Au-AA21 and Au-AA22
Solvent Extraction Trace Gold Analysis

Sample Decomposition:

Fire Assay Fusion (FA-FUS01 and FA-FUS02)

Analytical Method:

Atomic Absorption Spectroscopy (AAS)

A prepared sample is fused with a mixture of lead oxide, sodium carbonate, borax, silica, a 6 mg gold-free silver inquart and other reagents as required. The fused sample upon cooling yields a lead button containing the precious metals, which is subsequently cupelled to yield a silver bead containing gold.

The silver bead is digested in nitric acid followed by the addition of hydrochloric acid – The addition of hydrochloric acid forms Aqua-Regia, allowing for the dissolution of gold. The digested solution is cooled and diluted with 3 mL of water. The amount of gold in solution is then determined by Atomic Absorption Spectrometry, with background correction.

Method Code	Element	Symbol	Units	Sample Weight (g)	Lower Limit	Upper Limit	Default Overlimit Method
Au-AA21	Gold	Au	ppm	30	0.002	1	Au-AA25
Au-AA22	Gold	Au	ppm	50	0.002	1	Au-AA26

ME-MS41L, ME-MS42L & ME-MS41W – Lowest Detection Limit Super Trace Analysis for Soils and Sediments by Aqua Regia Digestion and ICP-MS/ICP-AES

Sample Decomposition:

Aqua Regia (GEO-AR01) or Weak Aqua Regia (GEO-AR01W)

Analytical Method:

Inductively Coupled Plasma - Atomic Emission Spectroscopy (ICP-AES)

Inductively Coupled Plasma - Mass Spectrometry (ICP-MS)

These Super Trace methods combine an aqua regia digestion with ICP-MS instrumentation utilizing collision/reaction cell technologies to provide ultra-low detection limits. Instrumentation has been optimized for long-term ICP-MS signal stability, in particular for samples with high Ca content.

The extremely low detection limits are particularly useful for exploration in soils or sediments, and the methods can also be performed on the clay fraction of soils. (Clay size fraction separation is available using ALS method SCR-CLAY.) This method is not appropriate for mineralized samples.

ME-MS41L: For the ALS standard aqua regia digestion a prepared sample (nominal 0.5g) is digested with 75% aqua regia (3:1 ratio of $HCl:HNO_3$) in a graphite heating block.

ME-MS42L: This method is an effective option when analytical results for one or only a few elements are required rather than the full suite of analytes available from the ME-MS41L package. With this method you can create your own package of elements specific to your exploration program. Pricing is by analyte.

Note: Analytes are reported via ICP-MS only therefore reporting ranges and analytes are not identical to those reported from the full package ME-MS41L.

ME-MS41W: A "weak" aqua regia option is also available whereby a prepared sample (nominal 0.5g) is digested with a modified aqua regia (1:1 ratio $HCl:HNO_3$) in the graphite heating block.

The final solution is then analyzed by inductively coupled plasma-atomic emission spectrometry and inductively coupled plasma-mass spectrometry with results corrected for spectral inter-element interferences.

NOTES: An aqua regia leach is an ideal medium for the dissolution of sulphide minerals and for the release of elements adsorbed on clay particles or trapped in manganese and iron oxides and oxyhydroxides. However, it represents only the leachable portion of the particular analyte and will not dissolve significant quantities of the silicate and alumino-silicate minerals. Major refractory minerals such as chromite, columbite – tantalite, cassiterite, rutile, scheelite, wolfram and zircon are only slightly soluble. The solubility of certain elements such as Ba and Sr will depend on the mineralisation in which they occur. The sulphates of these elements (barite and celestite) are basically insoluble, whereas the carbonates are readily soluble.

Coarse and malleable minerals such as native gold and silver, platinum and palladium are not representatively characterized by the small sample size.

Add On Packages Available for the Full Packages

See following pages for details.

- Rare Earths by ICP-MS (MS41L-REE, MS41W-REE)
- Lead Isotopes by ICP-MS (MS41L-PbIS, MS41W-PbIS)
- Si, Zr and Ti by pXRF (pXRF-34)

List of Reportable Analytes for both the ME-MS41L and ME-MS41W Packages:

Analyte	Symbol	Units	Lower Limit	Upper Limit
Gold	Au	ppm	0.0002	25
Silver	Ag	ppm	0.001	100
Aluminum	Al	%	0.01	25
Arsenic	As	ppm	0.01	10000
Boron	B	ppm	10	10000
Barium	Ba	ppm	0.5	10000
Beryllium	Be	ppm	0.01	1000
Bismuth	Bi	ppm	0.001	10000
Calcium	Ca	%	0.01	25
Cadmium	Cd	ppm	0.001	1000
Cerium	Ce	ppm	0.003	500
Cobalt	Co	ppm	0.001	10000
Chromium	Cr	ppm	0.01	10000
Cesium	Cs	ppm	0.005	500
Copper	Cu	ppm	0.01	10000
Iron	Fe	%	0.001	50
Gallium	Ga	ppm	0.004	10000
Germanium	Ge	ppm	0.005	500
Hafnium	Hf	ppm	0.002	500
Mercury	Hg	ppm	0.004	10000
Indium	In	ppm	0.005	500
Potassium	K	%	0.01	10
Lanthanum	La	ppm	0.002	10000
Lithium	Li	ppm	0.1	10000
Magnesium	Mg	%	0.01	25
Manganese	Mn	ppm	0.1	50000
Molybdenum	Mo	ppm	0.01	10000
Sodium	Na	%	0.001	10
Niobium	Nb	ppm	0.002	500
Nickel	Ni	ppm	0.04	10000
Phosphorus	P	%	0.001	1
Lead	Pb	ppm	0.005	10000
Palladium	Pd	ppm	0.001	25
Platinum	Pt	ppm	0.002	25
Rubidium	Rb	ppm	0.005	10000
Rhenium	Re	ppm	0.001	50
Sulphur	S	%	0.01	10
Antimony	Sb	ppm	0.005	10000
Scandium	Sc	ppm	0.005	10000
Selenium	Se	ppm	0.1	1000
Tin	Sn	ppm	0.01	500

Analyte	Symbol	Units	Lower Limit	Upper Limit
Strontium	Sr	ppm	0.01	10000
Tantalum	Ta	ppm	0.005	500
Tellurium	Te	ppm	0.01	500
Thorium	Th	ppm	0.002	10000
Titanium	Ti	%	0.001	10
Thallium	Tl	ppm	0.002	10000
Uranium	U	ppm	0.005	10000
Vanadium	V	ppm	0.1	10000
Tungsten	W	ppm	0.001	10000
Yttrium	Y	ppm	0.003	500
Zinc	Zn	ppm	0.1	10000
Zirconium	Zr	ppm	0.01	500

List of Analytes Available via ME-MS42L: Analytes reported are selected by the client.

Analyte	Symbol	Units	Lower Limit	Upper Limit
Silver	Ag	ppm	0.001	100
Arsenic	As	ppm	0.01	250
Gold	Au	ppm	0.0002	100
Barium	Ba	ppm	0.5	250
Beryllium	Be	ppm	0.01	100
Bismuth	Bi	ppm	0.001	250
Calcium	Ca	%	0.01	0.025
Cadmium	Cd	ppm	0.001	250
Cerium	Ce	ppm	0.003	500
Cobalt	Co	ppm	0.001	250
Chromium	Cr	ppm	0.01	250
Cesium	Cs	ppm	0.005	500
Copper	Cu	ppm	0.01	250
Iron	Fe	%	0.001	0.025
Gallium	Ga	ppm	0.004	250
Germanium	Ge	ppm	0.005	500
Hafnium	Hf	ppm	0.002	500
Mercury	Hg	ppm	0.004	250
Indium	In	ppm	0.005	500
Lanthanum	La	ppm	0.002	250
Lithium	Li	ppm	0.1	500
Manganese	Mn	ppm	0.1	250
Molybdenum	Mo	ppm	0.01	250
Niobium	Nb	ppm	0.002	500
Nickel	Ni	ppm	0.04	250
Lead	Pb	ppm	0.005	250
Palladium	Pd	ppm	0.001	100
Platinum	Pt	ppm	0.002	100
Rubidium	Rb	ppm	0.005	500
Rhenium	Re	ppm	0.001	50
Antimony	Sb	ppm	0.005	250
Scandium	Sc	ppm	0.005	250
Selenium	Se	ppm	0.1	250

Analyte	Symbol	Units	Lower Limit	Upper Limit
Tin	Sn	ppm	0.01	500
Strontium	Sr	ppm	0.01	250
Tantalum	Ta	ppm	0.005	500
Tellurium	Te	ppm	0.01	500
Thorium	Th	ppm	0.002	500
Titanium	Ti	%	0.001	0.025
Thallium	Tl	ppm	0.002	250
Uranium	U	ppm	0.005	10000
Vanadium	V	ppm	0.1	250
Tungsten	W	ppm	0.001	250
Yttrium	Y	ppm	0.003	500
Zinc	Zn	ppm	0.1	250
Zirconium	Zr	ppm	0.01	500

Add-on packages available with ME-MS41L or ME-MS41W

Rare Earth Element Add-On: MS41L-REE/MS41W-REE

The full suite of rare earth elements may be added to the method on request. Ce and La are reported in the standard package.

NOTE: Many REE-bearing minerals are not fully dissolved in an aqua regia digestion.

List of 12 Reportable Rare Earth Elements and Concentrations:

Analyte	Symbol	Units	Lower Limit	Upper Limit
Dysprosium	Dy	ppm	0.002	1000
Erbium	Er	ppm	0.002	1000
Europium	Eu	ppm	0.002	1000
Gadolinium	Gd	ppm	0.002	1000
Holmium	Ho	ppm	0.001	1000
Lutetium	Lu	ppm	0.001	1000
Praseodymium	Pr	ppm	0.002	1000
Neodymium	Nd	ppm	0.002	1000
Samarium	Sm	ppm	0.002	1000
Terbium	Tb	ppm	0.001	1000
Thulium	Tm	ppm	0.001	1000
Ytterbium	Yb	ppm	0.002	1000

Pb Isotope Add-On: MS41L-PbIS/MS41W-PbIS

Pb isotope concentrations may also be added on request. Pb isotopes are mass bias corrected; no correction for ^{204}Hg interference on ^{204}Pb is performed.

List of 4 Reportable Lead Isotope Concentrations:

Analyte	Symbol	Units	Lower Limit	Upper Limit
Lead 204	^{204}Pb	ppm	0.005	10000
Lead 206	^{206}Pb	ppm	0.005	10000
Lead 207	^{207}Pb	ppm	0.005	10000
Lead 208	^{208}Pb	ppm	0.005	10000

Si and Zr Add-On: pXRF-34

For lithogeochemical applications, Silicon and Zirconium may be obtained as a cost-effective add-on package using portable XRF analysis on sample pulps.

List of Elements & Concentrations:

Analyte	Symbol	Units	Lower Limit	Upper Limit
Silicon	Si	%	0.05	47
Zirconium	Zr	ppm	1	10000
Titanium	Ti	%	0.1	60

Geochemical Procedure

ME-MS61r
(REE Add-on package to ME-MS61)*
Ultra-Trace Level Method Using ICP-MS and ICP-AES

Sample Decomposition:

$HF-HNO_3-HClO_4$ acid digestion, HCl leach (GEO-4A01)

Analytical Method:

Inductively Coupled Plasma - Atomic Emission Spectroscopy (ICP - AES)
Inductively Coupled Plasma - Mass Spectrometry (ICP-MS)

A prepared sample (0.25 g) is digested with perchloric, nitric, hydrofluoric and hydrochloric acids. The residue is topped up with dilute hydrochloric acid and analyzed by inductively coupled plasma-atomic emission spectrometry. Following this analysis, the results are reviewed for high concentrations of bismuth, mercury, molybdenum, silver and tungsten and diluted accordingly. Samples meeting this criterion are then analyzed by inductively coupled plasma-mass spectrometry. Results are corrected for spectral interelement interferences.

NOTE: Four acid digestions are able to dissolve most minerals; however, although the term "*near-total*" is used, depending on the sample matrix, not all elements are quantitatively extracted.

Results for the additional rare earth elements will represent the acid leachable portion of the rare earth elements and as such, cannot be used, for instance to do a chondrite plot.

Element	Symbol	Units	Lower Limit	Upper Limit
Silver	Ag	ppm	0.01	100
Aluminum	Al	%	0.01	50
Arsenic	As	ppm	0.2	10 000
Barium	Ba	ppm	10	10 000
Beryllium	Be	ppm	0.05	1 000
Bismuth	Bi	ppm	0.01	10 000
Calcium	Ca	%	0.01	50

Geochemical Procedure

Element	Symbol	Units	Lower Limit	Upper Limit
Cadmium	Cd	ppm	0.02	1 000
Cerium	Ce	ppm	0.01	500
Cobalt	Co	ppm	0.1	10 000
Chromium	Cr	ppm	1	10 000
Cesium	Cs	ppm	0.05	500
Copper	Cu	ppm	0.2	10 000
Iron	Fe	%	0.01	50
Gallium	Ga	ppm	0.05	10 000
Germanium	Ge	ppm	0.05	500
Hafnium	Hf	ppm	0.1	500
Indium	In	ppm	0.005	500
Potassium	K	%	0.01	10
Lanthanum	La	ppm	0.5	10 000
Lithium	Li	ppm	0.2	10 000
Magnesium	Mg	%	0.01	50
Manganese	Mn	ppm	5	100 000
Molybdenum	Mo	ppm	0.05	10 000
Sodium	Na	%	0.01	10
Niobium	Nb	ppm	0.1	500
Nickel	Ni	ppm	0.2	10 000
Phosphorous	P	ppm	10	10 000
Lead	Pb	ppm	0.5	10 000
Rubidium	Rb	ppm	0.1	10 000
Rhenium	Re	ppm	0.002	50
Sulphur	S	%	0.01	10
Antimony	Sb	ppm	0.05	10 000
Scandium	Sc	ppm	0.1	10 000

Element	Symbol	Units	Lower Limit	Upper Limit
Selenium	Se	ppm	1	1 000
Tin	Sn	ppm	0.2	500
Strontium	Sr	ppm	0.2	10 000
Tantalum	Ta	ppm	0.05	100
Tellurium	Te	ppm	0.05	500
Thorium	Th	ppm	0.2	10 000
Titanium	Ti	%	0.005	10
Thallium	Tl	ppm	0.02	10 000
Uranium	U	ppm	0.1	10 000
Vanadium	V	ppm	1	10 000
Tungsten	W	ppm	0.1	10 000
Yttrium	Y	ppm	0.1	500
Zinc	Zn	ppm	2	10 000
Zirconium	Zr	ppm	0.5	500
Dysprosium	Dy	ppm	0.05	1 000
Erbium	Er	ppm	0.03	1 000
Europium	Eu	ppm	0.03	1 000
Gadolinium	Gd	ppm	0.05	1 000
Holmium	Ho	ppm	0.01	1 000
Lutetium	Lu	ppm	0.01	1 000
Neodymium	Nd	ppm	0.1	1 000
Praseodymium	Pr	ppm	0.03	1 000
Samarium	Sm	ppm	0.03	1 000
Terbium	Tb	ppm	0.01	1 000
Thulium	Tm	ppm	0.01	1 000
Ytterbium	Yb	ppm	0.03	1 000

ME-ICP06 and OA-GRA05
Analysis of major oxides by ICP-AES

ME-ICP06

Sample Decomposition:

Lithium Metaborate/Lithium Tetraborate ($LiBO_2/Li_2B_4O_7$) Fusion* (FUS-LI01)

Analytical Method:

Inductively Coupled Plasma - Atomic Emission Spectroscopy (ICP-AES)

A prepared sample (0.100 g) is added to lithium metaborate/lithium tetraborate flux, mixed well and fused in a furnace at 1000°C. The resulting melt is then cooled and dissolved in 100 mL of 4% nitric acid/2% hydrochloric acid. This solution is then analyzed by ICP-AES and the results are corrected for spectral inter-element interferences. Oxide concentration is calculated from the determined elemental concentration and the result is reported in that format.

Element	Symbol	Units	Lower Limit	Upper Limit
Aluminum	Al_2O_3	%	0.01	100
Barium	BaO	%	0.01	100
Calcium	CaO	%	0.01	100
Chromium	Cr_2O_3	%	0.01	100
Iron	Fe_2O_3	%	0.01	100
Magnesium	MgO	%	0.01	100
Manganese	MnO	%	0.01	100
Phosphorus	P_2O_5	%	0.01	100
Potassium	K_2O	%	0.01	100
Silicon	SiO_2	%	0.01	100
Sodium	Na_2O	%	0.01	100

Element	Symbol	Units	Lower Limit	Upper Limit
Strontium	SrO	%	0.01	100
Titanium	TiO_2	%	0.01	100

***Note**: For samples that are high in sulphides, we may substitute a peroxide fusion in order to obtain better results.

OA-GRA05, ME-GRA05

Sample Decomposition: Thermal decomposition Furnace or TGA (OA-GRA05 or ME-GRA05)
Analytical Method: Gravimetric

If required, the total oxide content is determined from the ICP analyte concentrations and loss on Ignition (L.O.I.) values. A prepared sample (1.0 g) is placed in an oven at 1000˚C for one hour, cooled and then weighed. The percent loss on ignition is calculated from the difference in weight.

Method Code	Parameter	Symbol	Units	Lower Limit	Upper Limit
OA-GRA05	Loss on Ignition (Furnace)	LOI	%	0.01	100
ME-GRA05	Loss on Ignition (TGA)	Moisture	%	0.01	100
		LOI	%	0.01	100

Geochemical Procedure

ME-MS81
Lithogeochemistry

Sample Decomposition:

Lithium Borate ($LiBO_2/Li_2B_4O_7$) Fusion (FUS-LI01)*

Analytical Method:

Inductively Coupled Plasma - Mass Spectroscopy (ICP - MS)

A prepared sample (0.100 g) is added to lithium metaborate/lithium tetraborate flux, mixed well and fused in a furnace at 1025°C. The resulting melt is then cooled and dissolved in an acid mixture containing nitric, hydrochloric and hydrofluoric acids. This solution is then analyzed by inductively coupled plasma - mass spectrometry.

Element	Symbol	Unit	Lower Limit	Upper Limit
Barium	Ba	ppm	0.5	10000
Cerium	Ce	ppm	0.1	10000
Chromium	Cr	ppm	10	10000
Cesium	Cs	ppm	0.01	10000
Dysprosium	Dy	ppm	0.05	1000
Erbium	Er	ppm	0.03	1000
Europium	Eu	ppm	0.03	1000
Gallium	Ga	ppm	0.1	1000
Gadolinium	Gd	ppm	0.05	1000
Hafnium	Hf	ppm	0.2	10000
Holmium	Ho	ppm	0.01	1000
Lanthanum	La	ppm	0.1	10000
Lutetium	Lu	ppm	0.01	1000
Niobium	Nb	ppm	0.2	2500

Element	Symbol	Unit	Lower Limit	Upper Limit
Neodymium	Nd	ppm	0.1	10000
Praseodymium	Pr	ppm	0.03	1000
Rubidium	Rb	ppm	0.2	10000
Samarium	Sm	ppm	0.03	1000
Tin	Sn	ppm	1	10000
Strontium	Sr	ppm	0.1	10000
Tantalum	Ta	ppm	0.1	2500
Terbium	Tb	ppm	0.01	1000
Thorium	Th	ppm	0.05	1000
Thullium	Tm	ppm	0.01	1000
Uranium	U	ppm	0.05	1000
Vanadium	V	ppm	5	10000
Tungsten	W	ppm	1	10000
Yttrium	Y	ppm	0.1	10000
Ytterbium	Yb	ppm	0.03	1000
Zirconium	Zr	ppm	2	10000

*__Note__: Minerals that may not recover fully using the lithium borate fusion include zircon, some metal oxides, some rare-earth phosphates and some sulphides. Basemetals also do not fully recover using this method.

Basemetals determined by either aqua regia or 4-acid digestion and ICP-AES may be added to the ME-MS81 package. See following page.

Geochemical Procedure

Addition of Basemetals

Sample Decomposition: Aqua Regia (GEO-AR01) or 4-Acid (GEO-4ACID)

Analytical Method: Inductively Coupled Plasma – Atomic Emission Spectroscopy (ICP-AES)

The lithium borate fusion is not the preferred method for the determination of base metals. Many sulfides and some metal oxides are only partially decomposed by the borate fusion and some elements such as cadmium and zinc can be volatilized.

Base metal and additional elements more appropriately analysed by acid digestion can be reported with ME-MS81 by either an aqua regia (**ME-AQ81**) or four acid digestion (**ME-4ACD81**). The four acid digestion is preferred when the targets include more resistive mineralization such as that associated with nickel and cobalt. Mercury is only offered with the aqua regia digestion.

ME-4ACD81

Element	Symbol	Units	Lower Limit	Upper Limit
Silver	Ag	ppm	0.5	100
Arsenic	As	ppm	5	10000
Cadmium	Cd	ppm	0.5	1000
Cobalt	Co	ppm	1	10000
Copper	Cu	ppm	1	10000
Lithium	Li	ppm	10	10000
Molybdenum	Mo	ppm	1	10000
Nickel	Ni	ppm	1	10000
Lead	Pb	ppm	2	10000
Scandium	Sc	ppm	1	10000
Thallium	Tl	ppm	10	10000
Zinc	Zn	ppm	2	10000

ME-AQ81

Note: Mercury is only available via the aqua regia digestion

Element	Symbol	Units	Lower Limit	Upper Limit
Silver	Ag	ppm	0.5	100
Arsenic	As	ppm	5	10000
Cadmium	Cd	ppm	0.5	1000
Cobalt	Co	ppm	1	10000
Copper	Cu	ppm	1	10000
Mercury	Hg	ppm	1	10000
Molybdenum	Mo	ppm	1	10000
Nickel	Ni	ppm	1	10000
Lead	Pb	ppm	2	10000
Zinc	Zn	ppm	2	10000

C-IR07 & S-IR08 – Evaluation of Ores and High Grade Materials

Sample Decomposition:

Leco Furnace

Analytical Method:

Infrared Spectroscopy

The sample is analyzed for total Sulphur and/or carbon using a Leco analyzer. While a stream of oxygen passes through a prepared sample (0.05 to 0.6g), it is heated in a furnace to approximately 1350°C. Sulphur dioxide and carbon dioxide released from the sample are measured by an infrared detection system and the total Sulphur and/or carbon result is provided.

Method Code	Element	Symbol	Units	Lower Limit	Upper Limit
C-IR07	Carbon	C	%	0.01	50
S-IR08	Sulphur	S	%	0.01	50
S-IR08t	Sulphur	S	%	0.01	100

ME-OG46- Ore Grade Elements by Aqua Regia Digestion Using Conventional ICP-AES Analysis

Sample Decomposition:

HNO_3 - HCl Digestion (ASY-AR01)

Analytical Method:

Inductively Coupled Plasma – Atomic Emission Spectroscopy (ICP-AES)

Assays for the evaluation of ores and high-grade materials are optimized for accuracy and precision at high concentrations. Ultra-high concentration samples (> 15 -20%) may require the use of methods such as titrimetric and gravimetric analysis, in order to achieve maximum accuracy.

A prepared sample (0.4 g) is digested with concentrated nitric acid for 90 minutes in a graphite heating block. The resulting solution is diluted with concentrated hydrochloric acid before cooling to room temperature. The samples are diluted in a volumetric flask (100 or 250) mL with demineralized water and analyzed using atomic absorption spectrometry.

*NOTE: ICP-AES is the default finish technique for ME-OG46. However, under some conditions and at the discretion of the laboratory an AA finish may be substituted.

Element	Symbol	Units	Lower Limit	Upper Limit
Silver	Ag	ppm	1	1500
Arsenic	As	%	0.01	60
Cadmium	Cd	%	0.001	10
Cobalt	Co	%	0.0005	30
Copper	Cu	%	0.001	50
Iron	Fe	%	0.01	100
Manganese	Mn	%	0.01	60
Molybdenum	Mo	%	0.001	10
Nickel	Ni	%	0.001	30
Lead	Pb	%	0.001	20
Sulphur	S	%	0.01	10
Zinc	Zn	%	0.001	30