



Interactive Geological Prospecting Using Innovative Analytics

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Summary

One of the major inefficiencies of working exploration projects in complicated rift basins is the time consuming (and technically unsatisfying!) process of identifying and drawing hundreds of structural closures, only to redo it again when a map gets updated or new data is received. GEOSEIS has developed an interactive geological prospecting workflow using innovative analytic workflow to focus more of the explorationists' time on interpreting the seismic and geology. Structural closures are automatically created from a structure map. A volumetric parameter and risk framework is defined and all closures are assigned risk and volumes based on this framework. Using data analytics, this lead database is interactively interrogated and explored to understand the opportunities and uncertainties of the study area. It is a workflow that streamlines all the steps from the mapped data to the final opportunity portfolio. Explorationists can now embrace the iterative process of geological prospecting without fear or dread.

Introduction

GEOSEIS developed and evolved the workflow during numerous rift basin exploration projects in Tanzania, Kenya and Yemen. What these rift basins have in common is a relatively large number of structural leads and complex, ever-changing fault mapping. This presentation will explore the methodology using an example dataset. There are three stages of this workflow:

1. *Automatic Closure Detection*
2. *Probabilistic Resource Estimate and Risk Assessment*
3. *Portfolio Analysis*

Theory and/or Method

1. *Automatic Closure Detection*

The Automatic Closure Detection program identifies and extracts closures in a robust and repeatable way. It identifies structural closures from a set of structure maps at multiple stratigraphic levels; recognizing 4-way structural closures, 3-way closures against faults, and complex multi-fault traps. The main output is a table of closure objects with extracted attributes such as closing contour, highest point, area, and gross rock volume.

The closure objects can also be tagged with attributes from spatial features such as distance to access roads, seismic coverage, geological map values and terrain types. This step provides the foundation dataset and is automated for efficiency and repeatability.

2. *Probabilistic Resource Estimate and Risk Assessment*

Geological knowledge and interpretation is systematically applied to the closure objects through a risk and volumetric parameter framework.

Volumetric parameters are assigned stratigraphically or spatially. This enables the interpreter to set parameters systematically and in bulk for large amounts of structural leads. For example, porosity can be related to a geological facies map with a depth modifier. Once the closure objects have been created,

size attributes and geologic volumetric parameters are input to an industry standard Monte Carlo probabilistic resource calculation.

Geologic risk for each closure object is also assigned stratigraphically or spatially. Individual risk elements are often related to a geological map of some sort. For example, migration risk could be related to the distance from the mature source kitchen. This results in a systematic, transparent and defensible risking framework.

The output from this step is a database of lead candidates with probabilistic resource ranges and assigned risks.

3. Portfolio Analysis

In this stage, the large amounts of data generated in Stages 1 and 2 are interrogated and analyzed using customized analytical workflows. Incorrect data will be identified, lead candidates will get high graded, and insights will be developed. Based on the analyses, the interpreter can modify input mapping and/or geologic parameters and the entire workflow can be easily rerun again until the desired level of refinement is achieved. Lead attributes can be cross-plotted and compared, stacking is investigated, and opportunities are ranked.

The final output is an inventory of exploration leads which can then be further analyzed, high graded and ranked into an opportunity portfolio.

Examples

This example includes three mapped horizons in a highly faulted rift basin setting.

1. Automatic Closure Detection

The Automatic Closure Detection program identifies 300+ closures across all horizons. Figure 1 shows a partial map of the automatically extracted closures for Horizon B.

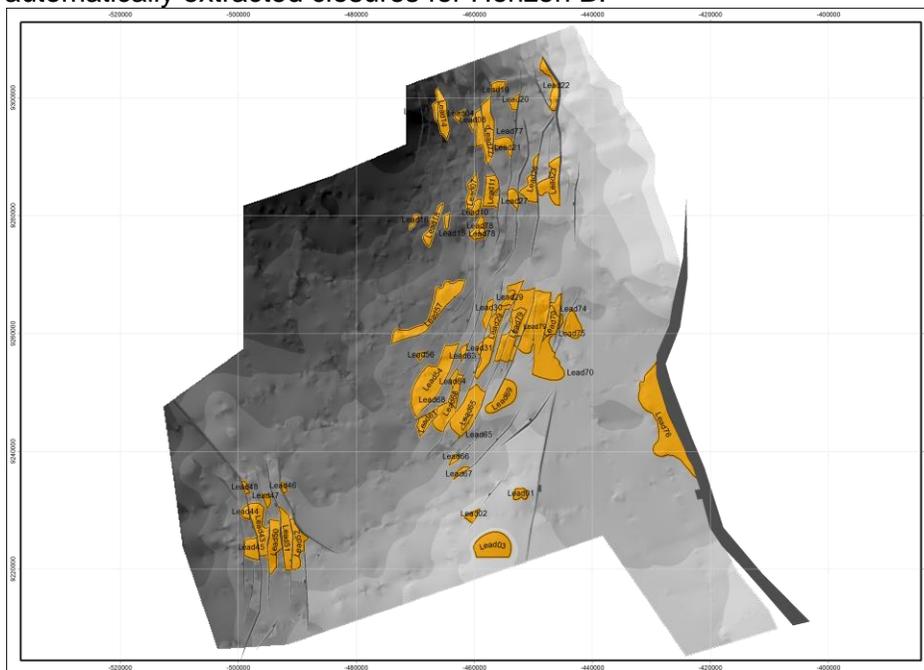


Figure 1: Automatic Closure Results for Horizon B.

2. Probabilistic Resource Estimate and Risk Assessment

The following parameters are input into a batch Monte Carlo probabilistic resource calculation and probabilistic resource distributions are output for each lead. Figure 2 shows an example output for a single lead;

- Geologic Volumetric Parameters
 - Gross rock volume is measured from the automatic analysis.
 - Net-to-gross is extracted from a regional net sand map.
 - Porosity and hydrocarbon saturation are assigned stratigraphically to each horizon.
 - Formation volume factor and recovery factor are assigned globally.
- Risk Parameters
 - Source risk is assigned globally.
 - Migration is assigned based on distance to the mature source kitchen with formation modifiers.
 - Reservoir and seal risk are assigned stratigraphically with depth modifiers.
 - Trap risk is related to seismic coverage and trap type.

Input Data:

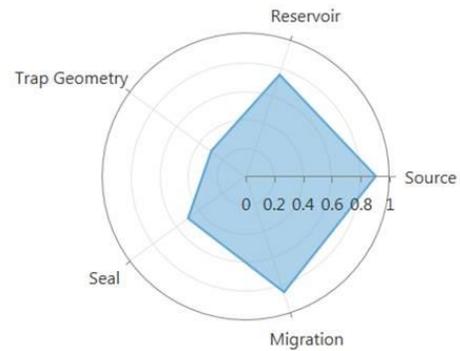
Recoverable Resource Calculation Input Parameters	P90	P50	P10	Mean
Area (km ²)			24.3	
Gross Pay Thickness (m)	n/a	n/a	n/a	n/a
Gross Rock Volume (10 ⁶ m ³)	341	1078.65	3412	1616.32
Net to Gross (fraction)	0.1	0.2	0.4	0.23
Geometric Factor (fraction)	n/a	n/a	n/a	n/a
Average Net Pay Thickness (m)	n/a	n/a	n/a	n/a
Porosity	0.1	0.17	0.3	0.19
HC Saturation (fraction [1-sw])	0.5	0.6	0.7	0.6
Oil Case FVF (coefficient)	1.01	1.27	1.6	1.3
Oil Case Recovery Factor (fraction)	0.1	0.2	0.3	0.2

Output Data:

Cumulative Probability Distribution Point (= or greater than)	Interpretation of Probability Distribution Points	Recoverable Resource Outcome
1%	Very Low Probability	348.50 MMbbbls
5%	Almost Never	157.89 MMbbbls
10%	Seldom	98.86 MMbbbls
Mean	Weighted Average	42.86 MMbbbls
Median - 50%	Even Chance	20.10 MMbbbls
Mode	Most Likely	10.00 MMbbbls
90%	High Probability	3.88 MMbbbls
95%	Virtually Certain	2.34 MMbbbls
99%	Very High Probability	0.87 MMbbbls

Risk Assessment:

Source	Migration	Seal	Trap Geometry	Reservoir	Chance of Success (CoS) Today	Geological Risk Assessment 1 in ...
0.9	0.85	0.5	0.3	0.75	0.09	11.62



Probability of Total Oil Resources being Greater or Equal

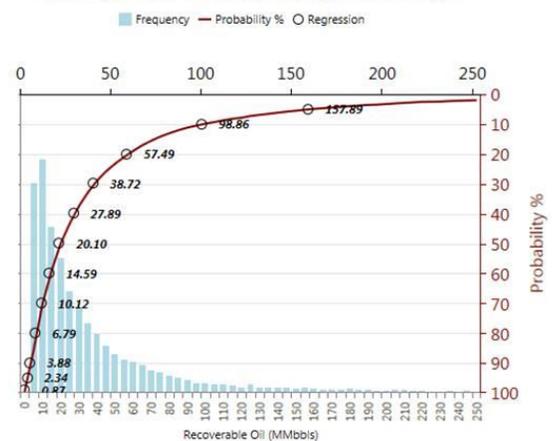


Figure 2: Probabilistic resource estimate and risk assessment results for a single lead.

3. Portfolio Analysis

The results from Stages 1 and 2 are used in the analytical workflow. Here, the database of closure objects and metadata is transformed into an opportunity portfolio. The analytics toolkit allows the explorationist to view and compare all outputs from the previous two stages. Visualization examples are shown in Figures 3 and 4.



Figure 3: Analytics display showing lead stacking and risked resource contributions from multiple zones.

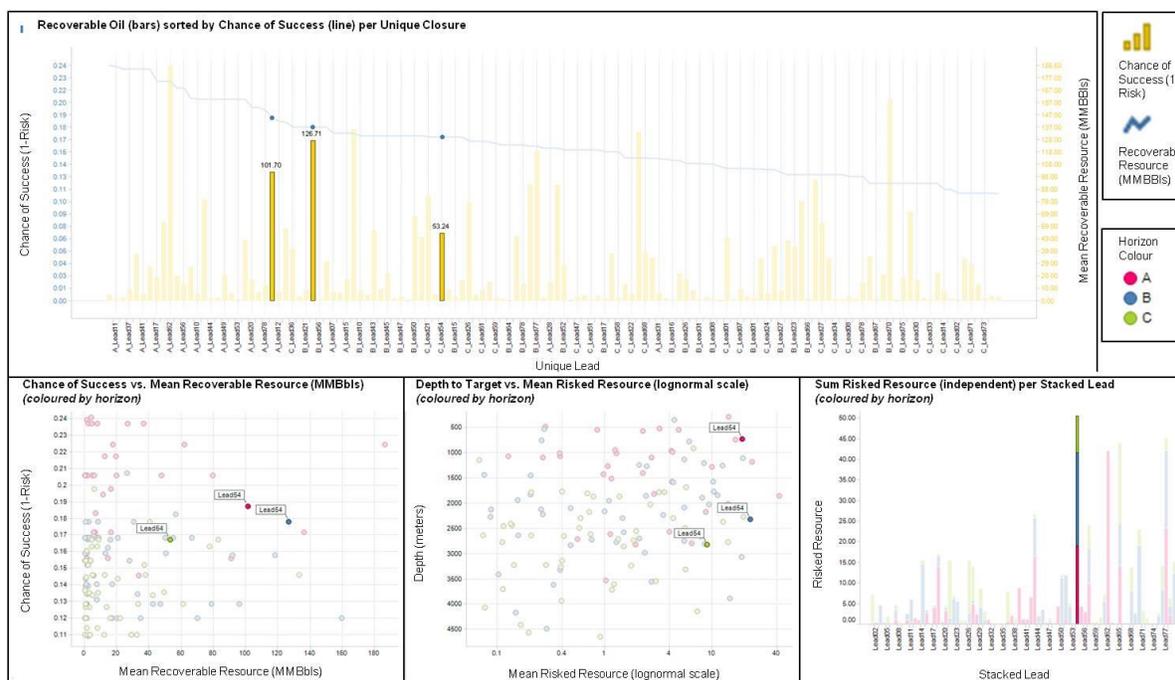


Figure 4: Visualizations showing relationships and ranking of leads interactively.

Conclusions

This streamlined workflow encourages explorationists to focus on the geological and geophysical inputs of their work and enables them to readily embrace mapping changes, rework ideas and/or add data as it becomes available. By documenting and systematically building an opportunity portfolio, the exploration team can optimize the evaluation, recommendations and work program for their property. The user will develop an intimate knowledge of the dataset and have a tool to communicate, document and defend recommendations. Company specific risking and volumetric standards can be implemented as required. This process promotes integration of disparate datasets, facilitates communication of ideas and concepts and embeds confidence and defendability into the decision making process.

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References

Otis, R. M., and Schneidermann, N, 1997, A Process for Evaluating Exploration Prospects, AAPG Bulletin, V81, No. 7 (July 1997), p 1087-1109