2014-05:

OPTIMIZATION OF ICP-MS PHASED-ARRAY SUITES FOR MINERAL EXPLORATION

The remarkable advances in technology allow for routinely obtaining, at an affordable cost, trace element analyses for a large portion of the periodic table of elements. However, only a relatively small proportion of the analyzed elements is used in mineral exploration. The potential use of the other elements remains poorly evaluated. To optimize the use of trace elements in mineral exploration, two approaches were used in the framework of this project: 1) documentation of trace elements of interest for mineral exploration, and 2) documentation of dissolution methods and the analysis of trace elements in the commercial laboratories.

To identify the trace elements of interest for exploration, their behaviours were documented in the alteration halos of four types of hydrothermal deposits: porphyritic, orogenic gold, VMS, and SedEx. A group of elements (Ge, As, Se, Cd, In, Sn, Sb, Te, Hg, Tl, Pb, Bi) identified as "volatile" are quasi-systematically detected in the alteration halos of the compiled deposits. To establish thresholds that denote abnormal concentrations for these elements in altered rocks, their concentration in fresh igneous rocks was established from the GEOROC database (Project 2012-05). Coupling this with values compiled from the published literature, we propose a series of thresholds compiled in the table below, indicating the concentrations (ppm) in fresh igneous rocks and alteration halos.

Table 1. Main "volatile" elements useful in mineral exploration.

(ppm)		Ge	As	Se	Sn	Sb	Hg	Tl	Pb
Faure, 1998	tramafic	1.3	0.8	0.05	0.5	0.1	0.01	0.04	0.5
	afic	1.4	2.2	0.05	1.5	0.6	0.09	0.21	7
	lsic rocks	1.3	.5 to 1.9	0.05	1.5 to 3	0.2	0.08	.72 to 2.3	15 to 19
	ale	1.6	13	0.6	6	1.5	0.4	1.4	20
Porphyry	tassium	N.A.		5 to 20	0.5 to 10		0.05	0.2	50
	eep sericitic		10 to 50	1	2 to 30	1 to 3	0.05	0.2	0 to 1 000
	rface sericitic		0 to 1 000	1	N.A.	to 100	0.2 to 10	1 to 50	0 to 100
Gold	anodiorite	N.A.	5	0.1	N.A.	0.9	N.A.	N.A.	N.A.
	salt		4 to 30	0.3		0.9			
	diment		6 to 40	N.A.		0.9			
	matite		5	0.15		0.45			
VMS		3	300	10	10	10	0.7	2	75
SEDEX		2	40	N.A.	N.A.	12	N.A.	1.5	55
Analyses undertaken		erger or 4 a ICP-MS	NAA or 4 a ICP-MS	INAA	erger or 4 a ICP-MS	AA or 4 a CP-MS	old vapour MS or INAA	erger or 4 a ICP-MS	erger or 4 a ICP-MS

There is no single method for analyzing all trace elements. For ICP-MS analyses, the proposed digestion method (either being complete via Li-metaborate fusion or Na-peroxide or being partial with *aqua regia* or four acids) is often a function of the sample type (sulphides or dominant silicates) and the elements sought. The elements of the "volatile" group generally have a low melting point and their use requires special precautions for the dissolution of the samples to avoid their volatilization (typical during the fusion process). It is therefore recommended to use an analysis method that does not involve dissolution (INAA - neutron activation). In addition, some of these "volatile" elements (Sb and Tl, for example) have ambivalent behaviours. They can behave as both chalcophiles and lithophiles (Tl) or siderophiles (SB). This behaviour permits them to be incorporated in both the structure of the sulphides and that of some silicates (example of Tl: pyrite and sericite). This behaviour offers particularly interesting prospects for the use of "volatiles" in exploration (recognition of alteration halos associated with economic mineralization, dispersal in the secondary environment, etc.), but involves a method of dissolution adequate to quantify the elements present in the structure of sulphides and silicates. A review of the methods of dissolution and analysis of trace elements by the commercial laboratories was therefore essential to identify the analytical methods proposed reliable by the commercial laboratories (**Table 1**).

Project 2014-05: Summary sheet	
Objectives	Produce a charter of useful elements, considering the extraction method used ɔstream of the analysis ICP-MS. Document the metal associations in different hydrothermal mineral deposits. Define abnormal thresholds for each element or combination of elements.
Results and innovations	Production of a charter presenting the useful elements in mineral exploration, ɕluding: The values of unaltered igneous rocks; The abnormal thresholds for four types of hydrothermal mineralization (Porphyry, ogenic gold, VMS, and SEDEX); The recommended methods of analysis. Use of volatile elements in exploration.