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Artificial intelligence for mineral and chemical stratigraphic correlations

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Summary

Chemical and mineralogical identifiers have long been used in the analysis and correlation of stratigraphic units in oil and gas exploration. Analytical technologies have improved over the years allowing for trace elements and minerals to be accurately quantified and more accurately compared from well to well. However, the amount of data that is produced during these studies typically overwhelm the user, making interpretation difficult if not prohibitive. As a result, observations of real trends in many elemental and mineral abundances go unobserved. Similarly most interpretation relies on ratios of major elements and specific trace elements but this approach can pose certain statistical problems which can generate false correlations (Lowey, G.W., 2015).

In this study we combine traditional geochemical datasets with quantitative mineralogical data derived from QEMSCAN analysis. However, although the integration of quantitative mineralogical data and textural information such as mineral size and lithotype distribution should allow significantly impoved correlation, it increases the already substantial amount of information by several orders of magnitude, particularly for multi-well studies, basin models and regional correlations.

In many other scientific fields, artificial intelligence and neural networks have allowed the processing of very large datasets without the need to reduce the data to a level that is manageable by human users. These methods allow for the gathering of as much information as possible from extensive and diverse datasets which are in turn processed and interpreted to reveal real variations and correlations. Therefore, we propose that by adapting algorithms used by evolutionary biologists (which evaluate heritable traits, such as DNA sequences or morphology) it is possible to use extremely large datasets to make inferences on the relationships between rock types, sediment provinance, alteration intensity or even mineralization systems.

By adaptating a phylogenetic algorithm (Delsuc and al., 2007) we have interrogated extensive datasets to create classes of evolution associated to rock samples. The interpretation of this geological evolution tree allows for the grouping of unclassified rock samples to domains according to different parameters depending on the scope of the study; correlation of channel sands within wells for example. In order to achieve this, the sample dataset, including chemical and mineralogical data, is run through the algorithm which conducts a star-decomposition method that uses an approximation of the minimum-evolution optimality criterion. In turn, building an evolutionary distance matrix between each data point that is used to infer the evolutionary tree of the dataset starting at a common ancestor.

This approach was used to conduct blind and/or detailed interpretation of sedimentary origin from samples and correlate them in multiples wells across an offshore conventional, clastic reservoir. The case study presented here will give an example of how the application of artificial intelligence can increase the geological value associated with the interpretation of extensive datasets.

References

Lowey, Grant W. Element/Aluminum Ratios in Chemostratigraphy: A dubious Normalization Resulting in Spurious Correlations. Abstract in GeoConvention 2015. May 2015.

Delsuc, F., Douzery, Emmanuel JP. Les methods probabilistes en phylogénie moléculaire : Les modèles d'évolution des séquences et le maximum de vraisemblance. HAL archive ouverte : https://hal.archives-ouvertes.fr/halsde-00193036. Nov 30, 2007.