Semi-supervised lithogeochemical classification of the Tanami Group

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Introduction

The Tanami Region, on the border between the Northern Territory and Western Australia, is a Proterozoic orogenic gold province with several operating and past producing gold mines. Prodigy Gold's Tanami Project is located 400 km northwest of Alice Springs and encompasses ~14,000 km^2 of the Tanami Region within the Northern Territory. Since 2017, Prodigy Gold has undertaken several lithogeochemical studies (Schmid *et al* 2018, Schmid 2019) in the region to identify preferred host rocks for gold mineralisation (Lambeck 2004, Pretella *et al* 2019) and allow levelling of pathfinder geochemistry by rock unit. Systematic exploration by Prodigy Gold using aircore drilling, soil sampling, and geochemical sampling of historic drill spoils, has generated a contemporary regional dataset of multi-element data (Schmid *et al* 2018, Schmid 2019, Briggs *et al* 2019).

Standard classification methods are restricted to the simultaneous use of two or three variables at a time. Machine learning-based methods allow for a multivariate approach to classification, potentially increasing classification success. Prodigy Gold processes 59 element ICP–MS data using Orange, an open source machine learning (ML) and data analytics software. This enables a geologist-guided 'supervised' ML clustering of the geochemical data and generation of a semi-automated process for classification of lithogeochemistry. Supervised ML algorithms are used for making predictions of any kind given the right data to train the algorithm to understand the relationship between attributes and outcomes within a high-dimensional dataset (Zuo 2017, Zuo *et al* 2019).

In 2018, Prodigy Gold recognised that the Capstan Prospect, located in the Bluebush Area, contained Dead Bullock Formation (DBF) rocks (with anomalous gold) hosted in a structurally similar setting to the Dead Bullock Soak Goldfield and the 14 Moz Callie gold deposit (Briggs *et al* 2019). The DBF hosts Callie and is considered the preferred host formation for gold deposits in the Tanami Region (Pretella *et al* 2019). Prodigy Gold undertook a geochemical study in collaboration with CSIRO to confirm the stratigraphic context and define lithogeochemical classification criteria to assist exploration through the Cenozoic cover at Capstan (Schmid 2019).

A subset of the lithogeochemical classification established by these previous multi-disciplinary studies (Schmid *et al* 2018, Schmid 2019) was used to generate a training dataset of 315 samples. The training dataset calibrates the supervised lithogeochemical classification in Orange, which can then be applied to unclassified data. The outcomes of the semi-automated classification algorithm compares favourably with the previous manual classification (**Figure 1**) and is consistent with district scale tectono-stratigraphic geochemical classification (Lambeck *et al* 2008, Bagas *et al* 2008, Joly *et al* 2012, Bagas *et al* 2014). Within these units, clustering was used to further subdivide the major units classified. A confidence score is calculated by the algorithm that assists in highlighting poorly clustered data, often carbonaceous sediments and weathered samples. The lithogeochemical classification is compared to geological logging observations; geological

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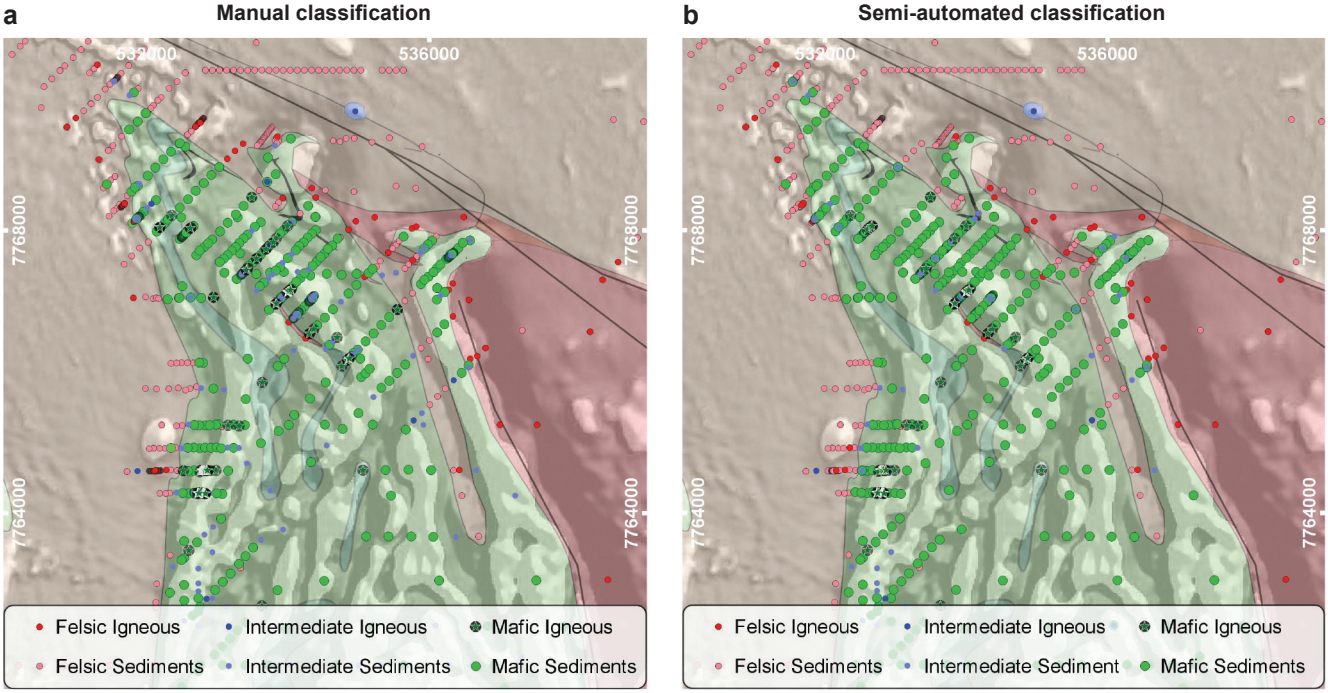

Figure 1. Lithogeochemical classification of multi-element data over the Capstan area. (**a**) Manual classification. (**b**) Semi-automated classification.

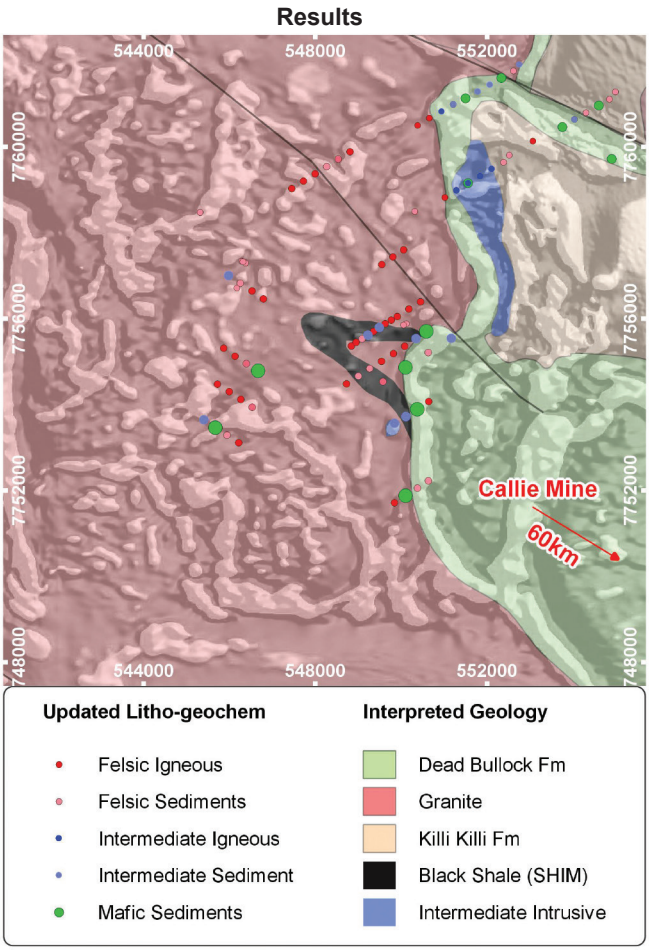

Figure 2. Prodigy Gold's lithogeochemical data at the Bluebush project demonstrates that the DBF (green dots) is widely distributed and that the project has structural and stratigraphic similarities to the Dead Bullock Soak goldfield, host of the 14 Moz Callie Gold Mine.

logging is also used as a category in the classification model on a separate branch of the model.

The semi-automated classification can be further enhanced by re-integrating the newly classified dataset into the Orange classification model to further train the model to classify samples in areas of limited knowledge such as the Bluehart Prospect, located 15 km to the southeast of Capstan. Prospectivity analysis by Prodigy Gold in 2019 identified the potential for DBF rocks associated with favourable structures at Bluehart. Visual observations of drill samples, in combination with supervised classification of the multi-element geochemical data with Orange, confirms that the rocks at Bluehart are DBF and Lower Killi Killi Formation (**Figure 2**). Confirmation of the presence of DBF enhances interpreted prospectivity and allows levelling of pathfinder elements by stratigraphic units.

Acknowledgements

Acknowledgements to Prodigy Gold's current and former geologists and Susanne Schmid at the CSIRO. The Company received funding for diamond drilling at the Capstan Prospect from the Northern Territory Government as part of the *Resourcing the Territory* initiative.

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