Modeling oil composition in reservoirs submitted to biodegradation in offshore oilfields in the Brazilian southeastern margin.


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Discussion

Volumetric and compositional petroleum prediction constitutes a crucial requirement to the exploratory process in areas subjected to biodegradation. It is well known that biodegradation causes a preferential loss of the light ends of oil, a relative enrichment in resins and asphaltenes, a reduction in API gravity, and an increase in acidity and viscosity. As a consequence, petroleum biodegradation entails a substantial decrease of the volume of oil in place, lower recovery factors, as well as a reduction in oil quality and price. Therefore, there is a great need for modeling tools capable of before-drilling prediction of the effects of biodegradation on petroleum accumulations in order to avoid prospects with greater risk of containing heavy oils.

This work was based on a detailed study of oil and gas samples subjected to variable extents of biodegradation from offshore oilfields in the Brazilian southeastern margin, and on numerical simulations to quantify the alterations in geochemical and physical properties in the petroleum accumulations due to biodegradation. The main objectives of this study were: 1) to quantify compositional changes in the oil and gas caused by progressive biodegradation; and 2) to propose a set of parameters to simulate and reproduce the volumes and compositions of petroleum affected by biodegradation.

Petroleum accumulations with non-biodegraded oil in the pre-salt (Aptian) reservoirs were compared with oils subjected to various intensities of biodegradation in Maastrichtian reservoirs. Among the laboratory procedures, gas chromatography was utilized to subdivide the oils in compositional classes (C6-C15, C15-C25, up to C55+), PVT analyses to quantify the fluid properties (API gravity, density, GOR, and others) and fractional distillation to estimate the oil mass losses with the advancement of biodegradation. A method was devised by Petrobras whereby cumulative distillation curves are used. For a range of oils from the study area encompassing non-biodegraded ones and others with variable extents of biodegradation, mass losses can be calculated considering the total cumulative yield and the residues at a high temperature. The integration of these techniques allowed to estimate around 35% of mass losses in a degraded oil with 18° API, which is the average value found for biodegraded oils in the Maastrichtian level (Fig. 1).

Equation (1):

\[
\text{Surface oil Volume (biodegraded) = VOIP}_{\text{(biodeg.)}} / B_{\text{O(biodeg.)}}, \text{where VOIP}_{\text{(biodeg.)}} = \text{in place biodegraded oil volume; } B_{\text{O(biodeg.)}} = \text{formation oil (biodegraded) factor.}
\]

\[
\text{Surface oil mass (biodegraded) = surface oil volume(biodeg.) * oil density on the surface (biodeg.)}
\]

\[
\text{Surface oil mass (non-biodegraded) = (surface oil mass (biodeg.) * 100%) / percent of mass loss.}
\]

\[
\text{Surface oil volume (non-biodegraded) = surface oil mass (non-biodeg.) / density (non-biodeg.)}
\]
VOIP (non-biodegraded) = surface oil volume (non-biodeg.) * Bo (non-biodeg.)

Biodegradation rates and degradable fractions were adjusted for each compound class until a good match was achieved between measured and calculated compositions. The simulated biodegraded accumulations reproduced the mass losses, API gravities and compositions of oils consistent with those assessed by the integration of laboratory techniques (Fig. 2).

Figure 2 - Graph of Maastrichtian reservoir filling history without petroleum biodegradation, graph of API gravity and temperature through time and results table comparing properties of the reconstituted oil (without biodegradation), oil in place and modeled biodegraded oil.

Conclusions
These new achievements enable, using the set of biodegradation parameters and reservoir filling history, to assess the biodegradation risk, as well as the volume and oil composition in new prospects located in areas subject to biodegradation. Further developments in this model will be made as these parameters are tested and validated in other geological areas.

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References:

