Gas Shale Potential of Cambay Formation, Cambay Basin, India*

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Abstract

Cambay Basin is an intracratonic rift graben located in the state of Gujarat, India. The general basinal axis is NNW-SSE, but swings are noticed across major lineaments/faults. The entire basin is divisible into five tectonic blocks (Figure 1), based on transverse fault system, and the associated depocenters are governed by rifted basement.

A thick column of fine grained clastic sediment termed as 'Cambay Shale' is present in all major depressions like Hazira, Broach, Tankari, Tarapur and Patan, and is Upper Paleocene to Middle Eocene in age. This formation has been proved as an excellent source rock for generation of oil and gas in the basin.

An approach has been made to evaluate the shale gas potential of Cambay Shale Formation of Cambay Basin. The thickness of the Cambay Shale varies widely from 50 to 70 m over structural highs like Mehsana horst, Ankaleswar high and 500-2000 m in Hazira, Broach, Tankari, Tarapur and Patan depressions (Figure 2). The temperature gradient in the basin has been noted to be high (varying from 3º - 6 º C/100 mt in different parts). This has provided a very favorable geological environment setting for hydrocarbon generation in the Shale in all depocenters.

The total organic carbon content present in the shale varies from 2 to 6 % (by weight) (Figure 3) with vitrinite reflectance (VRo) values ranging from 0.5 to 1.8 (Figure 4) and HI from 100-200 at different stratigraphic levels in those depressions. These sediments have mixed type II and III organic carbon matter (Figure 3). It has been noticed in some places that the organic content of the shales increases towards depocenters. The generation history curves on a number of wells show that generation, migration and accumulation of hydrocarbons initiated in the Lower Miocene and continued until Recent. The event charts of many studied wells in the basin depict critical moment in Late Miocene. Migration from source was initiated in early Middle Miocene. The generated large amount of oil and gas from the Cambay Shale

has migrated to overlying sandstone and siltstone reservoirs in the Ankleshwar, Gandhar, Kalol and Kadi fields of Middle to Upper Eocene age.

The Cambay Shale has undergone different phases of maturation at different stratigraphic levels and depressions. After the expulsion of oil and gas from the shale in different depocenters, the remaining hydrocarbon generated has been trapped in pores, fractures and in kerogen surfaces either in free state or adsorbed state. In context of the geological setting of the basin in general and with special reference to the Cambay Shale, there is the likely presence of excellent reservoir character like pores, fractures and a significant amount of kerogens. Also in many places the shale shows good brittleness. Thus Cambay Shale holds tremendous potential for generation and storage of gas shale.

The total hydrocarbon generated in the Cambay Shale is calculated on the basis of the widely accepted Schmoker (1994) approach. An attempt has been made to estimate the resource of this formation based on some parameters (like the thickness, areal extent, maturity, and transformation ratios of source) and geological knowledge.

The following equation (Schmoker, 1994) was used to estimate the resource:

$$HCG\ (kg\ HC) = R\ (mg\ HC/g\ TOC) \times M\ (g\ TOC) \times 10^{-6}\ (kg/mg)$$

Where HCG refers to total hydrocarbon generated, R refers to hydrocarbon generated per gram organic carbon and M refers to mass of organic carbon. For each depocenter, M values were calculated on the basis of TOC ranges (Figure 3) and thicknesses (Figure 2) of the shale. The hydrocarbon generated per gram of organic carbon for each depocenter was also estimated on the basis of the maturity status of the Cambay shale (Figure 4)

The estimated resource ranges from 1000 to 1300 TCF in the five major depocenters in the basin. Of course, the total gas storage capacity of the Cambay Shale has to be evaluated at each depocenter, which should vary from place to place. The Cambay Shale holds multi-TCF gas potential to be exploited and subsequently evaluated with the appropriate technologies.

References

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Schmoker, J.W., 1994, Volumetric calculations of hydrocarbon generated, *in* L.W. Magoon, and W.G. Dow editors, The petroleum system from source to trap: AAPG Memoir 60, p. 323-360.

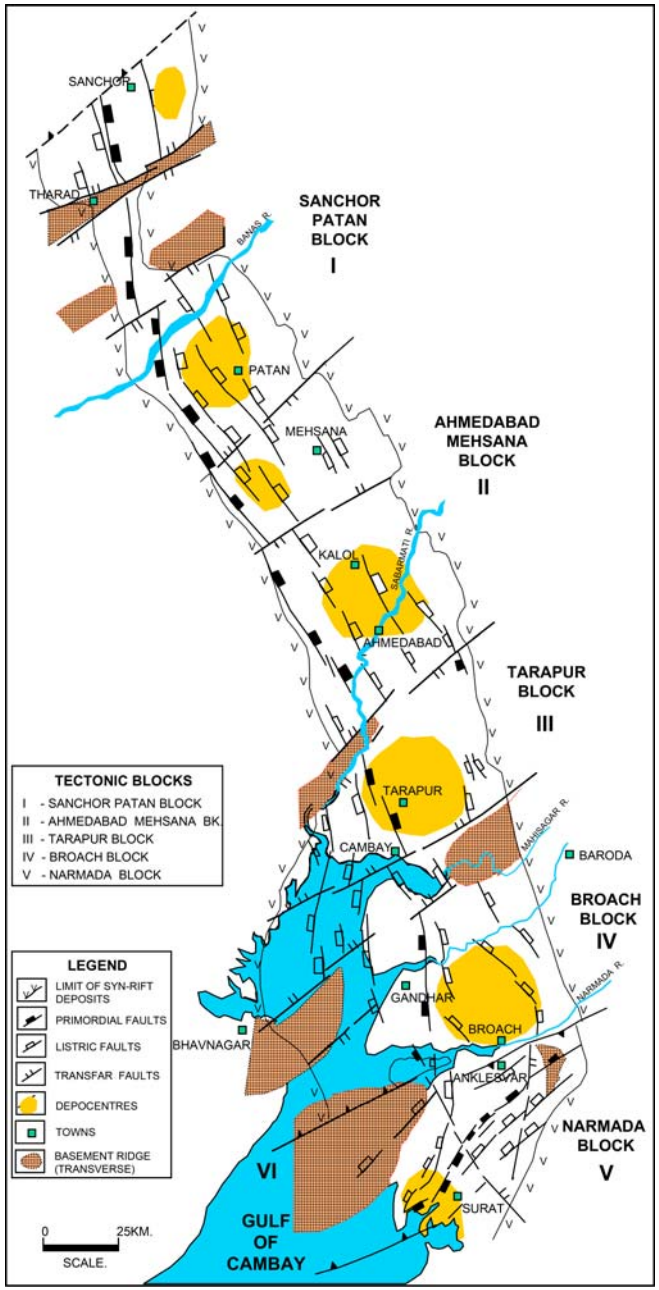

Figure 1. Tectonic blocks of Cambay Basin.

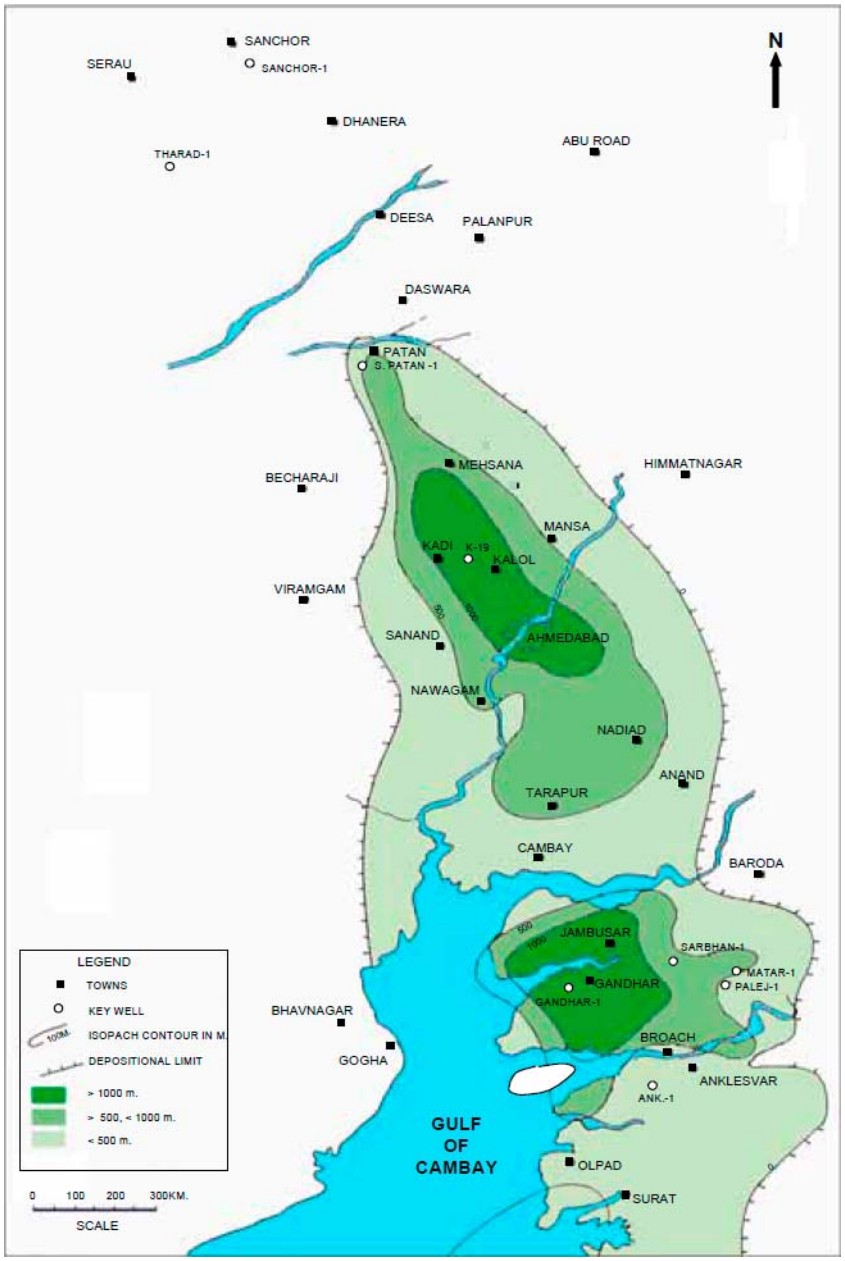

Figure 2. Isopach map of Cambay Shale, DGH (2009).

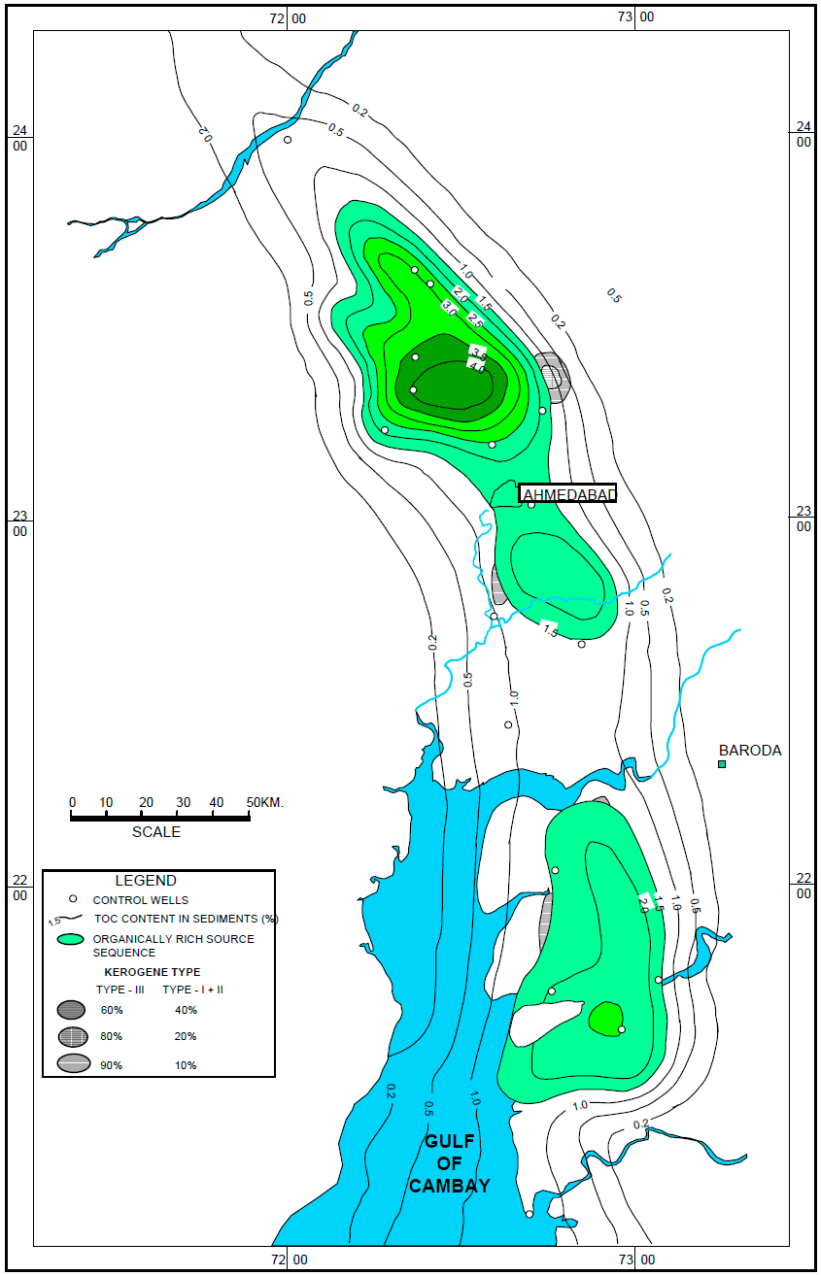

Figure 3. Map showing distribution of kerogen type and TOC in Cambay Shale, DGH (2009).

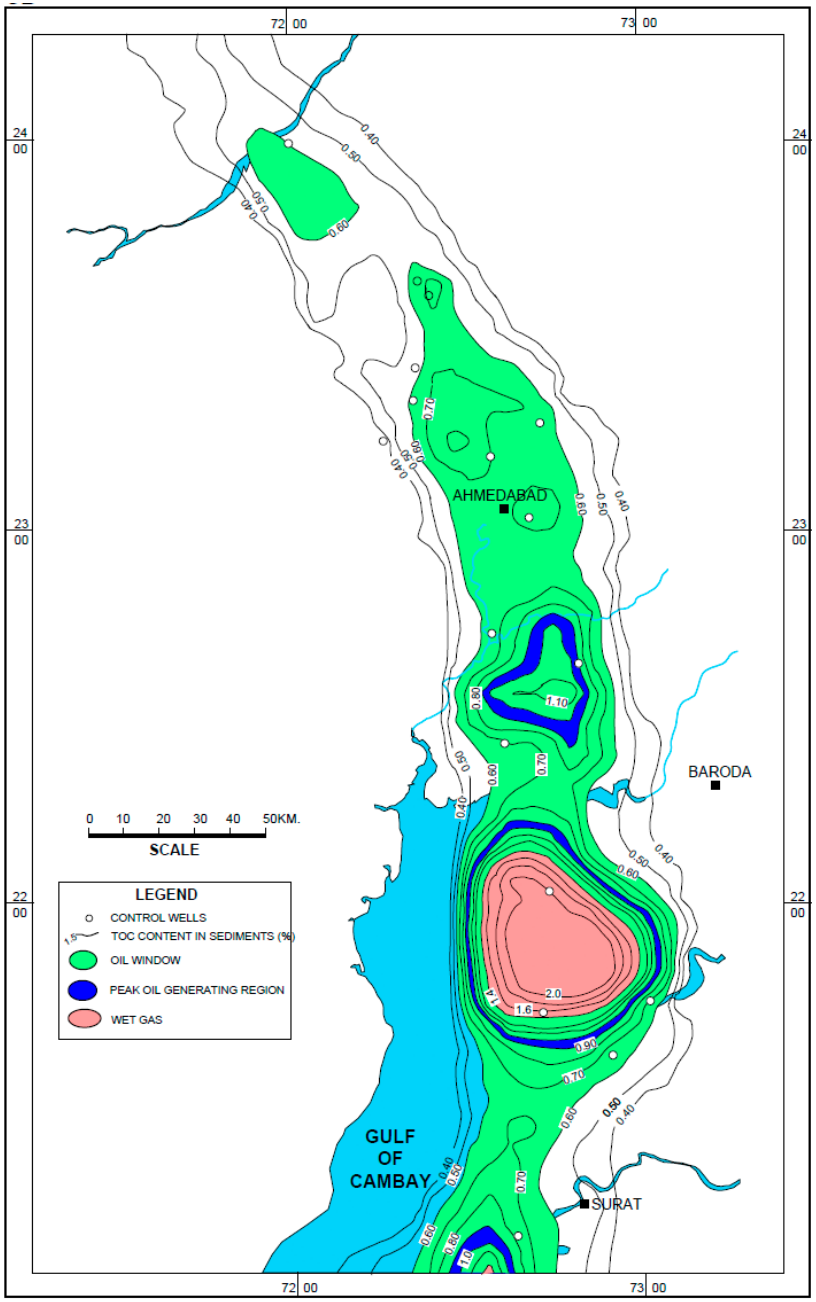

Figure 4. Maturity map of middle part of Cambay Shale, DGH (2009).