A new approach to manage non-traditional structural model geometries applied to Lubina - Montanazo field, Spain: Powered by Volume Based Modeling algorithm in Petrel

Rosa Aguilar (1), Carlos Nuñez (2), Vanessa Villarroel (2), Marcos Victoria (1)
(1)Repsol, (2)Schlumberger
Agenda

- Introduction
  - Background
  - Challenges
  - Proposed solutions
- Reservoir characterization
  - Faults
  - Horizons
- Fault framework and Volume Based Modeling (VBM)
- Stair-Step Gridding
- Results & Conclusions
Background

• Two oil wells producing from a fractured carbonate reservoir

• 5 km NE-SW elongated structure with rotated blocks limited by two lateral faults

• Two reservoir rocks over-imposed; sucrosic dolomites and karstified limestones

• Complex stratigraphic relationships with carbonates patches and onlaps/downlaps

• Complex fault geometries and truncations
Challenges

- Represent the complex carbonate’s geology in a 3D model capturing the reservoir behavior and connectivity.

- Several issues faced using Traditional Pillar gridding:
  1) Too complex fault modeling process; not all the faults included in the 3D grid
  2) Structural and stratigraphic complexity was not honored
  3) Resulting 3D grid with a large number of distorted cells; slow simulation and convergence problems
Proposed solutions

- Use the Structural Framework (SF), Volume Based Model (VBM) algorithm, and Stair-step gridding to:
  - Reduce the time spent on building the structural grids
  - Solve the stratigraphic and structural complexities
  - Assure to build the optimum grid to run dynamic simulations
Reservoir Characterization

Stratigraphic & Structural Model

INRODUCTION  RESERVOIR CHARACTERIZATION  FAULT FRAMEWORK AND VBM  STRUCTURAL GRIDDING  RESULTS AND CONCLUSIONS
Reservoir Characterization

Faults Interpretation

Fault extraction
Structural Map

Structural Model

Fault framework and VBM

Results and conclusions
Reservoir Characterization

Horizon Interpretation

Initial Horizon configuration

1\textsuperscript{st} stage

2\textsuperscript{nd} stage

3\textsuperscript{rd} stage

Final Horizon configuration

INTRODUCTION

RESERVOIR CHARACTERIZATION

FAULT FRAMEWORK AND VBM

STRUCTURAL GRIDDING

RESULTS AND CONCLUSIONS
Structural Modeling Workflow

Structural Modeling – Summary Workflow

Interpretation data → Data edition → Input data

3D Stair-step grid → Structural gridding → Structural Framework

Boundary definition
Fault framework
Horizon modeling

INTRODUCTION
RESERVOIR CHARACTERIZATION
FAULT FRAMEWORK AND VBM
STRUCTURAL GRIDDING
RESULTS AND CONCLUSIONS
Fault framework and VBM

Structural Modeling – Fault Framework

- Fault framework process simplifies the fault modeling
- All fault geometries and truncations easily handled
- Drastic reduction of time spent in fault modeling and editing
Fault Framework and VBM

Structural Modeling – Input Data Preparation

Horizon Clean-up:
Clean wrong sided data to avoid incorrect modeling of horizons
“Watertight model”: the creation of a model with closed boundaries was key to avoid the extrapolation of the horizons out of the faults limits.
Fault Framework and VBM

Structural Modeling – Horizon Modeling

Need of combining different horizons and changing stratigraphic relationships to capture complexity

Original

Conformable (3)
Base (5)

Base (4)

Conformable (3)

Final model

Discontinuous
(4 + 5 SW)

Conformable (5 NE)

Petrel 2016 – Base-Base horizon relationship available. No need of combining horizons anymore
Solution: Control points to constrain the horizon modeling
**Structural gridding**

- **Structural gridding** process generates **Stair-step grids** which avoid the shortcomings and limitations of the Pillar grids related to complex structural relationships and cells distortion.

- Stair-step grids are more suitable for simulation than traditional Pillar grids. Usually, less time is needed for review and QC.
Structural Gridding

Cell Angle property

Pillar grid

Vs.

Stair-Step grid
Results

I. All the faults were included in the final Structural grid. It was not possible in the Pillar grid.

II. Maximum cells angle drastically reduced.

III. No cells inside out and no cells with negative volume.

IV. Volumetrics showing similar values than the Pillar grid model, with a difference of less than 1%.

<table>
<thead>
<tr>
<th>Cell angle</th>
<th>% of cells (Stair-Step grid)</th>
<th>% of cells (Corner point grid)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;15°</td>
<td>95</td>
<td>37</td>
</tr>
<tr>
<td>&lt;25°</td>
<td>99</td>
<td>66</td>
</tr>
<tr>
<td>Max. Angle</td>
<td>44°</td>
<td>77°</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Original Interpretation</th>
<th>Modified Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>12.5m x 12.5m</td>
<td>60m x 60m</td>
</tr>
<tr>
<td>239.87 x 10^6 m^3</td>
<td>240.47 x 10^6 m^3</td>
</tr>
<tr>
<td>0.7% difference</td>
<td>0.6% difference</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Original Interpretation</th>
<th>Modified Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>12.5m x 12.5m</td>
<td>60m x 60m</td>
</tr>
<tr>
<td>241.54 x 10^6 m^3</td>
<td>242.01 x 10^6 m^3</td>
</tr>
<tr>
<td>0.7% difference</td>
<td>0.6% difference</td>
</tr>
</tbody>
</table>
Conclusions

- New modeling workflow implemented in Repsol
- Significant reduction of time spent on building the structural model compared to the traditional Pillar gridding workflow
- Improved quality of the 3D grid’s cells
- In simulation, reduction of convergence problems associated to grid geometry
- Final 3D stair-step grid ready for simulation