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Shale Gas in Place Calculation for a Single Well

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SUMMARY

The aim of this study is to estimate total gas-in-place volumes for the Lower Paleozoic shale rocks, in part the Baltic Basin of northern part of Poland. For one of the projected horizontal well in Poland, the investigation was carried out. Based on published and literature date the authors built 3D static model which consist structural and parametric data needed for volumetric calculation. The input data include porosity, density, water saturation. The calculations for Polish conditions were compared with production data from North America and China. The analysis were provided for four examples. Based on available data and provided analysis of gas reserves for a single, depending on the fracking results, that the GIIP are changing. The quality and number the input data used to volumetric calculations plays a very big difference on gas resources. Graphics comparison between minimal Canadians and Polish, maximal Chinese (Longmaxi) and USA (Barnett Shale) shows statistical data.
Introduction

During the first decade of XXI century North America experienced “energetic revolution” related to production of gas and oil from new type of fields in shale formations. During last years there was a few attempts to estimate shale gas resources.

The aim of this study is to estimate total gas-in-place volumes for the Lower Paleozoic shale rocks, in part the Baltic Basin of northern part of Poland (Polish Geological Institute, 2012). For one of the projected horizontal well in Poland, the investigation was carried out. Based on published and literature date the authors built 3D static model which consist structural and parametric data needed for volumetric calculation (Zakrevsky, K.E., 2011).  The input data include porosity, density, water saturation. The calculations for Polish conditions were compared with production data from North America and China. The analysis were provided for four examples (Case 1-4).

Methodology

The regional static model, with more than 2 million grid blocks, was subjected to gas-in-place calculations (Eq. 1-2) but for one well the results are mentioned in this paper. Natural gas was treated like pure methane and the thermobaric properties stable for all reservoir. The total gas storage, the shale gas-in-place volume are generally considered in terms of following (Hartman, R.C., Akkutlu, Y., 2011, Zou C. et al., 2013):

\[ G_s = G_f + G_a \]  
\[ (Eq. 1) \]

\( G_s \) – total gas storage [m³],  
\( G_f \) – free gas [m³],  
\( G_a \) – adsorbed gas [m³],

based on volumetric methodology the above equation could be extended:

\[ G_s = V_b \rho C_g + \frac{V_g}{B_g} \]  
\[ (Eq. 2) \]

\( V_b \) – bulk volume [m³],  
\( C_g \) – gas content [m³/t],  
\( \rho \) – shale rock density [t/m³],  
\( V_g \) – reservoir gas volume [m³],  
\( B_g \) – gas formation volume factor [dimensionless].

For different gas content and criteria assumed four cases (Tab.1):

- Case 1: min gas content in Canada (1.1 m³/t, follow Zou C. et al., 2013);
- Case 2: min gas content in Poland (1.5 m³/t, follow Polish Ministry of Environmental);
- Case 3: max gas content for Longmaxi Shale, China (5.1 m³/t, follow Zou C. et al., 2013);
- Case 4: max gas content for Barnett Shale, USA (9.91 m³/t, follow Zou C. et al., 2013).

<table>
<thead>
<tr>
<th>Distance from well [m]</th>
<th>Number of grid blocks ( \times 10^3 )</th>
<th>Gas Initially in Place Case 1 ( \times 10^6 )</th>
<th>Case 2 ( \times 10^6 )</th>
<th>Case 3 ( \times 10^6 )</th>
<th>Case 4 ( \times 10^6 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>164 ( \times 10^3 )</td>
<td>295 ( \times 10^6 )</td>
<td>10 ( \times 10^6 )</td>
<td>13 ( \times 10^6 )</td>
<td>32 ( \times 10^6 )</td>
</tr>
<tr>
<td>100</td>
<td>328 ( \times 10^3 )</td>
<td>567 ( \times 10^6 )</td>
<td>20 ( \times 10^6 )</td>
<td>24 ( \times 10^6 )</td>
<td>62 ( \times 10^6 )</td>
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<tr>
<td>150</td>
<td>492 ( \times 10^3 )</td>
<td>1117 ( \times 10^6 )</td>
<td>39 ( \times 10^6 )</td>
<td>48 ( \times 10^6 )</td>
<td>123 ( \times 10^6 )</td>
</tr>
<tr>
<td>200</td>
<td>656 ( \times 10^3 )</td>
<td>1383 ( \times 10^6 )</td>
<td>49 ( \times 10^6 )</td>
<td>59 ( \times 10^6 )</td>
<td>152 ( \times 10^6 )</td>
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<tr>
<td>250</td>
<td>820 ( \times 10^3 )</td>
<td>1909 ( \times 10^6 )</td>
<td>67 ( \times 10^6 )</td>
<td>82 ( \times 10^6 )</td>
<td>210 ( \times 10^6 )</td>
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<tr>
<td>300</td>
<td>984 ( \times 10^3 )</td>
<td>2312 ( \times 10^6 )</td>
<td>89 ( \times 10^6 )</td>
<td>82 ( \times 10^6 )</td>
<td>270 ( \times 10^6 )</td>
</tr>
</tbody>
</table>
Conclusions

Based on available data and provided analysis of gas reserves for a single well, depending on the fracking results, we can see current state of single well GIIP in Poland. The quality and number of input data used for volumetric calculations change gas resources. Graphics comparison (Fig. 1) between minimal Canadians and Polish, maximal Chinese (Longmaxi) and USA (Barnett Shale) shows statistical data from Tab. 1. That calculations and provided first well testing improve that Polish shale gas resources are big enough for commercial production with GIIP (for single well drainage) on level between ~0.2-2 x 10^6 [Nm³].

Acknowledgements

The Faculty of Geology, Geophysics and Environment Protection, AGH University of Science and Technology, is deeply grateful for making it possible to use the software from Schlumberger (Petrel), which has been delivered within the framework of the University Grant Program no CTT-tt-4/2012.

References


