Advantages and Potential of using Geostatistics in Depth Conversion and Volumetrics.

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<u>Introduction</u>

Oil & Gas companies need to construct structural models of their reservoirs to evaluate oil volumes, to find spill point location, to accurately drill new wells and to assess the corresponding risks. This short paper illustrates with a single layer anticline reservoir case study, the results that can be obtained in depth conversion and volumetrics when using optimal solutions provided by the geostatistical techniques.

<u>Depth Conversion and Structural Modeling</u>

Depth conversion is a major step in data integration and analysis. In practice, because of many factors, deterministic techniques such as regression or velocity inversion are used. The use of deterministic techniques can have a tremendous influence on the decisions made at the different stages of an oil & gas project. Conversely the use of geostatistical techniques which are based on well-known methods allow practitioners to use at the best the available data.

The main advantage of geostatistics is that it is a model-based approach, which incorporates the **spatial structures** of the different data (wells and seismic). Optimal results can then be obtained because geostatistics has for objective to **minimize errors** and to

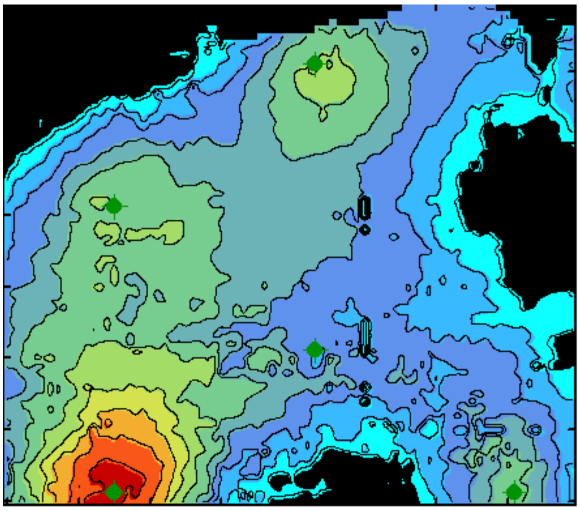

Figure.1 Depth map from regression Gridding. (red color is low depth)

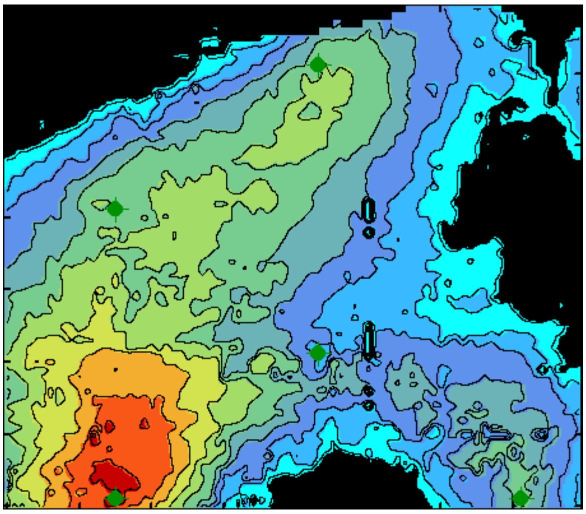

Figure.2 Depth map from Collocated Cokriging Gridding. (red color is low depth)

reproduce the spatial trends of the depth (here top reservoir depth). Figures.1 and 2 show two depth maps obtained respectively by regression and geostatistical Collocated Cokriging where 5 wells were available. Both techniques use seismic Two-Way-Time and stacking velocity maps as the seismic information to improve the depth gridding.

Only the geostatistical technique (figure.2) is able to **reproduce the trend** and the **continuity** in the structure of the different low depth (pale green to red color) part of the reservoir. Knowing the connectivity between the different part of the reservoir allowed to optimize the oil & gas production. Geostatistical depth conversion results gave valuable information on where to drill new production and injection wells.

Volumetrics

The next step that generally follows a depth conversion is to derive oil & gas volumes from the structural model of the reservoir. Practitioners generally think that using the best structural model obtained either by classical or geostatistical techniques will give them the best volumes (GRV, HCPV, STOIIP, etc.) evaluation. Unfortunately, volume calculation is not a simple linear operation. Therefore, gridding methods are **not** appropriate techniques to derive accurate volumes, because they always produce smoothed maps.

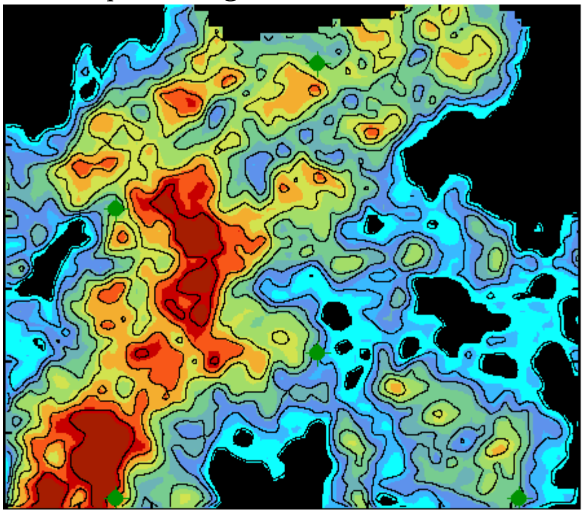

Figure.3 Depth map from one geostatistical simulation. (red color is low depth)

A simple application illustrated with the previous data shows how the geostatistical **simulations** are the most suitable tools to estimate accurate volumes as well as the associated uncertainties.

The basic output from a simulation is also a depth map (figure.3): one can see that this simulation map is much more variable than any map which could be obtained with gridding techniques (figures.1 & 2). The reason for this is that simulations aim to reproduce the spatial variability and connectivity characteristics of the depth of the layer. Possible continuous oil path and oil traps from the lower left corner to the upper middle part of the reservoir can now be seen. Many similar images of the reality can then be produced and analyzed. Statistical calculations on the various simulations allow to obtain **Iso-Probability maps, Quantile maps** and **Risk Distribution Curves** allowing the quantification of the uncertainties in drilling a new well, in locating the spill point and in volumetrics.

Finally, volumes (GRV) derived from the different techniques are displayed on table.1. The results are given for two different oil-water contact scenarios, and lead to several comments. First, **gridding methods underestimate volumes** unlike simulations. Simulation results are better because they reproduce the real depth variability of the top reservoir. In this example simulations give a volume which is 18% to 25% higher than with gridding for a low level oil-water contact. With a shallower oil-water contact, the discrepancy is even more severe, with **85%** gain in simulations.

Oil-Water contact	Regression	Collocated Cokriging (Geostatistics)	Geostatistical Simulations
Nb1 (deep)	295 Mm3	325 Mm3	394 Mm3
Nb2 (shallow)	16 Mm3	32 Mm3	118 Mm3

Table.1 GRV (Mm3) estimations from different depth conversion techniques

Second, simulations give access to connectivity maps, risk maps and volumes distribution curves (figure.4). Practically, the uncertainty on volumes is extracted from the distribution curve under the form of pessimistic (P10), most probable (P50) and optimistic (P90) scenarios.

<u>Conclusion</u>

When geostatistical techniques are used for depth conversion and volumetrics, they allow extracting in an optimal way the maximum of the data available.

For Depth Conversion, geostatistics provide a way to integrate the seismic and well data and to reproduce actual trends in depth maps of the top reservoirs.

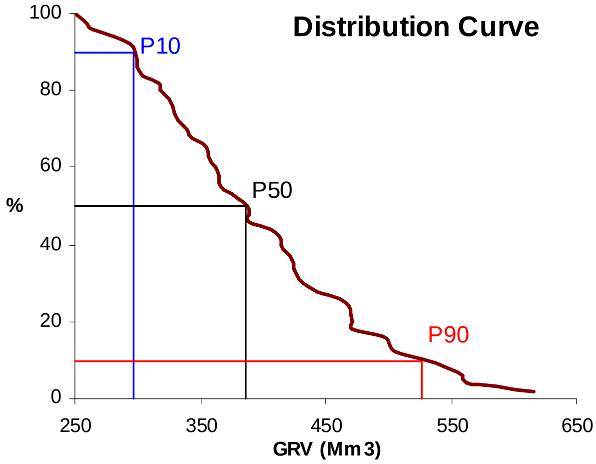

Figure.4 Risk Distribution Curve for GRV Nb1

For Volumetrics, geostatistical simulations offer optimal techniques to evaluate the different volumes and assess the corresponding risk. Simulation results can although have different practical usage like: connectivity maps, iso-probability closure maps, quantile maps, distribution curves, etc. This is also true for the petrophysics.