Trace Element Contents of Magmatic Sulfide and Oxide Minerals—How Can We Use This Information in Ore Deposits Studies?

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Over the past 15 years, the development of laser ablation-ICP-MS analysis has made it possible to determine the concentrations of trace elements in minerals down to the ppb level. This information has been used by the academic community to address petrogenetic problems. However, trace element contents can also be used in exploration for and exploitation of ore deposits. At LabMaTer, Université du Québec à Chicoutimi, we specialize in determining trace element contents of magmatic sulfide and oxide minerals. Our approach consists of studying well-characterized type examples of each ore type by considering the texture of the minerals, determining the whole-rock composition, and determining the trace element content of the minerals. Combining all of the data makes it possible to carry out a mass balance and deduce which mineral is controlling which element and try to deduce which process was important in controlling each element.

The results of our studies could be applied to less well known samples, to heavy mineral separates from till or stream samples, and to the evaluation of extraction efficiencies. Trace element contents of sulfide minerals are particularly important in exploitation of Ni and platinum group elements (PGE) deposits because the PGE may be present either in the sulfide minerals or as platinum group minerals (PGM). Efficient extraction requires an understanding of which minerals contain each of the PGE. We have found that in most deposits 20 to 40% of the Pd is present in pentlandite, with the balance in PGM. Almost all of the Pt is present as PGM, although some can be present in pyrite. Rhodium is mainly present in pyrrhotite, pentlandite, and pyrite. Osmium, Ir, and Ru are present in pentlandite and pyrrhotite. Chalcopyrite contains very little of the PGE budget. Sulfide minerals can be preserved in till samples. If pyrite is present in a heavy mineral separate and the pyrite contains Rh and or Pt, this would be a good indicator of the presence of a nearby Ni or PGE deposit. Furthermore, pyrite from magmatic deposits can be distinguished from other sources using plots of Co/Sb vs. Se/As. If pentlandite is present, plots of Rh vs. Pd can be used to distinguish pentlandite from PGE reef deposits and Ni-Cu sulfide deposits.

Trace element contents of oxides are also useful. Chromites from the mantle, boninites, komatiites, mid-ocean ridge basalt (MORB), layered intrusions, and ocean island basalt (OIB) are different, with incompatible element concentrations increasing from mantle chromites to OIB chromites. Interestingly, chromites from volcanic rocks contain the platinum group elements Ru and Rh, whereas the layered intrusion chromites do not. This could be used in exploration. For Fe oxides, it is possible to distinguish magnetites from layered intrusions, anorthosites, granites, magmatic sulfides deposits, hydrothermal deposits, etc. In each case, the exploration strategy could be adapted to the target.