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Petroleum System Modeling and Risk Analysis, Cambay Basin, India.

Exploration is associated with risks and uncertainties, especially due to limited or poor quality data. Understanding the uncertainties on the results is the goal of every explorationist and one of the best ways is to build several equi-probable stochastic models of our predictions.

The aim of this study is to risk the critical geochemical components and arrive at an unbiased understanding of the petroleum system. The study also defines the effects of these uncertainties and finds which particular component will have the highest sensitivity on the simulation result. The more specific objectives are:

1. Determination of generation potential of the source rock
2. Timing of hydrocarbon generation
3. Migration modeling of the hydrocarbon (if generated) in a 2D cross section along the basin.

The case study has access to only public domain data of Cambay Basin. The exploration stage usually has very limited data and this study is aimed at showing how meager amount of data may also be useful for better understanding of the geological system and thereby leading to better chance of success. Petromod Suite of software is used for the analysis.

The Cambay Basin is regarded as an important hydrocarbon bearing basin of India. Sedimentary rocks in this petroleum province ranges from Paleocene to Recent and were deposited on a Tertiary rift basin.

Methodology:

1D modeling at various locations in the basins was carried out. The total sedimentary column (lithology) at each location was worked out based on well data. The default lithologies were edited using lithology editor to derive the appropriate lithological mix for a particular layer. This is an important step as the compaction curve will vary according to the lithology (Figure1). The geochemical parameters like hydrogen index (HI), total organic carbon (TOC) and kinetics were risked in the study because of the limited availability of data and a tornado plot was generated to understand the parameter that has the greatest effect (Figure 2). In this case it is seen that the TOC has the largest uncertainty followed by kinetics and HI.

A 20 km 2D section through Ankleshwar to Dabka field (Biswas et al., 1994) is used for 2D migration modeling. Stratigraphic column is worked out and the boundary conditions ie. Heat flow, sediment water interface and palaeo-water depths are obtained from the 1D models. Both “hybrid method” as well as “invasion percolation” migration modeling is performed. Hybrid method provides the most accurate solution to the fundamental problem of simulating the relationship between hydrocarbon column heights and seal breakthrough while domain decomposition can be avoided by using invasion percolation method and thus one migration method can be applied for the whole model (Hantschel and Kauerauf, 2010).

Basin Evolution: The tectono-stratigraphic reconstruction of the basin indicates that prior to achieving its present day basin configuration; the lithosphere underwent a phase of rifting and drifting as the Indian plate disintegrated from the Gondwana supercontinent. The first stage of separation of the Western Gondwanaland from the Eastern Gondwanaland is recorded during Late Triassic/Jurassic (~196-203Ma). The second stage was the separation of Seychelles-India from Madagascar in Late Cretaceous (~93Ma). However, the final breakup of Seychelles at KTB (~65Ma) contiguous with the Deccan volcanism is associated with a series of rift basins along the western continental margins of which the Cenozoic Cambay Basin (Bhowmik et al) is the one discussed in the study.

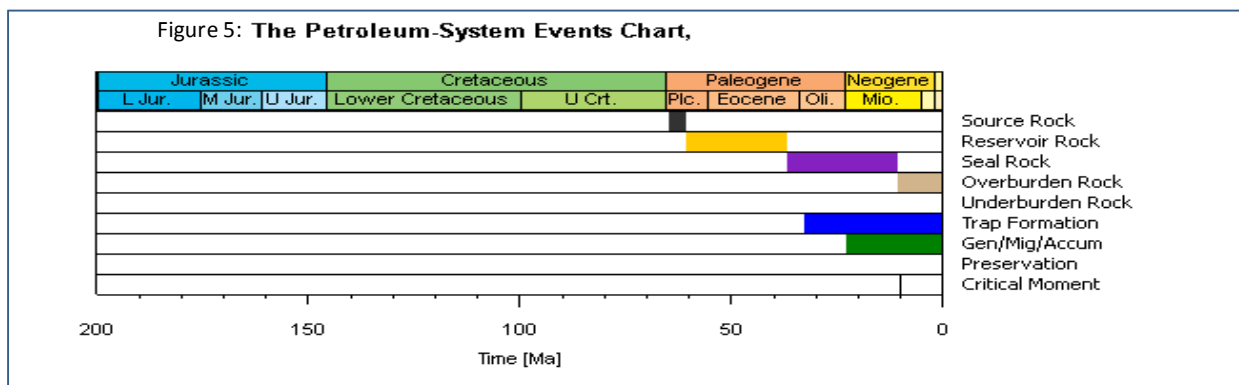
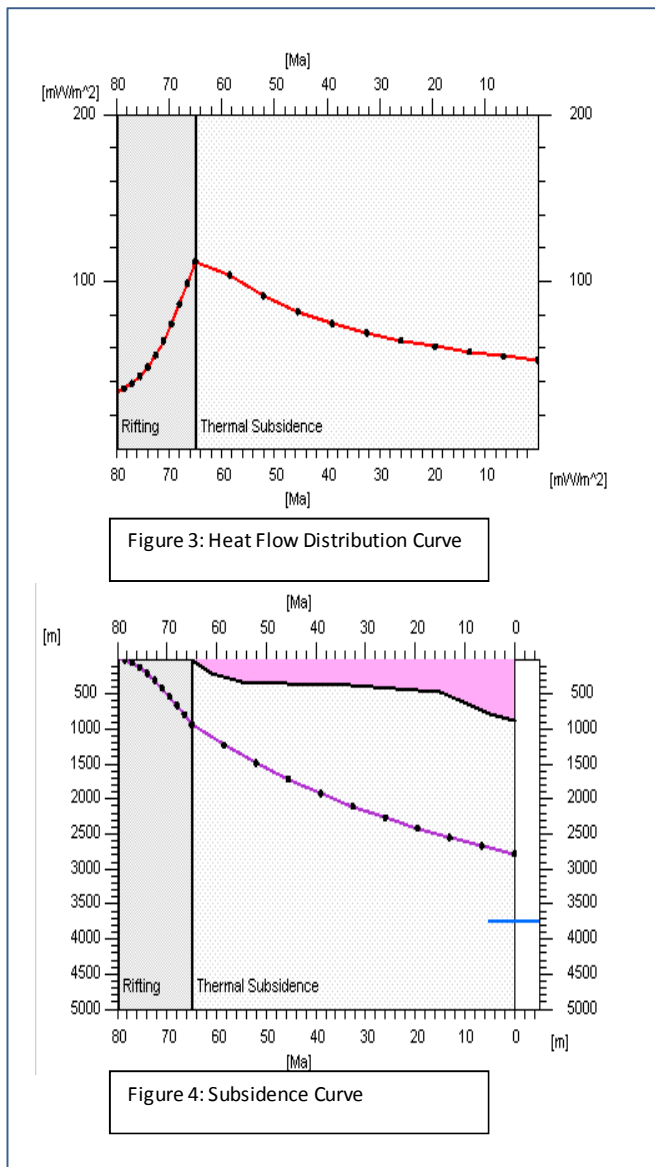
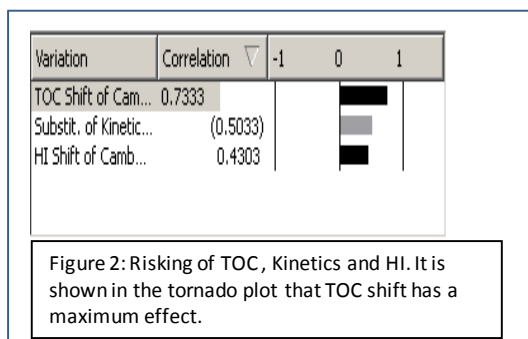
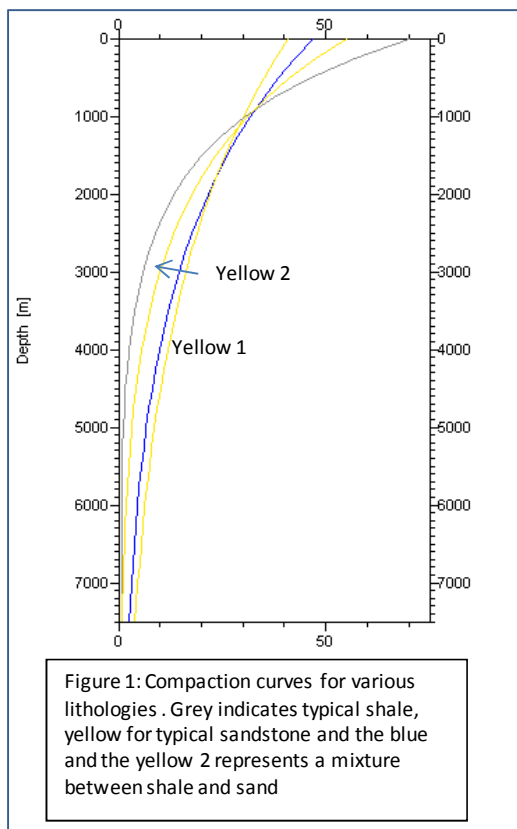
Geochemical Data: The main source rock of the area is the Cambay shale. Source rock (SR) data reveal six laterally extensive potential sources (PS) with kerogen type II/III in the middle Eocene-lower Paleocene. The Cambay Shale average TOC content varies from 2.6 % to 3 % and the average HI (hydrogen Index is (121mg/g TOC) (Banerjee et al., Biswas et al).

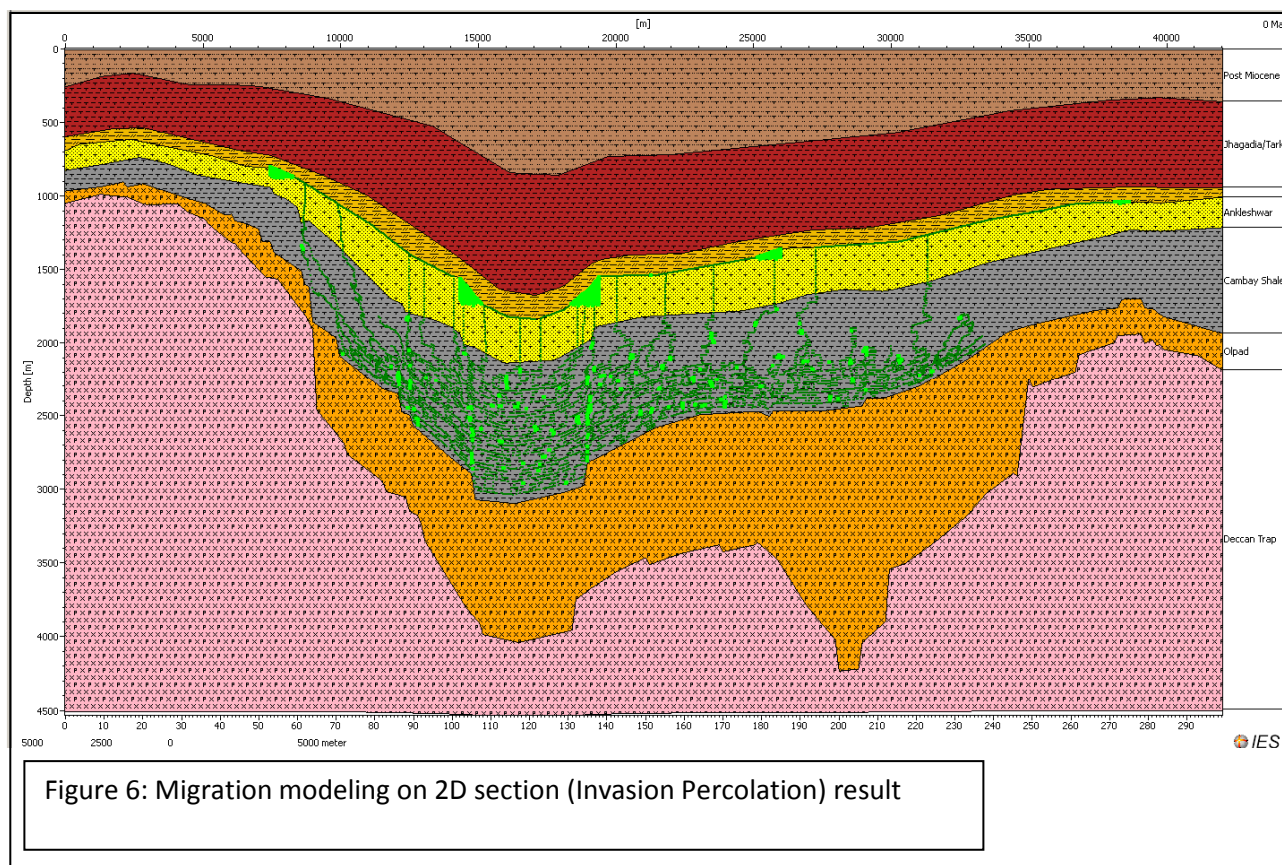
Boundary Conditions: The most important boundary condition is the heat flow in the basin. Since the basin is rift related and the source and the reservoirs are mainly the result of syn rift and post rift sedimentation McKenzie Stretching model is applied with a beta factor of 2 and a heat flow of 80mw/sq. m is obtained during the rift phase and around 50 mw/sq.m in the subsequent phase of thermal sag (Figure 3, Figure 4).

Sediment Water Interface Temperature is obtained automatically from the software. A paleo-reconstruction is done in the background to obtain the location of the basin throughout time. A constant paleowater depth was considered due to the lack of data. As mentioned earlier Kinetics was found to be a uncertain parameter and hence calculated using “Burnham” and “Pepper & Corvi (1995) _TII(B)”.

Results: Reconstruction of burial and thermal history indicates that a critical moment of generation in this basin was reached at Late Miocene. A Petroleum Event Chart is constructed (Figure 5). The trap and reservoir rock were in place by that time and a seal rock was deposited on top of the reservoirs indicating prevention of loss of hydrocarbon leading to a functional and working petroleum system in the area.

Ideally a detailed calibration should be performed but due to lack of public domain data this step cannot be attempted. However, the results obtained from migration modeling in the 2D section (Figure 6) when matched with the original section used, shows accumulation at known fields indicating that even with bare minimum data it is useful to carry out the generation as well as migration modeling to increase the confidence of exploration.





Key References:

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