cambay Basin

The study for Shale gas exploration in Indian basins especially for Cambay Shales is very new and challenging. The focus of this study is to look for any shale gas prospects in the area of Cambay-Tarapur Block. At present a bare minimum data pertaining to shale gas are available for any of the shale formations of Indian Basin. As far as the gas content of Shale is concern the TOC data and the maturation of shale plays a very vital role. The initial approach is to locate the highly maturated shale sections obtained from the limited available data consisting of Total Organic Carbon (TOC), depth of occurrence, temperature gradient and the most important information: the gas shows during drilling/ testing.

Most of the wells have been terminated at the top of Older Cambay Shale so the whole of Cambay shale section has not been drilled/ logged in most of the wells except few exploratory wells which have been drilled through Olpad formation underlying Cambay shale in Cambay Basin. Earlier in most of the wells, Cambay shale section has been drilled with very heavy mud as a part of safety measure to avoid any gas leakage from shale section since shale gas was not the objective at that point of time. Availability of conventional core is bare minimum; moreover these cores have not been tested for shale gas content estimation.

Well wise composite logs have been generated by integrating all the logs, overlays along with the available geochemical data to assess the shale gas prospectively of different facies/ zones.

Well Log Profile of Well A & Well B in Northern Part of Cambay-Tarapur Block

In well A Cambay shale has been encountered from 1556m to 2257+ (LD) m of 701+m thickness. The mud weight of Sp. Gr. 1.15 to 1.26 was used to drill Cambay shale formation. The Cambay shale is mainly composed of Shale, silty shale, siltstone with minor sandstone. The Shale is mainly light grey to dark grey; light brownish, bluish, mod hard to compact, poorly fissile, Silty in nature, non calc. The Silty shale part is grey to dark grey, light brown, bluish, mod hard, compact, poorly fissile. The Siltstone section is brownish grey to dark grey, mod hard, compact, friable, and non to feebly calc. The Hydrocarbon show was observed from 1556m to 1750m, 1800m to 1820m and 2097m to 2020m during drilling. Three conventional cores have been cut in Cambay shale (Well log profile for the same is shown in Fig 2).

The well B was drilled up 3688 M. In this well Cambay shale has been encountered from 1687m to 2640m of 953 m thickness. The mud weight of Sp. Gr. 1.42 to 1.65 was used to drill Cambay shale formation. The Cambay shale is mainly composed of Shale, siltstone with minor sandstone. The Shale is mainly dark grey to grey, soft to mod hard, mod to well fissile, occasionally sticky pyritiferous and laminated. The Siltstone section is brownish grey to grey, mod hard, compact and mod friable, mostly shaly in nature. Total gas was observed up to maximum 2.85 % from 2280m to 2500m and also Observed Gas cut mud continuously from 2406m to 2441m while drilling. During drilling at 2135m gas cut mud was observed and mud weight decreased from 1.56 to 1.47(Well log profile for the same is shown in Fig 3).

Based on the Well log Profile of the wells, this area is highly potential for the further Shale gas potential in Cambay-Tarapur Block (Fig 2 & Fig 3).

Source Rock Generation Potential of Cambay Shale

Cambay shale is dominantly dark grey to black fissile shale, non calcareous, often pyritic and rich in organic matter with minor siltstone streaks. In the Cambay Field a direct correlation has been observed between organic matter richness, its quality and thickness of the source rock sequences. Thus, in all the source rock sequences, total organic carbon (TOC) as well as the hydrogen index (HI), increases towards depositional centres where the source rocks are thicker (Mehrotra et al., 1990).

A similar increase is also noted in the maturity of the organic matter. Together with increasing hydrogen indices in the axial part of the basin, the organic matter - which is predominantly Type-III kerogen in both the northern and southern part and becomes type-II kerogen in the central part of basin. Most of' the gas generated in Older Cambay shale (OCS) is from thermal cracking of previously formed oil. Thus there is very good chance that good quantity of gas be trapped in pores within the shale.

Conclusions and Discussion

A brief study of total 27 wells belonging to different MLs and NELP blocks was carried out to understand the shale gas potential in Cambay –Tarapur block.

Cutting samples, Conventional core, Side wall core, Total Organic Carbon (TOC), Depth of occurrence, thickness of Cambay Shale and Gas Shows during Drilling/Testing were studied. Based on all the available data Composite log profile of different wells in different ML and NELP blocks were prepared.

In Akholjuni area maximum sediment thickness of cambay shale was found to be 274m and maximum TOC values goes up to 6.98mg/gm. Based on these data it is inferred that Northern margin area of Akholjuni area where sediment thickness is more, may have fair potential of shale gas. The number of wells in this area is less and can be explored.

Based on the studied data it is observed that Kathana area, Vasad Kathol area, Siswa area, Anklav area and Chaklasi Rasnol area fall on the extreme margin of tarapur depression. Here the sediment thickness is less. Cambay shale formation is thermally immature. Hence, these areas are not prospective for shale gas exploration.

The study of Chaklasi A well in Chaklasi Rasnol area show presence of hydrocarbon show in CBS and geochemical analysis data indicates source rock characteristics. CBS thickness in this well is around 610m. This area seems fairly prospective for shale gas.

In wells of Vadatal HC indication was observed during drilling. Also they have greater depth of sediments and thickness of CBS ranging up to 1240+m in well A. TOC values ranges from 2.11-4.19% in CBS. A few objects have been tested in CBS in well A and B. These areas of Nadiad, Vadatal and Kheda have good prospects of Shale Gas and are perfect area for Shale gas exploration.

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Figures

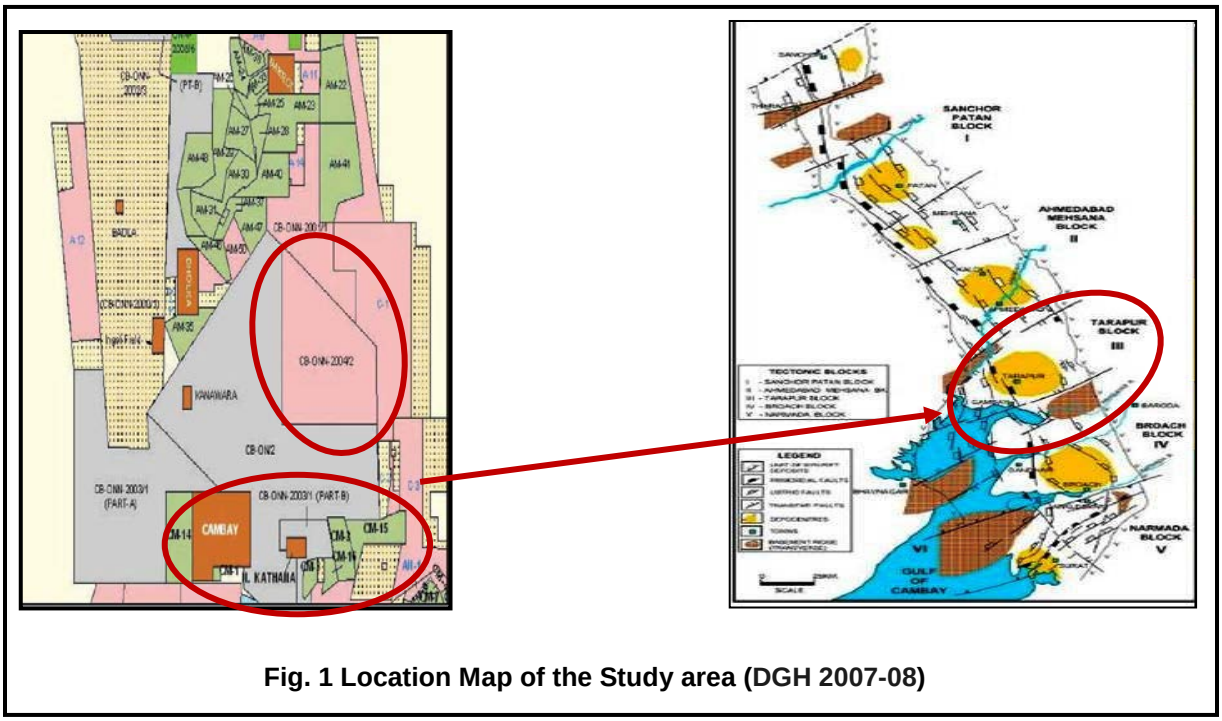


Fig. 1 Location Map of the Study area (DGH 2007-08)

Fig. 2 Well Log Profile of Well A

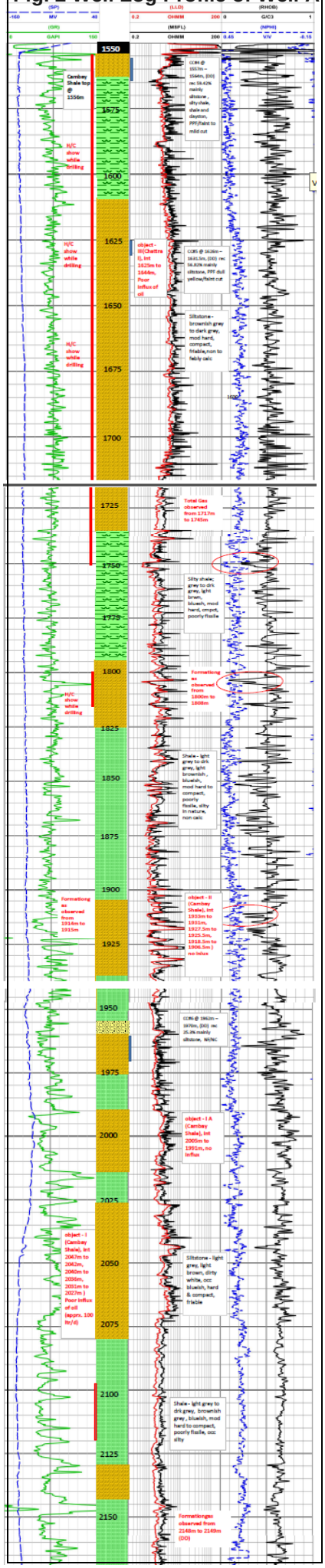
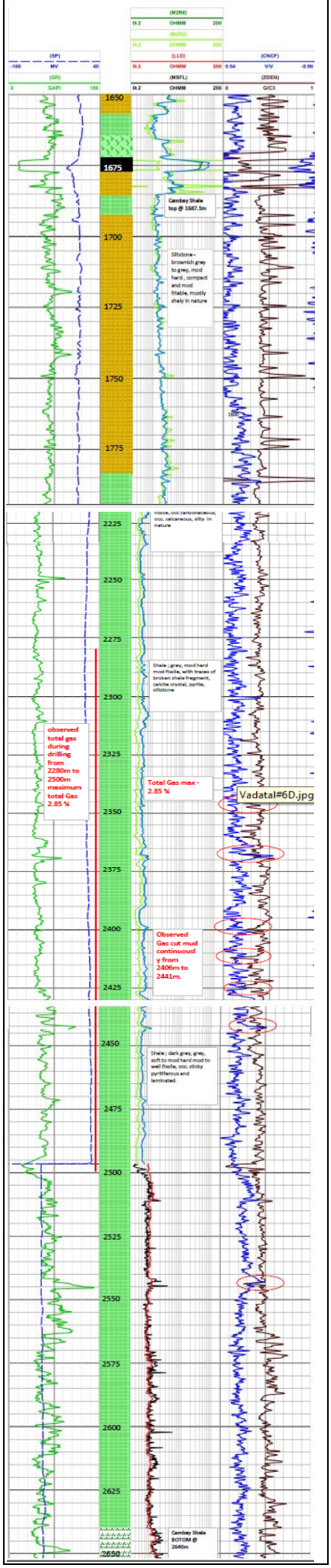


Fig. 3 Well Log Profile of Well B



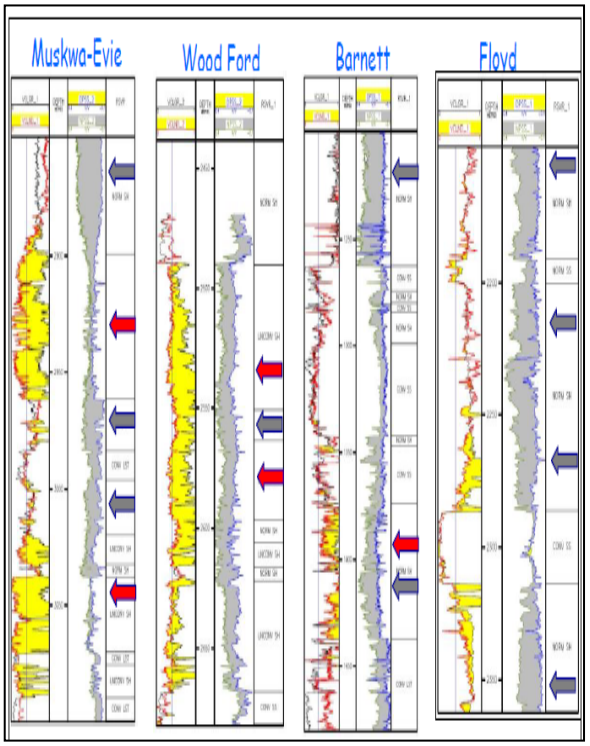


Fig. 4 Characteristic log response for North American Shales