Fig. 28: (A) - Porosity cut-off optimization.  
(B) - Water saturation cut-off optimization.  
KK 84-4A well, Nullipore rocks.
Fig. 29: (A) - Porosity cut-off optimization.
(B) - Water saturation cut-off optimization.
KK 84-8 well, Nullipore rocks.
In most cases the hydrocarbon saturation and porosity cut-offs are synonymous in terms of identifying reservoir quality rock (Keplinger, 1981). Therefore, net oil pay has been defined as intervals with:

1. Porosity ≥ 14 %
2. Hydrocarbon saturation ≥ 36 % (water saturation ≤ 64 %).

In this study, the Reservoir Summation (ResSum) module (under Geoframe 404_Sun) is used to compute the reservoir properties for each zone (see appendix-2).

Zone properties are calculated by applying user-defined cut-off sets to selected curve data and summing the log intervals, which pass the specified criteria at the following stages of the computation process:

- Gross
- Net Reservoir
- Net Bay

Individual reservoir is normally described by single-parameter values representative of their characteristics. The most common parameters required in Nullipore reservoir illustration are listed in (Table 5).

6.3 Representation of the Different Deduced Petrophysical Data

The different deduced petrophysical data using different well logging analyses were represented in two methods. The first is the vertical representation where the different deduced petrophysical parameters were represented vertically with depth in a number of what is called litho-saturation crossplots or petrophysical data logs (PDL), while the second is the lateral representation, where a number of iso-parameteric distribution maps were constructed.
<table>
<thead>
<tr>
<th>WELL</th>
<th>ZONE</th>
<th>INTERVAL</th>
<th>GROSS FT MD</th>
<th>GROSS FT TVD</th>
<th>PHOTON</th>
<th>PGN</th>
<th>Kh md</th>
<th>SUWI</th>
<th>NET RESERVOIR</th>
<th>NET PAY</th>
<th>N/G Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>KK 84 - 1</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ZONE I</td>
<td>2074</td>
<td>2265</td>
<td>2044</td>
<td>2235</td>
<td>0.26</td>
<td>0.25</td>
<td>0.22</td>
<td>0.255</td>
<td>0.25</td>
<td>1840</td>
<td>0.29</td>
</tr>
<tr>
<td>ZONE II</td>
<td>2265</td>
<td>2438</td>
<td>2235</td>
<td>2408</td>
<td>0.3</td>
<td>0.28</td>
<td>0.24</td>
<td>0.29</td>
<td>0.29</td>
<td>5014</td>
<td>0.38</td>
</tr>
<tr>
<td>ZONE III</td>
<td>2438</td>
<td>2770</td>
<td>2408</td>
<td>2740</td>
<td>0.26</td>
<td>0.24</td>
<td>0.21</td>
<td>0.25</td>
<td>0.26</td>
<td>212</td>
<td>0.58</td>
</tr>
<tr>
<td><strong>KK 84 - 11</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ZONE I</td>
<td>1986</td>
<td>2144</td>
<td>1822</td>
<td>1963</td>
<td>0.18</td>
<td>0.19</td>
<td>0.17</td>
<td>0.185</td>
<td>0.2</td>
<td>500</td>
<td>0.34</td>
</tr>
<tr>
<td>ZONE II</td>
<td>2144</td>
<td>2380</td>
<td>1963</td>
<td>2174</td>
<td>0.22</td>
<td>0.24</td>
<td>0.2</td>
<td>0.23</td>
<td>0.23</td>
<td>304</td>
<td>0.32</td>
</tr>
<tr>
<td>ZONE III</td>
<td>2380</td>
<td>3210</td>
<td>2174</td>
<td>2919</td>
<td>0.16</td>
<td>0.19</td>
<td>0.15</td>
<td>0.175</td>
<td>0.17</td>
<td>4</td>
<td>0.49</td>
</tr>
<tr>
<td><strong>KK 84 - 12</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ZONE I</td>
<td>2322</td>
<td>2664</td>
<td>2174</td>
<td>2435</td>
<td>0.23</td>
<td>0.25</td>
<td>0.22</td>
<td>0.24</td>
<td>0.24</td>
<td>260</td>
<td>0.35</td>
</tr>
<tr>
<td>ZONE II</td>
<td>2664</td>
<td>2768</td>
<td>2435</td>
<td>2636</td>
<td>0.26</td>
<td>0.28</td>
<td>0.26</td>
<td>0.27</td>
<td>0.27</td>
<td>740</td>
<td>0.55</td>
</tr>
<tr>
<td>ZONE III</td>
<td>2768</td>
<td>3116</td>
<td>2636</td>
<td>2978</td>
<td>0.26</td>
<td>0.26</td>
<td>0.25</td>
<td>0.26</td>
<td>0.27</td>
<td>100</td>
<td>0.80</td>
</tr>
<tr>
<td><strong>KK 84 - 8 (RF-B1)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ZONE I</td>
<td>2158</td>
<td>2334</td>
<td>2068</td>
<td>2244</td>
<td>0.24</td>
<td>0.28</td>
<td>0.24</td>
<td>0.26</td>
<td>0.26</td>
<td>2250</td>
<td>0.14</td>
</tr>
<tr>
<td>ZONE II</td>
<td>2334</td>
<td>2514</td>
<td>2244</td>
<td>2424</td>
<td>0.28</td>
<td>0.32</td>
<td>0.28</td>
<td>0.3</td>
<td>0.31</td>
<td>4135</td>
<td>0.17</td>
</tr>
<tr>
<td>ZONE III</td>
<td>2514</td>
<td>2692</td>
<td>2424</td>
<td>2602</td>
<td>0.31</td>
<td>0.31</td>
<td>0.3</td>
<td>0.31</td>
<td>0.31</td>
<td>1688</td>
<td>0.51</td>
</tr>
<tr>
<td><strong>KK 84 - 4A</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ZONE I</td>
<td>1987</td>
<td>2161</td>
<td>1955</td>
<td>2129</td>
<td>0.26</td>
<td>0.27</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>434</td>
<td>0.32</td>
</tr>
<tr>
<td>ZONE II</td>
<td>2161</td>
<td>2339</td>
<td>2129</td>
<td>2307</td>
<td>0.25</td>
<td>0.25</td>
<td>0.2</td>
<td>0.24</td>
<td>0.24</td>
<td>368</td>
<td>0.34</td>
</tr>
<tr>
<td>ZONE III</td>
<td>2339</td>
<td>2970</td>
<td>2307</td>
<td>2936</td>
<td>0.24</td>
<td>0.24</td>
<td>0.23</td>
<td>0.23</td>
<td>0.24</td>
<td>176</td>
<td>0.51</td>
</tr>
<tr>
<td><strong>RF - A2</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ZONE I</td>
<td>2527</td>
<td>2762</td>
<td>2153</td>
<td>2335</td>
<td>0.24</td>
<td>0.25</td>
<td>0.23</td>
<td>0.25</td>
<td>0.24</td>
<td>300</td>
<td>0.30</td>
</tr>
<tr>
<td><strong>RF - A3</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ZONE I</td>
<td>2558</td>
<td>2724</td>
<td>2219</td>
<td>2359</td>
<td>0.22</td>
<td>0.24</td>
<td>0.22</td>
<td>0.23</td>
<td>0.24</td>
<td>877</td>
<td>0.32</td>
</tr>
<tr>
<td><strong>RF - B2</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ZONE I</td>
<td>2519</td>
<td>2810</td>
<td>2059</td>
<td>2188</td>
<td>0.26</td>
<td>0.27</td>
<td>0.25</td>
<td>0.26</td>
<td>0.27</td>
<td>3668</td>
<td>0.14</td>
</tr>
<tr>
<td><strong>RF - B3</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ZONE I</td>
<td>2287</td>
<td>2521</td>
<td>2011</td>
<td>2170</td>
<td>0.24</td>
<td>0.28</td>
<td>0.25</td>
<td>0.26</td>
<td>0.26</td>
<td>1500</td>
<td>0.30</td>
</tr>
<tr>
<td>ZONE II</td>
<td>2521</td>
<td>2640</td>
<td>2170</td>
<td>2256</td>
<td>0.23</td>
<td>0.24</td>
<td>0.23</td>
<td>0.23</td>
<td>0.24</td>
<td>1677</td>
<td>0.42</td>
</tr>
</tbody>
</table>

**ABBREVIATIONS**

- GROSS: Total thickness of reservoir rock (ft)
- PHOTON: Density derived porosity (%)
- PGN: Neutron derived porosity (%)
- K: Sonic derived porosity (%)
- PIGN: Effective porosity (%)
- NET RESERVOIR: Effective thickness after 14 % porosity cut-off (ft)
- NET PAY: Effective thickness after 14 % porosity and 64 % water saturation cut-offs (ft)
- N/G Ratio: Net pay/Grass ratio

Table (5): Summary of petrophysical data results, Nullipore rock, Ras Fanar area.
6.3.1 Vertical Representation (Petrophysical Data Logs)

The petrophysical data log (PDL) is the final layout, which collects the different deduced petrophysical parameters, of prime interest, together and allows their interpretation vertically with depth.

Based on well logging and core samples analyses, it is found that the petrophysical characteristics of Nullipore rocks in the different studied wells, are nearly similar to large extent with some relative differences in the percentages of the lithological components, pore spaces and fluid content. The petrophysical data logs of the different studied wells are constructed and represented in Appendix (1). In all data logs, water saturation increases with depth and hydrocarbon content is represented only by oil. Only one exception is found in KK84-11 well where some saturations of secondary gases are detected. In this part, we will deal with the petrophysical data logs of only two wells as examples, one is chosen as representative for the oil-bearing wells (KK84-4A), while the other well is only one where gases were recorded (KK84-11 well).

Fig. (30) shows the petrophysical data log of KK84-4A well. It indicates that the lithology of Nullipore reservoir is uniform and mainly dolomitic in composition. The pore spaces range between 22% to 30% and exhibit regular distribution all over the Nullipore section with some remarked increasing in the uppermost and lowermost parts. The fluid content is mainly water and hydrocarbon. Downgoing, water saturation (43%) shows general trend of increasing, therefore hydrocarbons are concentrated in the middle and upper parts of Nullipore rock. The oil-water contact in this well is found to be at depth 2434 ft.
Petrophysical Data Log of Nullipore rocks

(Fig. 30)

KK 84-4a well

Moved Water
Moved Hydrocarbon
Water
Oil
Dolomite
Calcite
Anhydrite

<table>
<thead>
<tr>
<th>MD 1:1000 ft</th>
<th>GR (gAPI)</th>
<th>NPHI</th>
<th>MSFL</th>
<th>SUWI</th>
<th>PIGN</th>
<th>ELAN_VOLUMES</th>
<th>V/V</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2100</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ZONE II</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2200</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ZONE III</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2300</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2400</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>O.W.C.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2500</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The petrophysical data log of KK84-11 well, on the other hand, is represented in Fig. (31). Like in KK84-4A well, the lithological content is mainly dolomite, with little percent of limestone lithology. The pore spaces are uniform all over the whole section except in the upper and lower parts (unlike KK84-4A well) of the rock. They range from 17% (zone III) to 23% (zone II). Water saturation increases remarkably in the lowermost parts of the rock. An average water saturation value of 37% is given for Nullipore rocks in this well. Hydrocarbon content is represented by oil with some saturations of secondary gases in zone (I) and uppermost part of zone (II). Depth of 2185 ft is considered the gas-oil contact in this well.

6.3.2 Lateral Distribution of Petrophysical Parameters

As previously mentioned, Ras Fanar field is an elongated horst block trending NW-SE direction, bounded by east and west clysmic faults. The geometry of the different petrophysical parameters was controlled by the geological position of the Nullipore reservoir rock.

Lateral distribution of these parameters was also enhanced in the present study, especially those parameters concerning with the hydrocarbon potentialities. In this respect a number of distribution maps were constructed for Nullipore reservoir such as porosity, water and hydrocarbon saturation maps.

6.3.2.1 Porosity Distribution Maps

Porosity distribution maps for Nullipore zones I, II and III were constructed (Figs. 32, 33 and 34). These maps show that one low porosity semi-closure between another two high porosity lobes (A and B lobes) can be recognized in all zones. This low porosity semi-closure is found in the
central part of the map, in the area between RF-A4 and RF-B3 wells. It
attains the lowest porosity distributions allover the study area. Porosity
values are found in increasing order to the northwest (A lobe) and southeast
(B lobe) directions. These directions represent the highest porosity
distributions among the study area.

The porosity distribution map of zone II (Fig. 33) attains much higher
porosity values than in zones I and III. Maximum porosity value of 31 % is
detected in the porosity distribution map of zone III (Fig. 34). It is recorded
in KK 84-8 (RF-B1) well and represents the highest porosity closure in the
field (B lobe).

In general, B lobe (RF-B2, RF-B3, KK 84-8, KK 84-1, KK 84-11 and
KK 84-12 wells) attains higher porosity and better reservoir quality than A
lobe (RF-A2, RF-A3, and KK 84-4A wells).

6.3.2.2 Water Saturation Distribution Map

Water saturation map of Nullipore reservoir rock is represented in
Fig. (35). It appears clearly that water saturation increases in the eastern and
western boundaries of the field. Upgoing, the water saturation values
decrease to the central part along the northwest-southeast axis.

Two low water saturation closures are found in the study area. They
are represented by (A) lobe in northwestern part and (B) lobe in the
southeastern part of the field. The minimum water saturation is observed at
the central part of (B) lobe and represented by RF-B2 well (Sw = 15 %).
Meanwhile, maximum values of 45 % and 43 % are recorded in KK 84-12 and
KK 84-4A wells, respectively.
Fig. 32: ZONE (I) Porosity distribution map, Nullipore rocks, Ras Fanar field.
Fig. 33: ZONE (II) Porosity distribution map, Nullipore rocks, Ras Fanar field.
Fig. 34: ZONE (III) Porosity distribution map, Nullipore rocks, Ras Fanar field.
Fig. 35: Water saturation map of Nullipore rocks, Ras Fanar field.
6.3.2.3 Hydrocarbon Saturation Distribution Map

Fig. (36) shows the hydrocarbon saturation distribution map of Nullipore reservoir. The map illustrates that hydrocarbon saturation increases remarkably inside the two lobes (A and B).

The maximum hydrocarbon saturation (85%) was recorded in RF-B2 well, while the minimum saturation (55%) was detected in KK 84-12 well.

6.4 Nullipore Reservoir Quality Distribution

Porosity, water and hydrocarbon saturation maps of Nullipore reservoir show that the best reservoir quality is found at the central parts of (B) and (A) lobes. The reservoir quality decreases gradually towards the northwest and southeast directions, almost elongated as well as the general trend of the Ras Fanar horst block. They also indicate that the reservoir quality decreases rapidly towards the east and west directions, controlled by the east and west bounding faults.
Fig. 36: Hydrocarbon saturation map of Nullipore rocks, Ras Fanar field.