Automatic Determination of Sedimentary Units from Well Data

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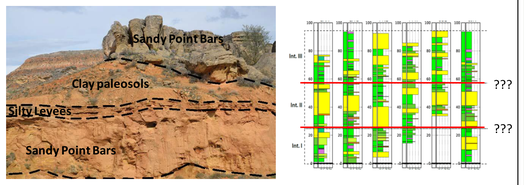
Introduction

Heterogeneous reservoirs often consist in several sub-horizontal geological units. The determination of these units is important in order to create realistic models of the reservoirs. The best solution is a geological expertise, which will provide all the information about reservoir stratigraphy. But if it is impossible to perform such expertise, or if there is no exact conclusion, we propose a new numerical analysis method which is able to describe the vertical heterogeneity of the reservoir and help defining optimally the geological units from the well data. This method can be useful for modeling heterogeneous reservoirs, using for instance a process-based modeling (e.g., Flumy software for meandering channelized reservoirs, Lopez et al., 2008) or a stochastic modeling like Truncated or Plurigaussian simulations (M. Armstrong et al., 2011).

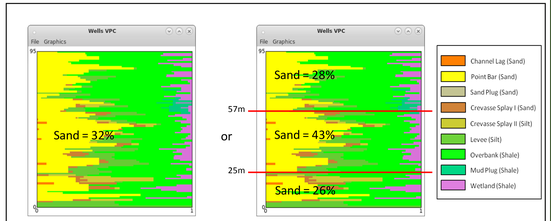
Problematic



Question: how to choose the geological units?

Fluvial reservoir analog, Loranca basin, Spain

Vertical Proportion Curves (VPC)



Example of wells VPC, data source – 8 wells of Loranca basin, Spain

Aim

To automate the geological units determination from the VPC data by a procedure **"stronger" than a visual criterion**

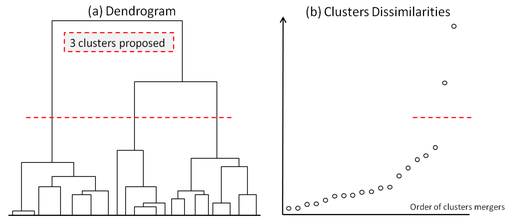
Note: for now, it is enough to compute strictly horizontal simulation units. Flumy performs the simulations in paleogeographic space (relative geological age).

Method

Geostatistical Hierarchical Clustering (T. Romary, 2015):

Hierarchical clustering: A division of data set into partitions (clusters) which become larger and larger with each step of the algorithm: each new cluster is obtained by a successive consolidation of two similar clusters.

Graphical Representation: Dendrogram (a) or graph of Clusters Dissimilarities (b):



Data set: We use the wells VPC statistics (Flumy):
- Vertical 1D data
- Each sample **i** has a vertical elevation value (z_i) and a sand proportion value ($sand_i$)

Additional method concepts:

Only **adjacent** VPC intervals can be grouped into clusters.
Example:

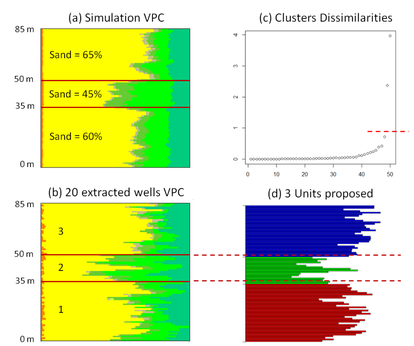
Initial dissimilarity between unit clusters i and j: $d_{ij} = (sand_i - sand_j)^2$

Linkage Criterion (LC) is used to compute the updated **intercluster dissimilarity** value resulting from the cluster merger.

Ward's Minimum Variance: intercluster dissimilarity is the increase of within-cluster variance after merging.

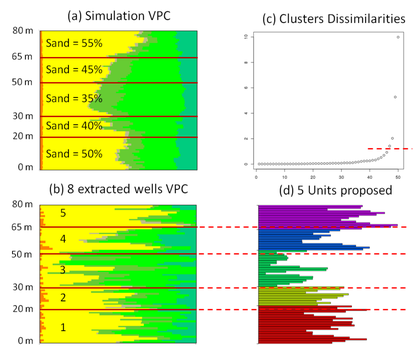
Results

Contrasted simulation units:



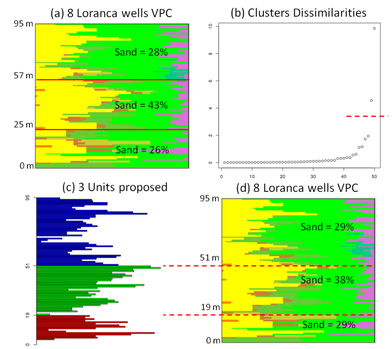
(a) Simulation VPC, red lines represent the limits between the initial units
(b) VPC of 20 extracted wells
(c) Clusters Dissimilarities graph, the 3 last clusters are the most dissimilar
(d) Sand part of the wells VPC, the colors correspond to the 3 last clusters

Non-contrasted simulation units:



(a) Simulation VPC, red lines represent the limits between the initial units
(b) VPC of 8 extracted wells
(c) Clusters Dissimilarities graph, the 5 last clusters are the most dissimilar.
(d) Sand part of VPC, the colors correspond to 5 last clusters.

Real data example – 8 wells (Loranca, Spain):



(a) VPC of 8 Loranca wells, plain red lines show 3 units proposed by geologists
(b) Clusters Dissimilarities graph, the 3 last clusters are the most dissimilar
(c) Sand part of VPC (3 last clusters)
(d) VPC of 8 Loranca wells, dotted red lines show the 3 simulation units proposed by clustering

Conclusions

The proposed clustering method for analyzing wells VPC shows good results on synthetic tests: it permits to determine the initial simulation units **even if the extracted wells VPC are not clearly representative**. Results for real data set (Loranca) are also quite interesting: geological units proposed by geologists are almost similar to the units obtained by clustering.

This method can be applied automatically in order to propose a division of a heterogeneous reservoir into several contrasted horizontal units.

Perspectives

- Automation of the choice of the units **optimal number** (from the graph of Clusters Dissimilarities).
- **Implementation** of the method into Flumy as a wells analysis tool.
- **Non-horizontal** units from the well data.

Acknowledgements

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References

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