Modeling the Spatial Relationship Between Lake Sediment/Till Geochemistry Anomalies and Kimberlites, Central Slave Province, NWT: Effects of Sample Media and Quality Control

Wilkinson, L.[1], and Kjarsgaard, B.A.[1]

1. Geological Survey of Canada, Ottawa, Ontario, Canada

Interest in diamond exploration in Canada is strongly focused in the Lac de Gras area of the Slave Structural Province (Figure 1). The area is covered by two recent Geological Survey of Canada source geochemical surveys (Kjarsgaard *et al.,* 1992; Ward *et al.,* 1996) which provide multi-element lake sediment/till analyses at a high sampling density. The diamondiferous Lac de Gras kimberlite field is thus an ideal area in which to evaluate potentially diverse geochemical populations from different surveys and characterized by different sample densities, locations and analytical methods and different media (clay vs. silt+clay). Results obtained from this study will be applied to the full range of element and oxide till chemistry data to generate a kimberlite favourability map based on till chemistry anomalies in the Lac de Gras area, and extrapolation of results to lesser known regions may result in the delineation of new high diamond potential areas in the Slave Province.

For the sake of brevity, a single element, Ba, will be used to demonstrate testing of the internal and external consistency of the geochemical data sources. Preliminary chemistry results from known kimberlites indicates that Ba concentration is 10 times higher than in other lithologies common to the Lac de Gras area. In the clay+silt fraction, Ba is measured in both source data sets, using INAA (neutron activation) and XRF (x-ray fluorescence) analytical techniques. Summary statistics and Q- (Quantile, showing the proportion of samples below a particular value) plots reveal that Ba data in both sources and both analytical methodologies, are log-normally distributed (Figure 2a). Ba data for the two INAA data sets are not significantly different as box and whisker plots of the Ba concentration by data set are characterized by similar median values (i.e., the 95% confidence interval for the median values overlap) (Figure 2a). The Ba data for each date set were separated into background and possibly anomalous (with respect to possible underlying kimberlite lithology) samples by inspecting obvious breakpoints on the Q-plots. A threshold of 6.4 (log Ba) can be recognized in each data set, flagging 28 (out of 177) and 14 (out of 104) samples in Open File (OF) 3205 and OF 2578, respectively (Figure 2a). INAA Ba data can therefore be merged into one without experiencing severe leveling problems. This has advantages for increasing sample density and distribution.

In the XRF data, median values are significantly different and anomalous thresholds vary from ≥ 6.32 for OF 3205 and ≥ 6.6 for OF 2578, identifying 15 (out of 48) and 23 (out of 104) samples, respectively (Figure 2b). These factors indicate the XRF data, unlike the INAA data, cannot be merged without introducing severe leveling problems. Given the lack of leveling problems with the INAA data, the problems with the XRF data are likely to be systemic and not related to differing sampling strategies and densities between the two sources.

Similar plots of Ba (analysed by emission spectrophotometry–OF 2578) are not shown but indicate a normally distributed population with an anomalous population of ≥ 630 ppm, flagging 12 (out of 104) samples, similar to the results from the OF 2578, INAA data.

An examination of the spatial distribution of the possibly significantly anomalous samples from all sources and analytical methodologies indicates a strong spatial and lithologic bias (Figure 3). Anomalous samples are concentrated primarily within the kimberlite-dominated areas (see Figure 1), clustered in underlying bedrock units 12 (muscovite-biotite granite/granodiorite—see Figure 3) and 13 (undifferentiated granite—see Figure 3) and spread in distribution within Yellowknife Supergroup metasedimentary rocks (unit 3). Box and whisker plots of Ba (log) by underlying bedrock unit (Figure 4) indicate unit 3 Ba (log) values are typical of rocks in this region, indicating the anomalies are not due to naturally occurring higher bedrock values. Given the large areal extent of unit 3 and its heterogeneous lithologic composition, the prevalence of scattered anomalies within it is likely due to some as-yet unknown process. Clusters of potentially significant anomalies of Ba in units 12 and 13 are more interesting due to the concentration of known kimberlite pipes in this area (see Figure 1). Examination of box and whisker plots by underlying bedrock lithology for Ba (Figure 4) indicate that unit 12 is relatively high with respect to other local lithologies, while unit 13 values overlap median background values of other units. This suggests Ba anomalies in unit 12 are related to naturally higher Ba concentrations in unit 12. Lithogeochemical analyses are needed to confirm this hypothesis. It remains possible, however, that the higher Ba values over unit 12 and the anomalies within unit 13 are related to the prevalence of

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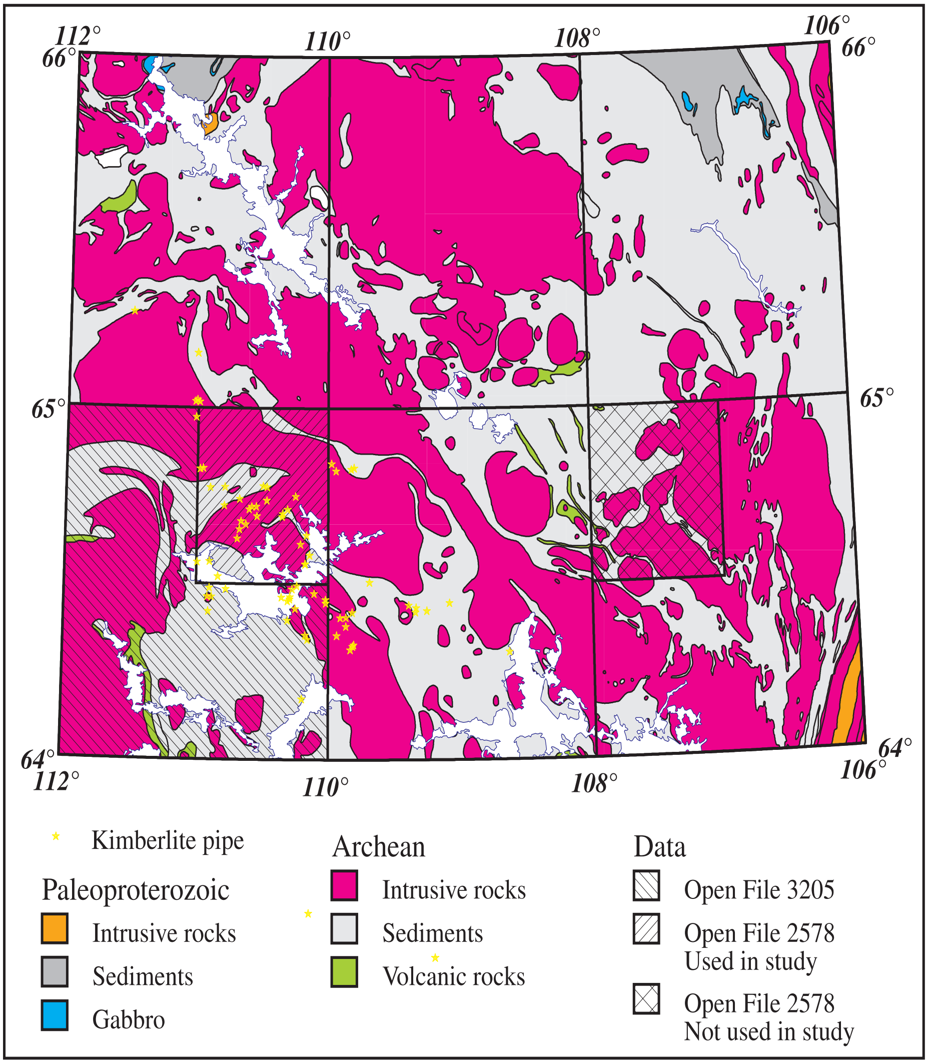

Figure 1: *Location of anomalous samples*

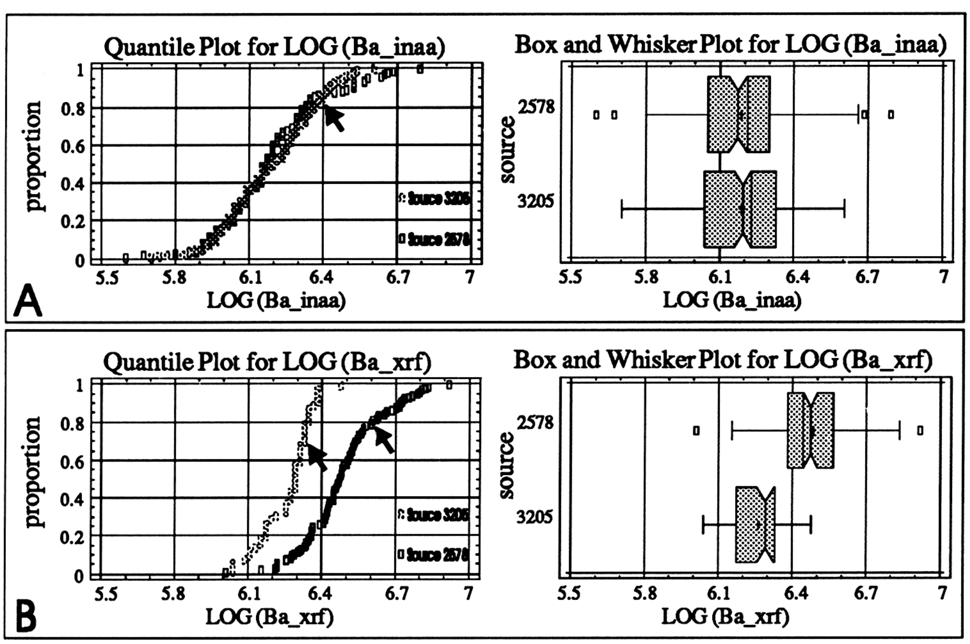

Figure 2: *Statistical evaluation by source dataset: (**a**) Ba INAA (**b**) Ba XRF. Arrows indicate preliminary anomalous thresholds.*

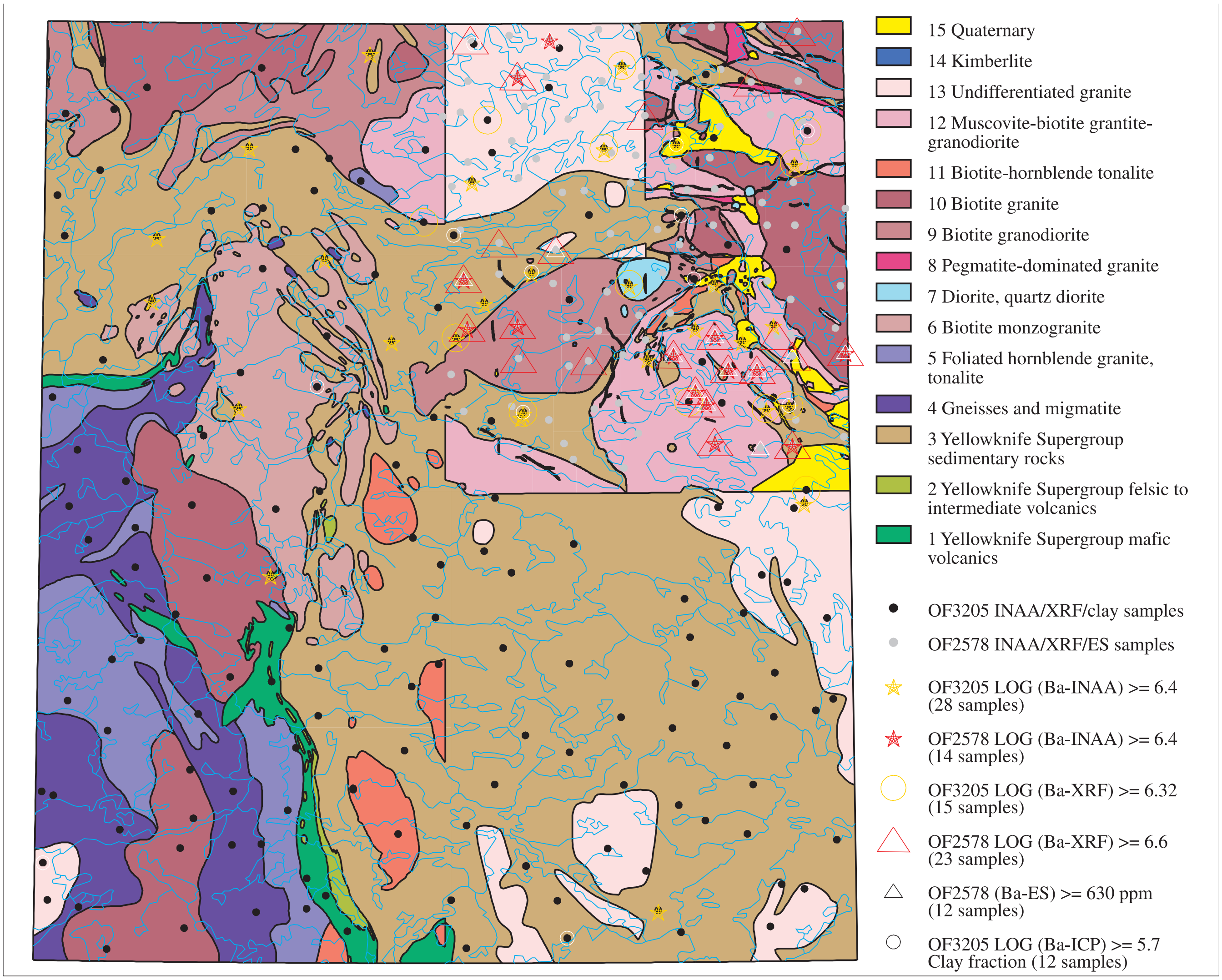

Figure 3: *Potential (kimberlite-related) till anomalies by source shown on underlying bedrock geology.*

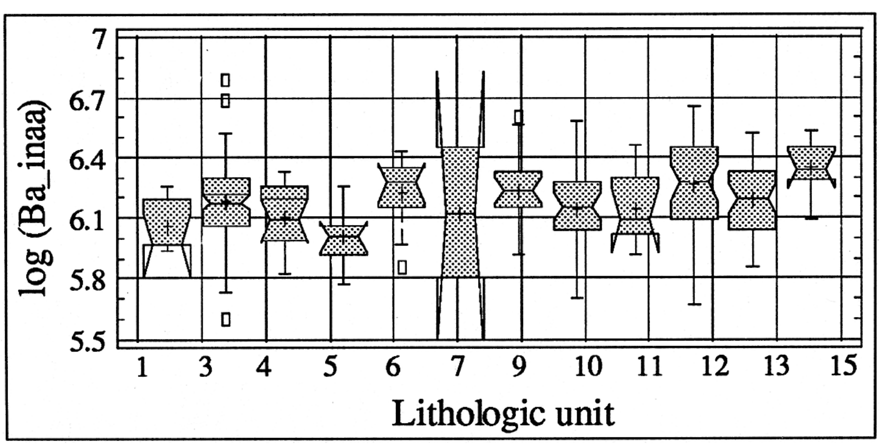

Figure 4: *Comparison of Log Ba values for combined OF 2578 and OF 3205 INAA data by mapped bedrock lithology. Overlapping notches indicate statistically overlapping median values.*

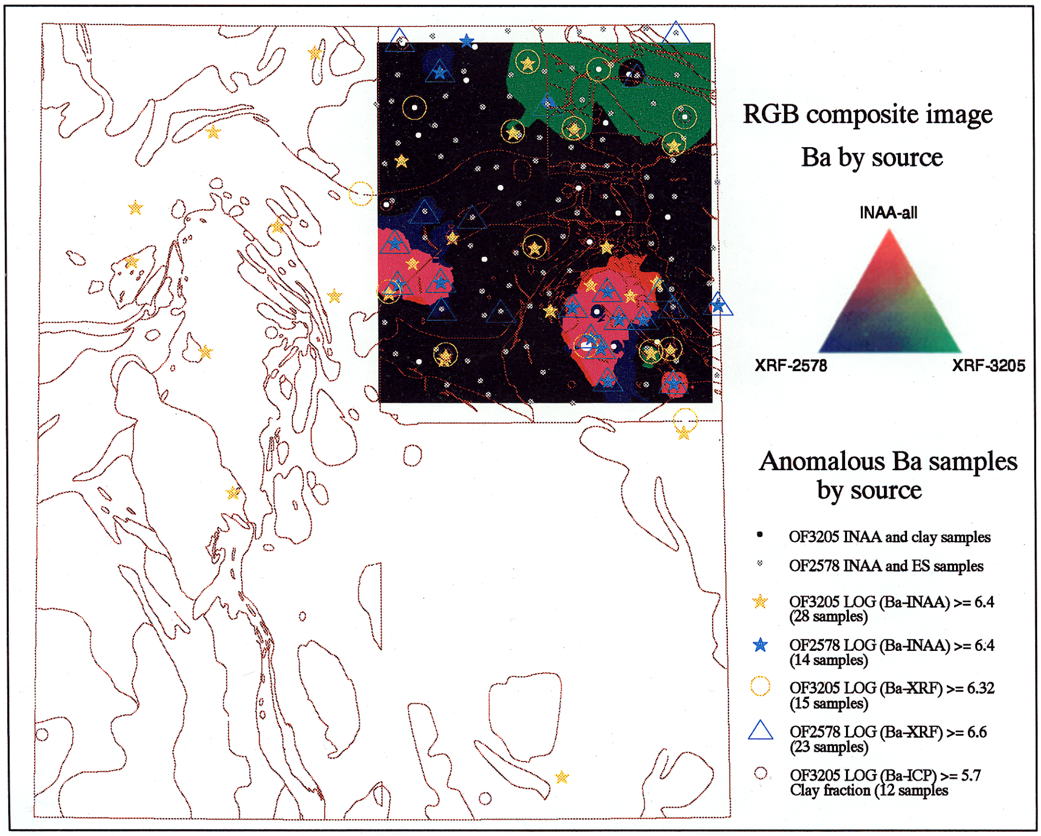

Figure 5: *RGB composite image comparing Ba INAA anomalous area (red) with XRF (3205), green and XRF (2578), blue areas.*

kimberlite pipes within these units, since the presence of kimberlite lithology will result in a 10 times higher influence on lake sediment Ba value in these units. Testing of this possible spatial association will be done with the weights of evidence technique.

Differing processes acting on the clay and silt components in the clay+silt fraction may make the interpretation of regional anomalies more difficult than those associated with the clay fraction alone (Ridler and Shilts, 1974). Ba in the clay fraction is log-normally distributed, with an apparent threshold determined via Q-plot examination of 5.7 (log), far lower than that for the regional clay+silt fraction (any source). The threshold value of 5.7 (log) identifies 12 (of 198) samples as anomalous, similar to the 12 ES (OF 2578), 14 INAA (OF 2578) and 15 XRF (OF 3205) clay+silt fraction populations. Half of the potentially anomalous samples fall within the diamondiferous area in units 3 and 13, and coincide with anomalies identified from other sources, particularly OF 3205 (XRF). These results lend credence to the hypothesis that these bedrock units have a strong effect on till geochemical anomalies. The spread of clay anomalies outside the mineralized area, coupled with the similarities of the clay anomalies with XRF clay+silt anomalies, indicates the clay fraction and XRF clay+silt data may be more sensitive to regional background variation than to kimberlite distribution.

INAA and XRF analytical data from both sources were contoured using an inverse distance-weighted algorithm with a minimum of six samples. Using the Q-plot-determined preliminary anomalous thresholds, binary maps were created and RGB composite images plotted for the spatial comparison of anomalous zones. An RGB composite image of combined INAA 3205/2578, red, OF 3205 XRF, green and OF 2578 XRF, blue indicates broad areas of overlap between the combined INAA data and OF 2578–XRF data (Figure 5). This is confirmed by a correlation coefficient of 0.6020 between the binary maps. All other correlation coefficients were very low, ranging from 0 to 0.0261. This suggests the levelling problem with the XRF data may be due to a problem with the OF 3205–XRF data. Only one clay anomaly is observed to overlap the dominant combined INAA and XRF 2578 areas, indicating the clay population is in fact responding to different processes than are operating on the clay+silt fraction.

Testing of the relationship between till chemistry and kimberlites will thus focus on the regional, combined INAA data set, with a comparison to the clay (ICP-3205) data set and will begin with an assessment of bedrock Ba values.

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