Mature Field Potential Assessment through Integrated and Accelerated Field Development Plan workflows: Colombia



Ecopetrol Team: D. Restrepo; C. Rojas; C. Gonzalez; F. Garzon; A. Hurtado; A. Velandia. **Schlumberger Team**: N. Sanabria; F. Abad; A. Villarroel; J. Torres; N. Vasconez; L. Mendoza; R. Ortiz; A. Mahesh; C. Okuku.



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Objective & High-Level Results

- Objective:
 - Characterizing a mature compartmentalized tight carbonate reservoir with a combination of natural fractures, expandable clays, and complex mineralogy with low-to-medium porosity values.
- Challenge:
 - Handle uncertainty in the characterization process through a semi-automated workflow considering 50 years of production and limited subsurface data.
- Solution:
 - Integrated and accelerated semi-automated workflow to evaluate the remaining potential of the target reservoir accelerated by On Demand Reservoir Simulation.



Petrophysical Characteristics



Tight carbonate reservoir with a combination of natural fractures, expandable clays, and complex mineralogy with low-to-medium porosity values



Static Model





DFN, Fracture Modeling Workflow





DFN, Fracture Drivers – Seismic Attributes



Fault Likelihood



Ant-Tracking - Gradient



Chaos



Variance





Sweetness



Ant- Tracking Max Curvature



Dip Angle



Ant- Tracking Dip
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DFN, Fracture Drivers – Seismic Attributes

Supervised Neural Net Estimation (Intensity)



	Seismic- FaultLikelihood	Seismic - Curvatura Ant- tracking	Seismic - Varianza Ant tracking	Seismic - D2 Ant tracking	Seismic - Dip Ant tracking	Seismic - gradiente tracking	Seismic - Sweetness	Seismic - Curvatura	Seismic - Variance	Seismic - Chaos	Seismic - G	Seismic - MY	Seismic - PR	Seismic DeepestDescent G_Extrema_Ex	Seismic - Dip (angle)	Seismic - D2	Intens
eismic- FaultLikelihood	1.0000	0.1549	0.3242	0.2354	0.1037	0.0819	0.1571	0.0838	0.0289	0.0419	0.0643	0.0946	0.3119	0.0037	0.0610	0.0420	0,
eismic - Curvatura Ant-tracking	0.1549	1.0000	0.0490	0.0420	0.1773	0.4750	0.1746	0.6512	0.0281	0.4749	0.1558	0.1458	0.1843	0.0776	0.1839	0.0792	0.
eismic - Varianza Ant tracking	0.3242	0.0490	1.0000	0.1914	0.0594	0.3709	0.2068	0.3370	0.4162	0.2568	0.0781	0.1121	0.3225	0.0321	0.0023	0.0629	0.
eismic - D2 Ant tracking	0.2354	0.0420	0.1914	1.0000	0.0625	0.0556	0.0471	0.2945	0.1962	0.0059	0.0521	0.0743	0.1714	0.0030	0.0640	0.4057	0.
eismic - Dip Ant tracking	0.1037	0.1773	0.0594	0.0625	1.0000	0.1150	0.2472	0.2365	0.3437	0.2340	0.1093	0.1046	0.1139	0.4931	0.5829	0.1511	0.
eismic - gradiente tracking	0.0819	0.4750	0.3709	0.0556	0.1150	1.0000	0.4498	0.4544	0.2625	0.4069	0.0447	0.0381	0.0166	0.0327	0.1317	0.0039	0
eismic - Sweetness	0.1571	0.1746	0.2068	0.0471	0.2472	0.4498	1.0000	0.3158	0.1786	0.4261	0.0727	0.0617	0.2493	0.3015	0.2073	0.0087	0
ieismic - Curvatura	0.0838	0.6512	0.3370	0.2945	0.2365	0.4544	0.3158	1.0000	0.3657	0.5404	0.2085	0.2284	0.0860	0.0204	0.0076	0.2911	0
ieismic - Variance	0.0289	0.0281	0.4162	0.1962	0.3437	0.2625	0.1786	0.3657	1.0000	0.0446	0.0237	0.0428	0.2171	0.2097	0.5207	0.1964	0
eismic - Chaos	0.0419	0.4749	0.2568	0.0059	0.2340	0.4069	0.4261	0.5404	0.0446	1.0000	0.0602	0.0566	0.0753	0.2152	0.4200	0.1393	0
ieismic - G	0.0643	0.1558	0.0781	0.0521	0.1093	0.0447	0.0727	0.2085	0.0237	0.0602	1.0000	0.9932	0.4496	0.0798	0.1297	0.2693	C
ieismic - MY	0.0946	0.1458	0.1121	0.0743	0.1046	0.0381	0.0617	0.2284	0.0428	0.0566	0.9932	1.0000	0.3562	0.0715	0.1093	0.2413	0
ieismic - PR	0.3119	0.1843	0.3225	0.1714	0.1139	0.0166	0.2493	0.0860	0.2171	0.0753	0.4496	0.3562	1.0000	0.1976	0.3160	0.2165	0
eismic DeepestDescentG_ Extrema_Ex	0.0037	0.0776	0.0321	0.0030	0.4931	0.0327	0.3015	0.0204	0.2097	0.2152	0.0798	0.0715	0.1976	1.0000	0.3920	0.0795	0
ieismic - Dip (angle)	0.0610	0.1839	0.0023	0.0640	0.5829	0.1317	0.2073	0.0076	0.5207	0.4200	0.1297	0.1093	0.3160	0.3920	1.0000	0.0878	0
ieismic - D2	0.0420	0.0792	0.0629	0.4057	0.1511	0.0039	0.0087	0.2911	0.1964	0.1393	0.2693	0.2413	0.2165	0.0795	0.0878	1.0000	0
otal	0.6172	0.8485	0.7134	0.5884	0.8280	0.7396	0.7098	0.9134	0.8309	0.8257	0.9991	0.9989	0.9621	0.6573	0.8992	0.6588	0



Correlation table





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DFN, Fracture Drivers – Distance from faults









Faults Corridor, NE/SW direction

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Faults Corridor, NW/SE direction

Predictions with Automated Workflows Update Frame **Evaluate** Decide ➤ aFDP Well Placement and Probabilistic Reservoir Quality Index and Geological Models & DFN Sweet Spot Screening **Trajectory Evaluation** Well Ranking IHCVPC 0.2800 Np target= 1.2 M Bls NPV target= 6 M USD 0.2077 IKHC 0.2139 KfIC Kma Sigma IC 0.0708 PRESSURE 0.4922 Integrated & Automated Workflow for FDP evaluation (from months to weeks), including Seismic Data to support reservoir characterization in green fields, best reservoir areas identification, probabilistic well types design, evaluation and ranking (profitability, production and risk criteria) 🕞 DELFI DrillPlan D Digital Forum **2022** Schlumberger

Integrate uncertainty workflows for sampling geological models



Discrete Fracture network to support reservoir characterization





Calculate RQI (targets: sweet spots)





Туре	Rating	Range
1	Bad	0-0.25
2	Not Bad	0.25-0.5
3	Good	0.5-0.75
4	Performer	0.75-1

Productivity = f (Kf, Km, HCVPm, Sigma, Pm)



IHCVPC	1.0000	0.8853	0.0674	0.0580	0.4425	0.4193	0.4964	0.2688	0.2800
ІКНС	0.8853	1.0000	0.0726	0.0495	0.3471	0.3013	0.3587	0.1878	0.2077
KfIC	0.0674	0.0726	1.0000	0.7442	0.1804	0.1896	0.2435	0.0410	0.2139
Sigma_IC	0.0580	0.0495	0.7442	1.0000	0.1324	0.1260	0.1449	0.0914	0.0708
PRESSURE	0.4425	0.3471	0.1804	0.1324	1.0000	0.7492	0.8845	0.4868	0.4922
Total	0.8983	0.8867	0.7665	0.7545	0.5040	0.7691	0.9067	0.5034	0.5396

Performer well



Productivity impact

SPE-181584-MS Innovative Approach for Building and Calibrating Multiple Fracture Network Models for Fractured Carbonate Reservoirs

SPE-175708-MS Development of Heterogeneous Immature Brownfield with Waterdrive Using Dynamic Opportunity Index: A Case Study from Iraqi Oilfields

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Create and run several cases on cloud to perform uncertainty analysis



SPE-178658-MS/URTeC:2169844 Automated Field Development Planning for Unconventional Shale Gas and Tight Oil

Automated well construction task

- ✓ Pad placement and Pad well design on the targets
- ✓ Resources Management and completion Schedule

100 Executions with and without net to Gross

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Probabilistic well ranking by specified criteria (NPV or Np)



Success probability from uncertainty analysis







Risk Identification





- ✓ Special Logging (FMI, Porosity)
- ✓ Compressibility Analysis
- ✓ Pressure Tests
- ✓ Selective Well Test Discretized by unit
- ✓ Assign Weight Factor Combining Uncertainty Areas with Well Ranking (NP/NPV)



Conclusions & Recommendations

- Integrated Uncertainty Analysis within an Agile Customized Workflow enabled to run hundreds of simulation cases to evaluate 5,000 well possibilities and its combinations in a record time (20 days) using digital capabilities: On Demand Reservoir Simulation.
- Risk & Uncertainty Assessment through a probabilistic approach identified 6 new well locations in addition to the existing Field Development Plan. The main variables with a direct effect on new wells EUR are: porosity, fractures conductivity, matrix compressibility.
- ✓ The characterization process showed unconventional stimulation techniques are needed to boost the recovery factor from the target formations. Conventional techniques can provide a RF of up to 10% with the current FDP.
- From current data availability, it is recommended to acquire the following data: Image logs, Sonic logs, Spectroscopy Logs.



for a New Future











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