Summary of Surficial Kimberlite-Indicator Mineral Surveys in Northern Alberta

D. Roy Eccles (Alberta Geological Survey) and Michael B. Dufresne (APEX Geoscience Limited)

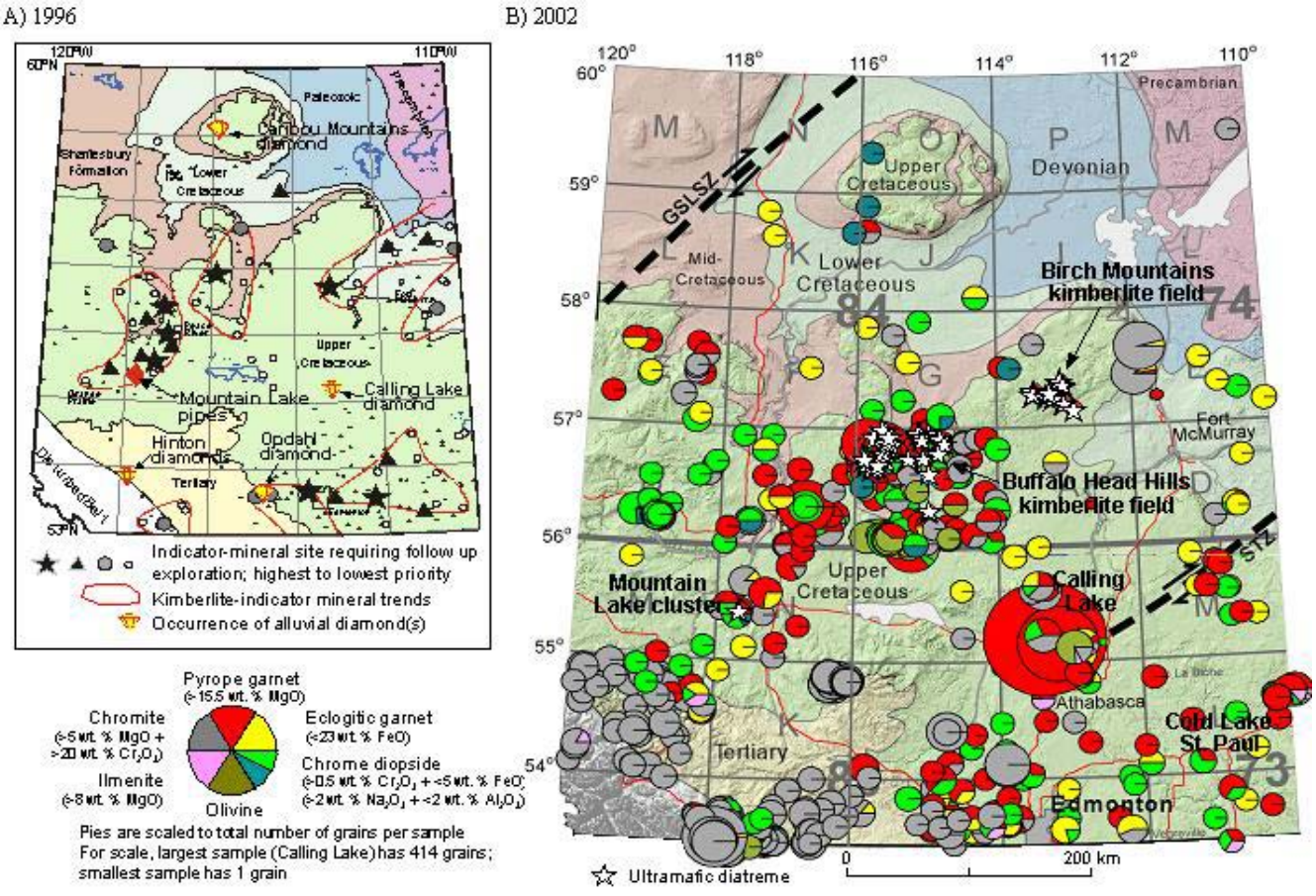
The first known summary of kimberlite-indicator minerals (KIM) in Alberta was published by Dufresne et al. (1994, 1996), which produced a KIM summary map based on the geochemistry from about 560 grains (northern Alberta presented in Figure 1A). This summary of broad-based KIM sample results nonetheless defined areas of high diamond potential, including the Buffalo Head Hills prior to the 1997 to 2003 kimberlite discoveries (Figure 1B). This strongly supports the importance of widely spaced KIM sampling in northern Alberta.

A more recent compilation by Eccles et al. (2001) includes geochemical data for more than 15,000 possible KIMs. Geochemically favourable KIM grains from this study are shown on Figure 1B. These data, relative to the current number of known kimberlite pipes discovered, make it clearly apparent that

- Alberta is under-explored. For example, Figure 1B shows that few KIM surveys have been completed north of latitude 58ºN; and

- There are other areas of northern Alberta (i.e., besides the known kimberlite areas) with high grain counts and excellent mantle xenocryst chemistry. These anomalous data and sample sites indicate that with continued exploration the potential for the discovery of other kimberlite fields, and potentially an economic pipe, in Alberta is high.

Figure 1. Kimberlite-indicator mineral trends in northern Alberta. A) 1996 and B) 2002.



Several important geochemical and spatial trends are evident in the dataset, particularly between northern Alberta (NAB, north of latitude 54ºN) and southern Alberta (SAB, south of latitude 54ºN). Selected results and observations from Eccles et al. (2001) and Dufresne and Eccles (in press) are presented below.

Garnet

- In general, Alberta garnets from KIM samples that have been collected to date are dominated by Group 9 calcic garnet on the Gurney et al. (1993) Cr_2O_3 versus CaO diagram (Figure 2A).
- Group 10 (G10) sub-calcic garnets occur predominantly in NAB (Figure 2A) where there currently are 17 sites with G10 garnets, versus 5 G10 sites in SAB. The G10 sites are mostly in the east half (longitudes 110ºW to 115ºW) of the province. Two sites of interest include the Calling Lake and Cold Lake-St. Paul areas of northeast-central and northeastern Alberta, respectively.
- NAB garnets have significantly higher Cr (in the 8 wt. % to 14 wt. % range) and moderately higher Ti content versus garnets in SAB. This is believed to represent a major fundamental difference in the mantle between northern and southern Alberta. Areas of high Cr pyropes in NAB include Peace River to Buffalo Head Hills, Calling Lake and the Cold Lake-St. Paul areas.
- In NAB, the garnets display a general trend of TiO_2 and CaO enrichment from east to west.
- Lastly, NAB eclogitic garnets have low concentrations of Na and Ti in comparison to SAB.

Clinopyroxene

- There is a huge scatter in data and no distinct clusters or populations.
- The majority of the NAB clinopyroxenes plot in the garnet peridotite paragenetic field of Ramsay (1992), based on discrimination of Al_2O_3 versus Cr_2O_3 (Figure 2B); 34% of the NAB clinopyroxenes have >23 wt. % CaO.
- A large population of Alberta clinopyroxene falls within the low-Cr suite (<0.5 wt. %).
- Lastly, NAB clinopyroxenes generally have low K_2O (<0.08 wt. %) versus SAB (<0.2 wt. %); although, a small subset of the NAB clinopyroxenes have high K_2O (between 0.25 and 0.8 wt. %).

Chromite

- A lot of anomalous chromite data exist in western Alberta at the edge of the deformed belt; this may possibly result from extensive sampling surveys in this region, or due to more abundant, albeit undiscovered, chromite sources in western Alberta.
- NAB chromites have generally low MgO (5 wt. % to 8 wt. %) and moderate to high Cr_2O_3 (40 wt. % to 60 wt. %).
- High Cr_2O_3 (>40 wt. %) and TiO_2 (>1.5 wt. %) chromites are restricted to samples from NAB (Figure 2C). Thus, only NAB displays the high Ti-Cr magmatic chromite trend characteristic of kimberlite.
- Lastly, in NAB the chromites display a slight increase in MgO and Cr_2O_3 content from east to west.

Ilmenite

- NAB ilmenites contain lower FeO and higher MgO in comparison to SAB; for example, ilmenite from NAB form a distinct cluster between 27 wt. % to 40 wt. % FeO, and 8 wt. % to 16 wt. % MgO (Figure 2D).

- NAB ilmenite tends to have higher Cr (1 wt. % to 5.5 wt. % Cr_2O_3) content than SAB, but this could be related to a sample density issue rather than real differences in chrome content between NAB and SAB.

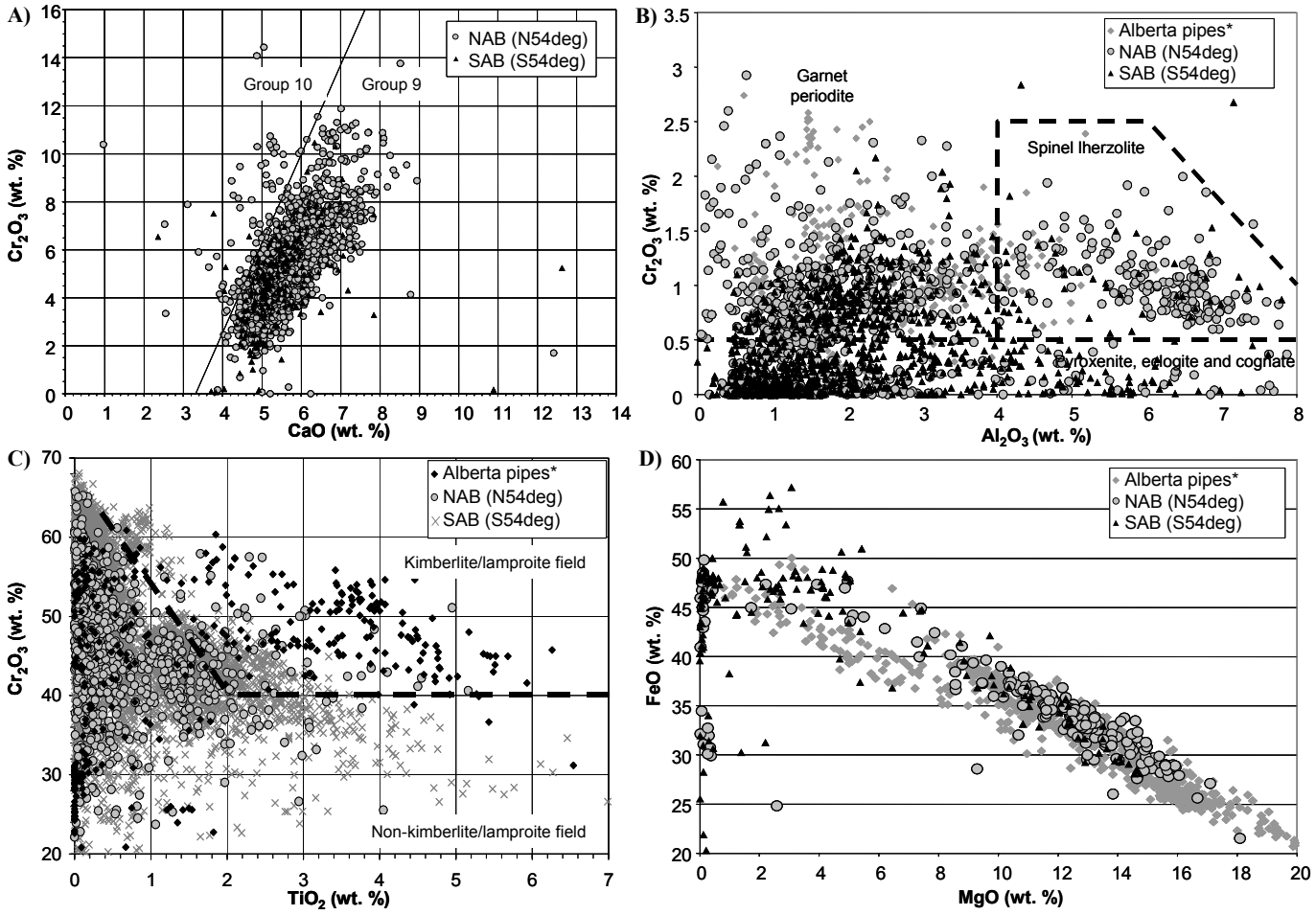


Figure 2. Selected discrimination diagrams for geochemical data from indicator-mineral sampling in Alberta.

References

Dufresne, M.B., Olson, R.A., Schmitt, D.R., McKinstry, B., Eccles, D.R., Fenton, M.M., Pawlowicz, J.G., Edwards, W.A.D. and Richardson, R.J.H. (1994): The diamond potential of Alberta: a regional synthesis of the structural and stratigraphic setting, and other preliminary indications of diamond potential; Alberta Geological Survey, Open File Report 1994-10, 348 p.

Dufresne, M. B., Eccles, D. R., McKinstry, D. R., Schmitt, D. R., Fenton, M. M., Pawlowicz, J. G. and Edwards, W. A. D. (1996): The diamond potential of Alberta; Alberta Energy and Utilities Board, EUB/AGS Bulletin No. 63, 158 p.

Dufresne, M.B. and Eccles, D.R. (in press): A guide to kimberlite-indicator mineral trends in Alberta including observations from recently compiled indicator-mineral data; Alberta Energy and Utilities Board, EUB/AGS Special Report 20.

Eccles, D.R., Dufresne, M.B., Copeland, D., Csanyi, W. and Creighton, S. (2001): Alberta kimberlite-indicator mineral geochemical compilation; Alberta Energy and Utilities Board, EUB/AGS Earth Sciences Report 2001-20, CD-ROM.

Fipke, C.E., Gurney, J.J. and Moore, R.O. (1995): Diamond exploration techniques emphasising indicator mineral chemistry and Canadian examples; Geological Survey of Canada, Bulletin 423, 86 p.

Gurney, J.J., Helmstaedt, H. and Moore, R.O. (1993): A review of the use and application of mantle mineral geochemistry in diamond exploration; Pure and Applied Chemistry, v. 65, no. 12, pp. 2423-2442.

Ramsay, R.R. (1992): Geochemistry of diamond indicator minerals; Ph.D. thesis, University of Western Australia, 246 p.