Unsupervised Facies Pattern Recognition of Brazilian Pre-Salt Carbonate Borehole Images

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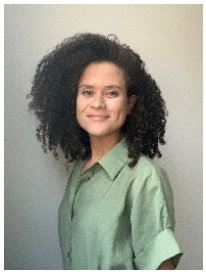
Abstract:

We apply our novel automated image interpretation workflow to Brazilian pre-salt ultrasonic borehole image data. We obtain an immediate, un-biased classification of the full data, requiring no further input data beyond the borehole image itself. This interactive solution combines statistical and deep learning algorithms for image embedding to provide data-driven, multi-purpose borehole image interpretation. Borehole images are a source of important information for building static reservoir models. Textures observed in these high-resolution well logs are the results of and provide insights into the different processes that have occurred: from the moment of the deposition until the image acquisition. Each field, reservoir, well, and interval has a unique textural assemblage, consequence of its own depositional facies, diagenetic processes, geomechanics and wellbore conditions or well intervention and completion. Efforts to automate facies interpretation in our industry often rely on applying supervised machine learning models. These supervised algorithms are restricted to executing very specific tasks, based on extensive amounts of consistently labeled data. In the example of depositional geological classification, generating labeled data can be a complex and extensive task, subject to interpreters' experience – resulting in a low human performance benchmark. The solution proposed here comprises a sequence of five steps:

- Prepare data;
- Apply a first embedding step using statistical methods or convolutional autoencoders;
- Apply PCA or t-SNE techniques as the second embedding step;
- Perform manual or automatic clustering;
- Finally, assign a facies class to each textural group.

This paper discusses applying this innovative workflow to acoustic borehole images of pre-salt carbonates from the Santos basin. Various preprocessing and embedding options were tested and compared to the geological core interpretation. Using statistics, semi-supervised t-SNE and k-means clustering methods, we divide the data into textural groups and describe these groups according to their distinct geological, diagenetic or geomechanical characteristics. With this new approach, facies are defined based solely on borehole image logs in a fast, consistent and less user biased form. Ultimately, our innovative workflow allows us to not only gain insights into the depositional, geological and geomechanical processes and their correlation with the pre-salt carbonates reservoir quality, but to establish a more efficient, reliable method for borehole image interpretation in general.

Bio:



Laura Lima is Interpretation Development Engineer at the Schlumberger Riboud Product Center (SRPC) in France, where she develops integrated solutions for geology and well construction. Prior to joining the SRPC, she was part of the Schlumberger Technology Integration Center in Rio de Janeiro.

She applies her background in geology, data science, and software development to the development of algorithms and UI/UX to make borehole data processing and interpretation more efficient and effective. Laura holds an MSc in Engineering with a specialization in Deep Learning for Borehole Image Classification and a BSc in Geology.