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A CASE STUDY OF UNDERSTANDING THE BONAPARTE BASIN USING UNSTRUCTURED DATA ANALYSIS WITH MACHINE LEARNING TECHNIQUES

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Summary

As part of exploration and production the oil and gas industry produce substantial amounts of data within different disciplines of which 80% are unstructured like reports, presentations, spreadsheets etc. The value of technical work is reduced due to the lack of time available for analysis and critical thinking and the under-utilization of the data. To assist geoscientist and engineers, Machine Learning (ML) and Artificial Intelligence (AI) technologies are applied to process the unstructured data from 440 wells from the Bonaparte Basin in Australia making it possible to perform more accurate analysis and make faster decisions.

Based on the play-based exploration pyramid concept, the time spent at the Basin Focus stage can be reduced, and more time are available to focus on the other project stages. The explorationist will be able to bring more value to the study.

It will be shown that potential issues encountered during exploration of the Bonaparte Basin can be identified. Based on a quick look and gathering of all information it can be concluded that most of the production in the Bonaparte Basin is from Jurassic and Triassic with observed net pay of 18-60m thickness, porosity of 11-29% and saturation of 11-55% Sw.

A Case Study of Understanding the Bonaparte Basin using Unstructured Data Analysis with Machine Learning Techniques

Introduction

As part of exploration and production the oil and gas industry produce substantial amounts of data within different disciplines of which 80% are unstructured like reports, presentations, spreadsheets etc and it is expected to grow exponentially. As a result, geoscientists and engineers spend 50 to 80% of their time searching and assembling data and only 1 to 5% of the data is fully utilized. The value of technical work is therefore reduced due to the lack of time available for analysis and critical thinking and the under-utilization of the data. To assist geoscientist and engineers, Machine Learning (ML) and Artificial Intelligence (AI) technologies are applied to process the unstructured data making it possible to perform more accurate analysis and make faster decisions.

In this case study the area of interest covers Bonaparte Basin, which is located north-west of the Australian continental margin (Figure 1). It joins the Money Shoal basin in the north-east and the Browse Basin in the south-west. Furthermore, the Timor Trough defines the northern boundary. The areal extent of the basin is approximately 270,000 sq. km. The objective of this study is to understand and obtain meaningful insights into the Bonaparte Basin based on the substantial amount of information available in previous studies, reports and presentations. The unstructured data of the Bonaparte Basin have been ingested in a Knowledge Container through consecutive ML and AI pipelines and analysed using big data analytics tools.

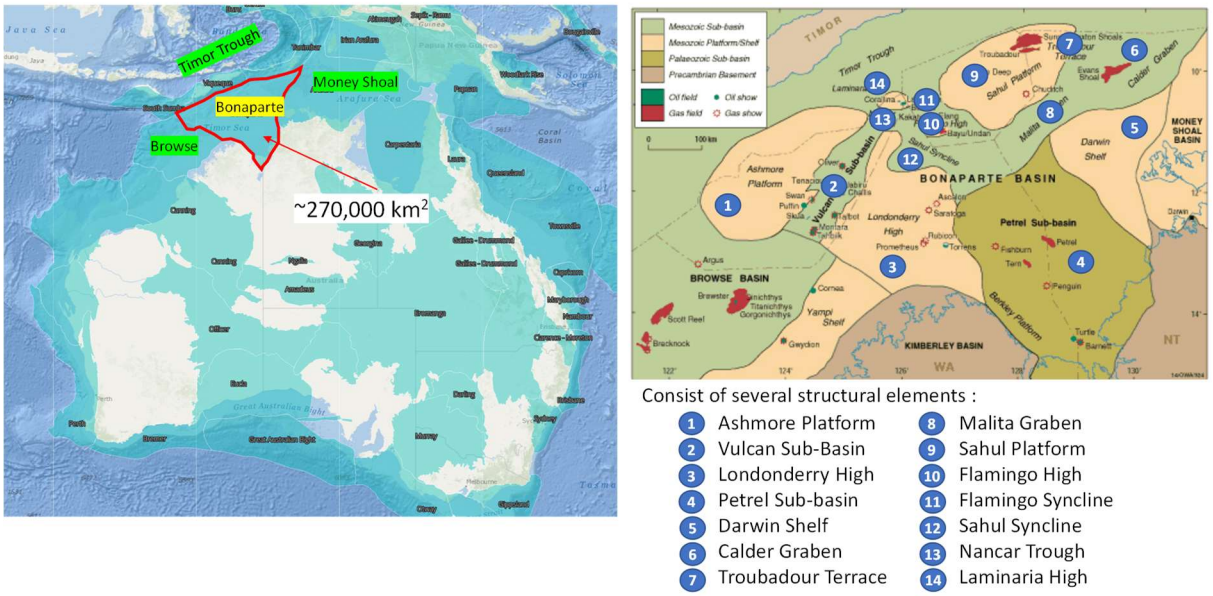

Figure 1 *Location of the Bonaparte Basin within the Australian continental margin (left) and 14 structural elements observed within the Bonaparte Basin (right).*

Methodology

As of 2021, the Bonaparte Basin encompasses 440 wells representing 58 years of exploration history summarized in over 270,000 pages of documents and in 250,000 images. It is estimated that billions of dollars have been invested over the years to acquire and interprete the data, making it a substantial source of information for new exploration activities.

The Play Based Exploration (PBE) approach is often used as a traditional framework to refine the geoscientists's understanding from a broad basin level to a narrow prospect focus (Lottaroli et al., 2016). As a start such an approach often involves capturing the current state of knowledge with massive background resources to understand and analyse the key features of the basin and the major risks associated to it. Such information is primarily available in unstructured data, requiring geoscientist and engineers to process and ingest the information before focusing on a specific play and prospect using structured data. Therefore, we have modified the existing PBE pyramid to introduce an additional

dimension associated with data science identifying the different types of data available at different stages, allowing us to better define the best suited ML/AI strategy for a given stage (Figure 2).

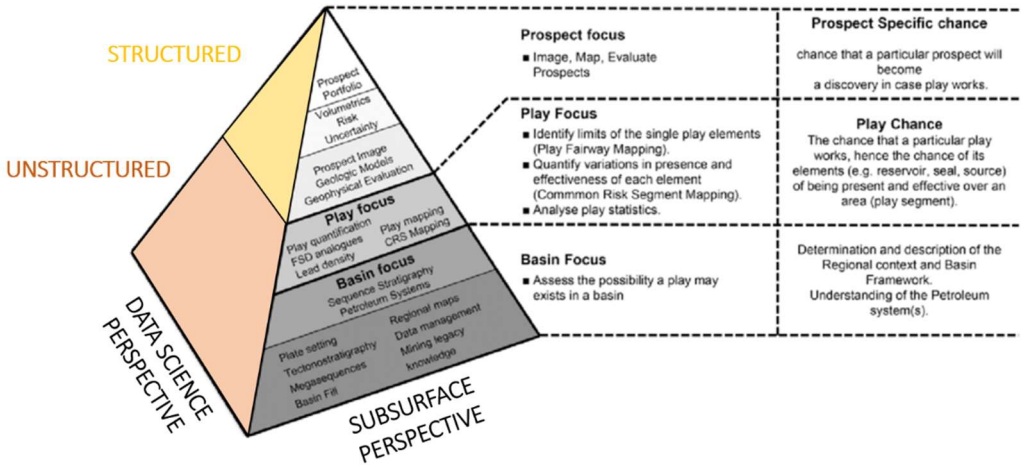

Figure 2 *Customized Play Based Exploration (PBE) pyramid with ML technology (Modified from Lottaroli et al., 2016).*

Focusing on the unstructured data associated with the Basin and Play Analysis, all the data from the Bonaparte Basin have been processed through a succession of AI/ML automated pipeline such as Natural Language Processing or Deep Convolutional Neural Network (Hernandez et al., 2019), (Figure 3). The sharable structured data is then further processed through deeper level of analytics to detect trends and anomalies present within the data. Machine assistance is heavily used in repetitive tasks early in the process during the processing of the data and up to 95% of the tasks will be performed by the machine. This provides additional time for the specialist to focus on critical thinking and cognitive skills to interpret the data.

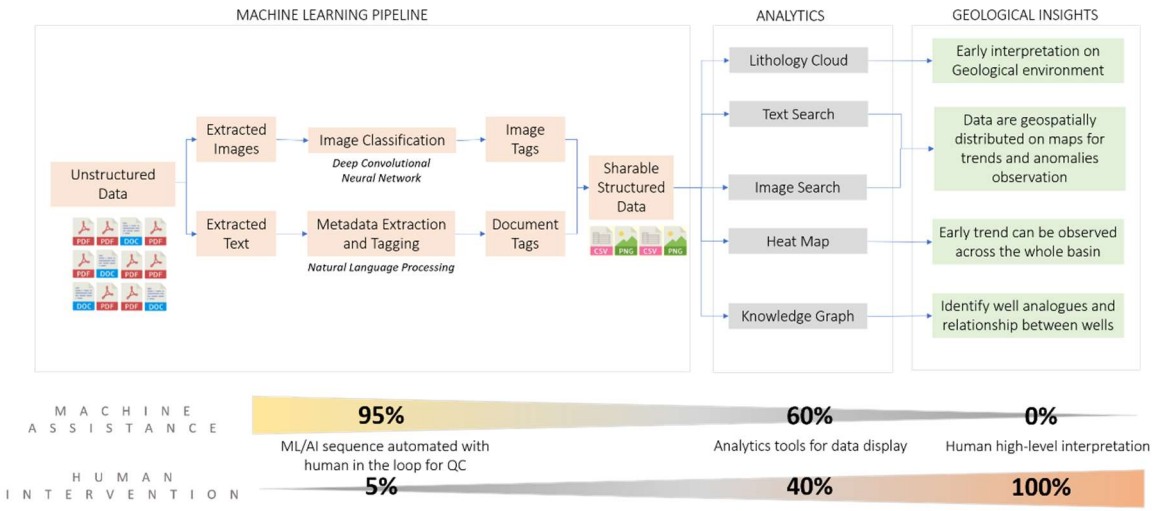

Figure 3 *Unstructured Big Data pipeline*

In this case study, interpretation using the Big Data workflow was used to understand the exploration history, how the basin developed, its petroleum system and the main issue of the dry wells occurrence to avoid repeating the mistakes of the past and improve future decision making.

By analysing the data, five potential issues are identified i.e. (i) Discrepancies in Formation Tops, (ii) Limited understanding of Lithology Distribution, (iii) Limited Mineral Composition Understanding, (iv) Fluid Distribution, and (v) Pressure/Temperature Patterns. Each potential issue is tackled by identifying trends and anomalies across the basin using images, tables and plots extracted from the unstructured data corpus.

Results

As an example, the analysis of the (ii) Limited Understanding of Lithology Distribution, shown in Figure 4, is performed using heatmaps. The heatmaps show the distribution of clastic and carbonates across the Bonaparte Basin and identify patterns and anomalies present in the area. The result can be supported by the stratigraphic chart where the carbonate environment occurs in the younger formation from Cretaceous to Neogene period, whereas clastic environment is present in the older formations from Triassic to Cretaceous.

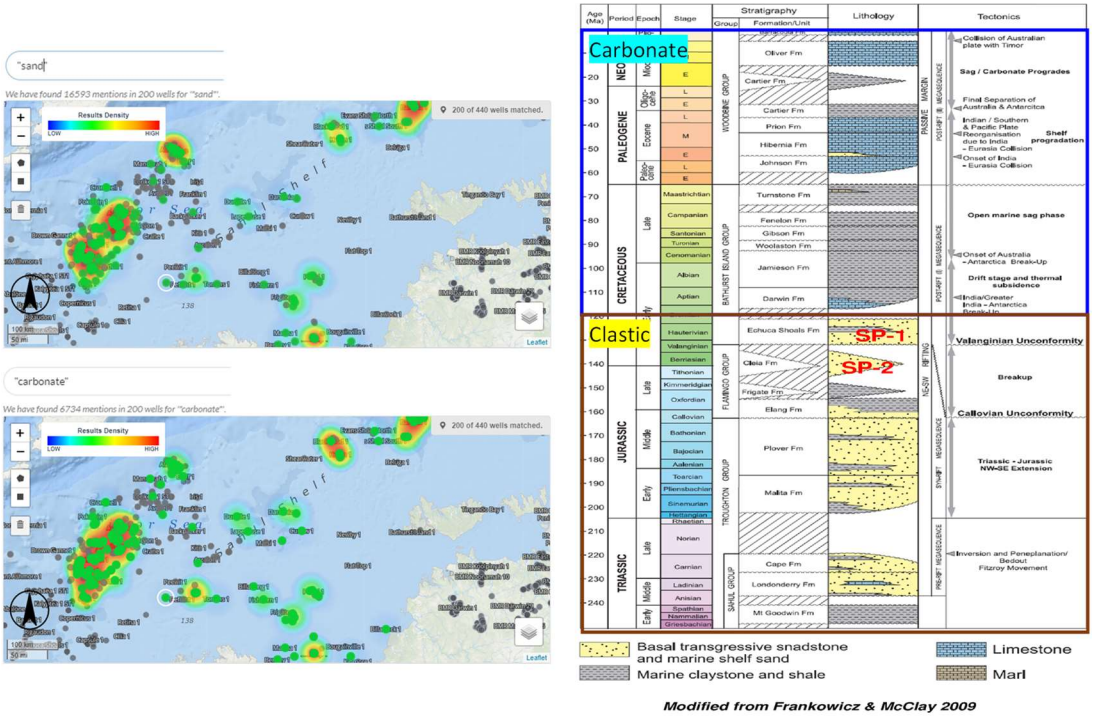

Figure 4 *Lithology distribution on heatmaps (left) and corresponding stratigraphic chart (right).*

The analysis of the (iii) Limited Mineral Composition Understanding, shown in Figure 5, utilizes the thin section automatically extracted using ML classification over the full area and suggests that:

- Quartz overgrowth and kaolinite are quite common in Bonaparte Basin
- Mica mineral can be observed at the north-eastern part of the basin
- Highly corroded, skeletal feldspar has been extensively dissolved, which forms secondary porosity, and can be observed in the northern part of the basin
- Some patchy siderites are also observed in the southern part of the basin

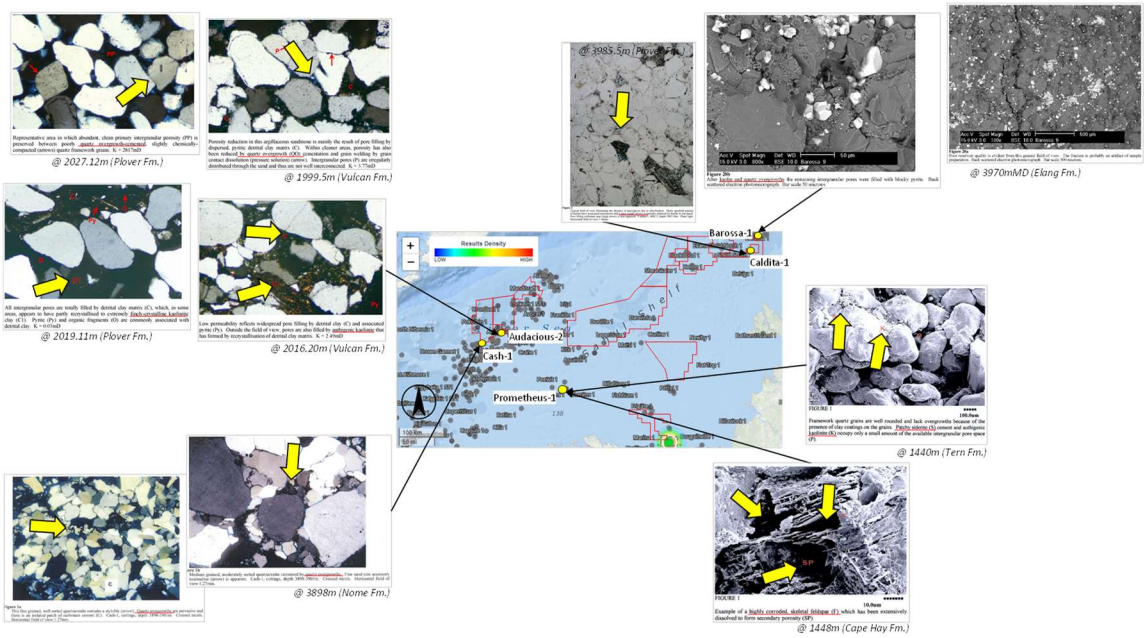

Figure 5 *Thin section images distributed on a map across the Bonaparte Basin.*

Conclusion

A regional understanding is critical and time consuming as it involves dealing with a very large data volume. Within a project time frame, based on PBE pyramid, the time spent at the Basin Focus stage can be reduced, and more time are available to focus on the other project stages. The explorationist will be able to bring more value to the study.

ML applications have proven to be able to play a crucial part in order to organize large unstructured data corpuses. This allows faster and accurate decision making within the fast-moving industry.

In this study, some potential issues encountered during exploration of the Bonaparte Basin can be identified. Based on a quick look and gathering of all information it can be concluded that most of the production in the Bonaparte Basin is from Jurassic and Triassic with observed net pay ~18-60m thickness, porosity ~11-29% and saturation ~11-55% Sw.

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