New Achievement in the Effect of Clay Mineral on the Movement of Hydrocarbons in the Source Rock

Fatemeh Saberi1 and Mahboubeh Hosseini-Barzi2

Search and Discovery Article #51701 (2023)**
Posted July 1, 2023

*Adapted from extended abstract based on oral presentation given at 2023 AAPG Rocky Mountain Section Meeting, Bismarck, North Dakota, June 4-6, 2023
**Datapages © 2023. Serial rights given by author. For all other rights contact author directly. DOI:10.1306/51701Saberi2023

1Department of Geology & Geological Engineering, University of North Dakota, Grand Forks, ND, USA
2Department of Geology and Petroleum Basins, Shahid Beheshti University of Tehran, Tehran Province, Tehran, Iran

Abstract

The Pabdeh Formation represents organic matter enrichment in some oil fields which can be considered as source rock. The effect of clay minerals on early migration in this formation was studied in an unknown well in Karanj oil field. Based on the results of the Rock-eval and the XRD as well as the electron microscopy imaging before and after heating of the samples and creation of artificial thermal maturation, it was found that the illitization process could play an important role in the development and opening of microfractures in this source rock. In fact, by maturing the immature source rock in the laboratory, it was shown that during the illitization process by releasing water and creating pore fluid pressure, the micro-fractures indicate particularly in shales with high smectite/illite content and could thus explain primary migration in Pabdeh source rock in Karanj oil field.

Keywords Primary migration, Microfracture, Illitization, Artificial maturation, Pabdeh Formation, Karanj oil field
New achievement in the effect of clay mineral on the movement of hydrocarbons in the source rock

Fatemeh Saberi1*, Mahboubeh Hosseini-Barzi2
1* Department of Geology & Geological Engineering, University of North Dakota, 264 Centennial Drive, Grand Forks, ND, USA
2 Department of Geology and Petroleum Basins, Shahid Beheshti University of Tehran, Tehran Province, Tehran, Iran

Introduction
Experimental studies have shown that the conversion of smectite into illite under pressure generates microfractures, and their propagation is influenced by the rock’s anisotropy and mechanical properties.

Methods
- Rock-Eval 6 data
- XRD
- Selected 4 samples were heated to study the effect of clay (especially smectite mineral) on the development of microfractures.
- SEM images captured before and after heating

Result
- Rock-Eval

Fig. 1 A-TOC vs. S1 diagram used to separate migrated hydrocarbons from non-migrated ones. B- HI against depth, determining the type of hydrocarbon produced from the studied samples. C- Plot of hydrogen index (HI) vs. Rock-Eval Tmax for the studied samples indicating that the Pabdeh Formation has lower maturity. D- Tmax against PI used to estimate the thermal maturity of the source rock (Saberi et al, 2023, Saberi et al, 2021, Saberi et al, 2021).

- XRD

Based on the XRD results (Table 1), we found that the mineral percentage of quartz, illite/smectite, dolomite, and pyrite increases. This heterogeneous distribution of minerals in different sizes and shapes during the layering of the source rock makes anisotropy cause microfracturing and hydrocarbon movement (Fouda et al, 2010).

- Itroscan

Itroscan sample 18 (5/3039), with the highest amount of TOC, indicates that this sample has produced hydrocarbons during the heating. Since shale formations have small pore throats, they act as barriers preventing the escape of produced hydrocarbons in the source rock. As a result, it leads to the accumulation of pore pressure until it reaches the fracture threshold of the rock (Cunfei et al, 2017).

Table 1. XRD data of Pabdeh Formation of Karanj oilfield

<table>
<thead>
<tr>
<th>Depth</th>
<th>Quartz</th>
<th>Calcite</th>
<th>Smectite</th>
<th>Kaolinite</th>
<th>I-S</th>
<th>Chlorite</th>
<th>Clays</th>
<th>Carbonate</th>
</tr>
</thead>
<tbody>
<tr>
<td>3026</td>
<td>8.81</td>
<td>51.19</td>
<td>0.00</td>
<td>19.44</td>
<td>12.28</td>
<td>0.00</td>
<td>31.73</td>
<td>56.34</td>
</tr>
<tr>
<td>3039.5</td>
<td>10.91</td>
<td>51.67</td>
<td>0.00</td>
<td>9.54</td>
<td>18.70</td>
<td>0.00</td>
<td>28.24</td>
<td>56.00</td>
</tr>
</tbody>
</table>

Fig 2 - Figure (A) shows the samples before heating, where no microfractures are observed. Figures (B, C) represent the microscopic images of the heated samples, demonstrating the transformation of smectite platelet edges into illite flakes (the enlarged portion of C is indicated by the arrow), accompanied by the process of illitization. With the increase in fracturing property during hydrocarbon production and the creation of local pressure, fractures have propagated in these areas.

Conclusions

References