

ADDING VALUE
throughout the
project life cycle



Four Acid Digest & Advanced ICP-MS Technology

Providing robust datasets for use in Lithochemical Mapping

Geochemistry

Near Total Sample Digestion followed by targeted analysis allows data to be used throughout the project life cycle.

Geochemical Analysis methods and the resultant datasets produced have the potential to be used throughout the life cycle of an economic ore deposit, adding substantial value at a range of stages throughout Exploration and Mining. However, budgets are often tight in Exploration and there is a temptation, particularly in Gold Exploration, to analyse samples for only Gold and a small number of associated elements. Defining the value of a resource project goes beyond determining the contained volume of metal. The four acid digestion based methods offered by ALS provide clients with data that can be used to estimate mineralogy and establish proxies for physical and chemical deposit characteristics such as the hardness of ore, deleterious gangue mineralogy, weathering and oxidation fronts, identification of construction materials such as road base and mapping of reactive sulphides for acid mine drainage management.

Through advances in technology and refinement of laboratory procedures, ALS continually strives to provide clients with the best possible solutions to their exploration problems. Extensive experience in analysing geochemical samples has provided a comprehensive understanding of how elements and minerals behave through digestion processes and instrumentation. The use of a "near total" four acid digest, coupled with the latest in Mass Spectrometry technology, delivers high quality robust exploration data packages with a range of sensitivity allowing clients to choose the method and detection limits most suited to their targets, deposit types and stages of exploration. The four acid digest is able to effectively decompose almost all rock forming minerals, with only the most resistive minerals not fully dissolved.

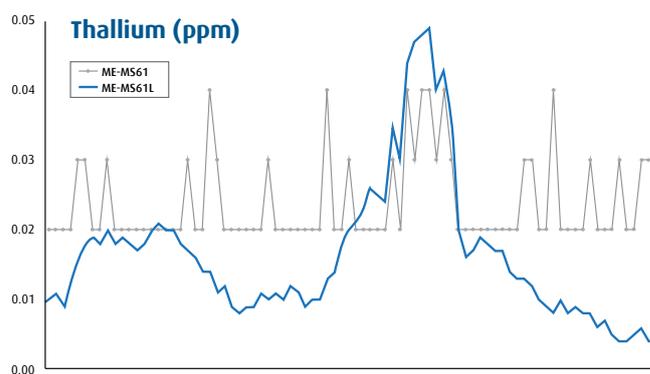
Why spend extra budget on low level analyses for your drill core?

Modelling of lithology and alteration zones are important parts of developing a robust resource model for an ore deposit, however data collected throughout the life of an exploration project will be collected by geologists with a wide range of experience and logging styles. Consistent logging of rock types and alteration minerals is often very difficult to achieve, particularly in drill chips from weathered horizons. By routinely obtaining a 48 element multi-element analysis on drill samples in addition to gold determination, companies are able to build very valuable and beneficial databases which can assist mining personnel throughout the life cycle of the mine and throughout the mining and processing stages. Interrogation of multi-element data collected from methods such as the ALS ME-MS61L™ and ME-MS61™ packages allows geologists to identify rock types correctly, determine alteration zonation, define the presence of clay minerals, quantify silicate and sulphide mineralogy, delineate alteration phases for input into robust 3D geological modelling, and mapping fluid pathways using pathfinder element data.

ME-MS61L™ provides robust results at levels well below the lowest regional backgrounds for most elements, allowing an unprecedented level of detail in major and trace element geochemistry on every sample. Previously, detection limits of multi-element methods were often close to the

background crustal abundances for many elements. Through the substantially reduced detection limits of the ME-MS61L™ package, ALS is able to provide clients with high quality multi-element data at levels up to an order of magnitude below crustal abundance. It also improves precision of trace element analyses by as much as an order of magnitude.

As shown below, detection limits this low allow for the regional background level of an element to be determined, while providing confidence in the resulting anomaly. An additional consideration with respect to the lower detection limits of the ME-MS61L™ method is that the precision of the data at crustal abundance levels is increased by lowering the detection limit below these background levels. Instead of database columns populated by < symbols, the geologist can have access to additional data on which to build and grow their interpretation and deposit model.



Such data is becoming more critical as exploration moves into covered terrains and other areas where deposits may be harder to find due to structural setting or stigma of previous negative exploration results. By providing a cost effective, robust and comprehensive multi-element package with crustal abundance sensitivity, ALS is working with clients to move forward in the modern exploration environment.

Adding value to an exploration project throughout the project life cycle

A range of lithological and geochemical parameters can be determined through proper interrogation of ME-MS61L™ data. Three primary objectives in Litho-geochemical data analysis are identification of rock types within the deposit, quantifying alteration and establishing useful pathfinder associations to assist in future exploration and resource definition.

Defining rock types: Within a typical project, geological logging is carried out by a large number of geologists with a wide range of experience. This makes it difficult to build reliable geological models based on subjective observations. Assay data is quantitative, and removes "observer bias". Lithological groups can be identified from point clusters within scatterplots of immobile trace elements, as per the example below. Once the analytical data is present within the project database, comparing the chemistry with the logging will lead to more accurate and more consistent logging, and it will allow geologists to see through the overprinting effects of alteration and mineralisation.

Classifying Alteration: Whole rock analyses from ME-MS61L™ data can be plotted in such a way that trends in the data can be related directly to mineralogy. This forms the basis for defining and modelling alteration zones within a project. Silica content is also very useful for this exercise, however this data is provided by an additional method due to the loss of Si in the four acid digestion process. Silica and several other elements can be provided by a cost effective portable XRF add-on method.

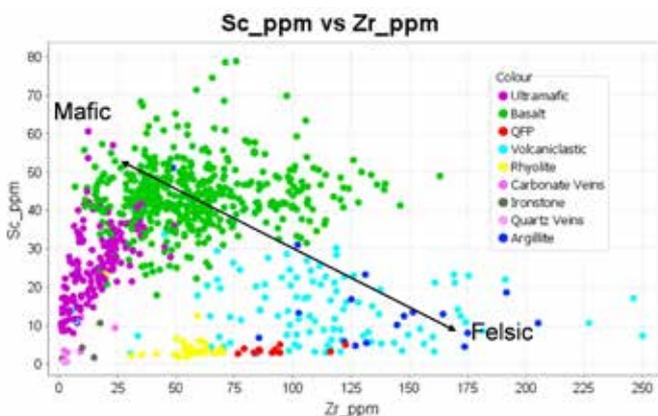
Definition of gangue mineral domains within an ore resource model has direct applications with respect to geometallurgy and mine planning, such as providing information on rock hardness for drill and blast and mill processing, proxies for mill throughput rates, and identification of high clay zones and weathering profiles which may affect the physical pit design. This exercise may also identify additional exploration targets.

CODE	ANALYTES & RANGES (ppm)											
ME-MS61L™	Ag	0.002-100	Ce	0.01-500	Hf	0.004-500	Na	0.001%-10%	Sb	0.02-10,000	Ti	0.001%-10%
	Al	0.01%-50%	Co	0.005-10,000	In	0.005-500	Nb	0.005-500	Sc	0.01-10,000	Tl	0.002-10,000
	As	0.02-10,000	Cr	0.3-10,000	K	0.01%-10%	Ni	0.08-10,000	Se	0.006-1000	U	0.01-10,000
	Ba	1-10,000	Cs	0.01-500	La	0.005-10,000	P	0.001%-1%	Sn	0.02-500	V	0.1-10,000
	Be	0.02-1,000	Cu	0.02-10,000	Li	0.2-10,000	Pb	0.01-10,000	Sr	0.02-10,000	W	0.008-10,000
	Bi	0.002-10,000	Fe	0.002%-50%	Mg	0.01%-50%	Rb	0.02-10,000	Ta	0.01-500	Y	0.01-500
	Ca	0.01%-50%	Ga	0.05-10,000	Mn	0.2-100,000	Re	0.0004-50	Te	0.005-500	Zn	0.2-10,000
	Cd	0.005-1,000	Ge	0.05-500	Mo	0.02-10,000	S	0.01%-10%	Th	0.004-10,000	Zr	0.1-500

The types of plots that could be utilised in a Lithogeochemistry Workflow to quantify alteration include:

1. K/Al (molar) vs Na/Al (molar) (sericite and advanced argillic alteration)
2. Ca-K-Na ternary plot (hydrothermal feldspars)
3. Al-K-Mg ternary plot (Mg metasomatism)
4. Fe vs S to (sulphidation)
5. Cu-Fe-S ternary (Cu-sulphide mineralogy)

variance than disseminated broad spread mineralisation. This information can also be employed to determine required sample spacings.



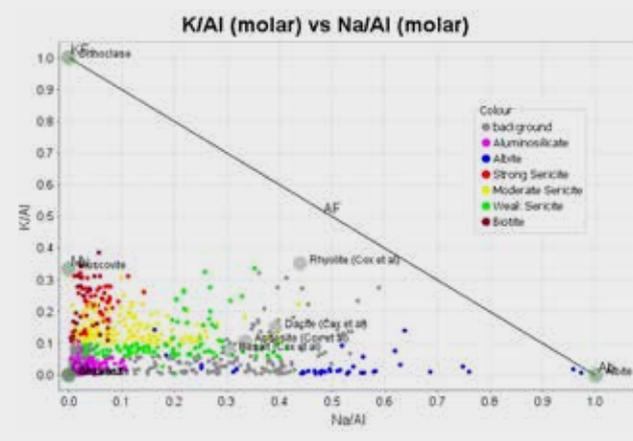
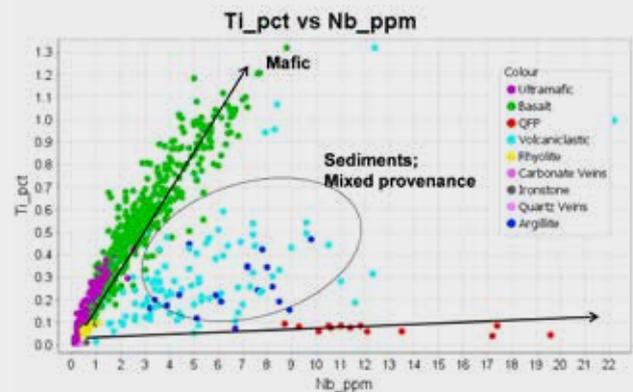
Pathfinder Elements:

Of primary interest to many exploration managers and geologists is the ability to identify and map pathfinder elements which have broader primary dispersions than the ore metals, are more mobile than gold and provide larger haloes around mineralisation. This data can also assist in identifying prospective structures and lithologies and allows geologists to use the data to define vectors towards mineralisation and therefore identify future exploration targets. Additionally, data can be used to ground truth results from previous work such as determining if historical drilling was deep enough or carried out on the best orientation.

A Lithogeochemistry Workflow to establish pathfinders may include generating split cumulative frequency plots, coloured by mineralogy to identify for correlations between pathfinders and alteration; Au, Cu, Mo, Sn, W, Se, Bi, Te, As, Sb, Tl. Mineralogical Controls can also be established, such as determining the host minerals for each element, their distribution, setting and associations. Information on assay "variance" can be collected, for example narrow vein hosted mineralisation with few pathfinders will have greater

A Lithogeochemistry Workflow may use a range of parameters to classify rock types, for example:

1. xY plots Sc vs Cr, Mg, Al, Zr (ultramafic rocks)
2. xY plots Sc vs Ti, Th, V, Zr, Nb, P, Cr, Al, La, Ce
3. xY plots Ti vs Sc, Th, V, Zr, Nb, P, Cr, Al, La, Ce
4. Plot Sc vs V (to check for magnetite and/or hornblende fractionation)
5. Plot Zr vs Hf (check for zircon fractionation)
6. REE spider plots or Sr vs Y (check for plagioclase fractionation)



Sb in pyrite provides a significantly larger exploration target than the Cu in chalcopyrite restricted to veinlets



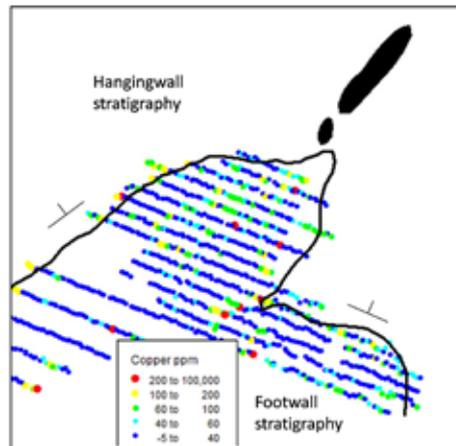
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The inside workings of ME-MS61L™ analysis

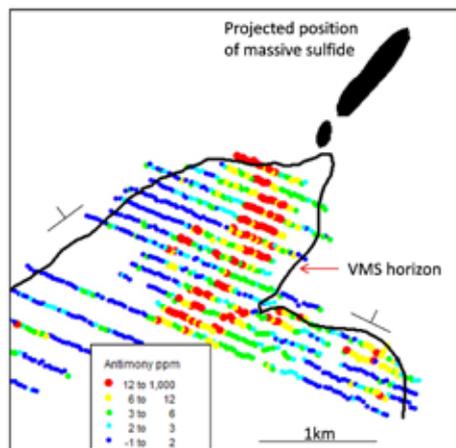
As with any tool, it is important to understand the benefits and limitations of an analytical method. While providing a “near total” digest, a number of elements are not fully dissolved by the four acid digest, and several elements are lost in the digestion stage as volatiles, most notably Si and Hg. Partial loss of semi-volatile elements including As, Se, Sb and Te often occur in this type of digest; however, ALS’s proprietary four acid digestion utilised with the ME-MS61™ and ME-MS61L™ methods mitigates volatility loss. Analysis is often said to be a compromise between the elements needed in solution and the elements which can be useful despite a lack of dissolution, or partial loss during the digestion process.

Nitric acid and perchloric acid are added to the pulverised sample, and proceed to oxidise the samples, changing the oxidation states of some semi-volatile elements and reducing loss in later stages of the dissolution process. Hydrofluoric acid is then added to the samples to dissolve the silicate lattice, allowing for release of the major rock forming elements such as Ca, K, Mg and Na. Depending on the mineral type and concentration, these major rock forming elements may be underreported; however, below a couple of percent results are robust. The solution is heated, then evaporated with addition of hydrochloric acid as a final step before instrument analysis.

Use of the newest ICP-MS technology allows ALS to minimise interferences thereby reducing detection limits to levels below typical crustal abundance for most elements.



VMS stringer zone. Cu is in chalcopyrite; restricted to sparse veinlets.



Sb is in the lattice of the pyrite. Maps the footprint of the stringer zone.

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