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Innovative Workflow to Differentiate Clastic Depositional Facies Using Inorganic Geochemical Fingerprinting

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Objectives/Scope

This study introduces a new workflow to use inorganic geochemical fingerprinting to differentiate siliciclastic depositional facies in the subsurface including those deposited in a range of environments e.g. Aeolian, Fluvial & estuarine depositional settings. This generates high confidence anchor points for the 3D reservoir model and enhance facies predication accuracy. Wells with geochemical logs can thereafter be used to identify with high confidence facies in un-cored wells

Methods, Procedures, Process

In the study area, 4 cored wells (drilled with oil-based mud) were selected for this study to eliminate any potential noise from water-based mud additives. The total number of analyzed core samples in the key wells is 340. Each sample was analyzed by Inductively coupled plasma Mass and optical emission spectrometry (ICP-MS and ICP-OES respectively) to obtain ppm-level precision and accuracy. Core samples are assigned to one of 8 unique depositional facies (e.g. Tidal Flat, estuary channel and playa). Machine learning platform was used to identify elements with highest feature importance.

Results, Observations, Conclusions

Resulting dataset contains 50 element measurements for 340 core samples, i.e. 17,000 geochemical datapoints in the dataset. Conventionally, elements such as silicon Si and Aluminum are considered of significant value to differentiate lithological units, however, this study conclude that the geochemical elements with significant link to reservoir facies in this study area are: beryllium Be, cerium Ce, potassium K, manganese Mn, neodymium Nd, lanthanum La, molybdenum Mo, copper Cu and bromine Br. Elements identified with the highest feature importance were used in a hierarchy cluster analysis approach to arrive at a distinctive geochemical signature for each facies. The generated workflow can be applied using new core geochemical data. This workflow can also be applied using log-based geochemical data, conditionally, if geochemical logs are reprocessed to obtain the necessary elements.

Novel/Additive Information

This is the first attempt to perform facies-based geochemical fingerprinting on the Permian sandstones of Saudi Arabia and any future efforts spent to re-process geochemical logs to obtain the necessary elements will be the first of its kind. This workflow also demonstrates that facies may carry characteristic geochemical fingerprints. This also adds value to existing core- and log-based geochemical datasets across the field. This also enables future characterization to unveil reservoir diagenesis across the basin.