30 YEARS OF DIAMONDS IN CANADA
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A Classification System Precisely Distinguishing Diamond Mineral Inclusion Compositions from Indicator Minerals from Barren Sources

Charles Fipke[1], Forough Hobuti[1], Norton Redlich[1], Michael Whitehead[1] and Chad Ulansky[2]

[1]C.F. Mineral Research Ltd., Kelowna, Canada, info@cfmresearch.com, herd@cfmresearch.com, data@cfmresearch.com, info@cfmresearch.com; [2]Metalex Ventures Ltd., Kelowna, Canada, culansky@metalexventures.ca

Introduction

The discrimination of indicator minerals with diamond inclusion compositions from those minerals from barren sources has perhaps been one of the most significant advances in diamond exploration since the realization that primary diamond deposits consist of kimberlites and lamproites.

In the 1970s the first diamond indicator minerals (DIMs) were recognized when particular compositions of garnets were found to be associated with diamond. With research focus, improved analytical techniques and an ever expanding dataset the number of minerals for which compositions could be related to diamonds increased.

Since the early 1990's CF Mineral Research Ltd. (CFM) has been refining a classification scheme for a suite of DIMs. This work, while still advancing, is now able to distinguish DIM compositions for a vastly enlarged suite of minerals.

History of DIM

DIM were first recognized in the early 1970s when the relationship of eclogitic and peridotitic garnet to diamond was discovered (Sobolev and Lavrent'ev, 1971; Gurney and Switzer, 1973). For the first time explorers had the ability to remotely assess the diamond potential of a kimberlite/lamproite without collecting and processing large and costly samples.

An example of the power of the interpretation of indicator mineral geochemistry occurred in 1990 when, prior to the discovery of a single diamond or kimberlite, John Gurney and Rory Moore evaluated the geochemistry of DIMs found in Dia Met Minerals' (Dia Met) till samples (Fipke et al, 1995a) and recognized that the DIM came from kimberlites that had sampled highly diamondiferous mantle. With this knowledge BHP Utah Intl. entered into a joint venture agreement with Dia Met and the project yielded the Ekati Diamond Mine.

A comprehensive review of the understanding of DIM at the time was published in 1995 (Fipke et al, 1995b). At that time the DIM compositions of eclogitic and peridotitic garnets and chromites were well understood. However, there was only a nascent understanding of most other potential DIMs.

CFM's Empirical Approach

A data driven approach has been used to develop a classification scheme for peridotitic, lherzolitic and eclogitic DIMs. The foundation of this classification scheme is a large, geographically diverse, high quality dataset. While much attention is often focused on the diamond associated minerals it is equally important to build a comprehensive collection of compositions from non-diamond bearing sources, be they barren kimberlites/lamproites, megacrysts or other non-diamond bearing sources, collectively called barren source indicators (BSI).

At the time of writing, the CFM dataset includes 11,711 grains which are known to be associated with diamond. These are either minerals included in diamond, intergrown with diamond or contained in diamond-bearing mantle xenoliths. The barren file contains 65,669 compositions of BSI.

For any given indicator mineral species a series of binary oxide diagrams have been constructed with separate diamond and barren fields. Most indicator minerals require multiple binary diagrams to effectively differentiate DIM from BSI; with up to 20 required in some cases.

Data quality is of paramount importance. As the classifications in many cases rely not only on major or minor element compositions but also trace elements accurate analyses are important. Experience has shown that long count times using an Electron Microprobe along with consistent use of high quality reference standards matching the mineral species being analyzed are necessary for a precise analysis. An imprecise analysis can result in a composition falling on the wrong side of a diamond and barren field division causing a classification error.

Lherzolite – An Underappreciated Diamond Source

Recently the significant contribution of lherzolite to the diamond population in some mines has been recognized. One example is the Victor Mine in Ontario, Canada (Stachel et al, 2018) where 85% of diamonds have been identified as having a lherzolitic origin. Relying on the traditional DIMs of garnets and chromites may have missed an economic mine.

Equally important is the discovery that many of the large type II diamonds are of lherzolitic origin (Korolev et al, 2018). These rare, high value stones require extremely large sample sizes to recover, thus the ability to recognize their potential from a small sample is a powerful technique to prioritize exploration efforts.

CFM has been able to not only differentiate DIM clinopyroxenes (CPXs) from BSI but has also discovered that CPXs from large, 50+ carat diamonds have a subtly different composition to those from smaller diamonds. Figure 1 displays one of ten binary diagrams used to classify CPXs. This is based on 3,456 DIMs including 233 from large diamonds, 6,755 BSIs and 1,501 Group 2 CPXs.

Summary

For over 30 years CFM has been refining an empirical classification scheme to differentiate between DIMs and BSIs. The classification scheme is now capable of distinguishing diamond inclusion group 1 eclogitic garnets, G9 / G10 / G11 pyrope garnets, orthopyroxenes, peridotitic CPXs, olivines and chromites. Both a comprehensive dataset and quality analyses are prerequisites for an effective classification scheme.

The ability to accurately distinguish indicator minerals from diamondiferous sources is an important techinque to guide exploration at all stages, from grass roots regional exploration to assessing large diamond potential in discovered kimberlites and lamproites.

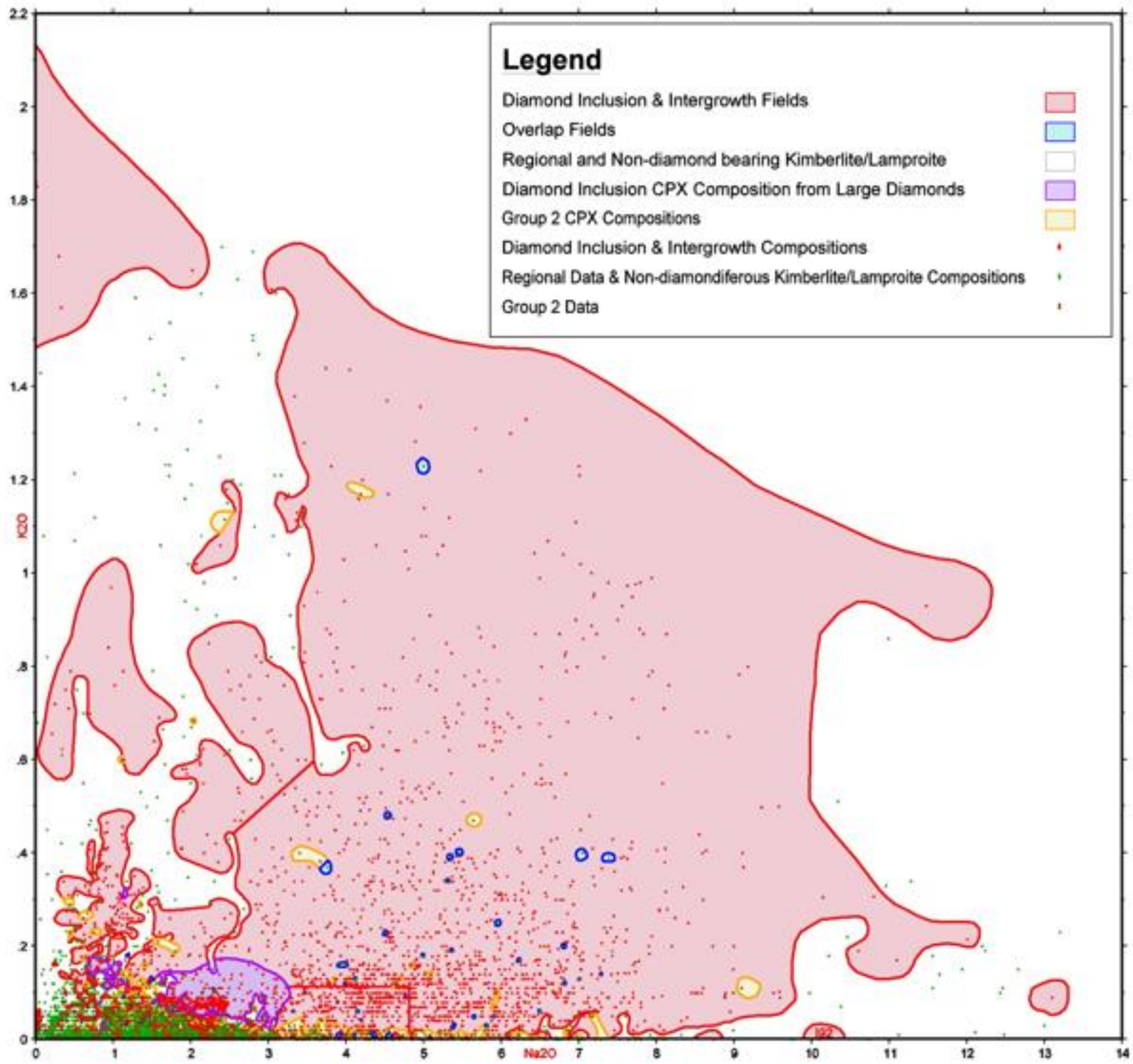

Figure 1. K_2O vs Na_2O binary diagram for CPX

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