GEO LABS

GEOSCIENCE LABORATORIES

2017

SCHEDULE OF FEES AND SERVICES

Ontario

Issue 9: Effective April 1, 2017

About the Geoscience Laboratories (Geo Labs)

History

The Geoscience Laboratories (Geo Labs) was established in 1898 and was housed in Toronto before moving to the Willet Green Miller Centre in 1991 as part of the Ministy of Northern Development and Mines' (MNDM) relocation to Sudbury.

Vision

To be a world-class, full service inorganic geoanalytical facility providing research quality analyses and services.

Mission Statement

To ensure that all clients are consistently provided with the highest level of service and quality of work by delivering, in a timely manner, high-quality, research-grade mineralogical and inorganic chemical analysis of rocks, minerals and other material, that meet method-specific precision and accuracy quality tolerances.

Quality Policy

It is the Quality Policy of the Geoscience Laboratories (Geo Labs) to consistently provide clients with the highest level of service and quality of work.

The management and employees at the Geo Labs accomplish this by:

- Delivering high-quality inorganic chemical and mineralogical analyses and services meeting method-specific precision and accuracy quality tolerances
- Committing to good professional practice and to the quality of its testing.
- Meeting or surpassing client priority and turnaround time requirements.
- Continuously improving the quality system through annual audits and reviews.
- Complying with the ISO 9001:2008 and ISO/IEC 17025:2005 International Standards by the adoption and implementation of a documented system of policies and procedures.
- Maintaining the culture that "at the Geoscience Laboratories quality is the responsibility of all staff".

Contact Information

Geoscience Laboratories (Geo Labs)
Ontario Geological Survey
Ontario Ministry of Northern Development and Mines
Willet Green Miller Centre
933 Ramsey Lake Road
Sudbury, Ontario P3E 6B5
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Ontario

Ontario Ministry of Northern Development and Mines
Ontario Geological Survey, GeoSerivces Section

ilac-MRA

CALA
Testing
Accreditation No. A 2927

Certified Syste
ISO 9001

Table of Contents

Sample Submission

Sample Submission and Shipping Instructions

Every effort is made to ensure that data produced are accurate and representative of the sample submitted. The client is requested to provide as much information about their samples as possible, such as rock type, sulphide content, mineralogy, alteration, and any other unusual characteristics. If submitting mineralized samples, or samples likely to contain high concentrations of any analyte, please consult with the Geo Labs prior to sample submission. Clients may be subject to a decontamination charge to clean areas of the Geo Labs contaminated by submitted samples with undeclared mineralization or high analyte concentrations.

It is the client's responsibility to disclose all hazardous materials. The Geo Labs reserves the right to refuse such samples. The samples will be returned at cost and their disposal will be the client's responsibility.

Samples can be shipped to:

Sample Receiving
c/o Geoscience Laboratories
Ministry of Northern Development and Mines
Willet Green Miller Centre
933 Ramsey Lake Road
Sudbury, Ontario P3E 6B5 CANADA

The client's name and address must be clearly marked on each shipment package. Individual samples should be properly numbered or identified and accompanied by a copy of our Sample Submission Form – Request for Analysis. Samples that are poorly labelled and/or unorganized will increase turnaround time and will be subject to a sample sorting charge. Samples will not be processed until adequate written instructions are received from the client. Optimal sample size for submission: 300 g.

All samples shipped from outside Canada should be labelled "GEOLOGICAL SAMPLES FOR ANALYSIS ONLY – NO COMMERCIAL VALUE"

Sample Storage

Samples are retained for a minimum of 30 days following the issue of the final Certificate of Analysis. After 30 days, samples will be discarded. If requested at the time of submission, samples can be

Quality Assurance Program

The Geo Labs is certified under ISO 9001:2008 and accredited to ISO/IEC 17025:2005 for specific test methods. A copy of the Geo Labs' Scope of Accreditation is available upon request.

The Geo Labs participates in proficiency testing (PT) programs organized by a range of national and international PT providers, including CALA, CANMET, Environment Canada, and the IAG.

The Quality Assurance (QA) program at the Geo Labs consists of adding a duplicate for at least every ten samples as a measure of precision. Additionally, one inter-laboratory reference material (RM) and one blank (if appropriate) are generally included with every twenty samples to help assess accuracy. Geo Labs offers a variety of RMs (both certified and in-house) for matrix matching. A specific RM may be available upon request. The Geo Labs QA program is applied to all sample submissions.

Data Release (Certificate of Analysis)

Data will only be released to those who are designated on the Geo Labs' Sample Submission Form – Request for Analysis. Written authorization will be required from the primary contact person if data are to be released to a second or third party.

The Geo Labs will provide electronic and hard copies of data, upon request, for up to one year from the date of issue of the Certificate of Analysis. Retrieval of archived data after one year will be subject to a $50.00/hour charge.

Liability

Any analysis, testing, investigating or service in connection with any work performed by the Geo Labs shall be conducted in accordance with recognized professional analytical standards. Neither the Geo Labs, nor its subcontractors, consultants, agents, officers, nor employees shall be held responsible for any loss or damage resulting directly or indirectly from any default, negligence, error, or omission. Geo Labs' liability, if any, shall be limited to the cost of performing the analyses.

Terms and Conditions

Results are for samples as received. Clients will be notified prior to performing any analytical work if non-routine analyses are required.

All prices are in Canadian funds and are subject to HST. Payment is due 30 days from the invoice date. Anything over 30 days is deemed overdue. All overdue accounts are subject to interest charges unless governed by legislation or approved exemption, or due from federal or provincial governments and agencies. The Ontario Ministry of Finance determines the interest rate. Contact the Geo Labs for payment options.

Sample Preparation

The preparation of samples represents the most important step in the analysis of geological materials. The Geo Labs uses a variety of sample preparation procedures on a routine basis for assay and geochemical analysis. While processing rock samples, the procedure uses a jaw-crusher with steel plates, a riffle to split the sample, and di ferent grinding media to pulverize the sample.

Assay Preparation

The assay preparation technique (**SAM-SPA**) uses high chrome steel mills. Approximately 150 ppm chromium (Cr) and 0.1% iron (Fe) contamination may be expected.

Geo Preparation

The geo preparation technique (**SAM-SPG**) is used whenever detailed whole-rock geochemical analysis is required. The samples are pulverized in a 99.8% pure aluminum oxide (Al_2O_3) planetary ball mill. A minor amount of aluminum (Al) may be added to the sample.

Agate Mill Preparation

The agate mill preparation technique (**SAM-AGM**) significantly reduces the amount of contamination (Cr, Fe, Al) compared to the assay and geo preparation methods. Minor amounts of silica (Si) may be added to the sample.

Chittick Sample Preparation

The Chittick sample preparation technique (**SAM-CTK**) is used when a Chittick determination is required. Samples are prepared using a mortar and pestle. The minus 200 mesh (<75 µm fraction) is used for analysis.

Particle Size Sample Preparation

The particle size sample preparation technique (**SAM-PSA**) is used when particle size analysis (PSA) is required. Samples are sieved through a 10 mesh screen. The minus 10 mesh (<2000 µm fraction) is used for the analysis.

Sediment Sample Preparation

The sediment sample preparation technique (**SAM-SSP**) is used to prepare sediment samples for analysis. Samples are processed using a zirconium mill for 10-20 seconds and the material is sieved through a 60 mesh screen. The minus 60 mesh (<250 µm fraction) is used for the analysis.

Sample Drying

Wet samples received at the Geo Labs that require drying (**ADM-DRY**) will be subject to a drying charge.

Oversized Samples

The Geo Labs is equipped to handle samples up to 3 kg in size. Anything over that will be subject to an oversized sample charge (**ADM-OVER**).

Sample Preparation Costs Summary

Method Code	Sample Preparation Method	Minimum Sample Size	Mesh Size	Cost per Sample
SAM-SPA	Assay Preparation	150 g	100 mesh (150 µm)	$9.30
SAM-SPG	Geo Preparation	150 g	170 mesh (90 µm)	$14.80
SAM-AGM	Agate Mill Preparation	150 g	170 mesh (90 µm)	$16.50
SAM-CTK	Chittick Sample Preparation	100 g	200 mesh (75 µm)	$9.55
SAM-PSA	Particle Size Sample Preparation	100 g	10 mesh (2000 µm)	$8.45
SAM-SSP	Sediment Sample Preparation	100 g	60 mesh (250 µm)	$6.30
ADM-DRY	Sample Drying	n/a	n/a	$2.15
ADM-OVER	Oversized Samples	n/a	n/a	$1.15 per kg over

X-Ray Fluorescence (XRF)

Major Element Analysis (ISO/IEC 17025 Accredited)

The major element XRF method (**XRF-M01**) is designed for the analysis of major elements in geological samples. The samples are run for loss on ignition (LOI: 105 °C under nitrogen atmosphere, 1000 °C under oxygen atmosphere). The calcined samples are then fused with a borate flux to produce a glass bead for analysis. The total content of each analyte is expressed as its oxide. This package is not suitable for ores and sulphide-rich samples.

Working Ranges for XRF-M01 Method

Analyte	Lower Limit (wt%)	Upper Limit (wt%)	Analyte	Lower Limit (wt%)	Upper Limit (wt%)
Al_2O_3*	0.02	100	MgO*	0.01	50
BaO	0.004	1	MnO*	0.002	5
CaO*	0.006	100	Na_2O*	0.02	15
Cr_2O_3	0.002	5	P_2O_5*	0.002	40
Fe_2O_3*	0.01	100	SiO_2*	0.04	100
K_2O*	0.01	20	TiO_2*	0.01	33
			Total Loss on Ignition (LOI) at 1000 °C*	±0.05	n/a
			Nitrogen Loss on Ignition (LOI) at 105 °C	0.05	n/a

** Major oxides accredited for ISO/IEC 17025*

Working Ranges for XRF-M02 Method (available on request)

Element	Analyte	Lower Limit (ppm)	Upper Limit (ppm)
Cobalt	Co	12	5 000
Copper	Cu	14	15 000
Nickel	Ni	9	15 000
Vanadium	V	8	7 500
Zinc	Zn	5	5 000

X-Ray Fluorescence Costs Summary

Method Code	Analytical Method Description	Minimum Sample Size	Cost per Sample
XRF-M01	XRF Major Oxides Analysis	10 g	$36.40
XRF-T02	XRF Trace Element Analysis	15 g	$54.60
XRF-T03	XRF Trace Element Analysis	15 g	$35.20
XRF-W01	XRF Trace Element Analysis (Halogens)	15 g	$13.60

Trace Element Analysis

The trace element XRF methods (**XRF-T02**, **XRF-T03** and **XRF-W01**) are designed for the analysis of trace elements in geological samples. Samples are prepared as pressed pellets and analyzed using optimized parameters for each element.

Working Ranges for XRF-T02 Method

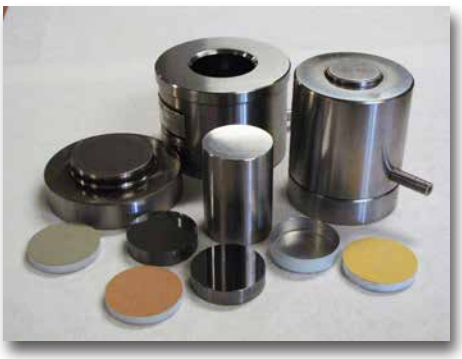
Element	Analyte	Lower Limit (ppm)	Upper Limit (ppm)	Element	Analyte	Lower Limit (ppm)	Upper Limit (ppm)
Arsenic	As	6	4 000	Rubidium	Rb	0.8	3 500
Bromine	Br	1.2	240	Strontium	Sr	0.8	6 000
Copper	Cu	9	7 000	Thorium	Th	1.5	220
Gallium	Ga	1.3	100	Uranium	U	1.6	1 600
Lead	Pb	1.7	6 000	Yttrium	Y	0.7	800
Molybdenum	Mo	0.8	2 000	Zinc	Zn	1	7 000
Nickel	Ni	1.6	7 000	Zirconium	Zr	1.8	2 400
Niobium	Nb	0.7	2 000				

Working Ranges for XRF-T03 Method

Element	Analyte	Lower Limit (ppm)	Upper Limit (ppm)	Element	Analyte	Lower Limit (ppm)	Upper Limit (ppm)
Barium	Ba	8	2 700	Lanthanum	La	7	800
Cerium	Ce	15	2 500	Manganese	Mn	9	4 000
Cesium	Cs	7	700	Scandium	Sc	4	100
Chromium	Cr	9	4 000	Vanadium	V	3	5 000
Cobalt	Co	1.3	3 500				

Working Ranges for XRF-W01 Method

Element	Analyte	Lower Limit (ppm)	Upper Limit (ppm)
Chlorine	Cl	50	15 000



Loss On Ignition (LOI)

Loss on Ignition (LOI)

The Loss on Ignition (LOI) method is a measure of the change in weight as a result of heating to drive off volatiles and/or remove components by thermal decomposition and/or burning in an oxygen-rich atmosphere. At any particular temperature, the LOI will be the sum of several processes and can express a net weight gain (negative value) or loss (positive value).

Samples submitted for major element analysis (XRF-M01, page 6) and for which the LOI at 500 °C are required should be submitted for the 3 Step LOI method (LOI-3ST).

Working Ranges for Loss on Ignition Programs

LOI Program	Program	Lower Limit (wt%)
2 Step LOI	• Nitrogen 105°C • Oxygen 500°C • Total LOI 500°C	±0.05
3 Step LOI	• Nitrogen 105°C • Oxygen 500°C • Oxygen 1000°C • Total LOI 1000°C	±0.05
4 Step LOI	• Nitrogen 105°C • Oxygen 371°C • Oxygen 500°C • Oxygen 1000°C • Total LOI 1000°C	±0.05
Lake Sediment LOI	• Oxygen 500°C • Total LOI 500°C	±0.05

Dry weight LOI available upon request.

Loss on Ignition Costs Summary

Method Code	Analytical Method Description	Minimum Sample Size	Cost per Sample
LOI-2ST	2 Step LOI	2.0 g	$5.30
LOI-3ST	3 Step LOI	2.0 g	$6.95
LOI-4ST	4 Step LOI	2.0 g	$12.00
LOI-LK1	Lake Sediment LOI	2.0 g	$5.30

Carbon and Sulphur (ISO/IEC 17025 Accredited)

The carbon and sulphur methods (**IRC-100** and **IRC-101**) are designed for the determination of total carbon (C) (expressed as CO_2) and total sulphur (S) (expressed as either S or SO_3) in a variety of materials such as rocks, soils, cement, limestone, and coal. Combustion of a sample in an oxygen-rich environment oxidizes carbon and sulphur, which are then measured by infrared absorption.

Working Ranges for IRC-100 and IRC-101 Method

Method Code	Analyte	Reported As	Lower Limit (wt%)	Upper Limit (wt%)
IRC-100	Total Carbon	CO_2*	0.023	110
	Total Sulphur	S*	0.003	54
IRC-101	Total Sulphur	SO_3	0.01	2.23

** Analyte accredited for ISO/IEC 17025*

Moisture Content

The moisture content method (**IRW-H2O**) is designed for the determination of free water (moisture) and total crystalline water in rocks and other materials. Free water (H_2O^-) is driven off at 105 °C and crystalline water (H_2O^+) at 1000 °C. The water is then measured by infrared absorption.

Working Ranges for IRW-H2O Method

Analyte	Reported As	Lower Limit (wt%)
Free Water	H_2O^-	0.01
Crystalline Water	H_2O^+	0.03

Ferrous Iron

The ferrous iron method (**FEO-ION**) dissolves samples in an aggressive, non-oxidizing acid mixture. The solubilized ferrous iron is quantified by potentiometric titration with a standardized permanganate solution. Samples rich in manganese (Mn) are not suitable for this method.

Working Ranges for FEO-ION Method

Analyte	Reported As	Lower Limit (wt%)
Ferrous Iron	FeO	0.06

Whole Rock Additions Costs Summary

Method Code	Analytical Method Description	Minimum Sample Size	Cost per Sample
IRC-100	Carbon-Sulphur Analysis (CO_2, S)	1 g	$33.70
IRC-101	Total Sulphur Analysis (SO_3)	1 g	$19.60
IRW-H2O	Moisture Content Analysis	1 g	$25.75
FEO-ION	Ferrous Iron Analysis	1 g	$15.40

Solution Preparation

Open Vessel Multi-Acid Digest

The open vessel multi-acid digest methods (**SOL-OAIO**, **SOL-OT3**, and **SOL-OT1**) are used for the preparation of samples to be analyzed by ICP-MS, ICP-AES, or Flame-AAS (page 12-15) and are designed to dissolve most silicate phases present in rock samples. Although the methods achieve a near total digestion of the sample, some resistant mineral phases may not be dissolved.

Closed Vessel Multi-Acid Digest

The closed vessel multi-acid digest method (**SOL-CAIO**) is used for the preparation of samples to be analyzed by ICP-MS and ICP-AES (page 12-13), and is designed for the complete dissolution of silicate rock samples. This method is preferred for the determination of the rare earth elements (REE: La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu), the high field strength elements (HFSE: Zr, Nb, Hf, Ta), and large ion lithophile elements (LILE: Rb, Sr, Cs, Ba) plus Y, Th, and U.

Sample Pre-Leach

Samples flagged high in carbonates are pre-leached using dilute nitric acid to remove excess calcium prior to acid-digestion (**SOL-PLN**). The leachate is combined with the digested sample prior to analysis for a complete determination.

Aqua Regia Digest

The aqua regia extraction method (**SOL-ARD**) is used for the preparation of samples being analyzed by ICP-MS and ICP-AES (page 14-16) and is designed to leach labile elements from silicate, sulphide, and oxide matrices, in particular base and precious metals. This method is most commonly applied to the analysis of soils, unconsolidated sediments, and humus samples.

Sodium Carbonate Fusion

The sodium carbonate fusion method (**SOL-FDI**) is used for the determination of fluoride (F^-) by ion selective electrode (page 24-25). This method is not suitable for the analysis of sulphide-rich samples (S >0.5 wt%).

Solution Preparation Costs Summary

Method Code	Solution Preparation Method	Analytical Method Code(s)	Minimum Sample Size	Cost per Sample
SOL-OAIO	Open Vessel Multi-Acid Digest	• IMO-100 • IAO-100	1 g	$15.90
SOL-OT3	Open Vessel Multi-Acid Digest	• AAF-101 • AAF-102 • AAF-103 • IAT-100	2 g	$12.75
SOL-OT1	Open Vessel Multi-Acid Digest	• AAF-200	2 g	$12.75
SOL-CAIO	Closed Vessel Multi-Acid Digest	• IMC-100 • IAC-100	1 g	$21.30
SOL-PLN	Sample Pre-Leach	• IMC-100 • IAC-100	1 g	$10.60
SOL-ARD	Aqua Regia Digest	• IML-100 • IML-101 • IAL-100	2 g	$10.60
SOL-FDI	Sodium Carbonate Fusion	• ISE-R01	3 g	$31.70

ICP-MS (ISO/IEC 17025 Accredited)

The ICP-MS (Inductively Coupled Plasma Mass Spectrometry) methods (**IMO-100** and **IMC-100**) are designed for the analysis of minor and trace elements in non-mineralized geological samples prepared using either a closed or open vessel multi-acid digestion (SOL-OAIO, SOL-CAIO, page 10-11). Due to the greater efficiency of the closed vessel digestion, data obtained from the IMC-100 method are considered more accurate for elements contained in acid-resistant phases (e.g., chromite, zircon, monazite, xenotime, and/or garnet).

Working Ranges for Methods IMO-100 and IMC-100

Element	Analyte	Lower Limit (ppm)	Upper Limit (ppm)	Element	Analyte	Lower Limit (ppm)	Upper Limit (ppm)
Antimony†	Sb	0.04	28	Neodymium*	Nd	0.06	760
Barium*	Ba	0.8	1 740	Nickel	Ni	0.7	4 100
Beryllium†	Be	0.04	360	Niobium*	Nb	0.028	277
Bismuth†	Bi	0.47	47	Praseodymium*	Pr	0.014	240
Cadmium‡	Cd	0.013	4	Rubidium*	Rb	0.11	3 800
Cerium*	Ce	0.12	2 420	Samarium*	Sm	0.026	128
Cesium*	Cs	0.013	600	Scandium	Sc	1.1	63
Chromium	Cr	3	4 500	Strontium*	Sr	0.6	1 560
Cobalt	Co	0.13	187	Tantalum*	Ta	0.007	320
Copper	Cu	1.4	2 900	Terbium*	Tb	0.0023	21
Dysprosium*	Dy	0.009	135	Thallium*	Tl	0.002	20
Erbium*	Er	0.007	87	Thorium	Th	0.018	109
Europium*	Eu	0.0031	19	Thulium*	Tm	0.0019	13
Gadolinium*	Gd	0.009	118	Tin‡	Sn	0.16	14
Gallium	Ga	0.04	58	Titanium	Ti	7	25 000
Hafnium*	Hf	0.14	29	Tungsten	W	0.05	141
Holmium*	Ho	0.0025	29	Uranium*	U	0.011	1 620
Indium	In	0.0018	1.9	Vanadium	V	0.8	370
Lanthanum*	La	0.1	1 380	Ytterbium*	Yb	0.009	70
Lead	Pb	0.18	700	Yttrium	Y	0.05	740
Lithium†	Li	0.4	207	Zinc	Zn	1.8	9 100
Lutetium*	Lu	0.002	9	Zirconium*	Zr	6	1 450
Molybdenum‡	Mo	0.08	44				

** Elements accredited for ISO/IEC 17025 (IMC-100 only).*
† Accuracy better than ± 10-20%.
‡ Accuracy better than ± 10-30%. Data for information purposes only.

ICP-AES

The ICP-AES (Inductively Coupled Plasma Atomic Emission Spectrometry) methods (**IAO-100** and **IAC-100**) are designed for the analysis of major and trace elements in non-mineralized geological samples prepared using either a closed or open vessel multi-acid digestion (SOL-OAIO and SOL-CAIO, page 10-11). This technique compliments the IMO-100 and IMC-100 packages (page 12).

Working Ranges for Methods IAO-100 and IAC-100

		IAO-100 Method		IAC-100 Method	
Element	Analyte	Lower Limit (ppm)	Upper Limit (ppm)	Lower Limit (ppm)	Upper Limit (ppm)
Aluminum	Al	260	12 0000	260	120 000
Barium	Ba	2	1900	2	1 900
Beryllium†	Be	0.1	300	0.1	300
Cadmium†	Cd	n/a	n/a	0.8	610
Calcium	Ca	46	300 000	46	300 000
Chromium	Cr	17	1400	17	1 400
Cobalt	Co	1	450	1	450
Copper	Cu	3	280 000	3	280 000
Iron	Fe	110	320 000	110	320 000
Lead	Pb	n/a	n/a	8	48 000
Lithium	Li	2	220	2	220
Magnesium	Mg	140	330 000	140	330 000
Manganese	Mn	1	13 000	1	13 000
Molybdenum†	Mo	n/a	n/a	2	17 000
Nickel	Ni	4	14 000	4	14 000
Phosphorus	P	4	7 000	4	7 000
Potassium	K	98	49 000	98	49 000
Scandium	Sc	0.3	60	0.3	60
Sodium	Na	530	62 000	530	62 000
Strontium	Sr	3	1 500	3	1 500
Sulphur†	S	n/a	n/a	81	14 0000
Titanium	Ti	6	25 000	6	25 000
Tungsten†	W	n/a	n/a	13	4 000
Vanadium	V	3	580	3	580
Yttrium	Y	0.6	340	0.6	340
Zinc	Zn	3	210 000	3	210 000
Zirconium	Zr	n/a	n/a	7	610

† *Non-validated elements: data are for information purposes only.*

Rock Analysis (Mineralized)

ICP-AES - Mineralized Material

The ICP-AES method (**IAT-100**) is designed for the analysis of major and trace elements in non-mineralized and mineralized geological material digested using the open vessel digestion technique (SOL-OT3, page 10-11).

Working Ranges for IAT-100 Method

Element	Analyte	Lower Limit (ppm)	Upper Limit (ppm)	Element	Analyte	Lower Limit (ppm)	Upper Limit (ppm)
Aluminum	Al	20	110 000	Manganese	Mn	1	8 000
Barium	Ba	1	1 500	Nickel	Ni	2	12 000
Calcium	Ca	25	95 000	Potassium	K	65	45 000
Chromium	Cr	2	500	Scandium	Sc	1	100
Cobalt	Co	1	500	Sodium	Na	45	31 000
Copper	Cu	1	15 000	Strontium	Sr	1	1 200
Iron	Fe	40	380 000	Titanium	Ti	1	17 000
Lead	Pb	35	45 000	Vanadium	V	1	400
Lithium	Li	1	200	Yttrium	Y	1	200
Magnesium	Mg	20	59 000	Zinc	Zn	4	190 000

Flame-AAS (ISO/IEC 17025 Accredited)

The atomic absorption methods (**AAF-101**, **AAF-102**, **AAF-103**, and **AAF-200**) are designed for the determination of base metals, lithium (Li), or silver (Ag) in mineralized geological samples digested using the open vessel digestion techniques (SOL-OT3, SOL-OT1, page 10-11) and can accommodate higher concentrations than the ICP-AES and ICP-MS techniques.

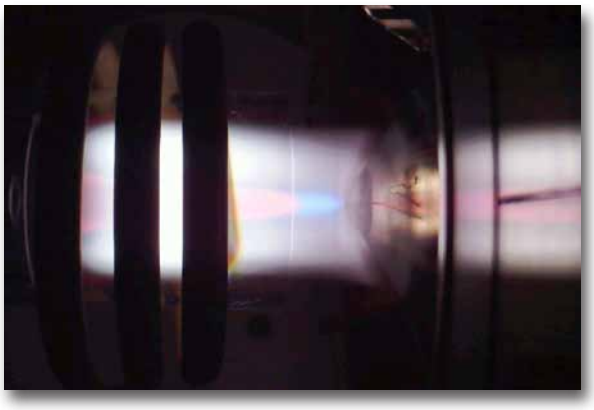
Working Ranges for Flame-AAS

Method Code	Element	Analyte	Lower Limit (ppm)	Upper Limit (ppm)
AAF-101	Cobalt	Co	8	20 000
	Copper*	Cu	7	250 000
	Nickel*	Ni	16	475 000
AAF-102	Copper*	Cu	7	250 000
	Lead*	Pb	14	75 000
	Zinc	Zn	4	450 000
AAF-103	Lithium	Li	5	400
AAF-200	Silver	Ag	2	75

** Elements accredited for ISO/IEC 17025.*

Rock Analysis Costs Summary

Method Code	Analytical Method	Solution Prep Code	Cost per Sample
IMO-100	ICP-MS Analysis with Open Vessel Multi-acid Digest	SOL-OAIO	$26.50
IMC-100	ICP-MS Analysis with Closed Vessel Multi-acid Digest	SOL-CAIO	$26.50
IAO-100	ICP-AES Analysis with Open Vessel Multi-acid Digest	SOL-OAIO	$14.70
IAC-100	ICP-AES Analysis with Closed Vessel Multi-acid Digest	SOL-CAIO	$14.70
IAT-100	ICP-AES Analysis with Open Vessel Digest for Mineralized Material	SOL-OT3	$14.70
AAF-101	Flame Atomic Absorption Analysis (Co, Cu, Ni)	SOL-OT3	$15.40
AAF-102	Flame Atomic Absorption Analysis (Cu, Pb, Zn)	SOL-OT3	$15.40
AAF-103	Flame Atomic Absorption Analysis (Li)	SOL-OT3	$10.10
AAF-200	Flame Atomic Absorption Analysis (Ag)	SOL-OT1	$10.10



Precious Metals Analysis

Lead Fire-Assay with Gravimetric Finish (ISO/IEC 17025 Accredited)

The lead fire-assay method (**GFA-PBG**) is used to determine gold (Au) and silver (Ag) in geological samples. The content of the precious metals collected in the fire-assay process is quantified gravimetrically.

Working Ranges for GFA-PBG Method

Element	Analyte	Lower Limit (oz/ton)
Gold*	Au	0.016
Silver	Ag	0.1

**Element accredited for ISO/IEC 17025.*

Lead Fire-Assay with ICP-MS Finish

The lead fire-assay method (**IMP-101**) is used to determine gold (Au), platinum (Pt), and palladium (Pd) in geological samples. The content of the precious metals collected in the fire-assay process is quantified by ICP-MS.

Working Ranges for IMP-101 Method

Element	Analyte	Lower Limit (ppb)	Upper Limit (ppb)
Gold	Au	0.6	5 000
Platinum	Pt	0.06	11 000
Palladium	Pd	0.14	5 000

Nickel Sulphide Fire-Assay (ISO/IEC 17025 Accredited)

The nickel sulphide fire-assay method (**IMP-200**) is considered the foremost method for determination of low-level gold (Au) and platinum group elements (PGEs) in geological samples. To ensure efficiency and reduce the possibility of contamination, it is recommended that samples containing >1% base metal sulphides be submitted for base metal (method AAF-101, page 14-15) and total sulphur analysis (method IRC-100, page 9).

In order to maintain the low detection limits and high quality data offered by this technique, samples expected to contain >500 ppb of any individual precious metal (or 100 ppb rhodium, Rh) should be flagged at sample submission. In addition, samples expected to be elevated in organic carbon, chromite, or zinc should also be flagged

Working Ranges for IMP-200 Method

Element	Analyte	Lower Limit (ppb)	Upper Limit (ppb)
Gold*	Au	0.4	3 600
Platinum*	Pt	0.17	4 700
Palladium*	Pd	0.12	4 800
Rhodium*	Rh	0.04	970
Ruthenium*	Ru	0.08	8 000
Iridium*	Ir	0.01	1 900

**Elements accredited for ISO/IEC 17025.*

Precious Metals Analysis Costs Summary

Method Code	Precious Metal Analysis Method	Minimum Sample Size	Cost per Sample
GFA-PBG	Lead Fire Assay with Gravimetric Finish	30 g	$21.30
IMP-101	Lead Fire Assay with ICP-MS Finish	30 g	$24.75
IMP-200	Nickel Sulphide Fire Assay with ICP-MS Finish	15 g	$185.75

Aqua Regia Extraction (Mineralized Rocks)

ICP-MS for Mineralized Rocks (ISO/IEC 17025 Accredited)

The ICP-MS method (**IML-101**) is designed for the analysis of minor and trace elements in mineralized rocks.

Working Ranges for IML-101 Method

Element	Analyte	Lower Limit (ppm)	Upper Limit (ppm)	Element	Analyte	Lower Limit (ppm)	Upper Limit (ppm)
Antimony	Sb	0.01	500	Nickel	Ni	1.6	22 000
Arsenic	As	0.1	1 800	Palladium	Pd	0.02	5
Bismuth	Bi	0.02	700	Platinum	Pt	0.005	3
Cadmium	Cd	0.02	50	Rhodium	Rh	0.003	2
Cobalt*	Co	0.03	1 000	Selenium	Se	0.2	90
Copper	Cu	0.6	12 000	Silver*	Ag	0.2	80
Gold	Au	0.002	100	Tellurium	Te	0.02	40
Iridium	Ir	0.003	2	Thallium	Tl	0.001	11
Lead*	Pb	0.2	8 000	Tin	Sn	0.1	90
Mercury	Hg	0.1	30	Zinc*	Zn	3	30 000
Molybdenum	Mo	0.06	1 200				

** Elements accredited for ISO/IEC 17025.*

Aqua Regia Extraction (Soil, Humus, Sediments)

ICP-MS (ISO/IEC 17025 Accredited)

The ICP-MS method (**IML-100**) is designed for the analysis of minor and trace elements in soils, humus, and unconsolidated sediments. Because the sample is incompletely digested during sample dissolution, the data produced by this package represent the composition of only the more easily acid-soluble components in the sample.

Working Ranges for IML-100 Method

Element	Analyte	Lower Limit (ppm)	Upper Limit (ppm)	Element	Analyte	Lower Limit (ppm)	Upper Limit (ppm)
Antimony*	Sb	0.004	100	Nickel*	Ni	0.1	2 400
Arsenic*	As	0.01	600	Niobium	Nb	0.001	20
Barium*	Ba	0.09	800	Palladium	Pd	0.005	2
Beryllium*	Be	0.002	20	Platinum	Pt	0.001	2
Bismuth	Bi	0.001	50	Praseodymium	Pr	0.001	60
Cadmium*	Cd	0.008	50	Rhodium	Rh	0.002	2
Cerium	Ce	0.01	560	Rubidium	Rb	0.007	140
Cesium	Cs	0.0009	30	Samarium	Sm	0.001	60
Chromium*	Cr	0.03	720	Scandium	Sc	0.008	30
Cobalt*	Co	0.006	210	Selenium	Se	0.03	24
Copper*	Cu	0.3	3 500	Silver	Ag	0.01	100
Dysprosium	Dy	0.0009	30	Strontium*	Sr	0.02	600
Erbium	Er	0.0004	30	Tantalum	Ta	0.0002	5
Europium	Eu	0.0003	30	Tellurium	Te	0.002	40
Gadolinium	Gd	0.0009	30	Terbium	Tb	0.0003	30
Gallium	Ga	0.004	20	Thallium	Tl	0.0003	11
Gold	Au	0.0007	100	Thorium	Th	0.002	60
Hafnium	Hf	0.0003	8	Thulium	Tm	0.0002	30
Holmium	Ho	0.0002	30	Tin*	Sn	0.03	90
Indium	In	0.0008	15	Titanium	Ti	0.2	2 300
Iridium	Ir	0.0005	2	Tungsten	W	0.004	90
Lanthanum	La	0.01	300	Uranium*	U	0.0005	30
Lead*	Pb	0.02	5 000	Vanadium	V	0.01	210
Lithium	Li	0.005	140	Ytterbium	Yb	0.0003	30
Lutetium	Lu	0.0002	30	Yttrium	Y	0.002	120
Mercury	Hg	0.007	30	Zinc*	Zn	0.8	6 000
Molybdenum	Mo	0.01	110	Zirconium	Zr	0.006	20
Neodymium	Nd	0.005	240				

** Elements accredited for ISO/IEC 17025*

Aqua Regia Extraction (Soil, Humus, Sediments)

ICP-AES

The ICP-AES method (**IAL-100**) is designed for the analysis of major and minor elements in soils, humus, and unconsolidated sediments and compliments the IML-100 and IML-101 methods (pages 18-19).

Working Ranges for IAL-100 Method

Element	Analyte	Lower Limit (ppm)	Upper Limit (ppm)	Element	Analyte	Lower Limit (ppm)	Upper Limit (ppm)
Aluminum	Al	9	42 000	Phosphorus	P	10	15 000
Arsenic	As	6	500	Potassium	K	30	25 000
Barium	Ba	0.6	5 000	Scandium	Sc	0.2	500
Beryllium	Be	0.09	500	Selenium	Se	9	500
Calcium	Ca	6	150 000	Silicon	Si	90	5 000
Chromium	Cr	2	2 500	Sodium	Na	17	15 000
Cobalt	Co	1	2 500	Strontium	Sr	0.1	2 500
Copper	Cu	3	20 000	Sulphur	S	24	17 000
Iron	Fe	90	150 000	Tin	Sn	3	500
Lithium	Li	1	500	Titanium	Ti	0.6	5 000
Magnesium	Mg	70	50 000	Vanadium	V	3	1 500
Manganese	Mn	0.3	25 000	Yttrium	Y	0.4	1 500
Molybdenum	Mo	2	500	Zinc	Zn	1	26 000
Nickel	Ni	2	22 000	Zirconium	Zr	0.9	500

Aqua Regia Extraction Analysis Costs Summary

Method Code	Analytical Method	Solution Prep Code(s)	Cost per Sample
IML-101	ICP-MS Analysis with Aqua Regia Digest (Mineralized Rock)	SOL-ARD	$26.50
IML-100	ICP-MS Analysis with Aqua Regia Digest (Soils, Humus, Sediments)	SOL-ARD	$26.50
IAL-100	ICP-AES Analysis with Aqua Regia Digest (Soils, Humus, Sediments)	SOL-ARD	$10.75

Water Filtration and Preservation

Sample filtration and preservation is the responsibility of the client prior to submitting samples. Unpreserved and unfiltered samples for the ICP-MS and ICP-AES will be treated without exception and where necessary at the client's cost (**SOL-ACID** and **SOL-FILT**). For best results, samples should be preserved by adding ultra-pure nitric acid to a concentration of 1% v/v and maintained at cool temperatures.

ICP-AES

The ICP-AES method (**IAW-200**) determines major and trace element concentrations in fresh water samples. This method can tolerate up to 1 wt% total dissolved solids (TDS) without dilution. Samples with high TDS may be subject to a dilution charge.

Working Ranges for IAW-200 Method

Element	Analyte	Lower Limit (ppb)	Upper Limit (ppb)	Element	Analyte	Lower Limit (ppb)	Upper Limit (ppb)
Aluminum	Al	10	50 000	Manganese	Mn	1	50 000
Boron	B	4	10 000	Molybdenum	Mo	5	10 000
Barium	Ba	1	10 000	Nickel	Ni	2	10 000
Beryllium	Be	1	10 000	Phosphorus	P	60	50 000
Cadmium	Cd	2	10 000	Potassium	K	80	50 000
Calcium	Ca	35	500 000	Silicon	Si	15	50 000
Chromium	Cr	4	10 000	Sodium	Na	720	500 000
Cobalt	Co	5	10 000	Strontium	Sr	1	10 000
Copper	Cu	3	10 000	Sulphur	S	135	67 000
Iron	Fe	15	50 000	Titanium	Ti	7	10 000
Lead	Pb	10	10 000	Vanadium	V	2	10 000
Lithium	Li	1	10 000	Zinc	Zn	1	10 000
Magnesium	Mg	80	750 000				

Mercury by Atomic Fluorescence Spectroscopy

Cold-vapour atomic fluorescence spectroscopy (**HGW-100**) determines parts-per-trillion (ppt) concentrations of total mercury in water samples after a bromochloride digestion for the release of organomercury and other mercury compounds into solution. For best results, samples should be preserved in 2% v/v hydrochloric acid (HCl) and kept refrigerated at 4 °C.

For samples with concentrations of mercury above the upper limit of the method, please contact the Geo Labs for more information.

Working Ranges for HGW-100 Method

Element	Analyte	Lower Limit (ppt)	Upper Limit (ppt)
Mercury	Hg	1.5	100

Water Analysis

ICP-MS (ISO / IEC 17025 Accredited)

This method (**IMW-100**) is designed to analyze a wide spectrum of elements. It is optimized for the determination of trace element concentrations in natural fresh water with low total dissolved solids contents (TDS <0.01 wt%). Samples with high TDS may be subject to a dilution charge. Owing to the high sensitivity of the ICP-MS instrument, it is recommended that major elements are determined by ICP-AES.

Working Ranges for IMW-100 Method

Element	Analyte	Lower Limit (ppb)	Upper Limit (ppb)	Element	Analyte	Lower Limit (ppb)	Upper Limit (ppb)
Aluminum*	Al	5	1 700	Manganese*	Mn	0.04	1 700
Antimony*	Sb	0.005	300	Molybdenum*	Mo	0.007	1 600
Arsenic*	As	0.03	300	Neodymium*	Nd	0.002	650
Barium*	Ba	0.03	1 500	Nickel*	Ni	0.04	1 600
Beryllium	Be	0.004	250	Niobium†	Nb	0.0006	0.25
Bismuth	Bi	0.001	140	Potassium	K	0.7	38 000
Boron†	B	0.4	640	Praseodymium*	Pr	0.0003	80
Cadmium	Cd	0.002	300	Rubidium*	Rb	0.002	980
Calcium	Ca	16	200 000	Samarium	Sm	0.002	550
Cerium*	Ce	0.001	100	Scandium	Sc	0.1	200
Cesium	Cs	0.0009	660	Selenium	Se	0.09	330
Chloride†	Cl	340	81 000	Silver	Ag	0.002	100
Chromium*	Cr	0.02	1 600	Sodium	Na	3	110 000
Cobalt*	Co	0.005	1 600	Strontium*	Sr	0.05	1 400
Copper*	Cu	0.1	1 600	Tantalum†	Ta	0.0003	225
Dysprosium	Dy	0.0003	450	Terbium	Tb	0.0002	110
Erbium	Er	0.0003	600	Thallium*	Tl	0.0003	210
Europium	Eu	0.0002	200	Thorium	Th	0.001	175
Gadolinium	Gd	0.0006	550	Thulium	Tm	0.0001	140
Gallium	Ga	0.001	60	Tin	Sn	0.009	310
Gold†	Au	0.0007	2	Titanium	Ti	0.4	1 700
Hafnium†	Hf	0.0008	0.5	Tungsten	W	0.002	30
Holmium	Ho	0.0001	125	Uranium*	U	0.0004	450
Iron*	Fe	1	1 800	Vanadium*	V	0.002	1 700
Lanthanum*	La	0.0007	90	Ytterbium	Yb	0.0003	450
Lead*	Pb	0.02	1 500	Yttrium*	Y	0.0005	900
Lithium*	Li	0.009	200	Zinc*	Zn	0.4	1 500
Lutetium	Lu	0.0001	160	Zirconium†	Zr	0.01	130
Magnesium	Mg	1	36 000				

** Elements accredited for ISO/IEC 17025*

† Data for information purposes only

Ion Chromatography (ISO/IEC 17025 Accredited)

The ion chromatography method (**ICW-100**) is used for the determination of several anions of geological and environmental importance in unacidified waters. Samples should be unpreserved (unacidified) and kept refrigerated at 4 °C. Certain anions are stable for a limited time frame, even when properly preserved, and may reduce, oxidize, or decompose to a form undetectable by this method.

Working Ranges for ICW-100 Method

Anion	Analyte	Lower Limit (ppm)	Upper Limit (ppm)
Bromide	Br^-	0.05	100
Chloride*	Cl^-	0.04	100
Fluoride*	F^-	0.01	100
Total Nitrogen* as $NO_2^- + NO_3^-$	N_{TOT}	0.02	40
Nitrite	NO_2^-	0.03	50
Nitrate	NO_3^-	0.03	100
Phosphate	PO_4^{3-}	0.05	100
Sulphate*	SO_4^{2-}	0.05	150

** Elements accredited for ISO/IEC 17025*

Waters Analysis Costs Summary

Method Code	Analytical Method	Minimum Sample Size	Cost per Sample
SOL-FILT	Sample Filtration	100 mL	$8.45
SOL-ACID	Sample Preservation	100 mL	$8.45
IAW-200	ICP-AES Water Analysis	100 mL	$8.20
HGW-100	Mercury Analysis by Atomic Fluorescence Spectroscopy	100 mL	$31.70
IMW-100	ICP-MS Water Analysis	100 mL	$37.20
ICW-100	Ion Chromatography Water Analysis	20 mL	$84.80

Other Analytical Services

Total Suspended Solids

The total suspended solids method (**TSS-100**) uses an aliquot of well-mixed sample that is passed through a 0.45 µm filter paper to determine the total mass of suspended solids

pH Determination

The pH determination methods (**PHP-100** and **PHS-200**) test solid or liquid samples for their acidity and/or alkalinity by direct measurement with an electronic pH meter.

Acid Base Accounting

The acid base accounting method (**ABA-200**) is designed to determine the balance between the acid producing and acid consuming components of samples. The samples are lightly digested and back-titrated using an automated titrator.

Particle Size Analysis

The particle size analysis method (**PSA-100**) is designed to analyze the physical characteristics and structural properties of soil. The Geo Labs can provide analysis of grain sizes between 0.025 to 2816 µm.

Specific Gravity

The specific gravity method (**SGT-R01**) is designed to measure the density of a material. Specific gravity of powders cannot be measured at the Geo Labs.

Calcite and Dolomite by Chittick Apparatus

The calcite and dolomite method (**CTK-100**) is designed to determine the carbonate content and calcite/dolomite ratio of sedimentary rock and till samples.

Analyte	Lower Limit (wt%)
% Dolomite	0.01
% Calcite	0.01
Calcite/Dolomite Ratio	0.01
% Total Carbonate	0.01

Fluorine by Ion Selective Electrode

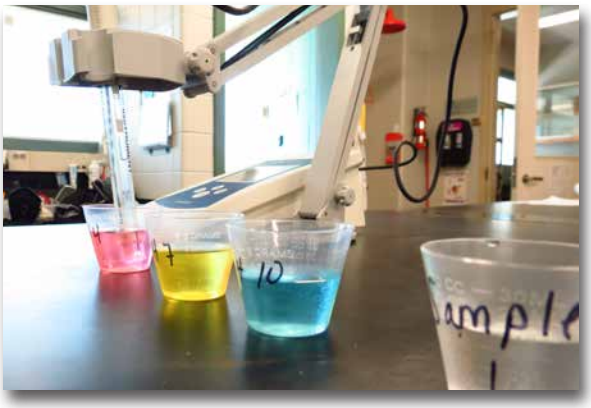
The ion selective electrode method (**ISE-R01**) is designed to determine the total fluorine (F) contents of non-mineralized geological samples. Samples are brought into solution following a sodium carbonate fusion (SOL-FDI, page 10-11) and analyzed using a direct-measure ion selective electrode.

This technique is not suitable for the analysis of sulphide-rich samples (S >0.5 wt%).

Element	Analyte	Lower Limit (ppm)	Upper Limit (ppm)
Fluorine	F	115	110 000

Other Services Costs Summary

Method Code	Method Description	Minimum Sample Size	Price per Sample
TSS-100	Total Suspended Solids	100 mL	$18.55
PHP-100	pH Paste Determination	10 g	$15.90
PHS-200	pH Solution Determination	25 mL	$9.10
ABA-200	Acid Base Accounting	10 g	$52.00
PSA-100	Particle Size Analysis	10 g	$46.50
SGT-R01	Specific Gravity	>100 g to <2 kg	$15.90
CTK-100	Chittick Analysis	5 g	$26.50
ISE-R01	Fluorine by Ion Selective Electrode	3 g	$12.55



X-Ray Diffraction (XRD)

Mineral Identification Without Interpretation

The mineral identification (without interpretation) method (**XRD-100**) provides the qualitative XRD analyses of powdered rock samples only. Interpretation of the XRD pattern is the responsibility of the client.

Mineral Identification With Interpretation

The mineral identification (with interpretation) method (**XRD-101**) provides the qualitative XRD analyses of samples, with interpretation of the mineral phases present. The method is intended to provide the client with a summary of the major mineral phases (>5%) present in the sample. The ability to properly identify all of the phases may be limited by the complexity of the sample. Note that routine XRD analysis is only intended to provide classification of general structural groups and cannot provide detailed compositional information.

XRD Rental Without Operator

The XRD equipment is available for rent on an hourly basis. Clients should contact the Geo Labs for further information and scheduling. Charges for equipment training will be applicable.

Phyllosilicate Mineral Identification (Clay Speciation)

This package (**XRD-103**) is intended to provide a comprehensive list of clay mineral species present in a sample. The amount of sample required for this method depends to a large extent on the clay content in the sample. Contact the Geo Labs prior to sample submission.

X-Ray Diffraction Costs Summary

Method Code	Method Description	Price per Sample
XRD-100	Mineral Identification Without Interpretation	$36.90
XRD-101	Mineral Identification With Interpretation	$143.55
XRD-102	X-Ray Diffraction Rental Without Operator	$42.65 per hour
XRD-103	Clay Speciation: • Mineral Separation • Mg^{2+} Saturation • Mg^{2+} glycol, Mg^{2+} glycerol • K^{+} Saturation, K^{+} 550°C	$588.85

Scanning Electron Microscopy (SEM)

The Geo Labs currently operates a Zeiss EVO-50 Scanning Electron Microscope (SEM). Routine capabilities of this instrumentation include qualitative mineral identification, X-ray mapping, modal analysis, cathodoluminescence (CL) imaging, secondary electron (SE) imaging, and fully integrated back scatter electron (BSE) imaging including montage generation.

Clients should contact the Geo Labs for further information regarding scheduling of jobs and access to the instrument. Charges for equipment training will be applicable.

SEM Rental

The SEM may be rented on an hourly basis with or without an operator (**SEM-101** and **SEM-102**). The client should contact the Geo Labs for further information regarding the scheduling of SEM rental time. Charges for equipment training will be applicable.

Scanning Electron Microscopy Costs Summary

Method Code	Method Description	Price per Hour
SEM-101	SEM Rental With Operator	$148.75
SEM-102	SEM Rental Without Operator	$90.00

Mineralogy Services

Electron Microprobe Analysis

The Geo Labs currently operates a Cameca SX-100 Electron Probe Micro Analyzer (EPMA). This instrument is equipped with 5 wavelength dispersive (WD) spectrometers that utilize an array of large area diffraction crystals that are needed to produce the best possible sensitivity during quantitative mineral analysis.

The mineralogy section currently uses a number of different analytical packages that are optimized for various mineral species. Our strategy is to employ dual analytical conditions (low and high beam current settings) for minerals that are not susceptible to decomposition in order to produce the best possible sensitivity. Routines may be customized to suit the needs of the client to include any combination of elements, counting times, and analytical conditions.

Clients should contact the Geo Labs for further information regarding scheduling of jobs and access to the instrument. Charges for equipment training will be applicable.

Electron Microprobe Costs Summary

Method Code	Method Description	Price
EMP-100	Microprobe Analysis per Grain • Minimum of 50 grains. • For KIMs, the price includes mounting and photography.	$14.40 per grain
EMP-101	Microprobe Rental With Operator • Minimum of ½ day (4 hours)	$185.75 per hour
EMP-102	Microprobe Rental Without Operator • Minimum of ½ day (4 hours)	$116.50 per hour

Kimberlite Indicator Minerals (KIMs) (ISO/IEC 17025 Accredited)

Mineral separates submitted to the Geo Labs are mounted in 1 inch epoxy plugs that are exposed, polished and photographed prior to analysis on the Cameca SX-100 electron microprobe (EMP-100 method). Note: the Geo Labs does not perform either the heavy mineral separation or hand picking of indicator minerals.

The analytical routines have been optimized so that key elements associated with the various indicator mineral groups are analyzed in an appropriate fashion. This involves the use of dual analytical conditions (low and high beam current settings) in order to produce appropriate counting statistics for both major and minor elements thereby ensuring the best precision possible.

Sample Submission

KIM grains should be submitted to the Geo Labs in clearly labelled vials that are mineral specific. Individual batches must contain a minimum of 50 grains. For high volume jobs (>2000 grains) contact the Geo Labs for alternate sample submission protocols and scheduling information.

Current Analytical Schemes and Limits of Detection for the KIM suite

	Garnet	Pyroxene	Ilmenite	Chromite	Olivine
Oxide	Lower Limit (wt%)	Lower Limit (wt%)	Lower Limit (wt%)	Lower Limit (wt%)	Lower Limit (wt%)
SiO_2	0.025*	0.025	0.005	0.006	0.026
TiO_2	0.007*	0.008	0.025	0.007	0.007
Al_2O_3	0.021*	0.019	0.025	0.030	0.004
V_2O_3	0.006	n/a	0.008	0.008	n/a
Cr_2O_3	0.012*	0.013	0.017	0.036	0.006
Nb_2O_3	n/a	n/a	0.013	n/a	n/a
MgO	0.022*	0.021	0.029	0.034	0.018
CaO	0.011*	0.013	0.004	n/a	0.005
MnO	0.008*	0.008	0.033	0.008	0.008
FeO^{TOT}	0.018*	0.018	0.047	0.033	0.022
CoO	n/a	n/a	n/a	0.008	0.008
NiO	n/a	0.006	0.007	0.008	0.006
ZnO	n/a	n/a	0.011	0.014	n/a
Na_2O	0.006*	0.006	n/a	n/a	n/a
K_2O	0.003*	0.003	n/a	n/a	n/a

** Analyses accredited for ISO/IEC 17025*
Note that the Lower Detection Limit may vary depending on the service status of the spectrometers.

Reference Materials (RMs)

Reference Materials (RMs)

The Geo Labs has a fully-equipped facility with specialized equipment to produce reference materials in batches from 1 kg up to 500 kg (depending on the specific gravity of the material)

The Geo Labs Reference Material Program focuses on three aspects:

- Production of reference materials for in-house use
- Production of reference materials to meet individual client requirements
- Production of reference materials for purchase

Production of Reference Materials for In-house Use

The Geo Labs has produced over 40 in-house reference materials for internal use, with a focus on material collected from various geological sites in Ontario, Canada. Materials are crushed, pulverized to -200 mesh, screened, blended, and bottled. The material then undergoes in-house homogeneity testing to determine the provisional composition and to ensure within-bottle and between-bottle consistency.

Production of Reference Materials for Client Requirements

The Geo Labs can produce reference materials based on individual client requirements. Contact the Geo Labs for further information and price quote.

Reference Materials Available for Purchase

LDI-1 (low grade) and LDI-3 (high grade) are two Pt-group element (PGE) reference materials collected from the Lac des Iles PGE deposit. The deposit is hosted by a gabbro located 85 km north of Thunder Bay, Ontario, Canada. See the chart on the next page for provisional in-house data.

PJV-1, PJV-2, and PJV-3 are three reference materials collected from the Porcupine Joint Venture gold project in Timmins, Ontario, Canada. See below for provisional in-house data.

LK-NIP-1 is a diabase collected from a Nipigon diabase sill in Kitto Township, south of Beardmore, Ontario, Canada. See the chart on the next page for provisional in-house data.

Contact the Geo Labs for further information and pricing.

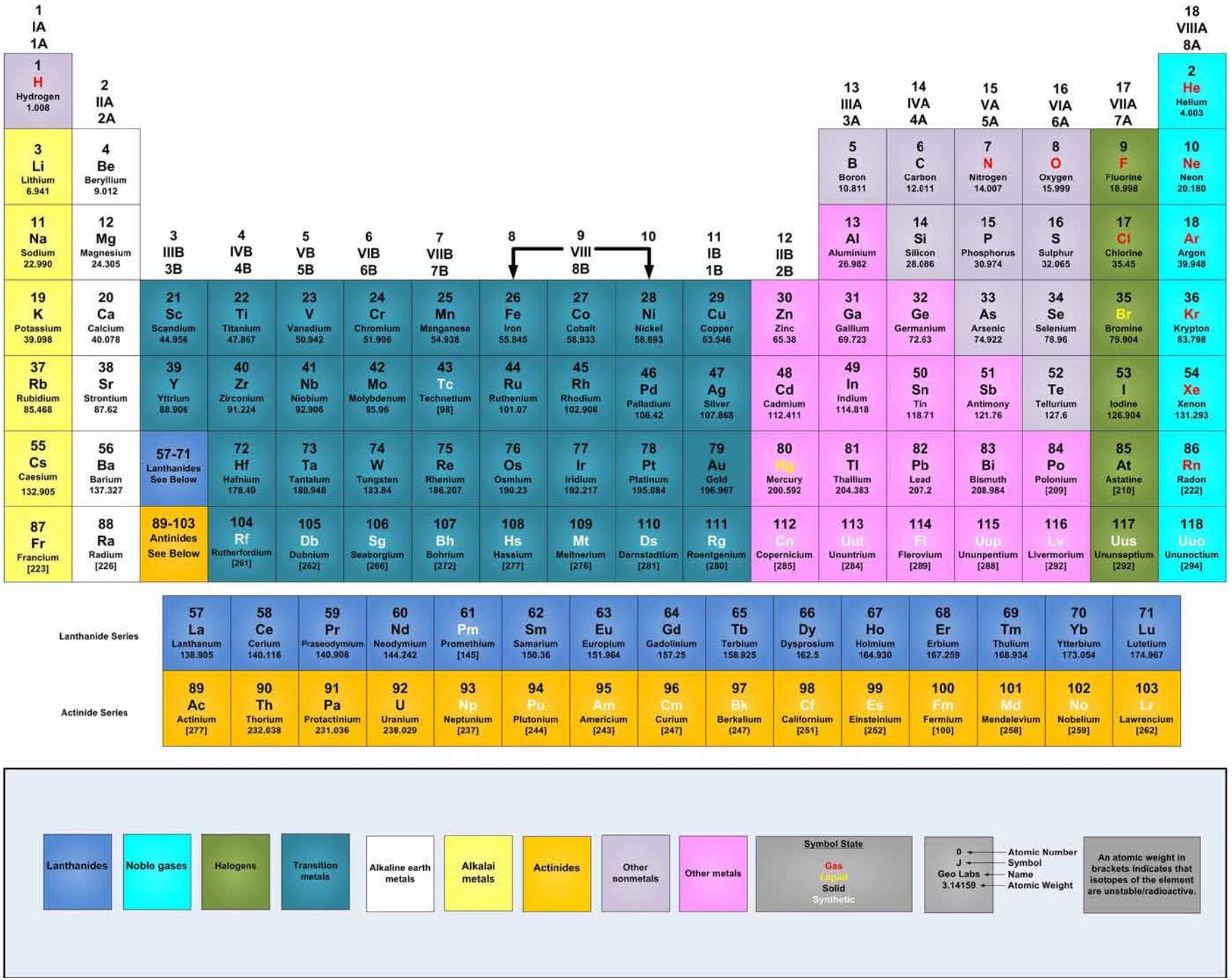
Provisional Composition of Porcupine Joint Venture In-House RMs

Element	Unit	PJV-1	PJV-2	PJV-3
Au	oz/ton	0.23	0.28	0.95
Ag	ppm	1.12	1.28	3.98
Cu	ppm	180	210	150
Ni	ppm	**83**	81	108
S	wt %	1.15	1.29	0.76
CO_2	wt %	3.52	4.04	9.61

Provisional Composition of LDI-1, LDI-3 and LK-NIP-1 In-House RMs

Element	Unit	LDI-1	LDI-3	LK-NIP-1	Element	Unit	LDI-1	LDI-3	LK-NIP-1
Al_2O_3	wt %	17.36	10.50	15.84	Ir*	ppb	0.08	0.17	0.19
CaO	wt %	10.16	7.17	10.46	La	ppm	1.2	1.2	9.27
Fe_2O_3	wt %	7.69	12.51	13.79	Li	ppm	18	25	n/a
K_2O	wt %	0.21	0.24	0.47	Lu	ppm	0.05	0.07	0.352
MgO	wt %	10.87	15.94	7.38	Mo	ppm	<1.0	<1	1.42
MnO	wt %	0.13	0.20	0.20	Nb	ppm	0.22	0.27	4.9
Na_2O	wt %	1.89	0.79	2.43	Nd	ppm	1.2	1.3	12.50
P_2O_5	wt %	<0.01	<0.01	0.1	Ni	ppm	656	657	160.5
SiO_2	wt %	48.77	48.51	49.65	Pb	ppm	2.6	4.6	3.3
TiO_2	wt %	0.12	0.19	1.18	Pd*	ppb	834	4820	17.96
LOI	wt %	2.74	4.02	0.17	Pr	ppm	0.30	0.33	2.776
S	wt %	0.12	0.15	0.02	Pt*	ppb	98.2	290	13.43
CO_2	wt %	n/a	0.09	0.04	Rb	ppm	7.8	9.5	14.04
FeO	wt %	5.46	9.03	9.90	Rh*	ppb	0.70	1.79	0.90
H_2O^+	wt %	3.25	5.07	0.61	Ru*	ppb	0.32	0.82	0.44
H_2O^-	wt %	0.15	0.11	0.16	Sc	ppm	24.5	37.8	34.9
Au*	ppb	83.9	103	4.63	Sm	ppm	0.28	0.32	3.33
Ba	ppm	55	36	142.3	Sr	ppm	183	88	176.9
Ce	ppm	2.5	2.5	20.59	Ta	ppm	<0.3	<0.3	0.30
Co	ppm	52	84	60.6	Tb	ppm	0.06	0.07	0.682
Cr	ppm	n/a	343	183	Th	ppm	0.12	0.12	1.65
Cs	ppm	1.07	1.08	0.0690	Tl	ppm	<0.03	<0.3	0.11
Cu	ppm	413	456	165.3	Tm	ppm	0.05	0.06	0.368
Dy	ppm	0.39	0.48	4.238	U	ppm	0.04	0.05	0.485
Er	ppm	0.28	0.36	2.553	V	ppm	93	135	306
Eu	ppm	0.18	0.17	1.174	Y	ppm	2.4	3.1	23.37
Ga	ppm	10	9	19.8	Yb	ppm	0.31	0.41	2.36
Gd	ppm	0.32	0.39	4.072	Zn	ppm	n/a	86	98
Hf	ppm	0.2	0.2	2.5	Zr	ppm	n/a	7	84
Ho	ppm	0.09	0.12	0.888					

** Analysis by Nickel Sulphide Fire-Assay with ICP-MS Finish*
Note: results are based on the average of triplicate analysis on 12 randomly selected bottles


1 IA 1A
2 IIA 2A
3 IIIB 3B
4 IVB 4B
5 VB 5B
6 VIB 6B
7 VIIB 7B
8
9 VIII 8B
10
11 IB 1B
12 IIB 2B
13 IIIA 3A
14 IVA 4A
15 VA 5A
16 VIA 6A
17 VIIA 7A
18 VIIIA 8A
1 H Hydrogen 1.008
2 He Helium 4.003
3 Li Lithium 6.941
4 Be Beryllium 9.012
5 B Boron 10.811
6 C Carbon 12.011
7 N Nitrogen 14.007
8 O Oxygen 15.999
9 F Fluorine 18.998
10 Ne Neon 20.180
11 Na Sodium 22.990
12 Mg Magnesium 24.305
13 Al Aluminium 26.982
14 Si Silicon 28.086
15 P Phosphorus 30.974
16 S Sulphur 32.065
17 Cl Chlorine 35.45
18 Ar Argon 39.948
19 K Potassium 39.098
20 Ca Calcium 40.078
21 Sc Scandium 44.956
22 Ti Titanium 47.867
23 V Vanadium 50.942
24 Cr Chromium 51.996
25 Mn Manganese 54.938
26 Fe Iron 55.845
27 Co Cobalt 58.933
28 Ni Nickel 58.693
29 Cu Copper 63.546
30 Zn Zinc 65.38
31 Ga Gallium 69.723
32 Ge Germanium 72.63
33 As Arsenic 74.922
34 Se Selenium 78.96
35 Br Bromine 79.904
36 Kr Krypton 83.798
37 Rb Rubidium 85.468
38 Sr Strontium 87.62
39 Y Yttrium 88.906
40 Zr Zirconium 91.224
41 Nb Niobium 92.906
42 Mo Molybdenum 95.96
43 Tc Technetium [98]
44 Ru Ruthenium 101.07
45 Rh Rhodium 102.906
46 Pd Palladium 106.42
47 Ag Silver 107.868
48 Cd Cadmium 112.411
49 In Indium 114.818
50 Sn Tin 118.71
51 Sb Antimony 121.76
52 Te Tellurium 127.6
53 I Iodine 126.904
54 Xe Xenon 131.293
55 Cs Caesium 132.905
56 Ba Barium 137.327
57-71 Lanthanides See Below
72 Hf Hafnium 178.49
73 Ta Tantalum 180.948
74 W Tungsten 183.84
75 Re Rhenium 186.207
76 Os Osmium 190.23
77 Ir Iridium 192.217
78 Pt Platinum 195.084
79 Au Gold 196.967
80 Hg Mercury 200.592
81 Tl Thallium 204.383
82 Pb Lead 207.2
83 Bi Bismuth 208.984
84 Po Polonium [209]
85 At Astatine [210]
86 Rn Radon [222]
87 Fr Francium [223]
88 Ra Radium [226]
89-103 Antinides See Below
104 Rf Rutherfordium [261]
105 Db Dubnium [262]
106 Sg Seaborgium [266]
107 Bh Bohrium [272]
108 Hs Hassium [277]
109 Mt Meitnerium [276]
110 Ds Darnstadtium [281]
111 Rg Roentgenium [280]
112 Cn Copernicium [285]
113 Uut Ununtrium [284]
114 Fl Flerovium [289]
115 Uup Ununpentium [288]
116 Lv Livermorium [292]
117 Uus Ununseptium [292]
118 Uuo Ununoctium [294]
Lanthanide Series
57 La Lanthanum 138.905
58 Ce Cerium 140.116
59 Pr Praseodymium 140.908
60 Nd Neodymium 144.242
61 Pm Promethium [145]
62 Sm Samarium 150.36
63 Eu Europium 151.964
64 Gd Gadolinium 157.25
65 Tb Terbium 158.925
66 Dy Dysprosium 162.5
67 Ho Holmium 164.930
68 Er Erbium 167.259
69 Tm Thulium 168.934
70 Yb Ytterbium 173.054
71 Lu Lutetium 174.967
Actinide Series
89 Ac Actinium [277]
90 Th Thorium 232.038
91 Pa Protactinium 231.036
92 U Uranium 238.029
93 Np Neptunium [237]
94 Pu Plutonium [244]
95 Am Americium [243]
96 Cm Curium [247]
97 Bk Berkelium (247)
98 Cf Californium [251]
99 Es Einsteinium [252]
100 Fm Fermium [100]
101 Md Mendelevium [258]
102 No Nobelium [259]
103 Lr Lawrencium [262]
Lanthanides
Noble gases
Halogens
Transition metals
Alkaline earth metals
Alkalai metals
Actinides
Other nonmetals
Other metals
Symbol State
Gas
Liquid
Solid
Synthetic
0 Atomic Number
J Symbol
Geo Labs Name
3.14159 Atomic Weight
An atomic weight in brackets indicates that isotopes of the element are unstable/radioactive.

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Quote Number: _____
Price Code: _____

Geo Labs Job Number: _____

Date: _____

SAMPLE SUBMISSION FORM – REQUEST FOR ANALYSIS

Submitted By:
Company:
Address:

Phone Number:
Fax Number:
E-mail:

Data Report To:
Company:
Address:

Phone Number:
Fax Number:
E-mail:

Additional Report To:
Company:
Address:

E-mail:

Invoice To:
Company:
Address:

Phone Number:
Purchase Order No.:
Quote No.:

No. of Samples	Sample ID	Sample Description	Sample Prep Code	Solution Prep Code	Method Codes / Elements			

Comments / Special Instructions

Sample Management:	Rejects (90 Days Free)	Pulps (30 Days Free)	Solutions (90 Days Free)
Discard	( )	( )	( )
Return (collect)	( )	( )	( )

Samples will be discarded if instructions are not provided

DISCLAIMER:
Values are reported as achieved on each instrument. If values are above or below the working limit, it is the responsibility of the client to request another type of analysis for conclusive results at the expense of the client.

Note: Please contact the Geo Labs for a digital (accessible) version of the Sample Submission Form.

Sample Submission Form

PRECISE ANALYSIS

ACCURATE RESULTS

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