2013-01: Indicator minerals in secondary environments for base metal deposit exploration (porphyry, IOCG, magmatic Cu-Ni, VMS)

Using indicator minerals (IM) found in secondary environments is a well-known technique, especially in diamond exploration. They help in tracing kimberlite pipes using a specific suite of minerals that is distinctive of their environment (called KIM). In another vein, native gold is also used as an indicator mineral in a variety of gold-bearing contexts. When looking for other types of mineralisation however, the techniques may be more difficult to establish.

An IM must be specific, that is to say, it has to point toward a discriminant component: paragenesis of the mineralisation, the type of host rock, alteration or chemical changes caused by metamorphism or fractional crystallisation. The problem is that few studies exist about the chemical variability of possible IM candidates within the crust. However, only such research will help identify minerals with discriminant chemical compositions.

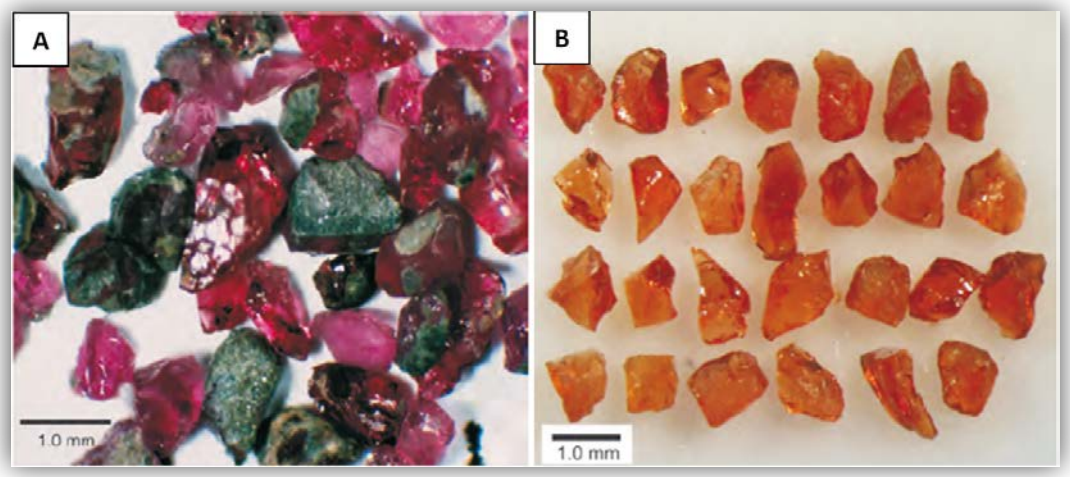

Figure 1. Examples of indicator minerals: A) Cr-pyrope B) pyrope-almandine; (McClenaghan and Kjarsgaard, 2007).

The objective of this project was to document the main IM using published sources and to learn about the ways they are typically used. Subsequently, the compilation of the chemical composition of the collected minerals from a wide variety of rocks allowed us to assess the real or unsupported difference between phases that crystallised during a mineralising event or that were associated with the event, and phases that were simply present in the crust or the mantle. Analyses of minerals contained in databases such as GEOROC were processed using a reconnaissance tool called Pseudo-Norme, developed as part of this project. The tool helped clarify the nature of the minerals based on the host-rock lithology and thus to make certain observations for broad rock families. Figure 2 shows an example of findings for aluminum garnet found in all rock types, but in different proportions.

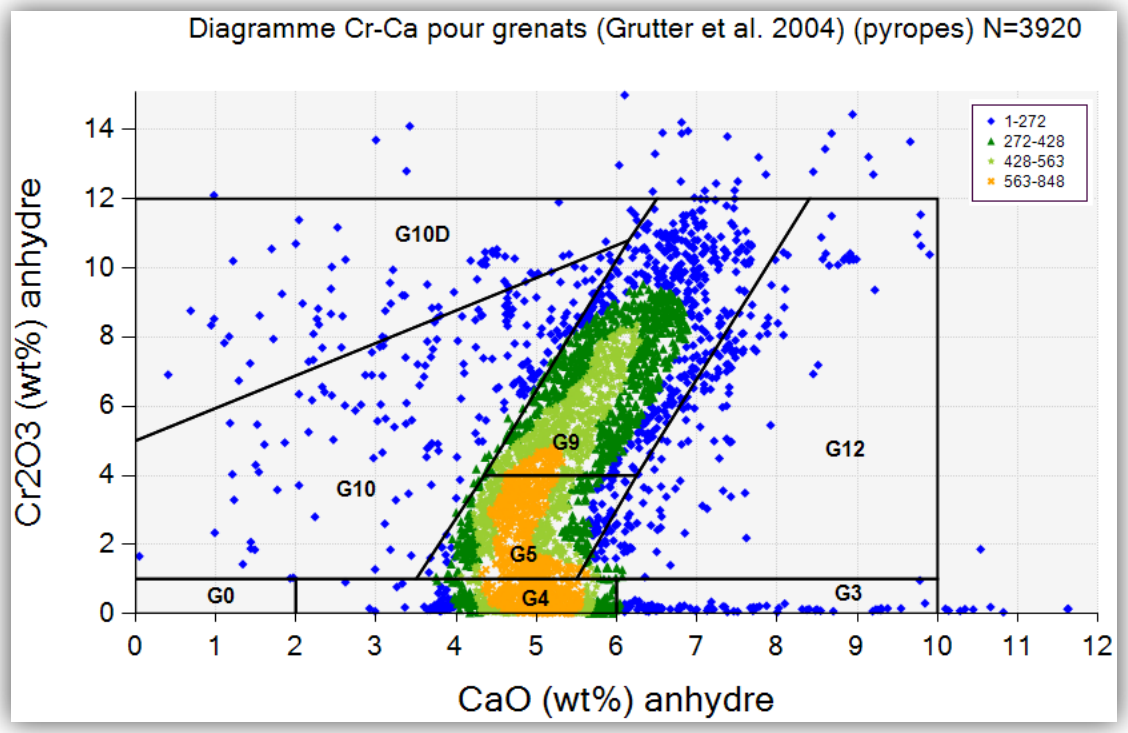

Figure 2. Pyropes compiled from GEOROC (defined as garnets containing > 50 wt% pyrope, composition determined using the Pseudo-Norme recognition tool developed during this project) and plotted on the Grutter et al. (2004) discrimination diagram. Note that GEOROC includes very few kimberlites, thus contains few G10-G10D, the garnets traditionally associated with diamond-bearing kimberlites, thus making this diagram potentially very discriminating for diamond mineralisation.

This project identified several challenges in using IM for exploration. Among others, it became obvious that the establishment of more substantial in-situ mineral analysis databases than those used during this project would improve our understanding of IM chemistry and thus help us differentiate their signals better during exploration. GEOROC, without a doubt, is the example to follow; it contains thousands of analyses documenting magmatic rocks.

An IM can also be a mineral transported by water or ice that can be linked to a source rock. This challenge affects sampling procedures, which could be improved to obtain a heavy mineral concentrate representative of its bedrock source. There is also the challenge of exploiting the results: that is to say corrections followed by geostatistical methods. This facet of the problem was not studied in detail during this project.

Finally, the collection of public Canadian survey data showed that the measurements carried out on till samples were not suitable for exploiting the full potential of IM. Systematic use of new technologies is recommended (e.g. MLA, QEMSCAN, etc.) to document samples from secondary environments.

Project 2013-01: Summary	
Objectives	• To review research on indicator minerals currently used in exploration for a variety of deposits with the exception of diamond-bearing kimberlites. • To suggest ways of addressing the complex questions raised by these minerals.
Results and Innovations	• Investigation of a wide range of minerals and accurate documentation of some of these minerals resulting in the creation of 16 data sheets. • Establishment of chemical analysis databases documenting the mineral phases of interest. • Construction of Pseudo-Norme, a mineral recognition tool based on the chemical composition of minerals. The development of this method allows the creation of an easy to use classification using a database. • Study of the distribution of various mineral phases in different rock types via the introduction of a new classification scheme. • Integration of published discrimination diagrams into the CONSOREM LithoModeleur software.