Geochemical investigation of inclusion-free and inclusion-bearing quartz diorite in the Sudbury area

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The 1.85 Ga Sudbury Igneous Complex (SIC) in Ontario, Canada, is the host of a large part of the world known resources of Ni, Cu and Platinum Group Elements (PGEs). About 25% of the mineral resource in the area is found in association with “Offset Dikes”, quartz-diorite bodies distributed either radially or concentrically around the SIC. These deposits are generally characterized by Cu/Ni ratios higher than 1 (typically between 1.5 and 2) and Pt+Pd+Au concentrations greater than 2.5 ppm. Most of mineral resources associated with the offset dikes are hosted by the Copper Cliff and Frood-Stobie Offsets and, to a lesser extent, by the Worthington Offset, with the remaining dikes being significantly less mineralized. The offset dikes comprise two main phases: a fine to coarse-grained quartz-diorite, commonly free of inclusions, and a fine to medium-grained diorite containing inclusions of local country rocks and sulfides. The relationship between the two components, particularly the relative timing of emplacement, has been a common subject of debate in the literature. However, the published studies generally investigated one dike system, with relatively few studies comparing different offset dikes. This study focuses on the comparison between different offset dikes, investigating in particular the relationship between the inclusion-free (QD) and inclusion-bearing (IQD) components of the dikes. A key objective of this research is to improve our current understanding of processes responsible for mineralization in the Sudbury region in order to develop new exploration strategies to enable the discovery of new ore deposits. For this purpose, new geochemical data from different offset dikes is currently being acquired and will be compared to public geochemical data. A preliminary investigation was conducted using exploration data analysis (EDA) techniques, on a geochemical dataset provided by Wallbridge Mining Company Limited. The dataset contains assays for major and trace elements from different offset dikes around the SIC. The analysis of the data shows that QD and IQD are similar in terms of major and lithophile trace elements. The REE concentrations in QD and IQD samples are also similar, although IQD samples are slightly depleted in LREEs and slightly enriched in HREEs compared to QD samples. Inclusion-bearing quartz diorites also display a negative Eu anomaly not observed in QD samples. The main difference between the two groups of samples lies in the metals and sulfur concentrations. Inclusion-bearing samples are on average more enriched in S, Cu, Ni, Au, Pt, Cd, Sb, and Ag compared to QD samples. In summary, the investigation of the data revealed that QD and IQD have similar major and trace elements concentrations, but differ in terms of specific ore elements. Overall, these observations may suggest that the two components might be derived from a similar source. This hypothesis will be further tested, particularly through the incorporation and investigation of new geochemical data.