

ACCELERATED CYANIDE LEACH ORE-GRADE ANALYSIS GEOMETALLURGY FIRE  
ASSAY ORE CHARACTERIZATION PYROSULPHATE FUSION X-RAY FLUORESCENCE  
FUSION TECHNIQUES HYDRIDE ELEMENTS ICP-AES PGE ANALYSIS QUALITY  
CONTROL PRECIOUS METALS ANALYSIS SCOPING STUDIES SODIUM  
PEROXIDE FUSION 2-ACID DIGESTION PILOT PLANT TESTING BASE METAL ANALYSIS  
ASSAYS LITHIUM METABORATE FUSION X-RAY DIFFRACTION RADIOACTIVE ELEMENT  
ANALYSIS SPECIFIC GRAVITY GOLD DEPARTMENT RARE EARTH ELEMENT  
ANALYSIS ATOMIC ABSORPTION BOTTLE ROLLS TRACE ELEMENT ANALYSIS  
ANALYSIS COMMERCIAL-GRADE ANALYSIS PARTICLE SIZE ANALYSIS CYANIDE  
EXTRACTABLE GOLD (BLEG) ON-SITE LABORATORIES MOBILE SAMPLE PREPARATION  
PREPARED PELLETS ANALYSIS THERMOGRAVIMETRIC ANALYSIS WHOLE ROCK  
ANALYSIS GOLD BULLION ANALYSIS MOISTURE TESTS MULTI-ACID DIGESTION  
ANALYSIS HYDRIDE AAS LOSS ON IGNITION TESTS AQUA REGIA SILVER BULLION  
ANALYSIS MOBILE METAL ION (MMI™) GEOCHEMISTRY NICKEL SULPHIDE  
ENVIRONMENTAL MINERALOGY MAJOR ELEMENT ANALYSIS GRAVIMETRIC ANALYSIS  
DENSITY FLOWSHEET DEVELOPMENT SCREENED METALLICS BORATE FUSION  
P-MS CARBON AND SULFUR ANALYSIS MULTI-ELEMENT TRACE ANALYSIS GEOCHEMICAL  
ANALYSIS CLASSICAL TECHNIQUES SETTLEMENT AND UMPIRE ANALYSIS

# ANALYTICAL SERVICES

When you need:

- **UNPARALLELED** network of commercial and mine-site labs
- Uniform **ANALYTICAL** methods
- Unequalled analytical **TECHNOLOGY** to detect deeply buried deposits
- Secure Internet data access at <https://qlab.sgs.com>

Contact **SGS** to be sure

Geochemical sampling and analysis is the basis for many decisions in exploration.

**WHEN YOU NEED TO BE SURE** of procedures, protocols or lab practice, we hope that you will turn to our free publication.

Rocks to Results - A practical guide to laboratory operations.

Order yours online at [www.sgs.com/geochem](http://www.sgs.com/geochem)

2017

# INDEX

<b>WELCOME TO SGS</b>	<b>2</b>
<b>QUALITY POLICY STATEMENT</b>	<b>4</b>
<b>CODE OF ETHICS</b>	<b>6</b>
<b>YOUR PARTNERSHIP WITH SGS</b>	<b>6</b>
<b>ON-SITE TESTING SERVICES</b>	<b>9</b>
On-Site Labs	9
Mobile Sample Preparation Units	10
Core Logging Services	11
Portable XRF	12
<b>COMMERCIAL TESTING SERVICES</b>	<b>13</b>
Sample Administration	13
Sample Preparation	15
Precious Metals	21
Exploration-Grade Analysis	31
Ore-Grade Analysis	48
Control-Grade Analysis	53
Commercial Trade Analysis	58
Select Methods	60
Ores and Commodities	64
<b>ELEMENTS AND PACKAGES</b>	<b>70</b>
<b>MINERALOGY SERVICES</b>	<b>72</b>
<b>METALLURGY SERVICES</b>	<b>73</b>
<b>APPENDICES</b>	<b>75</b>
Conversion Factors	75
SGS Minerals Locations (Geochemistry)	78
SGS Minerals Locations (Metallurgy)	84
SGS Minerals Locations (Engineering Services)	86

[www.sgs.com/geochem](http://www.sgs.com/geochem)

[www.sgs.com/metallurgy](http://www.sgs.com/metallurgy)

# WELCOME TO SGS

SGS was founded in 1878 and is recognized as the global leader in inspection, testing, verification and monitoring services for international trade in the minerals, agricultural, petroleum and consumer products sectors.

SGS operates a global network of over 2,000 offices and laboratories around the world and employees over 90,000 employees in 300+ countries.

SGS provides support to you as a strategic partner and a technical advisor. Through our unequalled global network of operations and laboratories, we deliver a broad spectrum of independent geochemical and metallurgical testing, process engineering and quality and quantification services for minerals, coal and coke, bio-fuels, non-ferrous metals, steel and steel-making raw materials, fertilizers, cement and industrial minerals.

The SGS Group has a unique depth and breadth of expertise and experience that can be accessed by clients from our global network.

## USING THIS GUIDE

This guide details SGS' core competencies in analytical services and is designed to help you choose the analytical methodology that most appropriately fits your needs. It will direct you to the right methodology for the type of sample, element and species of that element you need. It also helps you select the smallest number of methods you need so you can maximize your analytical dollar.

- This guide is divided into sections based on sample grade, analysis techniques and analyte offerings. The purpose of this guide is to provide the best SGS analytical services available in our core competencies.
- This guide includes an elements and packages table on page 70 with determinative procedures highlighted. This table groups elements into analytical schemes which you can use to pick the best analytical method for your needs.

This guide outlines the most common procedures required by the geological community. Regional capabilities can differ throughout the SGS network based on available equipment and expertise. Contact your regional client services representative for details and pricing. Samples can be submitted to any analytical laboratory in the SGS network for forwarding to the most appropriate SGS testing laboratory for that sample type, element and test method. If samples have to be shipped out you will be notified prior to shipping via our quotation and then our final data reports will note where the samples were processed.

This guide represents only a small selection of the methods available at SGS. Please contact us to obtain a quote for your particular program. We can help you and supply you with an individually tailored quotation and analysis program that meets all of your needs.

## DEFINITIONS

SGS' analytical services are used by a broad spectrum of clients in the mining sector - from those needing analysis for property assessment during exploration to those needing analysis of metallurgical products, to those requiring commercial analysis for trade transactions. To support these various needs, we have organized our services into categories and have included short explanations concerning the purpose of a test, its advantages and limitations. The categories carry over into our method-coding nomenclature so you can be sure to get the method that is fit for your specific purpose.

Types of analyses offered by SGS include:

- **Exploration-grade analysis** – This class of analysis is intended for large scale reconnaissance exploration programs. Typically, such programs generate rock or soil samples with low metal contents. In general, the frequency of inserted quality control materials is a minimum of 11% and methods with upper measurement limits of about 1% are used.
- **Ore-grade analysis** – This group of tests is used when analysing medium to high grade mineralized rock or core samples containing percent levels of target elements. The data from these analyses are often used for resource/reserve estimation. In general, the frequency of inserted quality control materials is a minimum of 12% and select methods with upper limits of about 30% are used.
- **Control-grade analysis** – Also known as process control, metallurgical support or metal accounting, the data from control-grade analyses are used to monitor or control a metallurgical or mining process. The frequency of inserted quality control materials is a minimum of 18% to a maximum of 120%. Control-grade methods can analyse samples that contain up to 100% of the target element in some cases. High precision and accuracy is achieved using control-grade methodology and can be increased with the number of assays per sample.

- **Commercial-grade analysis** – Commercial-grade analyses provide high precision and accuracy data that can be used to finalise commercial transactions. This data is used for commercial contract settlement or assay exchange (party analysis) and to settle disputes between buyers and sellers of traded commodities (umpire analysis). The frequency of inserted quality control materials is a minimum of 125%. Commercial-grade methods can analyse samples that contain up to 100% of the target element.

## ROCKS TO RESULTS

For more information and a background to the topics in this guide, please refer to our publication, Rocks to Results. This book provides geoscientists with an introduction to geoanalysis and is available at [www.sgs.com/geochem](http://www.sgs.com/geochem).

## QUALITY POLICY STATEMENT

SGS is committed to customer satisfaction and providing a consistent level of quality service that sets the industry benchmark. The quality objectives that we measure and assess are:

- The delivery of high quality geochemical and mineralogical analyses of rocks, minerals, ores, and other materials in a timely manner.
- The use of methods which are suitably validated, fit-for-purpose and based on internationally recognized methods when possible.
- The use of a Quality Management System that strives to provide customer satisfaction by ensuring, through its documented policies and procedures, that all quality-related activity is clearly demonstrated, assessable and followed.

We will achieve this by:

- Being innovative and providing added-value to your product or service.
- Giving a committed team effort.
- Standardizing our processes.
- Using a Quality Management System that meets, as a minimum requirement, ISO 9001 and ISO/IEC 17025.

- Employing a detailed quality audit program that ensures corporate and customer feedback.
- Utilizing a continuous improvement system.
- The clever and extensive use of quality control and quality assurance to ensure delivery that exceeds the industry benchmark.
- Providing appropriate staff training.
- Reviewing our Quality System annually.

SGS management and staff are appropriately empowered to ensure these requirements are met. All employees and contractors are familiar with the requirements of the Quality Management System, the above objectives and process outcomes. We welcome your feedback on this program.

## QUALITY AND RESPONSIVENESS

SGS has an on-going intensive program to monitor quality. Supervised by dedicated quality management personnel, the program is proactively and continuously monitored. It enables us to react promptly to fluctuations in performance.

SGS labs follow a global procedure to select appropriate quality control materials. We define the specified frequency with appropriate acceptance and rejection data criteria for each of our methods. Data are monitored both short term and long term on a continuous basis. Client specific reports are generated with our SLIM (SGS Laboratory Information Management) system and are readily available. Please see our Laboratory Quality Control Summary at [www.sgs.com/geochem](http://www.sgs.com/geochem) for more details on these procedures.

This concern for quality extends to SGS' market attitude. SGS recognises that not all analytical problems can be solved with routine methodology. We value close communication with you, not only to address individual sample situations, but also to address issues confronted by the minerals industry as a whole.

The backbone of the "local" service you receive at SGS laboratories is a global quality protocol used by over 300 SGS minerals analytical laboratories. It controls procedures and methodology, data management and reporting, quality control and governing activities, service attitudes and response. Thus you are assured of a uniform, standardized response from any SGS laboratory worldwide. You can trust us and rely upon us.

# CODE OF ETHICS

Integrity is the core of SGS; it is the common thread through all our activities. Our ethical compliance program is based on our Code of Integrity and Professional Conduct, and ensures that the highest standards of integrity are applied to all of our activities worldwide in accordance with international best practice. It has been approved by the SGS Board of Directors and our Operations Council and all SGS employees are trained in it yearly.

The purpose of this code is to document rules of behavior and to provide guidance in our day-to-day business. These rules apply to all employees of SGS. Our joint venture partners, agents, intermediaries, consultants and subcontractors are also required to comply with them. It is the responsibility of all of us at SGS, at all levels of our organization, to live by our code.

Our code is explained in detail on our website and can be summarized by the following common sense principles:

- Do not do anything which you know or believe to be illegal or unethical.
- Do not use any company property for your own benefit.
- Do not engage in any transaction which does not have a genuine, legitimate business purpose.
- Ask yourself whether any contemplated transaction or business practice would withstand the scrutiny of the public eye if exposed.
- Do not do anything which could require you to be untruthful.
- Seek advice when in doubt.

# YOUR PARTNERSHIP WITH SGS

SGS' Centres of Excellence conform to the ISO/IEC 17025 standard and most of our major regional facilities are ISO 9001 certified. SGS provides analytical services for every stage of your project.

- exploration
- developmental studies
- mine production
- shipment
- trade
- mine closure

# ANALYTICAL METHODS AND LIMITS

There are several distinct stages in the evaluation of a project – from a grassroots exploration (early stage) to the final stages of process/grade control at mine development and operation. At each stage, the analytical technique should be carefully considered with respect to the needs of the program. For example, grassroots exploration generally requires methods based on a partial or weak extraction followed by multi-element analysis. In contrast, analyses for a feasibility stage program generally involve a complete digestion followed by the analysis of a specific elemental suite focused on pay and penalty elements.

In the early stages of exploration, precision at low concentrations, sensitivity and cost effectiveness are usually key when defining an anomaly. Accuracy might not be as important as the ability of the method to reproduce and detect subtle anomalies above background or threshold levels. A partial or weak extraction method that is followed by multi-element scans could be acceptable at this stage.

In process or grade control situations, both accuracy and precision are critical. A total dissolution of the sample followed by the analysis of specific elements is more appropriate.

Commercial transaction assays require highly precise and accurate assays involving classical methodology. Please see page 58 for details.

In mineral analysis, the concept and application of detection limit is not defined universally nor is it governed by a regulated policy. The terminology used to describe this concept is varied, misused and often confusing. The lower limit in SGS laboratories is frequently used to market method ranges and capabilities but depending upon how this limit is defined, developed and tested, these ranges and capabilities can be misleading. It is important when selecting a method, that all factors are considered.

- What are the elements of interest and their concentration range?
- What is the required precision at or near the concentration of the analyte of interest?
- What is the mineral composition or source of my samples and will this affect the detection limit for the elements of interest?

Method choice should not be exclusively selected based on the lower limit or without consideration of the points above. Limits must be well defined and established using rigorous studies that involve matrix equivalent samples taken through the entire method process and not simply by using a reagent or water blank. Statistical analysis must be used both to estimate

and test the lower limit at a suitable confidence level. At SGS, our laboratories take pride in our determination of method/analyte specific limits to ensure that this limit can be confidently projected across a wide range of samples and is fit for purpose.

There are many different analytical methods available in the industry. More detailed descriptions of the common analytes, grades and methods follow in this guide and can help you with method selection. A more exhaustive list of methods is available at your local laboratory. An SGS professional is also always available to assist you with analytical technique selection.

## ELECTRONIC DATA AVAILABILITY

Many clients use our web-based data access tool “QLab” (<https://qlab.sgs.com>) for immediate and secure retrieval of their analytical data over the internet. QLab allows you to track the progress of samples and view information such as job status, turn-around-time, scheme/method, client-specific quality control data and the results of your analyses. To maintain the integrity of our sophisticated LIMS (Laboratory Information Management System), QLab does not access the database directly, but instead receives data transmissions on a regular basis.

## REPORTING

All results are reported electronically immediately upon completion. Fax and/or hardcopy can be sent - a fee may apply. Copies of all certificates and invoices are sent via PDF email to the address you specify. Our QLab data portal, located at <https://qlab.sgs.com>, is accessible over the internet. Reporting units can be specified as ppb, ppm, g/t, % or oz/tonne (as applicable).

## DATA TURNAROUND

Samples are processed at each SGS laboratory as promptly as possible. Sample batches requiring turnaround commitments outside contracted arrangements should be discussed with the appropriate laboratory client services personnel.

## FEES AND PAYMENT METHODS

This List of Services outlines the range of analytical services and methods offered by SGS. Please contact us for a quote. Payment terms are strictly 30 days for approved clients. Interest at 1.5% per month will be levied on overdue accounts. If credit has not been established, advance payment is required. SGS accepts payment by Visa or MasterCard in many locations. Please inquire.

## ON-SITE TESTING SERVICES

### ON-SITE LABS

SGS offers design, construction and management services for on-site laboratories. No matter how remote your operation, SGS services can be brought to your site and tailored to your specific needs. SGS's on-site laboratory expertise is unparalleled in the industry, with more than 80 on-site analytical laboratories currently in operation. We apply the same principles, procedures and quality standards to our outsourced laboratories that we do to our commercial labs.

Allowing SGS to design, staff and operate your lab will ensure that you have at your disposal a full scope of capabilities for the fast turn-around of accurate, reliable data needed to run and optimize your plant operations and confirm the value produced by your operations. Outsourcing of mine-site laboratories allows you to allocate capital and staff more efficiently, concentrate on your core competencies and ensure that the data you base important decisions upon is accurate and consistent. The impartiality of a third party outsourcing partner ensures your results are transparent and meet regulatory reporting requirements.

The SGS Build, Own, Operate, and Maintain (BOOM) initiative is available globally to the minerals industry. This program provides clients the opportunity to outsource capital requirements, engineering, construction, commissioning, maintenance and operation of non-core facilities.

## MOBILE SAMPLE PREPARATION UNITS



SGS offers sample preparation services globally and we have many Mobile Sample Preparation Units (MSPU) in some of the most remote locations in the world. Our MSPUs allow you to access our trusted third party sample preparation services in locations that might not otherwise support laboratory facilities. An SGS-designed, staffed and operated MSPU is safe, efficient, well staffed and operationally stable, thus giving you better speed to market and a competitive edge. By choosing our mobile laboratory services, you will:

- Take advantage of SGS's globally recognized technical expertise and laboratory quality management program.
- Reduce shipping delays.
- Benefit from fast turnaround and accurate, reliable geochemical and/or assay data.
- Gain flexibility by choosing the sample preparation protocol that best suits your needs.
- Gain NI 43-101/JORC defensible data with minimal operational demands on your project team.
- Allocate your financial and staff resources more effectively by focusing on the core aspects of your program.

## CORE LOGGING SERVICES

To maximize the return of the considerable investment in obtaining core, SGS provides expert and innovative geological exploration services for comprehensive core characterization in gold and precious metals, base metals, iron ore, coal, uranium and industrial minerals. At the most basic level it may include manual logging by an experienced team of SGS geologists. Chemical and mineralogical data can be obtained by hand held XRF, hyperspectral infrared spectrometers, or portable XRD at the drill site or in an SGS facility, at a sampling frequency suitable to the project requirements.

Should a more comprehensive service be required, automated core logging is available via high resolution VNIR-SWIR hyperspectral scanning that generates objective and consistent digital mineralogy, core photographs and textural data that is easily exported into standard modeling databases. This capability can be installed in exploration camps, mine-sites, or any SGS lab facility. The processed data can be accessed digitally anywhere in the world in a cloud based system, or reviewed on a customized, interactive viewing table that allows actual-size visualization with mineralogical overlays. Archived core can also be scanned to provide security against potential future core loss.

## PORTABLE XRF

Portable XRF spectrometers allow you to take the instrument to the sample, rather than the sample to the instrument. This is advantageous for use in the field at mobile sample preparation laboratories or in on-site laboratories where rapid semi-quantitative multi-element data can improve exploration and metallurgical process decision making. Qualitative base metal and mineralization pathfinder multi-element scan packages are available.

This technique is significantly influenced by sample mineralogy, particle size and sample matrix. It is best used on pulverized samples. Precious metals, Au, Ag, Pt, Pd and Rh are not available using this technique.

SGS has reviewed and compared all of the portable XRF units currently on the market. This extensive development work with a wide range of mineralogical assemblages has allowed SGS to offer the following element suites:

### HH XRF

MAJOR ELEMENTS	BASE METALS	OTHERS
Al	Co	As
Ca	Cu	Bi
Fe	Mo	Cr
K	Ni	Nb
Mg	Pb	Rb
Mn	Zn	Sb
S		Se
Si		Sr
Ti		V
		W
		Zr

Elemental suites and reporting limits are established on a project basis. The precision and accuracy of this technique is suitable for identifying anomalous samples to aid in exploration target definition, but is not appropriate for use in resource calculations. This technique can also be used for relative metallurgical plant process control but is not appropriate for metal accounting or final product characterizations. Please inquire.

## COMMERCIAL TESTING SERVICES

Most SGS laboratories provide exploration clients with dedicated sample preparation areas. Our Centres of Excellence dedicated to geochemical analysis are located strategically around the globe in Belo Horizonte, Chita, Johannesburg, Lakefield, Lima, Perth and Vancouver. Refer to the directory at the end of this guide for location details.

SGS analysts perform quality, multi-element analyses that target a wide variety of elements in many types of sample matrices. We are firmly committed to advancing the technologies for ICP-AES and ICP-MS. This commitment ensures we deliver on our promise to provide benchmark-setting quality service. Your needs are unique; therefore we have both tailored analytical packages and high-level custom service offerings.

## SAMPLE ADMINISTRATION

### SAMPLE SUBMITTAL, COLLECTION AND PICK UP

Samples can be submitted to the nearest SGS laboratory or sample preparation facility. When your samples are transported to SGS by a third party, please send notice of shipment dispatch directly to the SGS receiving laboratory. Please record the name of the freight company, date of dispatch, waybill numbers, number of pieces and number of samples. This ensures that we can help track overdue or missing shipments.

We recommend that all sample submissions be clearly labeled. Sample submissions that are poorly labeled or packaged can incur additional sorting charges. Please ensure that your sample documents have full details of the analytical tests you request and reporting details.

All sample shipments require a sample submittal form or letter with clear instructions to avoid delays. Sample submission forms can be found on our website at [www.sgs.com/geochem](http://www.sgs.com/geochem). Samples will not be analyzed until we have complete instructions. The minimum information required to proceed is:

- Company name and complete address.
- Contact name.
- Details for distribution of reports and invoices.



- Method codes.
- Instructions on sample preparation.
- List or range of sample numbers.
- Sample disposal / return requirements.
- Unusual sample characteristics.
- Warning if any samples are potentially hazardous.

To eliminate customs delays, please include the following information:

- Description of goods, such as “Geological sample for testing purposes only”.
- The receiving SGS laboratory will have the needed customs or quarantine certification to receive your submission promptly. Please contact the laboratory so we can provide the permit details that must be included with the transport documents prior to dispatch.
- Some national authorities require prior notification before samples can be received by certified laboratories. This includes NORM samples and International Soil Samples. SGS will facilitate this to avoid unnecessary delays in sample receipt. Please contact your local SGS representative.

Together, we can eliminate unnecessary delays and costs by using these sample submission protocols.

PKP01	Sample collection / pick up
LOG02	Pre-preparation processing, sorting, logging, boxing etc.
WGH79	Weighing of samples and reporting of weights

## SAMPLE TRACKING

All SGS laboratories run sophisticated LIMS systems, the SGS SLIM, which facilitates complete tracking of analyses throughout the laboratory. SLIM directly tracks all samples from the time they are received at the preparation facility until they are sent to an SGS Centre of Excellence, analyzed and reported. For more information about this process, please ask your local SGS laboratory for the SGS Chain of Custody document.

## SAMPLE RETURN, RETENTION, STORAGE AND DISPOSAL

Sample pulps will be stored for three months free of charge. Samples will be discarded after three months unless you specifically request their return. Disposal, storage and shipping costs may apply.

While SGS will take all reasonable care to protect your samples during analysis and storage, the samples shall at all times be at your risk.

RTN95	Return of rejects samples, per kg
RTN96	Return of pulp samples to client, per kg
RTR01	Retrieval of samples for re-analysis
STO97	Handling/retrieval of samples per hour rate
STO98	Storage of pulps, 30 day rate
STO99	Storage of rejects, 30 day rate
DIS93	Disposal of international soil samples, incineration, per kg rate
DIS94	Disposal of samples, per kg rate

## SAMPLE PREPARATION (SIZE REDUCTION)

Sample preparation (also referred to as sample reduction) is the process by which a sample is crushed and pulverized for analysis. This will almost always involve sub-sampling. The right sampling method will produce a sub-sample that is representative of the total sample. Good sample reduction practice is essential to obtaining meaningful and reliable analytical data. More information is available in Rocks to Results, Chapter 4.

SGS is committed to providing dedicated sample preparation procedures at each of our locations. This involves technologically advanced equipment and, in most cases, physically separated sample processing areas for each sample type.

The crushing and pulverizing options available are varied. Your choice can depend on the sample type and the mineral that hosts the element of interest within the sample matrix. Please consult with our staff for the best possible option for your samples before starting an analytical program.

During sample reduction, there are many critical points where sample contamination can occur. One such area arises from the type of equipment used. Unfortunately, during sample reduction, contamination can never be avoided but processes are utilised to keep the level of contamination to a minimum. The levels are dependent on sample hardness, crushing and pulverizing time as well as crushing / grinding media used. Contamination levels can be measured and the table below indicates the type of levels of possible contamination from a variety of grinding media. More information is available in Rocks to Results, Chapter 4.1.

## BOWL SELECTION

BOWL TYPE	SAMPLE CAPACITY	MAIN CONTAMINANT	MINOR CONTAMINANT
Standard mild steel bowl	To 3.5 kg	Fe, Cr	Mo
Cr-free steel	500 g to 1.5 kg	Fe	Mn
Zirconia	100 g	Zr, Hf	Al
Tungsten carbide	150 g	W, Co	Ta
Agate	100 g		Si

Note: Not all pulverizing bowl types are available at all locations. Please inquire.

## SAMPLE PREPARATION PROCEDURES

### DRYING

DRY10	Dry samples <3.0 kg, 105°C
DRY11	Dry samples >3.0 kg, 105°C, per kg rate
DRY12	Dry samples <3.0 kg, 60°C
DRY13	Dry samples >3.0 kg, 60°C, per kg rate
DRY14	Ambient temperature drying
DRY15	Dry excessively wet samples, per kg rate
DRY16	Dry and macerate vegetation
ASH01	Ashing of samples prior to analysis

### CRUSHING

CRU20	Coarse crush to 6mm
CRU21	Crush <3.0 kg, 75% passing 2 mm
CRU22	Crush >3.0 kg, 75% passing 2 mm, per kg rate
CRU23	Crush <3.0 kg, 75% passing various mm
CRU24	Crush >3.0 kg, 75% passing various mm, per kg rate
CRU26	Crush <3.0 kg, 90% passing 2 mm
CRU27	Crush >3.0 kg, 90% passing 2 mm, per kg rate

### SPLITTING

SPL25	Split into representative sub-samples by cone and quartering
SPL26	Split into representative sub-samples using riffle splitter, per kg
SPL27	Split into representative sub-samples using rotary splitter, per kg
SPL28	Split additional representative sub-samples

### SCREENING - Applicable to soils and sediments

SCR30	Dry screening to -180 microns, <1 kg
SCR31	Dry screening to -180 microns, >1 kg, per kg rate
SCR32	Dry screening, various microns, <1 kg
SCR33	Dry screening, various microns, >1 kg, per kg rate

Note: Wet screening options are available. Please contact your local lab for details.

### PULVERIZING

PUL45	Pulverize 250 g, Cr steel, 85% passing 75 microns
PUL46	Pulverize 500 g, Cr steel, 85% passing 75 microns
PUL47	Pulverize 1000-1500 g, Cr steel, 85% passing 75 microns
PUL48	Pulverize 1500-3000 g, Cr steel, 85% passing 75 microns
PUL49	Pulverize >3000 g, Cr steel, 85% passing 75 microns
PUL51	Pulverize 500-1500 g, mild steel, 85% passing 75 microns

Note: Samples can be pulverized in bowls made of other specialized materials if non-metallic preparation is required (e.g. tungsten carbide, zirconia, agate, etc.). Samples can also be pulverized at customer specified grain sizes (i.e. 106 or 120 microns) and % passing requirements. Please inquire.

## SAMPLE REDUCTION PACKAGES

PRP85	Dry, pulverize, 75 microns, <1.5 kg
PRP86	Dry, pulverize, 75 microns, <3.0 kg
PRP87	Weigh, dry, (<1.5 kg), crush to 75% passing 2 mm, split, pulverize to 85% pass at 75 microns
PRP89	Weigh, dry, (<3.0 kg), crush to 75% passing 2 mm, split 250 g, pulverize to 85% passing 75 microns
PRP90	Weigh, dry, (<3.0 kg), crush to 90% passing 2 mm, split 250 g, pulverize to 85% passing 75 microns
PRP91	Weigh, dry, (<3.0 kg), crush to 75% passing 2 mm, split 500 g, pulverize to 85% passing 75 microns
PRP92	Weigh, dry, (<3.0 kg), crush to 90% passing 2 mm, split 500 g, pulverize to 85% passing 75 microns
PRP94	Weigh, dry, (<3.0 kg), crush to 75% passing 2 mm, split 1000 g, pulverize to 85% passing 75 microns
PRP95	Weigh, dry, (<3.0 kg), crush to 90% passing 2 mm, split 1000 g, pulverize to 85% passing 75 microns
PRP104	Weigh, dry @ 60°, (<1 kg), screen -80mesh (180µm), for soil samples

## AUTOMATED SAMPLE PREPARATION

Automated sample preparation is the process by which a sample is crushed, split and pulverised mechanically in a closed system, with no human intervention. Such a system can be connected to an automated fused glass bead machine which produces a sample that is ready for analysis by XRF.

Automated sample preparation has several advantages. First, samples are prepared in a consistent reproducible fashion independent of any human habits or variability. Second, such preparation distances the operator from any hazardous materials that could be present, thus providing a much improved working environment. Third, an automated sample preparation system is much more reproducible. Finally, because the system is computer controlled, preparation parameters are traceable. Thus every sample can be tracked and all parameters pertaining to the sample preparation are recorded.

PRP72	Robotic Prep, 1 kg., reverse circulation, pulverize 106 microns
PRP73	Robotic Prep, 1 kg., drill core, pulverize 75 microns
PRP74	Robotic Prep, 3 kg., reverse circulation, pulverize 106 microns
PRP75	Robotic Prep, 3 kg., drill core, pulverize 75 microns
PRP76	Robotic Prep, 1 kg., drill core, pulverize 106 microns
PRP77	Robotic Prep, 3 kg., drill core, pulverize 106 microns

Note: This option is available only at certain locations. Samples can be prepared to a variety of mesh sizes. Please contact your local lab.

## MISCELLANEOUS PROCEDURES

WSH78	Barren wash between each sample - pulverizing stage
WSH79	Barren wash between each sample - crushing stage
COM77	Compositing samples - gravimetric
COM78	Compositing samples - volumetric
RAD01T	Radiation monitoring using scintillation counter
PRP70	Dedicated preparation environment (required for NORM or asbestos-bearing samples)
QRT03	Sample quarantine and handling
WST01	Waste disposal fee

## MOISTURE AND LOSS ON IGNITION (LOI)

Many materials contain volatile components or moisture. SGS has a variety of tests, including moisture (H<sub>2</sub>O), loss on ignition (LOI) (at various temperatures) and thermogravimetric analysis (TGA), that provide reliable, qualitative and quantitative analyses of these components.

### MOISTURE (H<sub>2</sub>O)

CODE	ELEMENT	LIMIT(S)	DESCRIPTION
G PHY08D	H <sub>2</sub> O-	0.1 - 100%	Gravimetric determination at 105°C
G PHY09B	H <sub>2</sub> O+	0.1 - 100%	Penfield tube

**LOSS ON IGNITION (LOI)**

CODE	ELEMENT	LIMIT(S)	DESCRIPTION
G PHY01K	LOI	-10 - 100%	Gravimetric determination at 1000°C
G PHY02V	LOI	-10 - 100%	Multi-point TGA at client-specified temperatures

Note: Moisture and LOI can be determined at other temperatures. Please inquire.

**SPECIFIC GRAVITY AND BULK DENSITY**

Specific gravity is the density of a material relative to water or air. Since rocks are comprised of several distinct mineral phases, they do not have a fixed specific gravity. Instead, a rock's "bulk density" arises as a result of the percentage of each mineral phase in a sample multiplied by the specific gravity of each phase. SGS has extensive experience determining specific gravity and bulk density and we can identify the mineral phases using QEMSCAN®. Specific gravity and bulk density provide key information needed to design your processing flowsheet.

SGS can determine the specific gravity (SG) and bulk density (BD) of rocks, ores and aggregates. International standards are used to control the analysis whether the determination is done using the pycnometer, water and air measurements or the wax method. Such data can yield:

- Precise and accurate identification of mineral composition, including pay, penalty and detrimental metals.
- The most effective processing method.
- Appropriate sizing parameters for processing equipment.
- The exact weight of an ore (often required to calculate shipping and storage costs).

G PHY03V Specific gravity - pycnometer

G PHY05V Specific gravity - volumetric

G PHY14V Specific Gravity - pycnometer bottle

G PHY04V Bulk density - immersion

Note: If samples are porous, PHY04V will require a pre-preparation charge if it is necessary to coat samples with a sealant or wax coating.

**PARTICLE SIZE ANALYSIS**

Particle size analysis is used to determine the size classification and structural properties of an ore sample or to produce sized fractions for additional testing/analyses. SGS offers particle size analysis by wet screening, dry screening, a combination of both, or laser diffraction.

Wet screening is preferable to dry screening for materials containing a high percentage of clays which tend to agglomerate and thus give erroneous dry screening results. Dry screen tests can be performed on a variety of materials, but the sample must be free flowing and the particles separate (e.g. unagglomerated).

Often wet and dry methods are combined. Wet screening is performed to remove excessive fines then dry screening is performed to remove the oversize. Depending upon the nature of the material, dry screening, wet screening or a combination of both can be used.

Laser diffraction is recommended for very fine grained samples, as it is capable of measuring particle sizes at very low limits (0.02 microns). Laser diffraction is suitable for use with both wet and dry flows.

G PHY06V Particle size, sieve analysis (dry or wet)

G PHY07V Particle size, laser diffraction

**PRECIOUS METALS**

Precious metals (gold, silver and platinum group elements) can be analyzed by many techniques. Procedures for gold determination must take into account the sample type, sample concentration, purpose of the analysis, sample mineralogy and form of the gold (if known). Lead collection fire assay is considered the most definitive technique while acid digests and accelerated cyanide leaches can be effective for specific purposes. Similarly, silver can be determined by fire assay or acid digest techniques.

Please discuss your particular circumstance with an SGS chemist so you can choose the most appropriate technique. For more details, see our publication, Rocks to Results, Chapter 4.3.

Some platinum group elements (PGE) can also be determined by lead collection fire assay but this is not recommended. The six element PGE suite is best determined by nickel sulphide collection fire assay and neutron activation or ICP-MS. Sulphide-rich samples can require a reduction in sample weight to fuse properly.

Note: Lower and upper reporting limits of a given method can vary slightly among SGS laboratories due to reagent quality, access to consumables and instrument availability. Please inquire.

## GOLD

### EXPLORATION-GRADE ANALYSIS

#### FIRE ASSAY GOLD

CODE	ELEMENT	LIMIT(S)	DESCRIPTION
GE FAA313	Au	5 - 10,000 ppb	30 g, Fire assay, AAS finish
GE FAA515	Au	5 - 10,000 ppb	50 g, Fire assay, AAS finish
GE FAI313*	Au**	1 - 10,000 ppb	30 g, Fire assay, ICP-AES finish
GE FAI515*	Au**	1 - 10,000 ppb	50 g, Fire assay, ICP-AES finish
GE FAI323	Au**	5 - 10,000 ppb	30 g, Fire assay, ICP-AES finish
GE FAI525	Au**	5 - 10,000 ppb	50 g, Fire assay, ICP-AES finish
GE FAM313	Au**	1 - 2,000 ppb	30 g, Fire assay, ICP-MS finish
GE FAM515	Au**	1 - 2,000 ppb	50 g, Fire assay, ICP-MS finish

Note: \*GE FAI313/515 methods use new fire assay pots to achieve lower limits. \*\* Pt and Pd can be included, refer to page 29.

Gold in soils and/or sediments can be determined by aqua regia digest and DIBK extraction. This is a partial leach and can require a pre-treatment such as roasting if samples contain significant sulphur bearing phases.

This gold analytical method has the following advantages:

- Use of large sample sizes (25 g - 50 g) which ensures representative results for materials exhibiting nugget effect.
- The digest used for gold can also be used for a large suite of additional elements.

#### GOLD BY ACID DIGESTION (AQUA REGIA)

CODE	ELEMENT	LIMIT(S)	DESCRIPTION
GE ARE145	Au	2 - 200 ppb	50 g, Aqua regia digest, DIBK extraction, AAS finish
GE ARE133	Au	0.02 - 200 ppm	25 g, Aqua regia digest, DIBK extraction, AAS finish
GE ARE155	Au	0.01 - 100 ppm	50 g, Aqua regia digest, DIBK extraction, AAS finish
GE ARM133	Au*	1 - 500 ppb	25 g, Aqua regia digest, ICP-MS finish
GE ARM155	Au*	1 - 500 ppb	50 g, Aqua regia digest, ICP-MS finish

\* Note: Refer to page 36 for additional elements that can be determined by this method.

Cyanide leach procedures are used to enhance small gold anomalies during exploration and to monitor gold extraction efficiencies in metallurgical applications.

Bulk Leach Extractable Gold (BLEG) is a cyanide-based partial leach procedure that uses a large sample size (0.5 kg to 5 kg). It is used to enhance small gold anomalies during exploration. The cyanide leachate solution is extracted into an organic solvent and measured by flame AAS or ICP-MS. Our active cyanide leach packages are available with a variety of sample sizes, detection limits and finishing methods. The mini cyanide leach package is available for smaller sample sizes, allowing for faster TAT than active cyanide leach.

Other elements are also partially extracted with the cyanide leach and can be measured on request.

#### CYANIDE EXTRACTABLE GOLD

CODE	ELEMENT	LIMIT(S)	DESCRIPTION
GE BLE643	Au	0.1 - 1000 ppm	Hot, 30 g, Mini cyanide leach, ICP-AES or AAS finish
GE BLE61K	Au	0.02 - 100 ppm	500 g, Active cyanide leach, 24 hr solvent extraction, AAS finish
GE BLE61N	Au	1 ppb - 100 ppm	2000 g, Active cyanide leach, 24 hr solvent extraction, AAS finish

GE BLL61K	Au	0.05 ppb - 100 ppm	500 g, Active cyanide leach, 24 hr ICP-MS finish
GE BLL61N	Au	0.05 ppb - 100 ppm	2000 g, Active cyanide leach, 24 hr ICP-MS finish

The Leachwell™ tab is a proprietary product and Leachwell™ is a patented process. Accelerated cyanide leach techniques are used to determine bulk leachable gold in exploration samples using modified cyanide leach (Leachwell™). The large sample is mixed with water and Leachwell™ tabs and tumbled. The gold is extracted into DIBK and analyzed by flame AAS or ICP-MS. Other elements (Cu, Ag, Pb and Zn) are also partially extracted by the cyanide leach and can be measured on request.

#### ACCELERATED CYANIDE LEACH FOR GOLD

CODE	ELEMENT	LIMIT(S)	DESCRIPTION
GE LWL69J	Au	0.01 - 1,000 ppm	200 g, Accelerated cyanide leach, AAS
GE LWL69K	Au	0.01 - 1,000 ppm	500 g, Accelerated cyanide leach, AAS
GE LWL69L	Au	0.01 - 1,000 ppm	800 g, Accelerated cyanide leach, AAS
GE LWL69M	Au	0.01 - 1,000 ppm	1000 g, Accelerated cyanide leach, AAS
GE LWL69N	Au	0.01 - 1,000 ppm	2000 g, Accelerated cyanide leach, AAS

#### ORE-GRADE ANALYSIS

##### INSTRUMENTAL AND GRAVIMETRIC ANALYSIS

CODE	ELEMENT	LIMIT(S)	DESCRIPTION
GO FAA303	Au	0.01 - 100 ppm	30 g, Fire assay, AAS finish
GO FAA505	Au	0.01 - 100 ppm	50 g, Fire assay, AAS finish
GO FAI303	Au	0.01 - 100 ppm	30 g, Fire assay, ICP-AES finish
GO FAI505	Au	0.01 - 100 ppm	50 g, Fire assay, ICP-AES finish
GO FAG303	Au	0.5 - 3000 ppm	30 g, Fire assay, gravimetric finish
GO FAG505	Au	0.5 - 3000 ppm	50 g, Fire assay, gravimetric finish

GO FAG323	Au	0.01 - 100 ppm	30 g, Fire assay, AAS finish (Au) gravimetric finish (Ag)
	Ag	10 - 5000 ppm	
GO FAG525	Au	0.01 - 100 ppm	50 g, Fire assay, AAS finish (Au) gravimetric finish (Ag)
	Ag	10 - 5000 ppm	
GO FAG333	Au	0.5 - 3000 ppm	30 g, Fire assay, gravimetric finish (Au, Ag)
	Ag	10 - 5000 ppm	

#### SCREEN METALLIC GOLD ANALYSIS

Analytical results can be difficult to reproduce using typical sample reduction and fire assay procedures when coarse grained metallic gold is present. To address this, the sample can be analyzed using the screened metallics sample preparation and assaying procedure. This consists of:

- Screening 500g of the sample to a defined grain size, usually 75 or 106 microns.
- Weighing the various fractions.
- Assaying the entire plus fraction.
- Weighing and analysing the undersize (usually in duplicate).
- Calculating and reporting of size-fraction weights, coarse and fine fraction gold content and total gold content.
- The finish technique may involve AAS, ICP-AES or gravimetric, depending upon concentration. Limits shown are based on gravimetric analysis. AAS and ICP-AES limits are lower, please contact us for more information.

Note: This technique requires a minimum sample of 500g. This technique can also be used for coarse grained native metals such as platinum, palladium, silver and copper.

## SCREENED METALLICS

CODE	ELEMENT	LIMIT(S)	DESCRIPTION
GO FAS30K	Au	0.5 ppm(grav)	500 g, Screen to 75 micron, fire assay
GO FAS31K	Au	0.5 ppm(grav)	500 g, Screen to 106 micron, fire assay
GO FAS50K	Au	0.5 ppm(grav)	1000 g, Screen to 75 micron, fire assay
GO FAS51K	Au	0.5 ppm(grav)	1000 g, Screen to 106 micron, fire assay

Note: A reporting limit of 0.01 ppm for Au can be achieved using AAS Finish when applicable to the sample concentration.

## CONTROL AND CONCENTRATE-GRADE ANALYSIS

### INSTRUMENTAL AND GRAVIMETRIC ANALYSIS

CODE	ELEMENT	LIMIT(S)	DESCRIPTION
GC FAA35V	Au	0.02 ppm	Variable wt, Fire assay, AAS finish
GC FAI34V	Au	0.02 ppm	Variable wt, Fire assay, ICP-AES finish
GC FAG323	Au	0.02 ppm	30 g, Fire assay, AAS finish (Au)
	Ag	10 ppm	30 g, Fire assay, gravimetric finish (Ag)
GC FAG333	Au	5 ppm	30 g, Fire assay, gravimetric finish (Au, Ag)
	Ag	10 ppm	

## GOLD IN PROCESS SOLUTIONS

CODE	ELEMENT	LIMIT(S)	DESCRIPTION
GC FSA84T	Au	>0.01 mg/L	Solution (non CN), fire assay, AAS finish
GC FSI84T	Au	>0.01 mg/L	Solution (non-CN), Fire assay, ICP-AES finish

## GOLD IN CYANIDE LIQUORS

CODE	ELEMENT	LIMIT(S)	DESCRIPTION
GC SOL81T	Au	>0.1 mg/L	CN solution, AAS finish
GC SOL81X	Au	0.01 - 50 mg/L	Solvent extraction, DIBK, AAS finish

## GOLD IN CARBON

CODE	ELEMENT	LIMIT(S)	DESCRIPTION
GC FAA01V	Au	5 - 50,000 ppm	1-2 g, Fire assay, AAS finish
GC ARS12D	Au	5 - 250,000 ppm	1 g, Ash, acid digest, AAS finish
GC FAG01V	Au	5 - 100,000 ppm	1-5 g, Fire assay, gravimetric finish

## GOLD BULLION

CODE	ELEMENT	LIMIT(S)	DESCRIPTION
GC BUL36V	Au	>10%	250-500 mg, Fire assay, gravimetric finish
	Ag	>0.1%	250-500 mg, Fire assay, gravimetric finish

# SILVER

## EXPLORATION-GRADE ANALYSIS

### ACID DIGESTION - INSTRUMENTATION

CODE	ELEMENT	LIMIT(S)	DESCRIPTION
GE AAS12E	Ag	0.3 - 100 ppm	2 g, 2-Acid digest, AAS finish
GE AAS21E	Ag	0.3 - 100 ppm	2 g, 3-Acid digest, AAS finish
GE AAS42E	Ag	0.3 - 100 ppm	2 g, 4-Acid digest, AAS finish

Note: It is recommended that mineralized samples with Ag >30g/t are analyzed using the GO\_AAS10D method below. Silver (Ag) can also be analyzed in many multi-element packages. Refer to page 32.

## ORE-GRADE ANALYSIS

### ACID DIGESTION - INSTRUMENTATION

CODE	ELEMENT	LIMIT(S)	DESCRIPTION
GO AAS10D	Ag	1 - 300 ppm	0.5 g, 2-Acid digest, AAS finish

## GRAVIMETRIC ANALYSIS

CODE	ELEMENT	LIMIT(S)	DESCRIPTION
GO FAG313	Ag	10 - 5000 ppm	30 g, Fire assay, gravimetric finish
GO FAG515	Ag	10 - 5000 ppm	50 g, Fire assay, gravimetric finish
GO FAG323	Au	0.01 - 100 ppm	30 g, Fire assay, AAS finish (Au) gravimetric finish (Ag)
	Ag	10 - 5000 ppm	
GO FAG333	Au	0.5 - 3000 ppm	30 g, Fire assay, gravimetric finish (Au, Ag)
	Ag	10 - 5000 ppm	
GO FAG525	Au	0.01 - 100 ppm	50 g, Fire assay, AAS finish (Au), gravimetric finish (Ag)
	Ag	10 - 5000 ppm	

## CONTROL AND CONCENTRATE-GRADE ANALYSIS

### INSTRUMENTAL AND GRAVIMETRIC ANALYSIS

CODE	ELEMENT	LIMIT(S)	DESCRIPTION
GC AAS42V	Ag	1 - 1000 ppm	Variable wt, 4-acid digest, AAS finish
GC FAG323	Au	0.02 ppm	30 g, Fire assay, AAS finish (Au) gravimetric finish (Ag)
	Ag	10 ppm	
GC FAG333	Au	5 ppm	30 g, Fire assay, gravimetric finish (Au, Ag)
	Ag	10 ppm	
GC ARS12D	Ag	2 - 2,000 ppm	Carbon, 1 g, ash, acid digest, extract, AAS finish
GC BUL37V	Ag	0.1 - 30%	100 mg, Fire assay, gravimetric finish

## GOLD, PLATINUM, PALLADIUM AND OTHER PRECIOUS METALS

### EXPLORATION-GRADE ANALYSIS

#### GOLD, PLATINUM AND PALLADIUM

CODE	ELEMENT	LIMIT(S)	DESCRIPTION
GE FAI313*	Au	1 - 10,000 ppb	30 g, Fire assay, ICP-AES finish
	Pt	10 - 10,000 ppb	
	Pd	1 - 10,000 ppb	
GE FAI515*	Au	1 - 10,000 ppb	50 g, Fire assay, ICP-AES finish
	Pt	10 - 10,000 ppb	
	Pd	1 - 10,000 ppb	
GE FAM313	Au	1 - 2,000 ppb	30 g, Fire assay, ICP-MS finish
	Pt	0.5 - 2,000 ppb	
	Pd	0.5 - 2,000 ppb	
GE FAM515	Au	1 - 2,000 ppb	50 g, Fire assay, ICP-MS finish
	Pt	0.5 - 2,000 ppb	
	Pd	0.5 - 2,000 ppb	
GE FAI323	Au	5 - 10,000 ppb	30 g, Fire assay, ICP-AES finish
	Pt	10 - 10,000 ppb	
	Pd	5 - 10,000 ppb	
GE FAI525	Au	5 - 10,000 ppb	50 g, Fire assay, ICP-AES finish
	Pt	10 - 10,000 ppb	
	Pd	5 - 10,000 ppb	

Note: \*GE FAI313/515 methods use new fire assay pots to achieve lower limits.



**PLATINUM GROUP ELEMENTS**

CODE	ELEMENT	LIMIT(S)	DESCRIPTION
GE NAA363	Pt	0.02 - 10 ppm	30 g, Fire assay nickel sulphide collection, NAA (neutron activation) finish
	Pd	0.02 - 10 ppm	
	Rh	0.005 - 10 ppm	
	Ru	0.05 - 10 ppm	
	Ir	0.001 - 10 ppm	
	Os	0.01 - 10 ppm	

Note: This method is not available in all SGS laboratories; please contact us for more information.

**ORE-GRADE ANALYSIS****GOLD, PLATINUM AND PALLADIUM**

CODE	ELEMENT	LIMIT(S)	DESCRIPTION
GO FAI303	Au	0.01 - 100 ppm	30 g, Fire assay, ICP-AES finish
	Pt	0.01 - 100 ppm	
	Pd	0.01 - 100 ppm	
GO FAI505	Au	0.01 - 100 ppm	50 g, Fire assay, ICP-AES finish
	Pt	0.01 - 100 ppm	
	Pd	0.01 - 100 ppm	

**PLATINUM GROUP ELEMENTS**

CODE	ELEMENT	LIMIT(S)	DESCRIPTION
GO FAM363 and/or GO NAA363	Pt	0.02 ppm	30 g, Fire assay nickel sulphide collection, ICP-MS or NAA finish
	Pd	0.02 ppm	
	Rh	0.02 ppm	
	Ru	0.05 ppm	
	Ir	0.04 ppm	
	Os	0.05 ppm	

Note: Samples can be analyzed by ICP-MS or sent for neutron activation. This method is not available in all SGS laboratories; please contact us for more information.

**CONTROL-GRADE ANALYSIS****GOLD, PLATINUM AND PALLADIUM**

CODE	ELEMENT	LIMIT(S)	DESCRIPTION
GC FAI34V	Au	0.02 ppm	Variable wt, Fire assay, ICP-AES finish
	Pt	0.02 ppm	
	Pd	0.02 ppm	

**PLATINUM GROUP ELEMENTS**

CODE	ELEMENT	LIMIT(S)	DESCRIPTION
GC FAM363 and/or GC NAA363	Pt	0.02 ppm	30 g, Fire assay nickel sulphide collection, ICP-MS or NAA finish
	Pd	0.02 ppm	
	Rh	0.02 ppm	
	Ru	0.05 ppm	
	Ir	0.04 ppm	
	Os	0.05 ppm	

Note: Samples can be analyzed by ICP-MS or sent for neutron activation. This method is not available in all SGS laboratories; please contact us for more information.

**EXPLORATION-GRADE ANALYSIS****MULTI-ELEMENT, TRACE ICP-AES AND ICP-MS PACKAGES**

A variety of approaches can be used for exploration analysis depending on your needs. In every case, each approach consists of a digestion technique and an instrumentation technique or "finish". Each combination provides a unique suite of elements and specific upper and lower reporting limits.

## SAMPLE DECOMPOSITION / DIGESTION

Sample digestion is the most important parameter to consider when choosing an analytical method. There are several types of digestion available, including:

- Aqua regia digestion.
- Multi-acid (two, three or four acid) digestion.
- Sodium peroxide fusion.
- Lithium metaborate fusion.

Rocks to Results also provides more details in Chapter 4.2.

Typically, reconnaissance exploration-grade samples (including regional soil samples) are analyzed by aqua regia digestion followed by a multi-element ICP-AES or ICP-MS scan for base metals, trace and lithological elements.

Drill-core and rock samples are generally analyzed by multi-acid or fusion digestion, with a multi-element finish. Where metal contents are high (or ore-grade), samples can require further testing or other methods to ensure data is precise and accurate enough for regulatory reporting. Refer to the Ore-Grade Analysis section in this guide.

## INSTRUMENTATION

ICP-AES and ICP-MS are the most widely used geoanalytical instrumentation techniques because they yield many elements concurrently. These instruments are widely accepted in the mineral exploration industry as rapid and cost-effective means of analysis. Other instruments that can be used are AAS (Atomic Absorption Spectrophotometer) and Hydride AAS.

## TWO-ACID / AQUA REGIA DIGESTION PACKAGES

The following packages are based on a two-acid digest (a combination of HNO<sub>3</sub> and HCl). After the digestion, the solution is analyzed by either ICP-AES or ICP-MS or both. We can also analyze these digestions by Hydride AAS to determine the hydride forming elements (Hg, Sb, As, Bi, Se, Te). Two-acid digests are the weakest of the digestions and will not attack silicate minerals. As such, the leach provides partial results for most elements.

The methods listed below with the designation “12” are based on a combination of 2:1 HNO<sub>3</sub> : HCl. This digest is recommended for samples with organic or high sulphide mineral content\*.

The methods listed below with the designation “14” are based on a combination of 3:1 HCl : HNO<sub>3</sub>. This is an aqua regia digest and is recommended for all samples which contain no organic material and are low in sulphide mineral content.

All elements and limits are identical in the “12” and “14” digests.

NOTE: Requires a minimum sample weight of 0.5g. Detection and upper limits can vary slightly among SGS laboratories because some laboratories may not have access to high purity reagents and consumables and/or they have slight differences in instrumentation. Please talk with your local lab manager to make sure you get the reporting limits you need.

\*High sulphide mineral content is defined as over 10%.

### TWO ACID / AQUA REGIA DIGESTION / ICP-AES PACKAGE (34 ELEMENTS)

#### GE ICP12B or GE ICP14B

#### ELEMENTS AND LIMIT(S)

Ag	2 - 100 ppm*	Hg	1 - 10000 ppm	Sb	5 - 10000 ppm
Al	0.01 - 15%	K	0.01 - 15%	Sc	0.5 - 10000 ppm
As	3 - 10000 ppm	La	0.5 - 10000 ppm	Sn	10 - 10000 ppm
Ba	5 - 10000 ppm	Li	1 - 10000 ppm	Sr	5 - 10000 ppm
Be	0.5 - 2500 ppm	Mg	0.01 - 15%	Ti	0.01 - 15%
Bi	5 - 10000 ppm	Mn	2 - 10000 ppm	V	1 - 10000 ppm
Ca	0.01 - 15%	Mo	1 - 10000 ppm	W	10 - 10000 ppm
Cd	1 - 10000 ppm	Na	0.01 - 15%	Y	0.5 - 10000 ppm
Co	1 - 10000 ppm	Ni	1 - 10000 ppm	Zn	1 - 10000 ppm
Cr	1 - 10000 ppm	P	0.01 - 15%	Zr	0.5 - 10000 ppm
Cu	0.5 - 10000 ppm	Pb	2 - 10000 ppm		
Fe	0.01 - 15%	S	0.01 - 5%		

\*Note: The upper limit of 100ppm for Ag is achieved with the GE\_ICP14B package only. GE\_ICP12B will not fully recover Ag in high concentrations. Refer to the Ag specific methods on page 28.

**TWO ACID / AQUA REGIA DIGESTION / ICP-MS PACKAGE (36 ELEMENTS)****GE IMS12B or GE IMS14B****ELEMENTS AND LIMIT(S)**

Ag	0.01 - 10 ppm	Ga	0.1 - 10000 ppm	Sb	0.05 - 10000 ppm
Al	0.01 - 10%	Hg	0.01 - 100 ppm	Sc	0.1 - 10000 ppm
As	1 - 10000 ppm	K	0.01 - 10%	Sn	0.3 - 1000 ppm
Ba	5 - 10000 ppm	La	0.1 - 10000 ppm	Sr	0.5 - 10000 ppm
Bi	0.02 - 10000 ppm	Mg	0.01 - 15%	Th	0.1 - 10000 ppm
Ca	0.01 - 15%	Mn	2 - 10000 ppm	Ti	0.01 - 10%
Cd	0.01 - 10000 ppm	Mo	0.05 - 10000 ppm	Tl	0.02 - 10000 ppm
Ce	0.05 - 1000 ppm	Na	0.01 - 10%	U	0.05 - 10000 ppm
Co	0.1 - 10000 ppm	Ni	0.5 - 10000 ppm	V	1 - 10000 ppm
Cr	1 - 10000 ppm	P	0.01 - 1%	W	0.1 - 10000 ppm
Cu	0.5 - 10000 ppm	Pb	0.2 - 10000 ppm	Y	0.05 - 10000 ppm
Fe	0.01 - 15%	Rb	0.2 - 10000 ppm	Zn	1 - 10000 ppm

**TWO ACID / AQUA REGIA DIGESTION / COMBINED ICP-AES AND ICP-MS PACKAGE (51 ELEMENTS)****GE ICM12B or GE ICM14B****ELEMENTS AND LIMIT(S)**

Ag	0.01 - 100* ppm	Hg	0.01 - 10000 ppm	Sc	0.1 - 10000 ppm
Al	0.01 - 15%	In	0.02 - 500 ppm	Se	1 - 1000 ppm
As	1 - 10000 ppm	K	0.01 - 15%	Sn	0.3 - 1000 ppm
Ba	5 - 10000 ppm	La	0.1 - 10000 ppm	Sr	0.5 - 10000 ppm
Be	0.1 - 100 ppm	Li	1 - 10000 ppm	Ta	0.05 - 10000 ppm
Bi	0.02 - 10000 ppm	Lu	0.01 - 1000 ppm	Tb	0.02 - 10000 ppm
Ca	0.01 - 15%	Mg	0.01 - 15%	Te	0.05 - 1000 ppm
Cd	0.01 - 10000 ppm	Mn	2 - 10000 ppm	Th	0.1 - 10000 ppm
Ce	0.05 - 1000 ppm	Mo	0.05 - 10000 ppm	Ti	0.01 - 15%
Co	0.1 - 10000 ppm	Na	0.01 - 15%	Tl	0.02 - 10000 ppm
Cr	1 - 10000 ppm	Nb	0.05 - 1000 ppm	U	0.05 - 10000 ppm
Cs	0.05 - 1000 ppm	Ni	0.5 - 10000 ppm	V	1 - 10000 ppm
Cu	0.5 - 10000 ppm	P	0.01 - 15%	W	0.1 - 10000 ppm
Fe	0.01 - 15%	Pb	0.2 - 10000 ppm	Y	0.05 - 10000 ppm

Ga	0.1 - 10000 ppm	Rb	0.2 - 10000 ppm	Yb	0.1 - 100 ppm
Ge	0.1 - 10000 ppm	S	0.01 - 5%	Zn	1 - 10000 ppm
Hf	0.05 - 500 ppm	Sb	0.05 - 10000 ppm	Zr	0.5 - 10000 ppm

\*Note: The upper limit of 100ppm for Ag is achieved with the GE\_ICP14B package only. GE\_ICP12B will not fully recover Ag in high concentrations. Refer to the Ag specific methods on page 28.

**TWO ACID / AQUA REGIA DIGESTION / HYDRIDE AAS PACKAGE****GE HAS12B or GE HAS14B****ELEMENTS AND LIMIT(S)**

As	0.1 - 500 ppm	Sb	0.1 - 500 ppm	Te	0.1 - 500 ppm
Bi	0.1 - 500 ppm	Se	0.1 - 500 ppm		

Very low detection limits can be obtained by aqua regia digest and ICP-MS finish. This technique is applicable to exploration work as it yields rapid and accurate data.

Note: GE ARM133 and GE ARM155 are not available in all SGS laboratories. Please inquire.

**AQUA REGIA DIGESTION ICP-MS PACKAGE (49 ELEMENTS)****GE ARM133 (25g) or GE ARM155 (50g)****ELEMENTS AND LIMIT(S)**

Ag	0.02 - 100 ppm	Hg	0.02 - 1000 ppm	Se	0.5 - 2500 ppm
As	0.5 - 2000 ppm	Ho	0.01 - 2000 ppm	Sm	0.02 - 1000 ppm
Au	1 - 500 ppb	In	0.01 - 2000 ppm	Sn	0.05 - 1000 ppm
Ba	0.5 - 5000 ppm	La	0.05 - 2000 ppm	Sr	0.1 - 1000 ppm
Be	0.02 - 1000 ppm	Li	0.01 - 2000 ppm	Ta	0.01 - 1000 ppm
Bi	0.01 - 2000 ppm	Lu	0.02 - 1000 ppm	Tb	0.005 - 1000 ppm
Cd	0.02 - 1000 ppm	Mn	0.5 - 5000 ppm	Te	0.05 - 1000 ppm
Ce	0.05 - 2000 ppm	Mo	0.02 - 2000 ppm	Th	0.01 - 1000 ppm
Co	0.1 - 1000 ppm	Nb	0.02 - 2000 ppm	Tl	0.01 - 1000 ppm
Cs	0.01 - 1000 ppm	Nd	0.05 - 2000 ppm	U	0.01 - 1000 ppm
Cu	1 - 5000 ppm	Ni	0.5 - 5000 ppm	W	1 - 1000 ppm
Dy	0.01 - 2000 ppm	Pb	0.2 - 1000 ppm	Y	0.02 - 1000 ppm
Er	0.01 - 2000 ppm	Pr	0.01 - 1000 ppm	Yb	0.01 - 1000 ppm

Eu	0.01 - 2000 ppm	Rb	0.05 - 1000 ppm	Zn	1 - 5000 ppm
Ga	0.05 - 1000 ppm	Re	0.01 - 100 ppm	Zr	0.1 - 2000 ppm
Gd	0.01 - 2000 ppm	Sb	0.02 - 1000 ppm		
Hf	0.01 - 2000 ppm	Sc	0.1 - 1000 ppm		

## MULTI-ACID (4-ACID) DIGESTION PACKAGES

### NITRIC, HYDROFLUORIC, PERCHLORIC AND HYDROCHLORIC ACID DIGEST

Multi-acid (4-acid) digestion is a very effective dissolution procedure for a large number of mineral species and is suitable for a wide range of elements. Multi-acid digestion uses a combination of HNO<sub>3</sub> (nitric acid), HF (hydrofluoric acid), HClO<sub>4</sub> (perchloric acid) and HCl (hydrochloric acid). Because hydrofluoric acid dissolves silicate minerals, these digestions are often referred to as “near-total digestions”. For more details, see our publication, Rocks to Results, Chapter 4.

NOTE: Requires a minimum sample weight of 0.5g. Detection and upper limit can vary slightly among SGS laboratories because some laboratories may not have access to high purity reagents and consumables and/or they can have slight differences in instrumentation. Please talk with your local lab manager to make sure you get the reporting limits you need.

NOTE: Refractory minerals such as oxides have limited solubility in multi-acid (4-acid) digestions. Often elements can precipitate or volatilize during digestion. These factors can compromise analytical results for Al, Ba, Cr, Hf, Mo, Mn, Nb, Pb, Si, Sn, Ti, Ta, W, Zr, As, Sb, Se and Te in some sample types.

### MULTI-ACID (4-ACID) DIGESTION / ICP-AES PACKAGE (33 ELEMENTS)

#### GE ICP40B

#### ELEMENTS AND LIMIT(S)

Ag	2 - 100 ppm	Fe	0.01 - 15%	S	0.01 - 5%
Al	0.01 - 15%	K	0.01 - 15%	Sb	5 - 10000 ppm
As	3 - 10000 ppm	La	0.5 - 10000 ppm	Sc	0.5 - 10000 ppm
Ba	1 - 10000 ppm	Li	1 - 10000 ppm	Sn	10 - 10000 ppm
Be	0.5 - 2500 ppm	Mg	0.01 - 15%	Sr	0.5 - 10000 ppm

Bi	5 - 10000 ppm	Mn	2 - 10000 ppm	Ti	0.01 - 15%
Ca	0.01 - 15%	Mo	1 - 10000 ppm	V	2 - 10000 ppm
Cd	1 - 10000 ppm	Na	0.01 - 15%	W	10 - 10000 ppm
Co	1 - 10000 ppm	Ni	1 - 10000 ppm	Y	0.5 - 10000 ppm
Cr	1 - 10000 ppm	P	0.01 - 15%	Zn	1 - 10000 ppm
Cu	0.5 - 10000 ppm	Pb	2 - 10000 ppm	Zr	0.5 - 10000 ppm

Note: Additional elements can be added. Please inquire.

### MULTI-ACID (4-ACID) DIGESTION / COMBINED ICP-AES AND ICP-MS PACKAGE (49 ELEMENTS)

#### GE ICM40B

#### ELEMENTS AND LIMIT(S)

Ag	0.02 - 100 ppm	K	0.01 - 15%	Sn	0.3 - 1000 ppm
Al	0.01 - 15%	La	0.1 - 10000 ppm	Sr	0.5 - 10000 ppm
As	1 - 10000 ppm	Li	1 - 10000 ppm	Ta	0.05 - 10000 ppm
Ba	1 - 10000 ppm	Lu	0.01 - 1000 ppm	Tb	0.05 - 10000 ppm
Be	0.1 - 2500 ppm	Mg	0.01 - 15%	Te	0.05 - 1000 ppm
Bi	0.04 - 10000 ppm	Mn	2 - 10000 ppm	Th	0.2 - 10000 ppm
Ca	0.01 - 15%	Mo	0.05 - 10000 ppm	Ti	0.01 - 15%
Cd	0.02 - 10000 ppm	Na	0.01 - 15%	Tl	0.02 - 10000 ppm
Ce	0.05 - 1000 ppm	Nb	0.1 - 1000 ppm	U	0.05 - 10000 ppm
Cs	1 - 1000 ppm	Ni	0.5 - 10000 ppm	V	2 - 10000 ppm
Co	0.1 - 10000 ppm	P	0.005 - 15%	W	0.1 - 10000 ppm
Cr	1 - 10000 ppm	Pb	0.5 - 10000 ppm	Y	0.1 - 10000 ppm
Cu	0.5 - 10000 ppm	Rb	0.2 - 10000 ppm	Yb	0.1 - 1000 ppm
Fe	0.01 - 15%	S	0.01 - 5%	Zn	1 - 10000 ppm
Ga	0.1 - 500 ppm	Sb	0.05 - 10000 ppm	Zr	0.5 - 10000 ppm
Hf	0.02 - 500 ppm	Sc	0.5 - 10000 ppm		
In	0.02 - 500 ppm	Se	2 - 1000 ppm		

Note: Select packages for rare earth elements can be found on pg 59.

## FUSION PACKAGES

Fusion involves the complete digestion of the sample in molten flux. Fusions are generally more aggressive than acid digestion methods and are suitable for many refractory, difficult-to-dissolve minerals such as chromite, ilmenite, spinel, cassiterite and minerals of the tantalum-tungsten solid solution series. Fusion analyses are presumed to provide a complete chemical analysis and are referred to as a “total” analysis.

For more details, see our publication, Rocks to Results, Chapter 4.

NOTE: Detection and upper limit can vary slightly among SGS laboratories because some laboratories may not have access to high purity reagents and consumables and/or they can have slight differences in instrumentation. Please talk with your local lab manager to make sure you get the reporting limits you need.

### SODIUM PEROXIDE FUSION

Sodium peroxide is a strongly oxidizing flux that is basic, not acidic in nature. It renders most refractory minerals soluble. Because the fusion temperature is lower than that of lithium metaborate fusions, the hydride elements are not volatilized. This technique requires a minimum sample weight of 0.2 g.

### SODIUM PEROXIDE FUSION / ICP-AES PACKAGE (29 ELEMENTS)

#### GE ICP90A

#### ELEMENTS AND LIMIT(S)

Al	0.01 - 25%	K	0.1 - 25%	Sc	0.0005 - 5%
As	0.003 - 10%	La	0.001 - 5%	Si	0.1 - 30%
Ba	0.001 - 5%	Li	0.001 - 5%	Sn	0.005 - 5%
Be	0.0005 - 2.5%	Mg	0.01 - 25%	Sr	0.001 - 0.5%
Ca	0.1 - 25%	Mn	0.001 - 10%	Ti	0.01 - 25%
Cd	0.001 - 5%	Mo	0.001 - 5%	V	0.001 - 5%
Co	0.001 - 5%	Ni	0.001 - 10%	W	0.005 - 4%
Cr	0.001 - 5%	P	0.01 - 25%	Y	0.0005 - 2.5%
Cu	0.001 - 5%	Pb	0.002 - 10%	Zn	0.001 - 5%
Fe	0.01 - 25%	Sb	0.005 - 10%		

### SODIUM PEROXIDE FUSION / COMBINED ICP-AES AND ICP-MS PACKAGE (56 ELEMENTS)

#### GE ICM90A

#### ELEMENTS AND LIMIT(S)

Ag	1 - 1000 ppm	Ge	1 - 1000 ppm	Sb	0.1 - 10000 ppm
Al	0.01 - 25%	Hf	1 - 10000 ppm	Si	0.1 - 30%
As	0.0005 - 10%	Ho	0.05 - 1000 ppm	Sm	0.1 - 1000 ppm
Ba	10 - 10000 ppm	In	0.2 - 1000 ppm	Sn	1 - 10000 ppm
Be	5 - 2500 ppm	K	0.1 - 25%	Sr	10 - 5000 ppm
Bi	0.1 - 1000 ppm	La	0.1 - 10000 ppm	Ta	0.5 - 10000 ppm
Ca	0.1 - 25%	Li	0.001 - 5%	Tb	0.05 - 1000 ppm
Cd	0.2 - 10000 ppm	Lu	0.05 - 1000 ppm	Th	0.1 - 1000 ppm
Ce	0.1 - 10000 ppm	Mg	0.01 - 25%	Ti	0.01 - 25%
Co	0.5 - 10000 ppm	Mn	0.001 - 10%	Tl	0.5 - 1000 ppm
Cr	0.001 - 5%	Mo	2 - 10000 ppm	Tm	0.05 - 1000 ppm
Cs	0.1 - 10000 ppm	Nb	1 - 10000 ppm	U	0.05 - 1000 ppm
Cu	10 - 10000 ppm	Nd	0.1 - 10000 ppm	V	5 - 10000 ppm
Dy	0.05 - 1000 ppm	Ni	5 - 10000 ppm	W	1 - 10000 ppm
Er	0.05 - 1000 ppm	P	0.01 - 25%	Y	0.5 - 1000 ppm
Eu	0.05 - 1000 ppm	Pb	5 - 10000 ppm	Yb	0.1 - 1000 ppm
Fe	0.01 - 25%	Pr	0.05 - 1000 ppm	Zn	5 - 10000 ppm
Ga	1 - 1000 ppm	Rb	0.2 - 10000 ppm	Zr	0.5 - 10000 ppm
Gd	0.05 - 1000 ppm	Sc	0.0005 - 5%		

SGS now offers an innovative, low cost, multi-element, analytical fusion package (GE\_IMS90A). This package offers the best recoveries, fastest analysis time with the widest range of limits and elements offered in a single pass.

### **SODIUM PEROXIDE FUSION / ICP-MS PACKAGE (33 ELEMENTS)**

#### **GE IMS90A**

##### **ELEMENTS AND LIMIT(S)**

Al	0.01 - 25%	Fe	0.01 - 25%	Sb	1 - 10000 ppm
As	3 - 10000 ppm	K	0.1 - 30%	Si	0.1 - 40%
Ba	10 - 10000 ppm	La	0.1 - 10000 ppm	Sn	1 - 10000 ppm
Be	1 - 2500 ppm	Li	5 - 10000 ppm	Sr	10 - 10000 ppm
Bi	0.1 - 1000 ppm	Mg	0.01 - 30%	Te	1 - 1000 ppm
Ca	0.1 - 25%	Mn	10 - 10000 ppm	Ti	0.01 - 30%
Cd	0.2 - 10000 ppm	Mo	2 - 10000 ppm	V	5 - 10000 ppm
Co	0.5 - 10000 ppm	Ni	5 - 50000 ppm	W	5 - 10000 ppm
Cr	5 - 10000 ppm	P	0.01 - 25%	Y	0.5 - 10000 ppm
Cs	0.1 - 10000 ppm	Pb	2 - 50000 ppm	Yb	0.1 - 1000 ppm
Cu	2 - 50000 ppm	S	1 - 25%	Zn	5 - 50000 ppm

Note: This package is currently only available at our Burnaby, Canada location. An additional 22 elements (Ce, Dy, Er, Eu, Ga, Gd, Ge, Ho, In, Lu, Nb, Nd, Pr, Rb, Re, Sm, Ta, Tb, Th, Tl, Tm, U) can be added. Please inquire.

### **SODIUM PEROXIDE FUSION / HYDRIDE AAS PACKAGE**

#### **GE HAS90A**

##### **ELEMENTS AND LIMIT(S)**

As	0.5 - 1000 ppm	Bi	0.5 - 1000 ppm	Sb	0.5 - 1000 ppm
----	----------------	----	----------------	----	----------------

### **LITHIUM METABORATE FUSION**

Lithium metaborate fusion is a high temperature procedure that dissolves rock forming minerals, trace minerals and refractory minerals. Lithium metaborate fusion solutions can be analyzed by ICP-AES, ICP-MS or both ICP-AES and ICP-MS. This technique requires a minimum sample weight of 0.2 g.

### **LITHIUM METABORATE FUSION / ICP-MS PACKAGE (33 ELEMENTS)**

#### **GE IMS95A**

##### **ELEMENTS AND LIMIT(S)**

Ag	1 - 1000 ppm	Ho	0.05 - 1000 ppm	Ta	0.5 - 10000 ppm
Ce	0.1 - 10000 ppm	La	0.1 - 10000 ppm	Tb	0.05 - 1000 ppm
Co	0.5 - 10000 ppm	Lu	0.05 - 1000 ppm	Th	0.1 - 1000 ppm
Cs	0.1 - 10000 ppm	Mo	2 - 10000 ppm	Tl	0.5 - 1000 ppm
Cu	5 - 10000 ppm	Nb	1 - 10000 ppm	Tm	0.05 - 1000 ppm
Dy	0.05 - 1000 ppm	Nd	0.1 - 10000 ppm	U	0.05 - 10000 ppm
Er	0.05 - 1000 ppm	Ni	5 - 10000 ppm	V	5 - 10000 ppm
Eu	0.05 - 1000 ppm	Pr	0.05 - 1000 ppm	W	1 - 10000 ppm
Ga	1 - 1000 ppm	Rb	0.2 - 10000 ppm	Y	0.5 - 1000ppm
Gd	0.05 - 1000 ppm	Sm	0.1 - 1000 ppm	Yb	0.1 - 1000 ppm
Hf	1 - 10000 ppm	Sn	1 - 10000 ppm	Zr	0.5 - 1000 ppm

Note: Additional packages containing rare earth elements (REEs) are found on pg 59.

## **XRF ANALYSIS**

X-ray fluorescence (XRF) spectroscopy has been available to the geochemical industry for over 50 years. It is the preferred method for the determination of the major oxides as well as some trace elements. The advantages of XRF include its:

- Accurate analyses, arising from the fact that inter-element corrections are well known and highly predictable.
- Precise determinations, due to inherent instrumental factors.
- Rapid analysis time.
- Ability to use a solid sample as opposed to a liquid digest.
- Wide analytical range which extends from the parts-per-million to tens of percent range.

Fusion and pressed pellet are the two industry-standard sample preparation techniques for XRF analysis. In pressed pellet XRF, samples are compressed into a pellet and analyzed instrumentally. Only lower levels of metals can be done accurately by this method. Fusion involves melting the sample with flux and casting it into a glass disc. Trace element and sulphide samples require specialized fusions or the pressed pellet technique. Please talk to us to determine the right method for your samples.

For information about fusion-XRF packages for whole rock samples, base metals, iron ores, REEs, and other minerals, please refer to the Ore-Grade Analysis section in this guide.

### **PRESSED PELLETT / XRF PACKAGE (26 ELEMENTS)**

#### **GE XRF75V**

#### **ELEMENTS AND LIMIT(S)**

As	3 - 10000 ppm	Mn	50 - 10000 ppm	Th	5 - 10000 ppm
Ba	10 - 4000 ppm	Mo	3 - 10000 ppm	Ti	4 - 10000 ppm
Ca	0.01 - 20%	Nb	2 - 4000 ppm	U	5 - 4000 ppm
Co	2 - 4000 ppm	Ni	2 - 4000 ppm	V	5 - 10000 ppm
Cr	5 - 4000 ppm	Pb	5 - 10000 ppm	W	5 - 4000 ppm
Cu	2 - 4000 ppm	Rb	2 - 4000 ppm	Y	2 - 4000 ppm
Ga	3 - 4000 ppm	Sb	3 - 4000 ppm	Zn	2 - 4000 ppm
Ge	5 - 10000 ppm	Sn	3 - 4000 ppm	Zr	3 - 4000 ppm
K	0.01 - 20%	Sr	2 - 4000 ppm		

Note: This method is not available at all SGS laboratories, please inquire. This technique requires a minimum sample weight of 12g.

## **MOBILE METAL ION – MMI™**

SGS is the owner and sole provider of MMI™ Technology. We have over 15 years of experience with this technology, and we are the market leaders in providing a weak extraction of the mobile form of the ions residing in near surface soils. MMI™ is a world-renowned exploration tool repeatedly proven to find buried mineral deposits.

MMI™ Technology is an innovative analytical process that uses a unique approach to the semi-quantitative analysis of metals in soils and weathered materials. Target elements are extracted using weak solutions of organic

and inorganic compounds rather than conventional aggressive acid or cyanide-based digests. MMI™ solutions contain strong ligands, which detach and hold the metal ions that were loosely bound to soil particles by weak atomic forces. The extraction does not dissolve the bound forms of the metal ions. Thus, the metal ions in MMI solutions are the chemically active or 'mobile' component of the sample. Because these mobile, loosely bound complexes are in very low concentrations, elemental determinations are made by conventional ICP-MS and the latest evolution of this technology, ICP-MS Dynamic Reaction Cell™ (DRC II™).

There are many benefits to using MMI™ Technology for soil geochemistry.

- Few false anomalies
- Focused anomalies
- Minimal nugget effects

### **SAMPLE COLLECTION**

Sample collection is the most critical part of a soil geochemistry program. The MMI™ Technology has specific sampling protocol based on years of experience and research. In the absence of an orientation survey, samples must be taken at a constant depth (10-25 cm) below the organic-inorganic soil interface. There is no sample preparation or drying. The analysis is done on a 50 gram sample and the extracted solution is analyzed via ICP-MS or ICP-MS DRCII™, providing determinations in the part per billion range. For detailed instructions for the MMI™ sampling protocols and orientation surveys, please visit [www.sgs.com/mining/mmi](http://www.sgs.com/mining/mmi) or contact us at [minerals@sgs.com](mailto:minerals@sgs.com).

### **ICP-MS DRC II™**

SGS is committed to the MMI™ Technology. With the development of the ICP-MS DRC II™, we have been able to further enhance this analytical approach. The lower detection limits provided by ICP-MS DRC II™ mean that we can better define anomalous targets. For instance, for the exploration of nickel deposits, kimberlites and layered intrusions, low level chrome (1 ppb) is an important geological trace element. For uranium exploration, low level vanadium (1 ppb) is also important. If either or both of these elements are required for your program, we can analyze your samples for low chrome and/or vanadium values using our MMI-ME package.

Sulfur, bromine, iodine and lead isotopes can be added to the MMI packages. For these additional elements, please contact us at [minerals@sgs.com](mailto:minerals@sgs.com).

#### **MOBILE METAL ION STANDARD PACKAGE / ICP-MS (53 ELEMENTS)**

##### **GE MMI-M**

##### **ELEMENTS AND LIMIT(S)**

Ag	0.5 ppb	Er	0.2 ppb	Nd	1 ppb	Tb	0.1 ppb
Al	1 ppm	Eu	0.2 ppb	Ni	5 ppb	Te	10 ppb
As	10 ppb	Fe	1 ppm	P	0.1 ppm	Th	0.5 ppb
Au	0.1 ppb	Ga	0.5 ppb	Pb	5 ppb	Ti	10 ppb
Ba	10 ppb	Gd	0.5 ppb	Pd	1 ppb	Tl	0.1 ppb
Bi	0.5 ppb	Hg	1 ppb	Pr	0.5 ppb	U	0.5 ppb
Ca	2 ppm	In	0.1 ppb	Pt	0.1 ppb	W	0.5 ppb
Cd	1 ppb	K	0.5 ppm	Rb	1 ppb	Y	1 ppb
Ce	2 ppb	La	1 ppb	Sb	0.5 ppb	Yb	0.2 ppb
Co	1 ppb	Li	1 ppb	Sc	5 ppb	Zn	10 ppb
Cr	100 ppb	Mg	0.5 ppm	Sm	1 ppb	Zr	2 ppb
Cs	0.2 ppb	Mn	100 ppb	Sn	1 ppb		
Cu	10 ppb	Mo	2 ppb	Sr	10 ppb		
Dy	0.5 ppb	Nb	0.5 ppb	Ta	1 ppb		

#### **MOBILE METAL ION ENHANCED PACKAGE / ICP-MS (55 ELEMENTS)**

##### **GE MMI-ME**

##### **ELEMENTS AND LIMIT(S)**

Ag	0.5 ppb	Er	0.2 ppb	Nd	1 ppb	Ta	1 ppb
Al	1 ppm	Eu	0.2 ppb	Ni	5 ppb	Tb	0.1 ppb
As	10 ppb	Fe	1 ppm	P	0.1 ppm	Te	10 ppb
Au	0.1 ppb	Ga	0.5 ppb	Pb	5 ppb	Th	0.5 ppb
Ba	10 ppb	Gd	0.5 ppb	Pd	1 ppb	Ti	10 ppb
Bi	0.5 ppb	Hg	1 ppb	Pr	0.5 ppb	Tl	0.1 ppb
Ca	2 ppm	In	0.1 ppb	Pt	0.1 ppb	U	0.5 ppb
Cd	1 ppb	K	0.5 ppm	Rb	1 ppb	V	1 ppb
Ce	2 ppb	La	1 ppb	Sb	0.5 ppb	W	0.5 ppb
Co	1 ppb	Li	1 ppb	Sc	5 ppb	Y	1 ppb

Cr	1 ppb	Mg	0.5 ppm	Se	2 ppb	Yb	0.2 ppb
Cs	0.2 ppb	Mn	100 ppb	Sm	1 ppb	Zn	10 ppb
Cu	10 ppb	Mo	2 ppb	Sn	1 ppb	Zr	2 ppb
Dy	0.5 ppb	Nb	0.5 ppb	Sr	10 ppb		

Note: S, Br, I and lead isotopes can be added to the MMI-ME package by special request.

#### **MOBILE METAL ION PRECIOUS METAL PLUS PACKAGE / ICP-MS (11 ELEMENTS)**

##### **GE MMI-MP**

##### **ELEMENTS AND LIMIT(S)**

Au	0.05 ppb	Ag	0.1 ppb	Cu	10 ppb	Zn	10 ppb
Pd	0.1 ppb	Cd	0.5 ppb	Ni	5 ppb	U	0.5 ppb
Pt	0.02 ppb	Co	1 ppb	Pb	5 ppb		

## **BIOGEOCHEMISTRY**

SGS has considerable experience in the preparation and analysis of a wide range of vegetation samples. Such samples may be dried and macerated or ashed prior to acid digestion and analysis by ICP-MS. Please consult your local lab for more information.

## **HYDROGEOCHEMISTRY**

The analyses offered in this section are suitable for groundwater samples used in mineral exploration, but NOT for salt water, brines, effluent solutions and metal-carrying solutions generated in processing circuits or environmental applications. Samples such as salt water, effluents or metal-carrying solutions will incur an extra charge and element detection limits can increase. Requests for environmental services will be forwarded to an SGS Environmental Services Laboratory.



**GROUND WATER ANALYSIS / ICP-AES PACKAGE (31 ELEMENTS)****GE ICP80T****ELEMENTS AND LIMIT(S)**

Ag	1 ppb	Co	10 ppb	Mo	10 ppb	Sr	1 ppb
Al	50 ppb	Cr	10 ppb	Na	50 ppb	Ti	10 ppb
As	30 ppb	Cu	5 ppb	Ni	10 ppb	V	10 ppb
Ba	10 ppb	Fe	50 ppb	P	50 ppb	W	50 ppb
Be	5 ppb	K	100 ppb	Pb	30 ppb	Y	5 ppb
Bi	50 ppb	La	10 ppb	Sb	50 ppb	Zn	5 ppb
Ca	50 ppb	Mg	50 ppb	Sc	1 ppb	Zr	10 ppb
Cd	10 ppb	Mn	5 ppb	Sn	50 ppb		

**GROUND WATER ANALYSIS / ICP-MS PACKAGE (49 ELEMENTS)****GE IMS80T****ELEMENTS AND LIMIT(S)**

Ag	0.01 ppb	Eu	0.01 ppb	Ni	0.1 ppb	Th	0.01 ppb
As	1 ppb	Ga	0.01 ppb	Pb	0.01 ppb	Tl	0.01 ppb
Ba	0.01 ppb	Gd	0.01 ppb	Pr	0.01 ppb	Tm	0.01 ppb
Be	0.1 ppb	Hf	0.01 ppb	Rb	0.1 ppb	U	0.01 ppb
Bi	0.01 ppb	Hg	0.2 ppb	Sb	0.1 ppb	V	1 ppb
Cd	0.01 ppb	Ho	0.01 ppb	Sc	0.1 ppb	W	0.01 ppb
Ce	0.01 ppb	In	0.01 ppb	Se	1 ppb	Y	0.01 ppb
Cs	0.01 ppb	La	0.01 ppb	Sm	0.01 ppb	Yb	0.01 ppb
Cr	1 ppb	Lu	0.05 ppb	Sn	0.01 ppb	Zn	1 ppb
Co	0.1 ppb	Mn	0.1 ppb	Sr	0.01 ppb	Zr	0.1 ppb
Cu	0.1 ppb	Mo	1 ppb	Ta	0.01 ppb		
Dy	0.1 ppb	Nb	0.01 ppb	Tb	0.01 ppb		
Er	0.01 ppb	Nd	0.01 ppb	Te	0.1 ppb		

Note: Au, Pt, Pd, Rh, Ru, Ir and Re can be added upon request.

**ADDITIONAL GROUND WATER ANALYSIS**

CODE(S)	ELEMENT	DESCRIPTION
GE PHY22V	Total dissolved solids (TDS)	Gravimetric
GE ISE06T	pH	Ion selective electrode (ISE)
GE ISE07T	Fluoride F <sup>-</sup>	Ion selective electrode (ISE)
GE ISE08T	Chloride Cl <sup>-</sup>	Ion selective electrode (ISE)

**INDIVIDUAL METHODS FOR EXPLORATION-GRADE ANALYSIS****SULPHUR AND CARBON**

CODE(S)	ELEMENT	LIMIT(S)	DESCRIPTION	MIN. SAMPLE WT.(g)
GE CSA06V	S	0.005 - 30%	IR Combustion	0.2
	C	0.005 - 30%		0.2
GE CSA07V	SO <sub>4</sub> <sup>2-</sup>	0.01%	Leach/ IR combustion	1.0
GE CSA08V	S <sup>2-</sup>	0.01%	Leach/Digest/ IR combustion	1.0
GE CSA09V	S (elemental)	0.01%	Leach/Gravimetry	1.0
GE CSA02V	CO <sub>2</sub> (Carbonate)	0.05%	IR combustion	1.0
GE CSB02V	CO <sub>2</sub> (Carbonate)	0.05%	Coulometry	1.0
GE CSA03V	C (organic, inorganic)	0.01%	IR combustion	1.0
GE CSB03V	C (organic, inorganic)	0.05%	Coulometry	1.0
GE CSA05V	C (graphitic)	0.05%	IR combustion	1.0
GE CSB05V	C (graphitic)	0.05%	Coulometry	1.0

### ADDITIONAL SINGLE ELEMENTS

CODE(S)	ELEMENT	LIMIT(S)	DESCRIPTION	MIN. SAMPLE WT.(g)
GE CVA20A	Hg	0.005 - 100 ppm	Cold vapour AAS	0.2
GE ISE07A	F	0.0025 - 10%	Ion specific electrode	0.2
GE ISE08B	Cl	50 - 5000 ppm	Ion specific electrode	0.5
GE CLA02V	Cl	0.005 - 1%	Titration	0.5

SGS offers a wide variety of specific element analyses. Please contact your local site.

## ORE-GRADE ANALYSIS

Ore-grade packages are used to analyse samples that have high concentrations of pay metals. They can be used in prefeasibility, feasibility or production circumstances. As well, these methods can be used to provide over range analysis when an upper limit of an element in an exploration package is exceeded. Typically, ore-grade analyses are accomplished by adjusting the sample weight and final solution volume ratio, thus expanding the linear range of the analysis.

### ORE-GRADE / OVER RANGE METHODS

CODE(S)	ELEMENTS	LIMIT(S)	DESCRIPTION
GO ICP13B	Refer to GE ICP14B	Minors (0.01 - 30%) Majors (0.1 - 30%)	Aqua regia digest / ICP-AES
GO ICP41Q	Refer to GE ICP40B	Minors (0.01 - 30%) Majors (0.1 - 30%)	4-Acid digest / ICP-AES

Note: For details on the above digestion techniques, refer to the Exploration-Grade Analysis section of this guide.

## MULTI-ACID (4-ACID) DIGESTION PACKAGES

### 4-ACID DIGESTION / AAS PACKAGE (16 ELEMENTS)

#### GO AAS42S

#### ELEMENTS AND LIMIT(S)

Ag	5 - 500 ppm	Cr	0.005 - 5%	Pb	0.002 - 2.5%
As	0.025 - 5%	Cu	0.001 - 50%	Sb	0.01 - 2%
Bi	50 - 5000 ppm	Fe	0.01 - 40%	V	0.005 - 5%
Ca	0.01 - 40%	Mn	0.001 - 5%	Zn	0.001 - 5%
Cd	5 - 5000 ppm	Mo	0.002 - 5%		
Co	0.002 - 2.5%	Ni	0.001 - 5%		

### 4-ACID DIGESTION / ICP-AES PACKAGE (26 ELEMENTS)

#### GO ICP42S

#### ELEMENTS AND LIMIT(S)

Ag	5 - 250 ppm	Fe	0.025 - 100%	Pb	0.0025 - 2.5%
Al	0.025 - 40%	K	0.1 - 40%	Sb	0.001 - 2%
As	0.002 - 2.5%	Li	5 - 2500 ppm	Sn	0.002 - 2%
Bi	0.005 - 2.5%	Mg	0.005 - 40%	Ta	0.005 - 2.5%
Ca	0.01 - 40%	Mn	0.002 - 2.5%	Ti	0.002 - 5%
Cd	0.0005 - 2%	Mo	0.002 - 2.5%	V	0.0005 - 2.5%
Co	0.001 - 2.5%	Na	0.01 - 40%	Zn	0.001 - 5%
Cr	0.002 - 5%	Ni	0.002 - 2.5%	Zr	0.001 - 5%
Cu	0.001 - 2.5%	P	0.01 - 25%		

Note: Requires a minimum sample weight of 0.5 g.

## FUSION-ICP PACKAGES

### SODIUM PEROXIDE FUSION / ICP-AES PACKAGE

#### GO ICP90Q

##### ELEMENTS AND LIMIT(S)

Co	0.01 - 30%	Mo	0.01 - 30%	Pb	0.01 - 30%
Cu	0.01 - 30%	Ni	0.01 - 30%	Zn	0.01 - 30%
Fe	0.05 - 50%				

Note: Additional elements can be added to this method upon request. Elements greater than 30% can require analysis by another technique for full recovery. Requires a minimum sample weight of 0.5 g.

### SODIUM PEROXIDE FUSION / ICP-AES NICKEL LATERITE PACKAGE (SAMPLES DRIED AT 105°C / 8 HOURS)

#### GO ICP90B

##### ELEMENTS AND LIMIT(S)

Al <sub>2</sub> O <sub>3</sub>	0.01 - 25%	Cu	0.01 - 10%	Ni	0.01 - 10%
CaO	0.1 - 35%	Fe <sub>2</sub> O <sub>3</sub>	0.01 - 30%	P <sub>2</sub> O <sub>5</sub>	0.01 - 25%
Cr	0.01 - 10%	K <sub>2</sub> O	0.1 - 25%	SiO <sub>2</sub>	0.01 - 25%
Co	0.01 - 10%	MgO	0.01 - 30%	TiO <sub>2</sub>	0.01 - 25%

Requires a minimum sample weight of 0.5 g.

### LITHIUM METABORATE FUSION / ICP-AES (LITHOLOGIC) PACKAGE (18 ELEMENTS)

#### GO ICP95A

##### ELEMENTS AND LIMIT(S)

Al <sub>2</sub> O <sub>3</sub>	0.01 - 75%	MgO	0.01 - 30%	Sr	0.001 - 10%
Ba	0.001 - 10%	MnO	0.01 - 10%	TiO <sub>2</sub>	0.01 - 25%
CaO	0.01 - 60%	Na <sub>2</sub> O	0.01 - 30%	Y	0.001 - 10%
Cr <sub>2</sub> O <sub>3</sub>	0.01 - 10%	Nb	0.001 - 10%	Zn	5 - 10000 ppm
Fe <sub>2</sub> O <sub>3</sub>	0.01 - 75%	P <sub>2</sub> O <sub>5</sub>	0.01 - 25%	Zr	0.001 - 10%
K <sub>2</sub> O	0.01 - 25%	SiO <sub>2</sub>	0.01 - 90%	LOI	0.01 - 50%

Requires a minimum sample weight of 0.2 g.

## FUSION-XRF PACKAGES

Whole rock analysis is the determination of major elements (reported as "oxides"). This analysis will approximate 100% in non-mineralized samples. SGS offers whole rock analysis using both ICP-AES or XRF below.

Whole rock analysis by XRF is particularly suitable for the analysis of bulk commodities such as iron ore, silicate, feldspar, gypsum and limestone. This method is not suitable for samples with a sulphide mineral content > 1%.

### BORATE FUSION / XRF WHOLE ROCK PACKAGE (13 ELEMENTS)

#### GO XRF76V

##### ELEMENTS AND LIMIT(S)

Al <sub>2</sub> O <sub>3</sub>	0.01 - 100%	MnO	0.01 - 100%	TiO <sub>2</sub>	0.01 - 100%
CaO	0.01 - 100%	Na <sub>2</sub> O	0.01 - 100%	V <sub>2</sub> O <sub>5</sub>	0.01 - 100%
Cr <sub>2</sub> O <sub>3</sub>	0.01 - 100%	P <sub>2</sub> O <sub>5</sub>	0.01 - 100%	LOI	-10 - 100%
K <sub>2</sub> O	0.01 - 100%	Fe <sub>2</sub> O <sub>3</sub>	0.01 - 100%	SUM	%
MgO	0.01 - 100%	SiO <sub>2</sub>	0.01 - 100%		

Additional major and minor elements can be added to the borate fusion / XRF method. Requires a minimum sample weight of 5.0 g. Please contact your local lab. Rare earth elements can also be analyzed by this technique. Refer to page 61. For iron ore samples (GO XRF78S), refer to page 65.

### PYROSULPHATE FUSION / XRF BASE METAL PACKAGE (10 ELEMENTS)

#### GO XRF77B

##### ELEMENTS AND LIMIT(S)

Co	0.01 - 100%	Mn	0.01 - 100%	W	0.01 - 100%
Cr	0.01 - 100%	Mo	0.01 - 100%	Zn	0.01 - 100%
Cu	0.01 - 100%	Ni	0.01 - 100%		
Fe	0.01 - 100%	Pb	0.01 - 100%		

Note: Requires a minimum sample weight of 1.0 g.

## INDIVIDUAL METHODS FOR ORE-GRADE ANALYSIS

### INTERNAL STANDARD / RESISTIVE MINERALS / XRF

#### GO XRF75F

#### ELEMENTS AND LIMIT(S)

As	>0.001%	Sn	>0.002%	ThO <sub>2</sub>	>0.005%	WO <sub>3</sub>	>0.002%
Sb	>0.002%	Ta	>0.002%	U <sub>3</sub> O <sub>8</sub>	>0.002%		

Note: Requires a minimum sample weight of 25 g. depending on the elements of interest. This method is not available at all SGS laboratories. Please inquire.

#### SULPHUR AND CARBON

CODE	ELEMENT	LIMIT(S)	DESCRIPTION
GO CSA06V	S	0.01 - 75%	IR combustion
	C	0.01 - 75%	

Note: Requires a minimum sample weight of 0.2 g. Carbon and sulphur can be speciated using a variety of methods. Please inquire.

#### ADDITIONAL SINGLE ELEMENTS

CODE(S)	ELEMENT	LIMIT(S)	DESCRIPTION	MIN. SAMPLE WT.(g)
GO CVA20B	Hg	0.3ppm - 100%	Cold vapour AAS	0.4
GO CLA10E	Insolubles (acid)	0.1%	Gravimetric	5
GO CLA07C	CaO	0.01%	Available lime	2
GO CLA01V	FeO	0.1 - 30%	Ferric/Ferrous iron titration	0.5

SGS can analyse a number of individual ore-grade elements. Please inquire.

## CONTROL-GRADE ANALYSIS

Metallurgical processes are monitored and controlled by the chemical analysis of feed and head samples, middlings, concentrates, metals, tails, slags, residues or pregnant solutions. A wide range of analytical techniques are needed to accommodate the varying matrices and complex nature of such samples. Several of the techniques are listed here, but this list is not meant to be comprehensive. We have extensive experience supporting metallurgical facilities and would be happy to speak with you regarding your specific project requirements.

## CUSTOMIZED SPECTROSCOPIC ANALYSIS

The analytical approach for control analysis differs from the standard geochemistry "package" methodology. Instead, we provide both multi-element packages and customized spectroscopic determinations that can include multiple dilutions and spectral analyses on an element-by-element basis to ensure that the interferences common in complex samples are identified and resolved.

These control assay methods are only a small selection of the methods and capabilities available at SGS. A wide variety of other methods are available including fire assay, manual and automated titrations, CVAA mercury analysis, AAS, carbon, sulphur and chromatography. Fire assay methods often require customized fluxes and finishes. Please contact us if you have any needs in this area – we have lots of expertise to share.

## TWO ACID/AQUA REGIA DIGESTION PACKAGES

### AQUA REGIA DIGESTION PACKAGE / ICP-AES (30 ELEMENTS)

#### GC ICP14C

##### ELEMENTS AND REPORTING LIMIT(S)

Ag	0.8 ppm	Co	3 ppm	Mo	6 ppm	Sr	0.02 ppm
Al	2 ppm	Cr	1 ppm	Na	20 ppm	Ti	0.2 ppm
As	30 ppm	Cu	1 ppm	Ni	6 ppm	Tl	30 ppm
Ba	0.07 ppm	Fe	2 ppm	P	50 ppm	V	2 ppm
Be	0.02 ppm	K	10 ppm	Pb	20 ppm	Y	0.2 ppm
Bi	10 ppm	Li	20 ppm	Sb	10 ppm	Zn	7 ppm
Ca	9 ppm	Mg	0.7 ppm	Se	30 ppm		
Cd	0.9 ppm	Mn	0.4 ppm	Sn	20 ppm		

Additional elements can be added. An ICP-MS option is available. Concentrate samples containing greater than 50% of the target element can require alternative analytical methods if full recovery is required. Requires a minimum sample weight of 1.0 g.

## MULTI-ACID (4-ACID) DIGESTION PACKAGES

### MULTI-ACID DIGESTION PACKAGE / ICP-AES (30 ELEMENTS)

#### GC ICP42C

##### ELEMENTS AND REPORTING LIMIT(S)

Ag	2 ppm	Co	4 ppm	Mo	5 ppm	Sr	0.03 ppm
Al*	2 ppm	Cr*	4 ppm	Na	10 ppm	Ti*	0.4 ppm
As*	30 ppm	Cu	0.5 ppm	Ni	20 ppm	Tl	30 ppm
Ba*	0.2 ppm	Fe	4 ppm	P	30 ppm	V	2 ppm
Be	0.03 ppm	K*	20 ppm	Pb	20 ppm	Y	0.2 ppm
Bi	20 ppm	Li	5 ppm	Sb*	10 ppm	Zn	2 ppm
Ca*	20 ppm	Mg*	1 ppm	Se	30 ppm		
Cd	2 ppm	Mn	0.3 ppm	Sn*	20 ppm		

Additional elements can be added. An ICP-MS option is available. Requires a minimum sample weight of 1.0 g. Concentrate samples containing greater than 50% of the target element can require alternative analytical methods if full recovery is required.

\*Recovery can be incomplete so analysis can be biased low.

### MULTI-ACID DIGESTION PACKAGE / FUSION / ICP-AES (30 ELEMENTS)

#### GC ICP46C

##### ELEMENTS AND REPORTING LIMIT(S)

Ag	2 ppm	Co	4 ppm	Mo	5 ppm	Sr	0.03 ppm
Al	2 ppm	Cr	4 ppm	Na	10 ppm	Ti	0.4 ppm
As	30 ppm	Cu	0.5 ppm	Ni	20 ppm	Tl	30 ppm
Ba	0.2 ppm	Fe	4 ppm	P	30 ppm	V	2 ppm
Be	0.03 ppm	K	20 ppm	Pb	20 ppm	Y	0.2 ppm
Bi	20 ppm	Li	5 ppm	Sb	10 ppm	Zn	2 ppm
Ca	20 ppm	Mg	1 ppm	Se	30 ppm		
Cd	2 ppm	Mn	0.3 ppm	Sn	20 ppm		

Additional elements can be added. An ICP-MS option is available. Requires a minimum sample weight of 1.0 g. Concentrate samples containing greater than 50% of the target element can require alternative analytical methods if full recovery is required. Data for volatiles (As, Sb) and/or precipitants (Pb) may be incomplete.

## FUSION PACKAGES

### FUSION / ICP-AES PACKAGE (28 ELEMENTS)

#### GC ICP93A

##### ELEMENTS AND REPORTING LIMIT(S)

Ag	200 ppm	Co	200 ppm	Mo	300 ppm	Tl	2000 ppm
Al	400 ppm	Cr	40 ppm	Ni	300 ppm	V	80 ppm
As	1200 ppm	Cu	40 ppm	Pb	800 ppm	Y	8 ppm
Ba	3 ppm	Fe	500 ppm	Sb	400 ppm	Zn	300 ppm
Be	0.8 ppm	K	400 ppm	Se	2000 ppm		

Bi	400 ppm	Li	800 ppm	Sn	800 ppm
Ca	800 ppm	Mg	30 ppm	Sr	10 ppm
Cd	40 ppm	Mn	20 ppm	Ti	8 ppm

Additional elements can be added. An ICP-MS option is available. Requires a minimum sample weight of 0.2 g. Concentrate samples containing greater than 50% of the target element can require alternative analytical methods if full recovery is required.

### FUSION / AAS PACKAGE (11 ELEMENTS)

#### GC AAS93A

#### ELEMENTS AND REPORTING LIMIT(S)

Al	0.02 %	Fe	0.01 %	Si	0.07 %	V	0.1 %
Ca	0.06 %	Mg	0.005 %	Sn	0.05 %	Zn	0.001 %
Cr	0.005 %	Mn	0.005 %	Ti	0.05 %		

Additional elements can be added. An ICP-MS option is available. Requires a minimum sample weight of 0.2 g. Concentrate samples containing greater than 50% of the target element can require alternative analytical methods if full recovery is required.

### FUSION / XRF CONTROL-GRADE PACKAGES

CODE(S)	ELEMENTS / LIMIT(S)	DESCRIPTION
GC XRF76V	Refer to Ore-Grade Analysis section for elements and ranges	Borate fusion / XRF
GC XRF77B	Refer to Ore-Grade Analysis section for elements and ranges	Pyrosulphate fusion / XRF
GC XRF75F	Refer to Ore-Grade Analysis section for elements and ranges	Internal standard / XRF

## PROCESS SOLUTION PACKAGES

### PROCESS SOLUTION PACKAGE / ICP-AES / NON-CYANIDE BASED (30 ELEMENTS)

#### GC SOL91T

#### ELEMENTS AND REPORTING LIMIT(S)

Ag	0.08 ppm	Co	0.3 ppm	Mo	0.6 ppm	Sr	0.002 ppm
Al	0.2 ppm	Cr	0.1 ppm	Na	2 ppm	Ti	0.02 ppm
As	3 ppm	Cu	0.1 ppm	Ni	0.6 ppm	Tl	3 ppm
Ba	0.007 ppm	Fe	0.2 ppm	P	5 ppm	V	0.2 ppm
Be	0.002 ppm	K	1 ppm	Pb	2 ppm	Y	0.02 ppm
Bi	1 ppm	Li	2 ppm	Sb	1 ppm	Zn	0.7 ppm
Ca	0.9 ppm	Mg	0.07 ppm	Se	3 ppm		
Cd	0.09 ppm	Mn	0.04 ppm	Sn	2 ppm		

Additional elements can be added. Requires a minimum sample volume of 5 mL. ICP-MS option may be available locally. Please inquire.

### PROCESS SOLUTION PACKAGE / ICP-AES / CYANIDE BASED (30 ELEMENTS)

#### GC SOL92T

#### ELEMENTS AND REPORTING LIMIT(S)

Ag	0.08 ppm	Co	0.3 ppm	Mo	0.6 ppm	Sr	0.002 ppm
Al	0.2 ppm	Cr	0.1 ppm	Na	2 ppm	Ti	0.02 ppm
As	3 ppm	Cu	0.1 ppm	Ni	0.6 ppm	Tl	3 ppm
Ba	0.007 ppm	Fe	0.2 ppm	P	5 ppm	V	0.2 ppm
Be	0.002 ppm	K	1 ppm	Pb	2 ppm	Y	0.02 ppm
Bi	1 ppm	Li	2 ppm	Sb	1 ppm	Zn	0.7 ppm
Ca	0.9 ppm	Mg	0.07 ppm	Se	3 ppm		
Cd	0.09 ppm	Mn	0.04 ppm	Sn	2 ppm		

Additional elements can be added. Requires a minimum sample volume of 10 mL. ICP-MS option may be available locally. Please inquire.

## INDIVIDUAL METHODS FOR CONTROL-GRADE ANALYSIS

### SULPHUR AND CARBON

CODE(S)	ELEMENT	LIMIT(S)	DESCRIPTION	MIN. SAMPLE WT.(g)
GC CSA06V	S	0.01 - 100%	IR combustion	0.2
	C	0.01 - 100%		0.2
GC CSA08V	S <sup>2-</sup>	0.01 - 100%	Leach/Digest/IR	1.0
GC CSA09V	S (elemental)	0.01 - 100%	Leach/Gravimetry	1.0

Single elements can be determined by numerous decomposition techniques and finishes. Please contact your local lab for options.

### VOLUMETRIC AND GRAVIMETRIC METHODS FOR CONCENTRATES

CODE(S)	ELEMENT	LIMIT(S)	DESCRIPTION	MIN. SAMPLE WT.(g)
GC CON13V	Cu	5 - 60%	Titration	2.0
GC CON03V	Cu	5 - 100%	Electroplating	5.0
GC CON07V	Ni	10 - 100%	Electroplating	5.0
GC CON11V	Pb	10 - 70%	Titration	2.0
GC CON12V	Zn	5 - 65%	Titration	2.0
GC CON08V	Fe	10 - 75%	Titration	0.5
GC CLA01V	FeO	>0.2	Titration	0.5

Note: these elements can be analyzed to party or umpire quality standards (GT) and can be reported up to 100%. Refer to the Commercial Trade Analysis section in this guide. Additional elements can be determined on concentrate samples in some SGS laboratories. Please inquire. Trade sample analyses typically require moisture analysis and may require a larger minimum sample weight.

## COMMERCIAL TRADE ANALYSIS

SGS is the global leader and innovator in inspection, verification, testing and certification services. Our Minerals Services group, with its global network of laboratories and offices, provides customers with weighing, inspection, sampling and analytical services that are highly respected throughout the industry.

When possible, we follow published, accredited procedures and test methods. As well, SGS can accept your speciality methods and jointly ensure that your analytical results meet your needs and are suitably in control. The SGS Centre of Excellence laboratories that perform these commercial assays conform to the requirements of the ISO/IEC 17025:2005 standard for specific registered tests. SGS recognizes that your reputation and financial position can be at stake during commercial transactions and so we strive to continually improve our services and processes.

SGS' commercial analysis offerings consist of:

- 'Load-port' or 'pre-shipment' assays used by underwriters to quickly confirm product quality and determine approximate value of the shipment. These assays can also be used to calculate partial payment while the parcel or cargo is en-route to the customer. Assay techniques are chosen based on the quality required and turn-around requirements that are demanded during some loading operations.
- Party analyses (also known as settlement or assay exchange analysis) are used to determine the quality of a commodity or product and thus its value and the payment due. The major or payable elements and all minor or penalty parameters are measured and reported. Party assays use commodity-specific methodology and require rigorous quality control steps. SGS employs rugged and reliable procedures, including traditional fire assay, classical gravimetric analysis, electroplating and volumetric titrimetry as well as AAS, ICP-AES and ICP-MS in this type of work.
- Umpire assays are used to resolve a dispute between a buyer and a seller. Samples of the cargo or product are analyzed in triplicate (at minimum) using approved, accredited methods and quality control protocols are set to provide the highest level of accuracy and precision.
- Product verification analysis for validation. SGS has the experience, ability and international approvals to test all types of products against published specifications, such as minimum or maximum limits, weights, quantities or other physical parameters.

SGS Minerals Services works for you to protect your interests and reduce your risk. Please contact us for the services and pricing specific to your commodity, cargo, product shipment and testing needs.

## SELECT METHODS

SGS offers a wide variety of select methods to analyze specific elements, species and/or groups of elements. These methods address specific circumstances that arise due to mineralogy, chemistry or commercial requirements. A selection of commonly requested methods are listed below and others are available. Please inquire.

### RARE EARTH ELEMENT ANALYSIS

Rare earth element (REE) samples can be analyzed using a variety of techniques depending on the concentration levels in the samples.

The following packages are available for trace to percent level concentrations. Please inquire to ensure we meet your requirements.

The following REE packages can be combined with the multi-trace packages for low grade mineralized samples, as listed in the Exploration-Grade Analysis section of this guide.

#### RARE EARTH ELEMENT TRACE PACKAGES

CODE(S)	ELEMENTS	DESCRIPTION
GE IMS12B / GE IMS14B	Pr, Nd, Sm, Eu, Gd, Dy, Ho, Er, Tm	2-Acid / AR digest / ICP-MS
GE ICM12B / GE ICM14B	Pr, Nd, Sm, Eu, Gd, Dy, Ho, Er, Tm	2-Acid / AR digest / ICP-AES / ICP-MS
GE ICM40B	Pr, Nd, Sm, Eu, Gd, Dy, Ho, Er, Tm	4-Acid digest / ICP-AES / ICP-MS
GE ICM90A	La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Yb, Lu, Tm, Th, U	Sodium peroxide fusion / ICP-AES / ICP-MS
GE IMS95A	La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Yb, Lu, Th, U, Y	Lithium metaborate fusion / ICP-MS

Note: For details on the above digestion techniques, refer to the Exploration-Grade Analysis section of this guide or contact your local SGS lab.

#### SODIUM PEROXIDE FUSION / ICP-MS REE PACKAGE (17 ELEMENTS)

##### GO IMS91B

##### ELEMENTS AND LIMIT(S)

La	50 ppm	Eu	1 ppm	Er	0.5 ppm	Y	5 ppm
Ce	50 ppm	Gd	5 ppm	Tm	0.1 ppm	U	1 ppm
Pr	10 ppm	Tb	1 ppm	Yb	1 ppm		
Nd	50 ppm	Dy	1 ppm	Lu	0.2 ppm		
Sm	10 ppm	Ho	0.1 ppm	Th	5 ppm		

Note: Other elements are available, please inquire. This technique requires a minimum sample weight of 0.5 g.

#### BORATE FUSION / XRF REE PACKAGE

##### GO XRF76R

##### ELEMENTS AND LIMIT(S)

La <sub>2</sub> O <sub>3</sub>	0.01 - 100%	Nd <sub>2</sub> O <sub>3</sub>	0.02 - 100%	Y <sub>2</sub> O <sub>3</sub>	0.02 - 100%
Ce <sub>2</sub> O <sub>3</sub>	0.02 - 100%	Sm <sub>2</sub> O <sub>3</sub>	0.05 - 100%	U <sub>3</sub> O <sub>8</sub>	0.01 - 100%
Pr <sub>2</sub> O <sub>3</sub>	0.03 - 100%	ThO <sub>2</sub>	0.01 - 100%		

Note: Other elements are available, please inquire. This technique requires a minimum sample weight of 5.0 g.

### SELECT COPPER METHODS

Copper can occur as oxide, sulphide and metallic forms in mineral deposits and metallurgical products so there are a variety of different analytical techniques available.

Note: Refer to the Exploration-Grade Analysis section for descriptions of the 12B, 14B, 40B and 90A digestion techniques. For descriptions of the 13B, 41Q, 42S and 90Q techniques, please see the Ore-Grade Analysis section, and for 13V and 03V refer to the Control-Grade Analysis section.



### EXPLORATION-GRADE COPPER METHODS

CODE(S)	LIMIT(S)	DESCRIPTION
GE ICP12B / GE ICP14B	0.5 ppm - 1%	2-Acid digest / Aqua regia – ICP-AES
GE IMS12B / GE IMS14B	0.5 ppm - 1%	2-Acid digest / Aqua regia – ICP-MS
GE ICM12B /GE ICM14B	0.5 ppm - 1%	2-Acid digest / Aqua regia – ICP-AES / ICP-MS
GE ICP40B	0.5 ppm - 1%	4-Acid digest – ICP-AES
GE ICM40B	0.5 ppm - 1%	4-Acid digest – ICP-AES / ICP-MS
GE ICP90A	10 ppm - 5%	Fusion – ICP-AES
GE ICM90A	10 ppm - 1%	Fusion – ICP-AES / ICP-MS
GE IMS90A	2 ppm - 5%	Fusion – ICP-MS

### ORE-GRADE COPPER METHODS

CODE(S)	LIMIT(S)	DESCRIPTION
GO ICP13B	0.01 - 30%	Aqua regia digest – ICP-AES
GO ICP41Q	0.01 - 30%	4-Acid digest – ICP-AES
GO AAS42S	0.001 - 50%	4-Acid digest – AAS
GO ICP90Q	0.01 - 30%	Fusion – ICP-AES

### CONCENTRATE-GRADE COPPER METHODS

CODE(S)	LIMIT(S)	DESCRIPTION
GC CON13V*	5 - 60%*	Short iodide titration
GC CON03V*	5 - 100%*	Electrogravimetry

\* These methods can be done at party or umpire quality (GT). In these cases, the upper end of the reporting range will be 100%.

### MINERAL SELECTIVE COPPER METHODS

CODE(S)	LIMIT(S)	DESCRIPTION
GO AAS71D	>0.002%	Cu oxide method, citric acid leach, AAS
GO AAS72B	>0.002%	Cu (non-sulphide method), H <sub>2</sub> SO <sub>4</sub> leach, AAS
GO AAS77C	>0.002%	Cu acetic acid soluble, AAS finish

GO CSC67D	>0.002%	CN soluble Cu, AAS finish
GO AAS01D	>0.001%	Metallic Cu, AgNO <sub>3</sub> digest, AAS
GO SQL01/02/03D	>0.002%	Sequential Cu leach (H <sub>2</sub> SO <sub>4</sub> soluble Cu, Cyanide soluble Cu, residual Cu), AAS finish

Note: Slight method and coding variations can occur in different regions.

## SELECT NICKEL METHODS

Nickel is used in stainless steels, metal alloys, plating, electric batteries and chemicals. It is found in either sulphide or laterite type ores so analytical methods are needed to ensure complete digestion.

Note: Refer to the Exploration-Grade Analysis section in this guide for descriptions of the 12B, 14B, 40B and 90A digestion techniques. For descriptions of the 13B, 41Q, 42S and 90Q techniques, please see the Ore-Grade Analysis section, and for 06V and 07V refer to the Control-Grade Analysis section.

### EXPLORATION-GRADE NICKEL METHODS

CODE(S)	LIMIT(S)	DESCRIPTION
GE ICP12B / GE ICP14B	1 ppm - 1%	2-Acid digest / Aqua regia – ICP-AES
GE IMS12B / GE IMS14B	0.5 ppm - 1%	2-Acid digest / Aqua regia – ICP-MS
GE ICM12B / GE ICM14B	0.5 ppm - 1%	2-Acid digest / Aqua regia – ICP-AES / ICP-MS
GE ICP40B	1 ppm - 1%	4-Acid digest – ICP-AES
GE ICM40B	0.5 ppm - 1%	4-Acid digest – ICP-AES / ICP-MS
GE ICP90A	10 ppm - 10%	Fusion – ICP-AES
GE ICM90A	5 ppm - 1%	Fusion – ICP-AES / ICP-MS
GE IMS90A	5 ppm - 5%	Fusion – ICP-MS

#### ORE-GRADE NICKEL METHODS

CODE(S)	LIMIT(S)	DESCRIPTION
GO ICP13B	0.01 - 30%	Aqua regia digest – ICP-AES
GO ICP41Q	0.01 - 30%	4-Acid digest – ICP-AES
GO AAS42S	0.001 - 5%	4-Acid digest – AAS
GO ICP90Q	0.01 - 30%	Fusion – ICP-AES

#### CONCENTRATE-GRADE NICKEL METHODS

CODE(S)	LIMIT(S)	DESCRIPTION
GC CON06V	5 - 65%	DMG separation / EDTA titration
GC CON07V	10 - 100%	DMG separation / electroplating

\* These methods can be done at party or umpire quality (GT). In these cases, the upper end of the reporting range will be 100%.

#### MINERAL SELECTIVE NICKEL METHODS

CODE	LIMIT(S)	DESCRIPTION
GO AAS03D	>0.002%	Metallic & sulphide nickel by bromine-methanol leach, AAS finish

Note: Additional selective methods for nickel may be available. Please inquire.

## ORES AND COMMODITIES

### IRON ORE

SGS has unmatched XRF expertise at many of our laboratories. Iron ore is common in many mineral forms (hematite, magnetite, goethite, limonite or siderite) and analytical methods must be carefully chosen as iron minerals respond differently to various analytical methods. Borate fusion/XRF analysis is an extremely robust technique for major and minor element analysis in complex ores and offers highly precise and accurate results for iron ore samples. This method is not suitable for materials in which sulphide minerals exceed 1%.

#### BORATE FUSION / XRF IRON ORE PACKAGE (14 ELEMENTS)

##### GO XRF78S

##### ELEMENTS AND LIMIT(S)

Al <sub>2</sub> O <sub>3</sub>	0.01 - 100%	MnO	0.01 - 100%	TiO <sub>2</sub>	0.01 - 100%
CaO	0.01 - 100%	Na <sub>2</sub> O	0.01 - 100%	V <sub>2</sub> O <sub>5</sub>	0.01 - 100%
Cr <sub>2</sub> O <sub>3</sub>	0.01 - 100%	P <sub>2</sub> O <sub>5</sub>	0.01 - 100%	SO <sub>3</sub>	0.01 - 100%
K <sub>2</sub> O	0.01 - 100%	Fe <sub>2</sub> O <sub>3</sub>	0.01 - 100%	LOI	0.01 - 100%
MgO	0.01 - 100%	SiO <sub>2</sub>	0.01 - 100%	SUM	%

Note: Additional minor elements can be added (As, Ba, Cl, Co, Cu, Ni, Pb, Sn, Sr, Ta, Zn and Zr). This method is available using robotic sample preparation as XRF78R in some SGS laboratories. This method is not suitable for samples with sulphide mineral contents > 1%. Please inquire.

#### VOLUMETRIC METHOD FOR IRON ORE

CODE	ELEMENT	LIMIT(S)	DESCRIPTION	MIN. SAMPLE WT.(g)
GC CON08V	Fe	10 - 75%	Titration	0.5

Note: these elements can be analyzed to party or umpire quality standards (GT) and can be reported up to 100%.

Magnetically susceptible minerals can be extracted from samples. Magnetic materials can be separated from nonmagnetic materials and materials with strong magnetic fields can be separated from materials with low magnetic fields. This property can be used to separate crushed iron ore at various stages of mineral processing.

The Satmagan test provides a measure of magnetic susceptibility, with results expressed as magnetic iron. The Davis Tube test also measures magnetic susceptibility, and can also separate various magnetic mineral phases. This allows for mass and elemental balancing.

SGS offers various magnetic separation techniques.

CODE(S)	TECHNIQUE	DESCRIPTION
GO PHY29V	Satmagan	Measures the total magnetic moment in a saturated magnetic field to determine the percentage of magnetic material present
GO PHY28V	Davis Tube	Separates and gravimetrically determines strongly magnetic particles from weak and non-magnetic particles

## URANIUM

SGS complies with all national licensing requirements associated with the safe handling and analysis of naturally occurring radioactive materials samples for transportation, workplace safety and environmental protection. The following analytical packages are specifically designed for uranium exploration and are offered at designated SGS laboratories.

Multi-element packages are listed in the Exploration-Grade Analysis section of this guide for low grade uranium analysis.

### URANIUM PACKAGES FOR LOW GRADE MINERALIZATION

CODE(S)	ELEMENTS/ LIMIT(S)	DESCRIPTION
GE IMS12B / GE IMS14B	U (0.05 - 10000 ppm)	2-Acid / aqua regia digest / ICP-MS
GE ICM12B / GE ICM14B	U (0.05 - 10000 ppm)	2-Acid / aqua regia digest / ICP-AES / ICP-MS
GE ICM40B	U (0.05 - 10000 ppm)	4-Acid digest / ICP-AES / ICP-MS
GE ICM90A	U (0.05 - 1000 ppm)	Sodium peroxide fusion / ICP-AES / ICP-MS
GE IMS95A	U (0.05 - 1000 ppm)	Lithium metaborate fusion / ICP-MS
GE MMI-ME	U (1 ppb)	Mobile Metal Ion Technology™ for soils

Multi-element packages are listed in the Ore-Grade Analysis section of this guide. These methods are for medium to highly mineralized samples that include uranium analysis.

### URANIUM PACKAGES FOR HIGHER GRADE MINERALIZATION

CODE(S)	ELEMENTS/ LIMIT(S)	DESCRIPTION
GO IMS91B	0.0001 - 1%	Sodium peroxide fusion / ICP-MS
GO XRF75F	0.002 - 3%	Internal standard / XRF
GO XRF76B	0.01 - 100%	Borate fusion with internal standard / XRF

## LITHIUM

SGS has the methodology to support exploration and production analysis of lithium. Multi-element packages are listed in the Exploration-Grade Analysis section of this guide for low grade lithium samples.

### LITHIUM PACKAGES FOR LOW GRADE MINERALIZATION

CODE(S)	ELEMENTS/ LIMIT(S)	DESCRIPTION
GE ICP12B / GE ICP14B	Li (1 - 10000 ppm)	2-Acid / aqua regia digest / ICP-AES
GE ICM12B / GE ICM14B	Li (1 - 10000 ppm)	2-Acid / aqua regia digest / ICP-AES / ICP-MS
GE ICP40B	Li (1 - 10000 ppm)	4-Acid digest / ICP-AES
GE ICM40B	Li (1 - 10000 ppm)	4-Acid digest / ICP-AES / ICP-MS

Multi-element packages are listed in the Exploration-Grade Analysis and Ore-Grade Analysis sections of this guide for medium to highly mineralized samples for lithium analysis.

### LITHIUM PACKAGES FOR HIGHER GRADE MINERALIZATION

CODE(S)	ELEMENTS/ LIMIT(S)	DESCRIPTION
GE ICP90A	Li (0.001 - 5%)	Sodium peroxide fusion / ICP-AES
GE ICM90A	Li (0.001 - 5%)	Sodium peroxide fusion / ICP-AES / ICP-MS
GE IMS90A	Li (0.0005 - 1%)	Sodium peroxide fusion / ICP-MS
GO AAS93B	Li (>0.001%)	Sodium peroxide fusion / AAS

## FLUORSPAR

SGS has the methodology to support testing of fluor spar material. Due to the nature of the test this scheme is only applicable to acid grade or other soluble fluor spar products.

### SOLUBLE FLUORSPAR PACKAGE

CODE(S)	ELEMENTS/ LIMIT(S)	DESCRIPTION
GC_CLA37V	Ca (1-50%)	EDTA Titration
	CaCO <sub>3</sub> (0.1-10%)	EDTA Titration
	CaF <sub>2</sub> (10-100%)	calculation

Note: For F results under 10%, CaF<sub>2</sub> can be determined by calculation from GC\_ISE05V. Samples with Ca content greater than 25% may not be suitable for GC\_ISE05V.

## GRAPHITIC CARBON

SGS has the methodology to support testing of graphitic carbon.

### GRAPHITIC CARBON PACKAGES

CODE(S)	ELEMENTS/ LIMIT(S)	DESCRIPTION	MIN. SAMPLE WT. (g)
GE_CSB05V	C graphitic (0.05%)	Coulometry	0.2
GC_CSA05V	C graphitic (0.05%)	Roast; HCl leach; IR Combustion	0.4
	C graphitic (>30%)	Roast; HCl leach; high temp IR combustion (*SC632)	0.4
GC_CSA06V	Total Carbon (<30%)	IR Combustion	0.2
	Total Carbon (>30%)	High temp IR Combustion (*SC632)	0.2
G_ASH01	**Ash content (0.01-10%)	Gravimetric	20

Note: \*SC632 high temperature IR combustion furnace provides greater precision for carbon >30%.

\*\*Ash content is not a suitable measurement of graphite purity for samples containing carbonates or other non-graphitic carbon species and is only recommended for samples >90% graphite.

### IMPURITIES FOR GRAPHITIC CARBON (12 ELEMENTS)

#### GC ICP95A

#### ELEMENTS AND LIMIT(S)

Al	10 ppm	K	8 ppm	P	20 ppm
Ba	0.3 ppm	Mg	3 ppm	Si	30 ppm
Ca	10 ppm	Mn	0.4 ppm	Ti	0.8 ppm
Fe	20 ppm	Na	5 ppm	Zr	0.3 ppm

Requires a minimum sample weight of 20 g.

Note: Trace impurities are determined by lithium metaborate fusion with ICP-AES analysis on residue obtained by ashing (G\_ASH01). Additional impurity elements are available upon request.

Graphitic carbon and impurity analysis is not available at all SGS locations, please inquire.

SGS offers a wide selection of analyses for ores, commodities and concentrates specific to your needs. The following list additional selections, and others are available. Please inquire.

- Manganese ores
- Aluminium ores (bauxite, including extractable SiO<sub>2</sub>, Al<sub>2</sub>O<sub>3</sub>, reactive Si, available Al)
- Tantalum ores
- Industrial minerals (limestone, chromite, borate)
- Fertilizers products (phosphate, sulphur, potash)
- Concentrates and metals
- Mineral sands



# MINERALOGY SERVICES

High Definition Mineralogy is the expert quantitative study of minerals using automated techniques. SGS is the world leader in providing comprehensive automated High Definition Mineralogy to the global minerals industry and other market sectors that need detailed material, product or residue characterizations.

SGS' world-class team of mineralogical professionals provides a significant interpretive value to the High Definition Mineralogy product at every stage of your project. Our expertise, years of experience and comprehensive capabilities allow us to provide crucial input into your strategic decisions, giving you the competitive advantage you need.

While we can support investigations and interpretations of mineralogical data in many industries, we specialize in applications rooted in the exploration and mining industry. High Definition Mineralogy can provide important insights at the acquisition, exploration, prefeasibility, feasibility and operational levels:

## **SUPPORT FOR MINERAL EXPLORATION AND RESOURCE DELINEATION**

Our EXPLOMIN™ products can help map the bulk mineralogy and ore textures with property development. Automated trace mineral searches are also available to identify precious or rare minerals including gold. We can also provide mineralogical, liberation and deportment data and interpretation in support of geometallurgical programs.

## **SUPPORT FOR METALLURGICAL OPERATIONS AND PLANTS**

Our ore characterization and process mineralogy offerings provide detailed snapshots of the factors that influence grindability and metallurgical recovery. Such data is used to support flowsheet development for grassroots start-ups, metallurgical accounting for on-going operations and to benchmark plants during audits and troubleshooting programs.

## **SUPPORT FOR ENVIRONMENTAL CONSIDERATIONS**

SGS provides the identification and deportment (texture) of minerals or phases in natural or industrial environments to:

- Support environmental programs (composition of waste rock, tailings and soils).
- Map deleterious mineral assemblages (As, Pb, Se).
- Establish sources of contaminants using forensic determinations.
- Analyze environments for industrial hygiene purposes (respirable silica and asbestos determinations).

SGS' team of applied and process mineralogists are experienced in the evaluation of ore samples and metallurgical products from a wide variety of commodities. Our Advanced Mineralogy Facilities are equipped with a wide variety of mineralogical equipment and techniques including:

- QEMSCAN®.
- X-ray diffraction (XRD).
- Scanning electron microscopy (SEM).
- Electronic microprobe.
- Optical mineralogy.

Refer to Rocks to Results, Section 5, and [www.sgs.com/mining/mineralogy](http://www.sgs.com/mining/mineralogy) for additional information.

# METALLURGY SERVICES

SGS's demonstrated success in metallurgical and process design has provided thousands of companies with effective flowsheets and practical technical solutions to processing problems. From that core of capability, we continue to provide the processing industry with innovative approaches to geometallurgy, process modeling, production forecasting and advanced control systems.

The major activities of SGS's mineral processing, metallurgy and process design experts include:

- Integrated analytical and mineralogical analysis.
- Risk mitigation using geometallurgical solutions.
- Development of environmentally sustainable processes and flowsheets for recovery and purification of pay metals.
- Confirmation of flowsheets via pilot plant testing programs.
- Development of new and innovative technologies for complex ore processing.
- Generation of engineering data for plant design purposes.
- Chemical engineering and process design for production facilities.

- On-site technical evaluations and audits.
- Evaluation and installation of advanced process control using expert systems.
- Evaluation and stabilization of discharge streams and waste products.

SGS provides solid, reliable, reputable, independent solutions for:

- Scoping studies.
- High Definition Mineralogy.
- Flowsheet development.
- Cyanidation technologies.
- Sustainable process development.
- Geometallurgy.
- Pilot plants.
- Bulk sample processing and market sample creation.
- Engineering data generation and modeling.
- Particulate testing.

For more information on the extensive range of bankable metallurgical services offered by SGS, please visit [www.sgs.com/metallurgy](http://www.sgs.com/metallurgy).

## CONVERSION FACTORS

### US STANDARD TEST SIEVE SERIES

AMERICAN ASTM	TYLER STANDARD SCREEN	INTERNATIONAL
INCH OR SIEVE	INCH OR SIEVE	MILLIMETERS OR MICRONS
1.06 inch	1.05 inch	26.50mm
1	-	25.00
7/8	0.883	22.40
3/4	0.742	19.00
5/8	0.624	16.00
0.53	0.525	13.20
1/2	-	12.50
7/16	0.441	11.20
3/8	0.371	9.50
5/16	2 1/2 mesh	8.00
0.265	3	6.70
1/4	-	6.30
3 1/2 sieve	3.5	5.60
4	4	4.75
5	5	4.00
6	6	3.35
7	7	2.80
8	8	2.36
10	9	2.00
12	10	1.70
14	12	1.40
16	14	1.18
18	16	1.00
20	20	850µm
25	24	710
30	28	600
35	32	500
40	35	425
45	42	355
50	48	300
60	60	250
70	65	212
80	80	180
100	100	150
120	115	125
140	150	106
170	170	90
200	200	75
230	250	63
270	270	53
325	325	45
400	400	38
450	-	32
500	-	25
635	-	20

### FREQUENTLY REQUESTED EQUIVALENTS

%	G/T (GRAMS / METRIC TONNE)	MG/KG	µG/KG	PPM	PPB
1	10,000	10,000	10,000,000	10,000	10,000,000
0.1	1000	1000	1,000,000	1000	1,000,000
0.01	100	100	100,000	100	100,000
0.001	10	10	10,000	10	10,000
0.0001	1	1	1000	1	1000

### CHEMICAL CONVERSION FACTORS

FORMULA	RESULT	FORMULA	RESULT
Al x 1.889	Al <sub>2</sub> O <sub>3</sub>	Mn x 1.291	MnO
Ba x 1.699	BaSO <sub>4</sub>	MnO x 1.2255	MnO <sub>2</sub>
Ba x 1.116	BaO	Mo x 1.668	MoS <sub>2</sub>
Be x 2.775	BeO	Na x 1.348	Na <sub>2</sub> O
Ca x 1.399	CaO	Nb x 1.431	Nb <sub>2</sub> O <sub>5</sub>
Ca x 2.497	CaCO <sub>3</sub>	P x 2.291	P <sub>2</sub> O <sub>5</sub>
CaO x 1.78479	CaCO <sub>3</sub>	Pb x 1.15474	PbS
Cr x 1.461	Cr <sub>2</sub> O <sub>3</sub>	Rb x 1.094	Rb <sub>2</sub> O
Cu x 1.25228	Cu <sub>2</sub> S	Si x 2.139	SiO <sub>2</sub>
F x 2.055	CaF <sub>2</sub>	Sn x 1.27	SnO <sub>2</sub>
Fe x 1.286	FeO	Sr x 1.185	SrO
Fe x 1.43	Fe <sub>2</sub> O <sub>3</sub>	Ta x 1.221	Ta <sub>2</sub> O <sub>5</sub>
Fe x 1.57414	FeS	Th x 1.138	ThO <sub>2</sub>
Fe <sub>2</sub> O <sub>3</sub> x 0.69943	Fe	Ti x 1.668	TiO <sub>2</sub>
Fe <sub>2</sub> O <sub>3</sub> x 0.89981	FeO	U x 1.179	U <sub>3</sub> O <sub>8</sub>
Fe <sub>2</sub> O <sub>3</sub> x 1.10101	FeS	V x 1.785	V <sub>2</sub> O <sub>5</sub>
K x 1.205	K <sub>2</sub> O	W x 1.261	WO <sub>3</sub>
Mg x 1.658	MgO	Y x 1.27	Y <sub>2</sub> O <sub>3</sub>
Mg x 3.46908	MgCO <sub>3</sub>	Zr x 1.351	ZrO <sub>2</sub>
MgO x 2.09176	MgCO <sub>3</sub>	Zn x 1.49044	ZnS

### DRILL CORE SPECIFICATION

	DIAMETER		VOLUME LENGTH	
	(MM)	(INCH)	M <sup>3</sup> X10 <sup>-3</sup> / M	INCH <sup>3</sup> / FOOT
AQ	27.0	1.062	0.57	10.6
TT	35.0	1.378	0.96	17.8
BQ	36.4	1.433	1.04	19.3
NQ	47.6	1.875	1.78	33.1
HQ	63.5	2.500	3.17	58.9
BQ3	33.5	1.320	0.88	16.4
NQ3	45.1	1.775	1.60	29.7
HQ3	61.1	2.406	2.93	54.6
PQ3	83.1	3.270	5.43	100.8
PQ	85.0	3.345	5.67	105.5

### CONVERSION FACTORS

	TROY OUNCES PER				
	PARTS PER MILLION (ppm)	PARTS PER BILLION (ppb)	METRIC TONNE	SHORT TON	LONG TON
1 Gram / MT	1	1000	0.03215	0.02917	0.0327
1 Troy oz / short ton	34.286	34286	1.1023	1	1.12



# SGS MINERALS LOCATIONS

## GEOCHEMISTRY CONTACTS

### AUSTRALIA

#### KALGOORLIE

---

17 Stockyard Way, Broadwood, WA, 6430  
Tel: + 61 (08) 9021 2911  
Jared Olsen, [au.kalgoorlielab@sgs.com](mailto:au.kalgoorlielab@sgs.com)

#### PERTH

---

28 Reid Rd., Perth Airport, WA, 6105  
Tel: + 61 (0)8 9373 3500  
Graeme Farrant, [au.newburnlab@sgs.com](mailto:au.newburnlab@sgs.com)

#### TOWNSVILLE

---

50 Leyland St., Garbutt, QLD, 4814  
Tel: + 61 (0)7 4725 2311  
Anthony Wilson, [au.townsvillelab@sgs.com](mailto:au.townsvillelab@sgs.com)

#### WEST WYALONG

---

Lot 9, Gelling St., West Wyalong, NSW, 2671  
Tel: + 61 (0)2 6972 1211  
Robert Moses, [robert.moses@sgs.com](mailto:robert.moses@sgs.com)

### BRAZIL

#### BELO HORIZONTE

---

SGS Geosol Laboratorios Ltda, Rodovia MG 010, Km 24, 5  
Bairro Angicos 33200-000 - Vespasiano - MG  
Tel: + 55 31 30450200  
Alberto Faria, [alberto.faria@sgsgeosol.com.br](mailto:alberto.faria@sgsgeosol.com.br)

### BURKINA FASO

#### OUAGADOUGOU

---

Zone Industrielle de Kossodo  
11 BP: 565 Ouagadougou 11  
Mob: + 226 70 21 21 02  
Helena Bouda, [helena.bouda@sgs.com](mailto:helena.bouda@sgs.com)

### CANADA

#### COCHRANE

---

1 First Ave., Cochrane, ON P0L 1C0  
Tel: + 1 705 272 2559  
Ken Williams, [minerals@sgs.com](mailto:minerals@sgs.com)

#### LAKEFIELD

---

185 Concession St., Lakefield, ON K0L 2H0  
Tel: + 1 705 652 2000  
Shelley Meyers, [minerals@sgs.com](mailto:minerals@sgs.com)

#### RED LAKE

---

16A Young St., Red Lake, ON P0V 2M0  
Tel: + 1 807 727 2939  
Susan Isaac, [minerals@sgs.com](mailto:minerals@sgs.com)

#### VANCOUVER

---

3260 Production Way, Burnaby, BC V5A 4W4  
Tel: + 1 604 638 2349  
Andrew Lai, [minerals@sgs.com](mailto:minerals@sgs.com)

### CHILE

#### ANTOFAGASTA

---

Av. El Cobre #400 Parque Industrial, La Negra, Antofagasta  
Mob: + 56 99 8680857  
Enrique Bravo, [enrique.bravo@sgs.com](mailto:enrique.bravo@sgs.com)

#### CALAMA

---

Camino a Antofagasta S/N, Sitio 34, Parque Industrial APIAC  
Mob: + 56 99 8680857  
Enrique Bravo, [enrique.bravo@sgs.com](mailto:enrique.bravo@sgs.com)

#### COPIAPO

---

Calle 4, N° 718, Barrio Industrial Paipote, Copiapo  
Mob: + 56 99 8680857  
Enrique Bravo, [enrique.bravo@sgs.com](mailto:enrique.bravo@sgs.com)

## **SANTIAGO**

---

Puerto Madero 9600, Parque Industrial Puerto Santiago  
Pudahuel – Santiago  
Mob: + 56 99 8680857  
Enrique Bravo, [enrique.bravo@sgs.com](mailto:enrique.bravo@sgs.com)

## **CHINA**

### **TIANJIN**

---

SGS Mansion, No. 41, The 5th Ave., TEDA, Tianjin, 300457  
Tel: + 86 (0) 22 6528 8209  
Freeman Bu, [freeman.bu@sgs.com](mailto:freeman.bu@sgs.com)

### **URUMQI**

---

No. 82, Nanyixiang, Huangshan St.  
2nd Development Area, Urumqi, XJ, 830026  
Tel: + 86 (0) 991 3775351  
Jenny Ma, [jenny.ma@sgs.com](mailto:jenny.ma@sgs.com)

## **COLOMBIA**

### **MEDELLIN**

---

Carrera 52 N° 14 Sur 26, Medellin  
Mob: + 57 4 3201080  
William Joleane, [william.joleane@sgs.com](mailto:william.joleane@sgs.com)

## **DEMOCRATIC REPUBLIC OF THE CONGO**

### **LUBUMBASHI**

---

No. 006838, Route Likasi, Quartier Jolie Site  
Commune Annexe, Ville de Lubumbashi  
Lubumbashi, Haut Katanga  
Mob: + 243 8130 77538  
Alex Adom, [alex.adom@sgs.com](mailto:alex.adom@sgs.com)

## **GHANA**

### **TARKWA**

---

Jerusalem Junction, Bankyim, Tarkwa  
Western Region, P.O. Box 38, Tarkwa  
Mob: + 233 (0) 24 432 3404  
Thelma Botes, [thelma.botes@sgs.com](mailto:thelma.botes@sgs.com)

## **INDONESIA**

### **JAKARTA**

---

Sentra Industri Terpadu, Pantai Indah Kapuk  
Blok E2 No. 28, 29, 37, 38, Jalan Kamal Muara VII, Jakarta Utara  
Mob: + 62 21 5698 2898  
Nopi Mujiyanto, [nopi.mujiyanto@sgs.com](mailto:nopi.mujiyanto@sgs.com)

## **MALAYSIA**

### **PORT KLANG (NEAR KUALA LUMPUR)**

---

Wisma SGS, Lot 603, Leboh Raja Lumu  
Kawasan Perindustrian PKNS, Pandamaran  
Port Klang, Selangor, 42000  
Tel: + 60 3 3165 2320  
Gopi Dass Sivanandan, [gopidass.sivanandan@sgs.com](mailto:gopidass.sivanandan@sgs.com)

## **MALI**

### **BAMAKO**

---

Zone Industrielle Sotuba, Rue 947, Porte 213, BPE 2514 Bamako  
Mob: + 223 66 74 62 39  
Firmin Bado, [firmin.bado@sgs.com](mailto:firmin.bado@sgs.com)

### **BAMAKO**

---

c/o Morila Gold Mine, BPE 1194, Bamako  
Mob: + 223 6558 9955  
E. Ohene Darko, [emmanuel.ohenedarko@sgs.com](mailto:emmanuel.ohenedarko@sgs.com)

## **MEXICO**

### **DURANGO**

---

Antimonio #121 Cd. Industrial, Durango, CP 34208  
Mob: + 52 1 618 125 1819  
Marco Barragan, [marco.barragan@sgs.com](mailto:marco.barragan@sgs.com)

## **MONGOLIA**

### **ULAANBAATAR**

---

Uildveriin toirgiin 101 toot, Bayangol district 20th khoroo, Ulaanbaatar 36  
Tel: + 976 7014 4415  
Ankhubayar L., [luv.ankhubayar@sgs.com](mailto:luv.ankhubayar@sgs.com)

## NEW ZEALAND

### WAIHI

---

43 Victoria St., Waihi, 3610, P.O. Box 135, Waihi, 3641  
Tel: + 64 7 863 8969  
Chris Morgan, [chris.morgan@sgs.com](mailto:chris.morgan@sgs.com)

### WESTPORT

---

5 Lyttelton St., Westport, P.O. Box 240, 7866  
Mob: + 64 3 788 9003  
Nick Lees, [nick.lees@sgs.com](mailto:nick.lees@sgs.com)

## PAKISTAN

### KARACHI

---

H3/3 Sector #5, Korangi Industrial Area, Karachi, 74900  
Tel: + 92 21 3512 1388  
Tasneem Ilyas, [tasneem.ilyas@sgs.com](mailto:tasneem.ilyas@sgs.com)

## PERU

### LIMA (CALLAO)

---

Ave. Elmer Faucett, 3348, Callao 1 (Lima)  
Tel: + 51 1 517 1900  
Maria Elena Napanga, [mariaelena.napanga@sgs.com](mailto:mariaelena.napanga@sgs.com)

## RUSSIA

### CHITA

---

5 Malaya St., 672014, Chita  
Tel: + 7 (3022) 31 46 44  
Anton Shatskikh, [anton.shatskikh@sgs.com](mailto:anton.shatskikh@sgs.com)

## SOUTH AFRICA

### ALLANRIDGE (NEXT TO TARGET MINE)

---

2 Buffalo St., Allanridge, Free State, 9490  
Tel: + 27 (57) 451 3412  
Dwyne Van Zyl, [dwyne.vanzyl@sgs.com](mailto:dwyne.vanzyl@sgs.com)

## BARBERTON

---

Rusplaas, Noordkaap, Barberton, Mpumalanga, 1300  
Tel: + 27 (13) 719 9775  
Wimpie Geldenhuys, [wimpie.geldenhuys@sgs.com](mailto:wimpie.geldenhuys@sgs.com)

### RANDFONTEIN

---

Zuurbekom Rd., Next to Cooke Recovery Plant Randfontein, Gauteng, 1760  
Tel: + 27 (0) 79 841 5877  
Stephan Botha, [stephan.botha@sgs.com](mailto:stephan.botha@sgs.com)

## RUSTENBURG

---

1 Ferro Street, Industrial Area, Rustenburg, 0299  
Tel: + 27 (0) 14 592 1654/8273  
Wilford Tapudzai, [wilford.tapudzai@sgs.com](mailto:wilford.tapudzai@sgs.com)

## TANZANIA

### MWANZA

---

Nyanza Glass Works, Shinyanga Rd., Mwanza  
Tel: + 255 28 2550861  
Siegmund Laryea, [sgs.mwanza@sgs.com](mailto:sgs.mwanza@sgs.com)

## TURKEY

### ANKARA

---

Ankara 1. Organize Sanayi Bölgesi  
Orhan Isik Cad No:11 Sincan Ankara, 06935  
Mob: + 90 533 020 2149  
Z. Nazli Hatipoglu, [nazli.hatipoglu@sgs.com](mailto:nazli.hatipoglu@sgs.com)

## ZAMBIA

### KALULUSHI

---

SGS Kalulushi Chibuluma Business Park, Kalulushi  
Tel: + 260 (212) 730045 / 46  
Joseph Chibesa, [joseph.chibesa@sgs.com](mailto:joseph.chibesa@sgs.com)

## ZIMBABWE

### HARARE

---

603 Shumba Rd., Ruwa, Harare  
Tel: + 263 273 3058 / 3069  
Masimera Mangana, [masimera.mangana@sgs.com](mailto:masimera.mangana@sgs.com)

## METALLURGY CONTACTS

### AUSTRALIA

#### PERTH

---

431 Victoria Rd., Malaga, WA, 6090  
Tel: + 61 (0)8 9209 8700  
Dwight Van Der Meulen, [dwight.vandermeulen@sgs.com](mailto:dwight.vandermeulen@sgs.com)

### BRAZIL

#### BELO HORIZONTE

---

SGS Geosol Laboratorios Ltda, Rodovia MG 010, Km 24, 5  
Bairro Angicos 33200-000, Vespasiano, MG  
Tel: + 55 31 30450200  
Fernanda Santos, [fernanda.santos@sgsgeosol.com.br](mailto:fernanda.santos@sgsgeosol.com.br)

### CANADA

#### LAKEFIELD

---

185 Concession St., Lakefield, ON K0L 2H0  
Tel: + 1 705 652 2000  
Richard Wagner, [minerals@sgs.com](mailto:minerals@sgs.com)

#### QUEBEC

---

125 rue Fortin, Suite 100, Québec, QC G1M 3M2  
Tel: + 1 418 661 6624  
Francois Verret, [minerals@sgs.com](mailto:minerals@sgs.com)

#### TORONTO

---

1140 Sheppard Ave. West, Unit #6, Toronto, ON M3K 2A2  
Tel: + 1 416 633 9400  
Alan Gomez, [minerals@sgs.com](mailto:minerals@sgs.com)

#### BURNABY (VANCOUVER)

---

3260 Production Way, Burnaby, BC V5A 4W4  
Tel: + 1 604 638 2349  
Sarah Prout, [minerals@sgs.com](mailto:minerals@sgs.com)

### CHILE

#### SANTIAGO

---

Puerto Madero 9600, Parque Industrial Puerto Santiago, Pudahuel – Santiago  
Tel: + 56 2 898 9100  
Reinaldo Barrera, [reinaldo.barrera@sgs.com](mailto:reinaldo.barrera@sgs.com)

### PERU

#### LIMA (CALLAO)

---

Ave. Elmer Faucett, 3348, Callao 1 (Lima)  
Tel: + 51 1 517 1900  
Edmundo Alfaro, [edmundo.alfaro@sgs.com](mailto:edmundo.alfaro@sgs.com)

### RUSSIA

#### CHITA

---

5 Malaya St., 672014, Chita  
Tel: + 7 (3022) 31 46 44  
Eugenia Glotova, [eugenia.glotova@sgs.com](mailto:eugenia.glotova@sgs.com)

### SOUTH AFRICA

#### BOOYSENS-JOHANNESBURG

---

259 Kent Ave., Ferndale, Randburg  
Mob: + 27 (0) 82 894 4165  
Gavin Martin, [gavin.martin@sgs.com](mailto:gavin.martin@sgs.com)

### UNITED KINGDOM

#### CORNWALL

---

Wheal Jane, Truro, Cornwall, TR3 6EE  
Tel: + 44 0 1872 561577  
Nigel MacDonald, [nigel.macdonald@sgs.com](mailto:nigel.macdonald@sgs.com)

# ENGINEERING SERVICES CONTACTS

## SOUTH AFRICA

### JOHANNESBURG

---

SGS Bateman (Pty) Ltd  
Woodmead North Office Park  
54 Maxwell Drive, Waterfall 2191  
Tel: + 27 11 100 9100  
Bert van Hege, [bert.vanhege@sgs.com](mailto:bert.vanhege@sgs.com)  
Ken Richardson, [ken.richardson@sgs.com](mailto:ken.richardson@sgs.com)

## UNITED STATES

### TUCSON

---

3845 N. Business Center Dr., Suite 111, Tucson, AZ, 85705  
Tel: + 1 520 579 8315  
John Holley, [john.holley@sgs.com](mailto:john.holley@sgs.com)

[WWW.SGS.COM](http://WWW.SGS.COM)

WHEN YOU NEED TO BE SURE

