Abstract

The primary focus of the present doctoral research work is to characterize and assess the resource potential of Cambay Shale in Jambusar-Broach block of Cambay Basin, Gujarat, India, in terms of the shale hydrocarbon resource. This was undertaken using wireline log data coupled to laboratory studies carried out on the shale samples. A comprehensive study was undertaken to evaluate the source quality (SQ), reservoir quality (RQ) and completion quality (CQ) parameters of the shale formation. Total organic carbon (TOC) content, an important SQ parameter, was estimated on shale samples, from laboratory analysis. The measured core-TOC, were observed to be in the range of 0.9 - 5.3 wt% (mean = 2.5 wt%). For continuous estimation of TOC from standard logs, a suitable Support Vector Regression (SVR) model was developed. The prediction of TOC by the SVR model is observed to be in good agreement with core-TOC data. An integrated analysis on shale samples using organic petrography, TOC estimation and Rock-Eval pyrolysis technique, revealed that the samples studied were indicative of good to excellent source rocks, with poor to good potential to generate hydrocarbons. The thermal maturity of the samples ranges from immature to peak oil window.

The RQ parameters like porosity, permeability and water saturation (S_w) were evaluated in a continuous manner with depth, using the available well log data. The effective porosity and permeability estimated from Combinable Magnetic Resonance log vary in the range 1-27% (mean ~ 8%) and 0.00001-10.21012 mD (mean ~0.03432 mD), respectively. In this study, an effective methodology with an improved equation (TOC-clay) has been proposed for the estimation of S_w. S_w derived from the developed TOC-clay equation is having the closest agreement to core-S_w data compared to other exiting models. The estimated S_w of Cambay Shale is mainly in the range of 50-90% with an average ~70%.

To examine the mineralogy and understand the depositional environment, a combined study, involving analysis of Spectral Gamma Ray (SGR) logs along with laboratory studies on core samples using XRD, and SEM-EDS, was undertaken. Results of these studies, reveals that the shale is primarily composed of clay (33–75%, average ~53%), quartz (10–38%, average ~25%), carbonate (8–29%, average ~19%) and with a smaller concentration of pyrite, feldspar and muscovite. The values of Th/U ratio obtained from SGR log, clay mineralogy and maceral type, indicates the possibility of the shale deposition under marginal marine environment. The estimation of various elastic

parameters was done using the Sonic Scanner log. Brittleness index (BI), a vital CQ parameter, was estimated by two different methods (mineral-based and elastic moduli-based). BI is observed to vary between 0.1-0.75. There are some regions with good BI (BI>0.48) which could be suitable zones for hydro-fracking.

Based on estimated SQ, RQ and CQ parameters, few potential zones were identified in the studied wells. The integrated analysis of these results, from various studies carried out, in the research work will be useful for a better understanding, assessment and further evaluation of the Cambay Shale, as a hydrocarbon resource. The present work is the first of its kind, to carry out research studies on Cambay Shale in the Jambusar-Broach block. This study will not only be useful in terms of its academic value but would also be beneficial, primary to the petroleum industry, to prepare an action plan, for further exploration and exploitation of Cambay Shale, as an energy resource, in the very near future.

Keywords: Cambay Shale, Wireline log, TOC, SVR, Rock-Eval Pyrolysis, Organic Petrography, Mineralogy, Water Saturation, TOC-Clay equation, Brittleness Index