12TH INTERNATIONAL KIMBERLITE CONFERENCE
30 YEARS OF DIAMONDS IN CANADA
8–12 July 2024 • Yellowknife

12th International Kimberlite Conference Extended Abstract No. 12IKC-166, 2024

Evolution of Kimberlite Exploration – Advances in Drift Prospecting in Canada's North (Part 2): Case Studies and Examples

Patrick DesRosiers[1], Dave Sacco[1], Chris Hrkac[2], Tom McCandless[3]
[1] Palmer/SLR Consulting Ltd, Vancouver, Canada, patrick.desrosiers@pecg.ca
[2] Auroura Geoscience Ltd., Yellowknife, Canada, chris.hrkac@aurorageosciences.com
[3] MCC Geosciences Inc., North Vancouver, Canada, temccandless@gmail.com

Drift prospecting has been a principal method for diamond exploration in Canada's Slave Geological Province for over 30 years. The concept is relatively simple: identify anomalous materials in surface sediments and use geomorphological principles to trace the sediments back to their bedrock source (McClenaghan and Kjarsgaard, 2001). The first diamond-bearing kimberlite discovery in the Slave craton of the Northwest Territories was made in 1991, principally by tracing kimberlite indicator minerals (KIMs) in sediment hundreds of kilometres back to kimberlite (Fipke *et al*., 1995). In hindsight, it was a relatively easy discovery given the large number of KIMs glacially entrained and dispersed from the extensive field of kimberlites. Early kimberlite exploration successes in the Slave have largely been within the context of idealized models: continuous linear KIM dispersal in glacial sediment (drift) leading to relatively easily identified geophysical anomalies. Working within this textbook model has limited discoveries to those that fit into the template and precludes discoveries in non-standard surficial environments or non-standard kimberlite emplacement.

A series of case studies and examples demonstrate how advancements in drift prospecting methodologies have improved the success of kimberlite exploration in non-standard environments. These advancements are premised on having a detailed understanding of the surficial environment to recognize geomorphological processes that contribute to landscape evolution and alter primary KIM dispersion patterns and concentrations. Determination of where processes are occurring combined with an understanding of their effects on dispersal patterns provide the data required to unravel the source of indicator minerals with complex transport histories.

Till, a glaciogenic sediment that is a first derivative of bedrock, produces a predictable dispersal pattern related to the flow-direction of glaciers (Shilts, 1996). These primary dispersal patterns in till are altered by deglacial meltwater processes that have been recognized throughout the Slave Geological Province (Knight, 2018; Sacco *et al*., 2018a). Within discrete, commonly subglacial, meltwater corridors, till has been eroded, remobilized, and reworked, potentially concentrating KIMs, or removing them from an area entirely, depending on what landforms were sampled. Within glacial lakes, KIM concentrations may be diluted through the introduction of barren glaciolacustrine sediment or concentrated by the energy of waves in shoreline environments. Recognition of these meltwater-affected sediments can be difficult in the field due to the homogenization of material through cold-climate processes such as cryoturbation. Detailed surficial geology mapping that delineates the areas affected by these processes can improve the success of kimberlite exploration. When practical, it is best to avoid sampling of meltwater modified sediments as part of surface sediment exploration programs. However, these processes cannot be avoided in some areas, and therefore, data must be evaluated with the knowledge of what processes affected the sampled material and the implications for KIM concentrations and dispersion.

Figure 1 demonstrates how these concepts can be applied at the dispersal-scale to refine and improve the definition of the primary till dispersion pattern. KIMs have been dispersed within till from an unknown source through an area that was subsequently affected by a subglacial meltwater corridor between 500 m and 1000 m in width. The dispersion is represented by only a few samples with generally low KIM concentrations, making it difficult to confidently identify a primary dispersal pattern (Figure 1a). The dispersion contrast was improved by first identifying the areas affected by meltwater processes through detailed surficial geology mapping. Then, by evaluating the data for internal variability based on sample material genesis, analytical methods, and sample collection methods. After removing unreliable samples and mitigating the effects of the dataset internal variability, the primary dispersion pattern is more recognizable (Figure 1b), improving the reliability of generated targets.

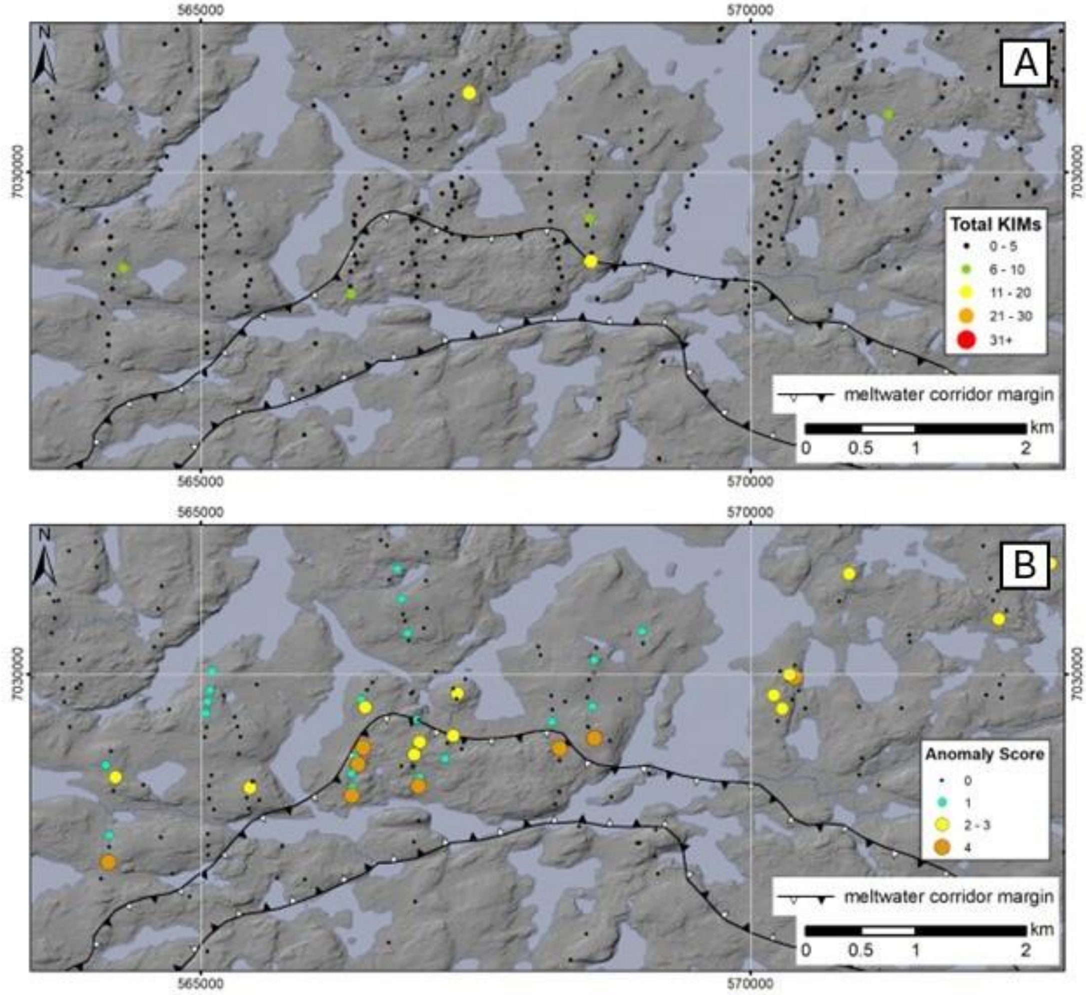

Figure 1: A) Total KIM counts in sediment samples symbolized based on the local background concentrations. Total KIM counts are relatively low and a dispersion pattern cannot be easily identified. B) The same dataset following a data evaluation that mitigates internal variability related to sample medium, analytical methods, and sample collection methods. The dispersal pattern is recognizable after the removal of samples from unrelaible materials and assigning a multi-variate anomaly score that helps level regional differences in background KIM concentrations.

The applications of a detailed surficial geology framework can also improve the utility of regional-scale data used to define prospective areas for detailed exploration initiatives. These data commonly have differences in sampling or analytical protocols that influence KIM concentrations and the recognition of dispersion patterns (*e.g.*, Sacco *et al.*, 2018b). Figure 2 demonstrates how a forensic evaluation of historical data (NTGS, 2018), compiled from numerous sources, can improve the recognition of KIM dispersion patterns. The additional detail provided by high resolution surficial geology mapping allows for genetic subpopulations to be distinguished. Anomaly thresholds specific to these subpopulations can then be determined, ensuring that, for example, higher KIM concentrations in samples collected from meltwater corridors are not masking primary dispersal in till that may have lower KIM concentrations. With less reliable samples removed, the surficial geology mapping can be used to collect new data from strategic locations. Prior to evaluating the data with the detailed surficial geology mapping and assessing variability due to sampling (*e.g.*, sample size; sieved in field or not) or analysis (*e.g.*, visual counts or probe-confirmed counts; normalization methods), there are only a few weak dispersal patterns apparent in the symbolized data (Figure 2a). Following a more detailed evaluation that corrects for internal variability in the dataset and strategic follow-up sampling, dispersal patterns are considerably more apparent (Figure 2b).

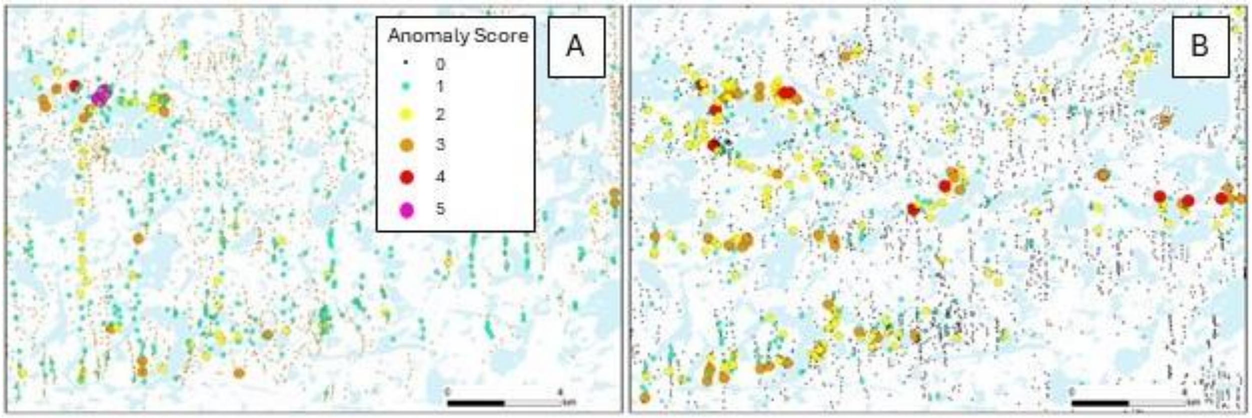

Figure 2: A) Regional, compiled dataset (NTGS, 2018) symbolized by anomaly score based on total KIM counts before data evaluation. B) The same dataset symbolized by anomaly score after data evaluation and strategic infill sampling. Dispersal patterns are apparent following a multi-variate data evaluation.

These refined data collection and evaluation methods provide a strategic approach that is customized to specific surficial settings and complex surficial environments. These advancements, combined with advances in geophysical methods and a refined understanding of kimberlite emplacement provide a new set of tools to bolster diamond exploration in the under-explored parts of Northwest Territories and provide new opportunities for significant discoveries.

References

Fipke, C. E., Dummett, H. T., Moore, R. O., Carlson, J. A., Ashley, R. M., Gurney, J. J., & Kirkley, M. B. (1995). History of the discovery of diamondiferous kimberlites in the Northwest Territories, Canada. International Kimberlite Conference: Extended Abstracts, 6(1), 158–160. https://doi.org/10.29173/ikc1816

Knight J (2018) An interpretation of the deglaciation history of the southern Slave Province using 1:50 000 surficial geology maps. Northwest Territories Geological Survey, NWT Open Report 2017-018.

McClenaghan B, Kjarsgaard A (2001) Indicator mineral and geochemical methods for diamond exploration in glaciated terrain in Canada. In: McClenaghan B, Bobrowsky T, Hall (2001) Drift Exploration in Glaciated Terrain. Special Publication, 185. Geological Society, London

Northwest Territories Geological Survey (NTGS) (2018) Kimberlite Indicator Diamond Database (KIDD). https://ntgs-open-data-ntgs.hub.arcgis.com/datasets/NTGS::kidd-data/about

Sacco D, McKillop R, Ward B, Ellis S (2018a) Surficial Geology and Till Sampling Suitability for NTS Map Sheets 075M09, parts of 075N05/06/11/12, and parts of 076D05/06/07/10/11/12, Slave Geological Province, Northwest Territories. Northwest Territories Geological Survey, NWT Open Report 2018-015, Scale 1:50 000

Sacco, D.A., Turner, D.G., and McKillop, R.J., (2018b) Standardization of compiled mineralogical and geochemical data sets: Lac de Gras (NTS 076D) and Aylmer Lake (NTS 076C) map areas, Northwest Territories; Northwest Territories Geological Survey, NWT Open Report 2017-013

Shilts, W. W. (1996) Drift exploration. In J. Menzies (Ed.), Past glacial environments, sediment forms, and techniques (pp. 411–439). Butterworth Heinemann.