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LEVERAGING AI TO ELIMINATE BIAS IN KIMBERLITE CORE LOGGING

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Introduction

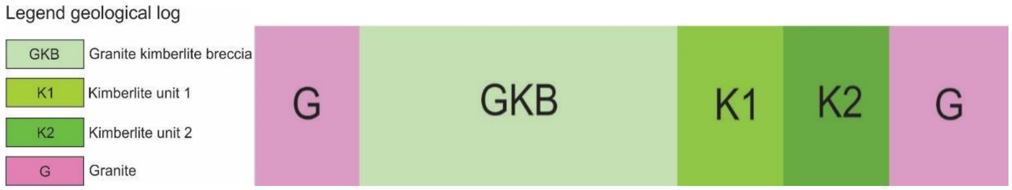
Artificial intelligence (AI) and machine learning (ML) has impacted all domains of the technical world with revolutionary ways to make technical workflows very efficient in processing time and decision making. One can achieve radical increases in the efficiency of repeated tasks through automation. Machine learning and AI have been around since the early 1960's, but the phenomenal rise of these technologies began with the fourth industrial revolution that started near the beginning of 2012, with the breakthrough in efficiencies of deep neural network algorithms [1].
Logging of drill cores is one of the most time consuming, labour-intensive, yet critical tasks during the discovery and economic assessment of mineral deposits. Numerous new technologies have been developed and existing techniques have undergone radical enhancements in recent years to improve the extraction of information from drill cores. Examples include hyperspectral imaging and analysis, high resolution digital core photography, X-ray fluorescence (XRF) analysis (a well-established technique for whole rock geochemistry), magnetic susceptibility mapping and geotechnical analysis.

Methods

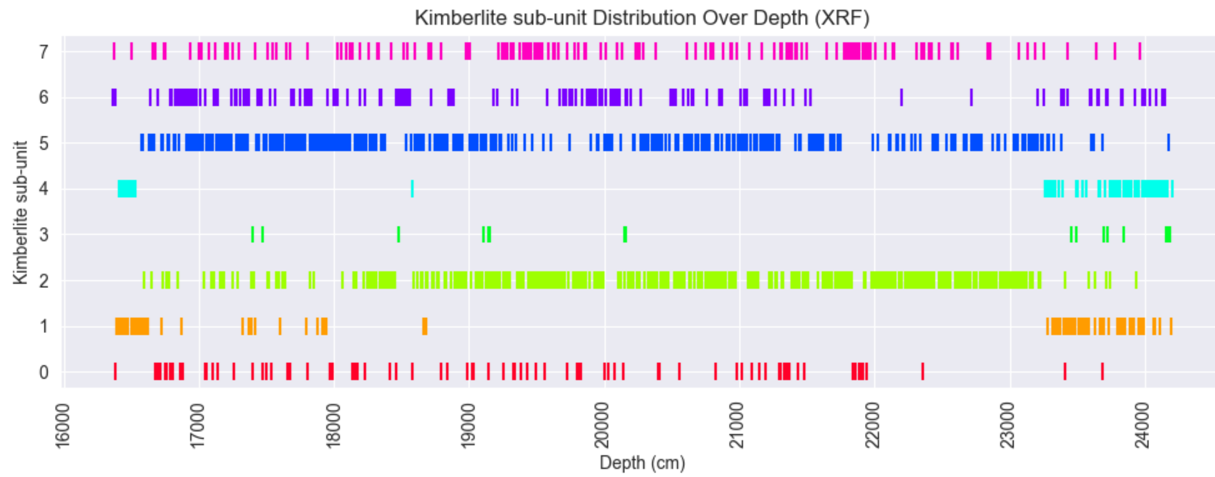
In kimberlite petrology, it is very important to obtain detailed analyses of rocks, then perform classification of kimberlite units and country rocks as a basis for microdiamond sampling and a validated resource evaluation. Frameworks have been developed in De Beers Group to standardize the evidence-based methods to discriminate between different types of kimberlite units and country rock lithologies with more confidence and eliminate bias in geological logging. With the help of the in-house developed algorithms, it is now possible to accelerate the decision-making process for accurate borehole lithological unit delineation and cross-borehole correlations and interpolation. Boundaries can be defined with more confidence with the addition of XRF geochemical analyses which aid in labelling the kimberlite units or subunits with increased confidence as depicted in Figure 1. The ability to identify and isolate internal dilution and quantify specific mineral assemblages with hyperspectral analysis against high resolution core photos can also be achieved.

Results

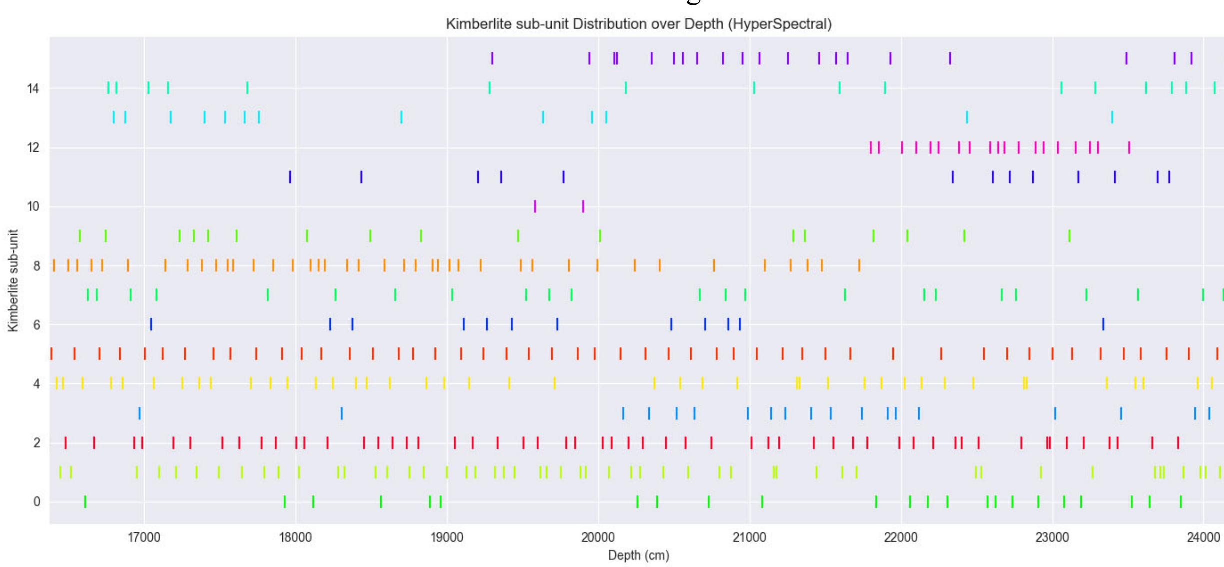
Leveraging high resolution digital photography can open new ways to understand and log the core in much more detail than ever with the development of well-trained models utilising validated lithology and RGB image data, with repeatable consistency and high accuracy in an efficient and cost-effective manner. A well-defined protocol is established in De Beers Group Exploration with thorough evaluation and testing by the subject matter experts for standardising all the above-mentioned methodologies for fully automated logging and data interpretation.



a. DeBeers Geological Log



b. XRF log



c. Hyperspectral log

Figure 1. Geological unit discrimination based on fully automated geochemical and hyperspectral data. The distinct geochemical regions and mineral assemblages are plotted against the geological log: (a) De Beers geological log; (b) Automated XRF geochemical log, and (c) Automated hyperspectral log.

There has been significant progress in segmenting and connecting the logged units with the RGB photos to accurately quantify dilution in each segment of the drill core as well as the dominant mineral assemblages of each unit based on the hyperspectral data. With our in-house solution, we can control the details of the analysis from a coarse level for discovery drilling to the finest level for economic resource modeling and assessment. All these analyses and reports can be generated as a near real-time solution once the raw data

is available, enabling us to greatly benefit from onsite decision-making and adjust drilling parameters accordingly when needed. All the mentioned solutions can be implemented onsite without any connectivity issues and executed with minimal technical knowledge of the powerful algorithms running behind the scenes.
In Figure 2, we describe the use of RGB imagery in the logging and dilution estimation process. This image segmentation pipeline is completely independent of the RGB imagery source. Well-defined protocols are in place to ingest imagery from any source and to register it accurately with other available modalities, including, but not limited to hyperspectral imagery, point data, XRF data, and magnetic susceptibility mapping data. Additionally, we can easily perform several basic geotechnical analyses using the above process, including rock quality designation (RQD) among others. The present work is merely a proof of concept demonstrating what can be achieved using computer vision in exploration and mining industry.

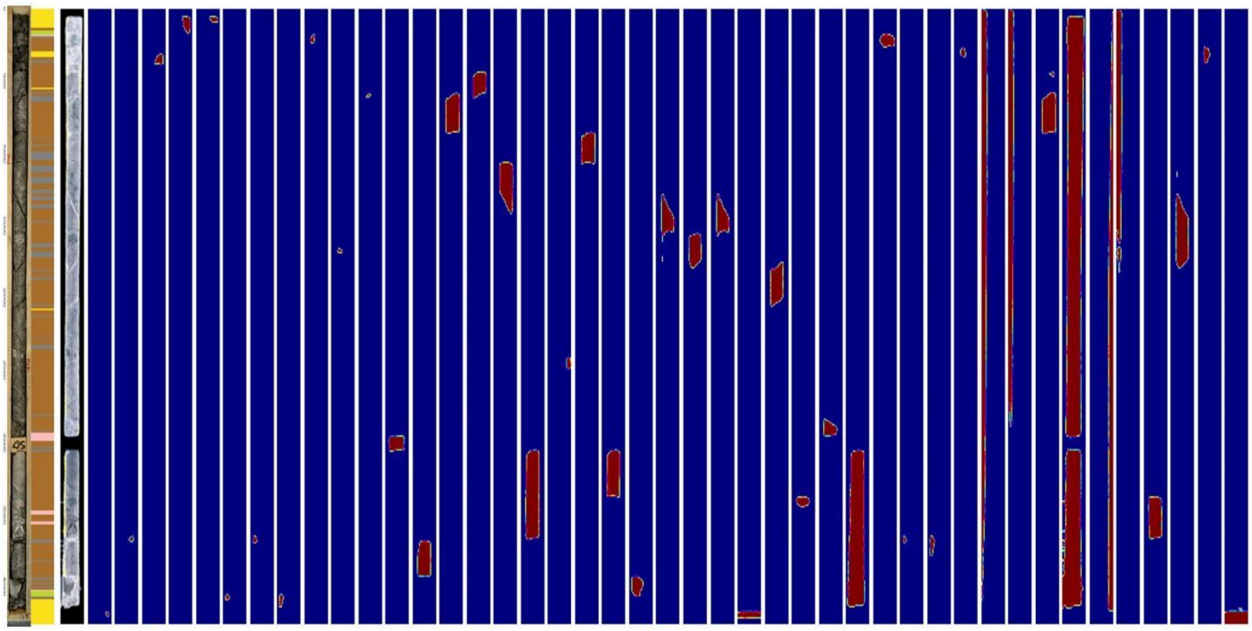


Figure 2. Fully Automated image segmentation pipeline to (a) discriminate the box and markers from the core imagery, (b) segment all the distinct regions for accurate percentile measurement and (dominant) mineral assemblage labeling, and (c) estimate accurate pixel-resolution dilution.

Conclusion

Integrating all these methodologies will enable the technical specialists and subject matter experts to work more efficiently and collaboratively, with more of their time dedicated to detailed data analysis for effective decision-making, eliminating the personal-bias factor to generate consistent logs from any site across the globe. In addition, the acquisition of geochemical and mineral strip logs will enable the subject matter experts to investigate the geochemical and mineral composition of the kimberlite units and country rock in a detail depending on the resolution of the used instruments.

References

1. History and Evolution of Machine Learning: A Timeline (2023) TechTarget. Available at: https://www.techtarget.com/whatis/A-Timeline-of-Machine-Learning-History