

GEOCHEMISTRY GUIDE 2020

THE FOUNDATION OF PROJECT SUCCESS

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SGS



ABOUT SGS

By incorporating an integrated approach, we deliver testing and expertise throughout the entire mining life cycle. Our services include:

- Helping you to understand your resources with a full-suite of geological services, including **XploreIQ**,
- Offering innovative analytical testing capabilities through dedicated on-sites, **FAST** or one of commercial laboratories,
- Consulting and designing metallurgical testing programs, unique to your deposit,
- Optimizing recovery and throughput through process control services,
- Keeping final product transparent through impartial trade analysis,
- Ensuring safe operations for employees while helping to mitigate environmental impact.

Whether your requirements are in the field, at a mine site, in a smelting and refining plant, or at a port, SGS has the experience, technical solutions and laboratory professionals to help you reach your goals efficiently and effectively.

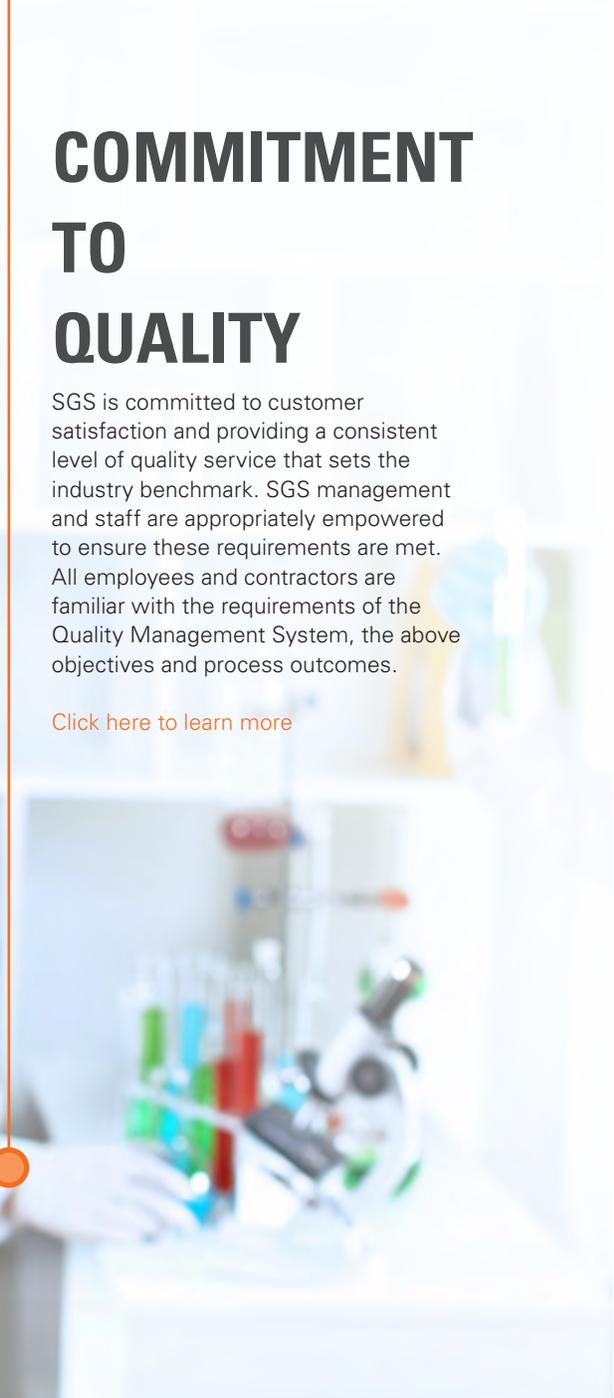
VISIT US AT:
WWW.SGS.COM/MINING



COMMITMENT TO QUALITY

SGS is committed to customer satisfaction and providing a consistent level of quality service that sets the industry benchmark. 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.

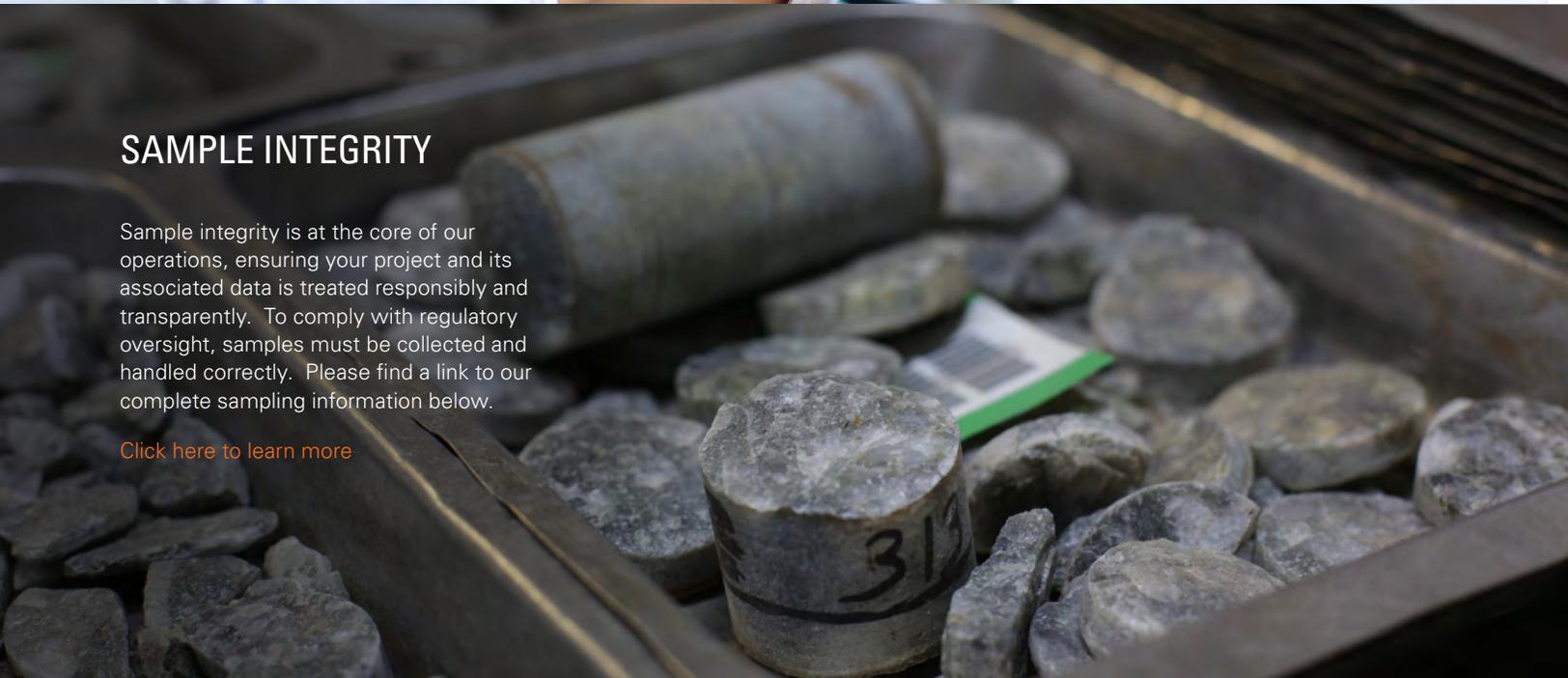
[Click here to learn more](#)



SAMPLE INTEGRITY

Sample integrity is at the core of our operations, ensuring your project and its associated data is treated responsibly and transparently. To comply with regulatory oversight, samples must be collected and handled correctly. Please find a link to our complete sampling information below.

[Click here to learn more](#)





ON-SITE LABORATORIES

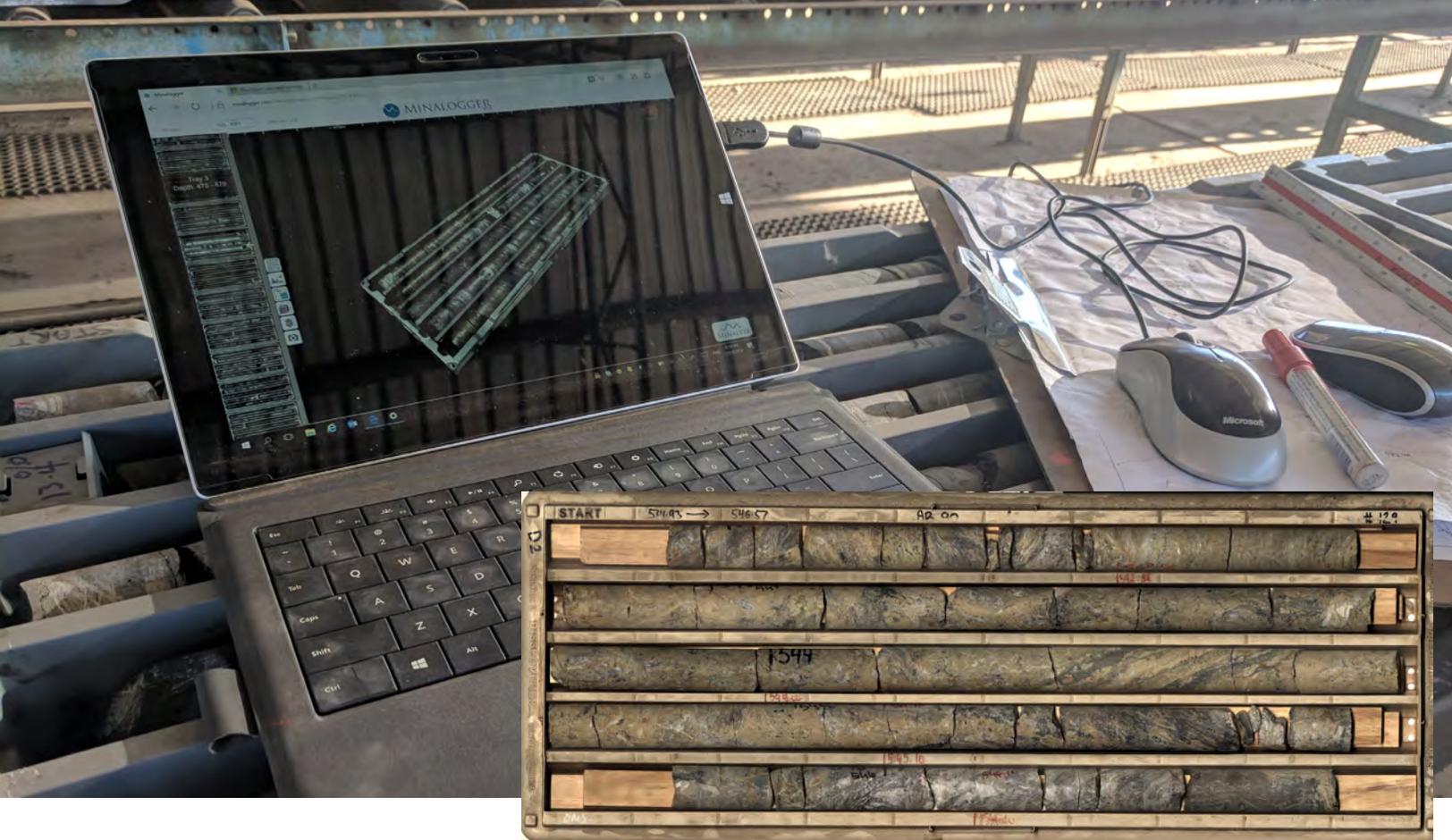
SGS offers integrated design, construction and management services for on-site laboratories. No matter how remote your operation, SGS services can be deployed to your site and tailored to your specific needs. SGS' on-site laboratory expertise is unparalleled in the industry, with more than 90 on-site analytical laboratories currently in operation. We apply the same principles, procedures and quality standards to our outsourced laboratories as are in practice in 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. 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, and provides clients the opportunity to outsource capital requirements, engineering, construction, commissioning, maintenance and operation of non-core facilities to industry specialists.





FAST

Field Analytical Services and Testing (FAST) transforms what has become the norm for the commercial laboratory. We have taken instruments into the field and can provide laboratory-quality data in as little as 24- to 48-hours, enabling operational decisions quicker than ever before. Samples stay on-site and you retain full control.

By using a combination of the instruments listed below, our industry-known QA/QC protocols, dedicated sample preparation in a Mobile Sample Prep Unit (MSPU) and site-calibrated data, you will be able to optimize operational spending and ensure speed-to-market ahead of your peers.

Our suite of services include:

- Fourier Transform Infrared spectroscopy (FTIR)
- pXRF
- Minalyzer CS EDXRF core scanning
- NIR spectroscopy
- Portable XRD

To maximize the return of the considerable investment in obtaining core, SGS provides expert geological exploration services for comprehensive core characterization in gold and precious metals, base metals, iron ore, coal, uranium and industrial minerals. Services may include manual logging by an experienced team of SGS geologists, and /or chemical and mineralogical data obtained by hand held XRF, NIR, or portable XRD units integrated with a MSPU and deployed at the drill site or in an SGS facility. Sampling frequencies can be flexible to project requirements.

We have incorporated the Minalyzer CS into our suite of instruments used in exploration because of its rapid, non-destructive, objective and standardized chemical testing and digital core logging through its proprietary, cloud-based Minalogger portal. When pairing the XRF data with SGS' AI and machine learning services can bring about a step change in core logging practices.

Taken on-site, the Minalyzer CS provides quality analysis in a fraction of the time compared to traditional analytical labs. By using the Minalyzer CS, you can expect to optimize operational spending and increase efficiency by:

- Receiving critical information quickly to enable field-based operational decision making, in-turn spending less time and money waiting for data to determine next steps.
- Obtaining lab quality data on-site through an instrument that is specifically calibrated for your geology, diverting costs away from traditional commercial lab expenses and into dedicated field- based analysis.
- Performing accurate and consistent logging of core through the Minalogger software for future availability of information.

FIND OUT MORE AT:
WWW.SGS.COM/FAST



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. Please contact us for other locations available at minerals@sgs.com.

SGS analysts perform quality, multi-element analyses that target a wide variety of elements in many types of sample matrices. The guide fully details the analyses available.

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.

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.

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.

[Click here to learn more](#)

MISCELLANEOUS ANALYSIS

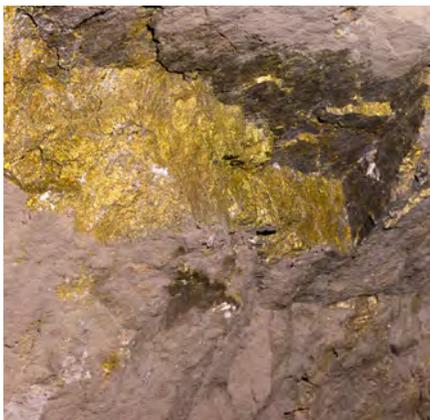
In addition to the analyses offered throughout this guide, we can provide a number of complimentary tests. These tests include:

- Moisture and Loss on Ignition (LOI)
- Particle size analysis
- Specific gravity and bulk density

Information on these tests are provided in the technical portion of this guide, located [here](#).



EXPLORATION ANALYSIS



PRECIOUS METALS

Precious metals (gold, silver and platinum group elements) can be analyzed by many techniques. Procedures for gold determination must take into account:

- 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.

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.

For more information, including analysis available, please find more information [here](#).

ORE-GRADE ANALYSIS (MINE GRADE CONTROL)

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 methods with select elements reaching upper limits of 30%.

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. Refer to [GO_ICP21B100](#) and [GO_ICP42Q100](#) in the technical portion of the [guide](#).

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% (process control analysis). 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.

Metallurgical processes are monitored and controlled by the chemical analysis of feed and head samples, middlings, concentrates, metals, tails, slags, residues and/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.

Information, including analysis available can be found [here](#).



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.

SGS is the global leader and innovator in inspection, verification, testing and certification services. Our Minerals group, with its global network of laboratories and offices, is fully supported by our flagship trade lab in Spijkenisse, Netherlands. Throughout the network, we provide 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 specialty 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 assays (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-OES 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 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.

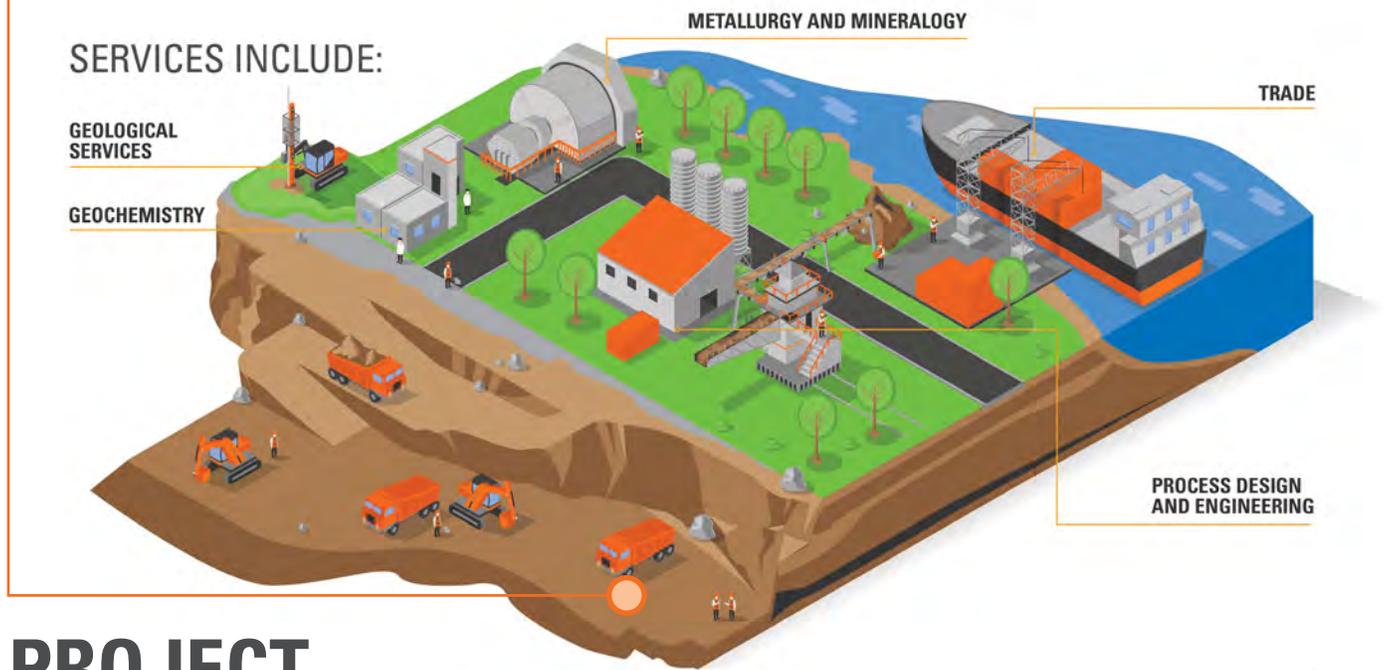
Information, including analysis available can be found [here](#).

ORES AND COMMODITIES

In addition to the analysis showcased here and in the technical guide, we provide analysis for additional ores and commodities of interest. These include:

- Iron Ore
- Uranium
- Lithium
- Fluorspar
- Graphitic carbon
- Base metals (Cu, Ni, Pb, Zn)

Information, including analysis available can be found [here](#).



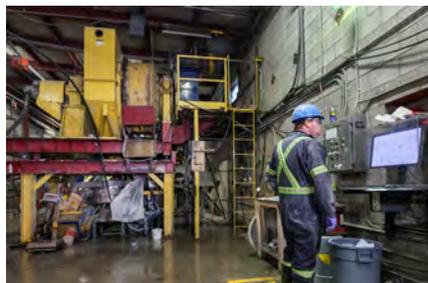
PROJECT LIFECYCLE



GEOLOGICAL SERVICES

The market has changed and SGS is technically competitive to bring your deposit to market quickly. We bring the disciplines of geology, geostatistics and mining engineering together to provide you with accurate and timely mineral project evaluation and consulting solutions.

- Technical reports & desktop studies,
- Geological modelling & resource estimation using GENESIS™ software,
- Sample selection to ensure representativity,
- Mine optimization including design, scheduling & financial analysis,
- Mine audits including resources, reserves, mine to plant reconciliation & technical due diligence,
- Industry leading and client proven drill-target creation through [XploreIQ](#).



METALLURGY AND MINERALOGY

With over 75 years of experience, SGS has earned the reputation as the leading supplier of proven, technologically advanced metallurgical and mineralogical services. Our expertise and capabilities will ensure optimal recovery, maximizing your project throughout its lifecycle.

- Complete testing capabilities: mineralogy, comminution, mineral processing, gold services, hydrometallurgy & rheology,
- Geometallurgical approach to robust flowsheets design by integrated simulation for comminution and mineral process flowsheets,
- Applied research & development at the bench & pilot scale,
- Expert grindability capabilities,
- Mine waste & acid rock characterization.



PROCESS DESIGN AND ENGINEERING

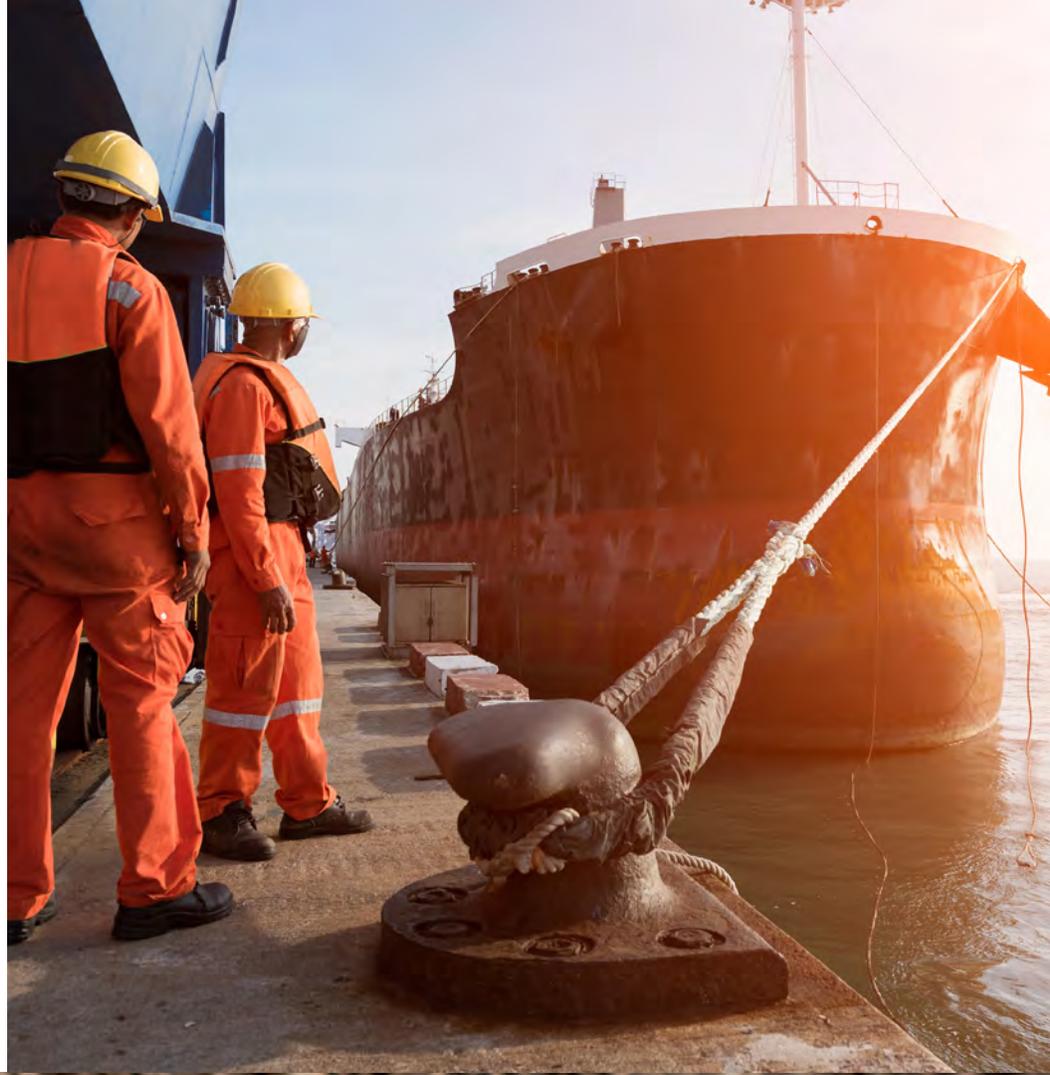
By including engineering and process design into our portfolio, SGS is the only minerals service provider to supply a full suite of services across the project lifecycle. Our engineering capabilities, complimented by our testing services, will give you the optimization required to differentiate your project in the marketplace.

- Specialists in advanced process control (APC) for increased throughput & recovery,
- Mine process and metallurgical audits to increase recovery and debottleneck operations.

TRADE

In a globalized trading world of minerals and metals commodities, SGS can reduce your commercial risk by ensuring that your shipments meet international standards and contractual specifications regarding quality and quantity. Our trusted inspectors and samplers are well-trained professionals who will represent your interests at international ports, warehouses, or facilities

- Pre-shipment audits & supervision of loading & discharge,
- Visual, hold & hatch inspections,
- Assessment of weight, tally & tally control,
- Draft surveys using our proprietary **DST** & stockpile inventories,
- Customized traditional & mechanical sampling solutions,
- Moisture, sieve & chemical testing,
- TML & FMP testing.



ENVIRONMENTAL SUSTAINABILITY, HEALTH & SAFETY

ENVIRONMENTAL SUSTAINABILITY

The metals and mining industry is becoming evermore dependent upon meeting sustainability requirements. We offer a full range of environmental services to clients with the intention of helping them to exceed stakeholder expectations. These include:

- Soil and water testing under government regulations during impact assessments and as part of a routine monitoring program.
- Mineralogical testing for closure plans.
- Acid Rock Drainage (ARD) testing.
- Climate change assessments, greenhouse gas accounting & carbon footprint certification.

OCCUPATIONAL HEALTH & SAFETY

Worker health and safety is an important part of every industry. We help our clients by providing the following services:

- Noise, air quality, & vibration monitoring.
- Asbestos identification.
- Occupational health & safety assessments and certifications
- Safety training



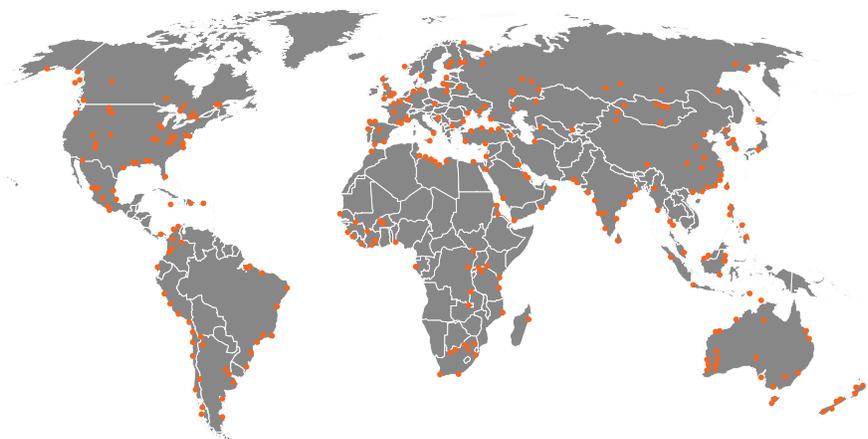
ADDITIONAL INFORMATION

CONVERSION FACTORS

Please see [here](#) for a full list of conversion factors.

LOCATIONS AND CONTACTS

SGS is the world's leading inspection, verification, testing and certification company. Our unparalleled network of on-site, commercial and trade offices and laboratories mean that we can provide a local approach to our global operations. We are in every major mining jurisdiction and port. For a complete listing of our locations, please visit us [here](#) or contact us at minerals@sgs.com.



TECHNICAL GUIDE

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www.sgs.com/en/mining/analytical-services/geochemistry

YOUR GLOBAL PARTNER

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 2,600 offices and laboratories around the world and employs over 94,000 employees in 300+ countries. Throughout this guide, you will see images from our world-class operations.

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, metallurgical, and mineralogical 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 minimum number of methods you need so you can maximize your analytical dollar.

SGS is currently in the process of upgrading our IT systems which includes implementing a new version of our Laboratory Information Management System. (LIMS). This upgrade represents a significant and generational change to our LIMS software. The new LIMS will be a fully cloud based, globally networked system that is being rolled out across the entire SGS laboratory network. The changes have been driven by major architectural advances in cloud-based technologies together with increasing demand to improve integrations with both internal and external systems. Major enhancements were also needed to further protect and preserve our analytical data and improve system and data security against unauthorized access.

As we transition to the new systems we have further standardized our global reference data. This has resulted in some changes to LIMS reference information and codes that are used in the configuration and set-up of the system.

- 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 74 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 customer services representative for details and pricing. Samples can be submitted to any analytical laboratory, through our on-line submission form found [here](#), 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 to another laboratory, 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 analytical needs.

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, monitored, accessible and followed.

We 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 internal audit program.
- Seeking customer feedback.
- Utilizing a continuous improvement system.
- Applying clever and extensive quality control and quality assurance protocols to ensure our delivery exceeds the industry benchmark.
- Providing appropriate staff training and competency testing.

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/en/mining/analytical-services/geochemistry 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 platform, SLIM, 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 undergo ethics and integrity training annually.

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 laboratories are ISO/IEC 17025 accredited. SGS provides analytical services for every stage of your project including:

- 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. An explanation of process and grade control is located at the front of the guide, [here](#).

Commercial transaction assays require highly precise and accurate assays involving classical methodology.

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 (detection limit) is frequently used to market method capabilities but depending upon how this limit is validated and tested, this limit 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. A 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 contractual arrangements should be discussed with the appropriate laboratory customer 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 enquire.

MSPU AND ON-SITE TESTING SERVICES

FIELD ANALYTICAL SERVICES & TESTING (“FAST”)

SGS has responded to the exploration and mining industries’ need for improved analytical turnaround by combining a suite of field-based testing technologies that offer short lead-time on results, in order to facilitate faster operational decisions. We can now offer exploration and mining projects consistent and quality data and FAST turnaround for a large suite of geologically and metallurgically significant analytes.

These robust and portable technologies can be deployed to the field to generate reliable data on a <48 hour TAT to meet the ever-evolving need for rapid analytical data, and have been incorporated into a suite of field-based service packages, which will be accessible to you under the banner of “FAST” – Field Analytical Services & Testing (“FAST”). The packages will be tailored to meet both the technical and financial requirements of the development phase of your project. More information can be found at www.sgs.com/FAST.

The current set of FAST portable analytical technologies generate both chemical and mineralogical data and will be continually updated and augmented with new technologies as they become available in the market and / or new industry testing requirements are identified. In each instance, SGS will complete comprehensive testing of each new technology to ensure that the quality requirements can be achieved, prior to their availability within FAST. Precious metals, Au, Pt, Pd and Rh are not available using this technique as they can be highly biased due to interelement and matrix effects that cannot be removed. Please enquire.

The FAST services currently offered globally are:

- Mobile Sample Preparation Units (MSPUs)
- Minalyze WD-XRF Core Scanning systems
- Portable XRF analysis systems (pXRF)
- FTIR analysis systems (FTIR)
- Machine learning and advanced data analysis

PORTABLE XRF (PXRF) (CHEMISTRY / ELEMENTAL ANALYSIS)

SGS offers a range of analytical techniques which generate indicative assay results, making use of a generic calibration setup and generic Quality Control samples (mid to low mineralized sediment, mineralized mine rock) with a wide analytical range. Portable XRF is the ideal technique for screening large volumes of samples for a comprehensive element range, and concentration ranges spanning exploration to ore grade mineralization(s). Highly mineralized samples, process feeds, materials and concentrates can also be screened either in the sample bag, or as prepared pulp. This flexibility allows its use throughout the whole mining cycle, from exploration, to process control to remediation.

SGS has partnered with Bruker and Olympus, to offer pXRF with client specific calibrations, which are superior to the traditional type standardization approach. This allows for a wider operating range, and can model the mineralogical and grain size range of the specific material.

For high grade ore, process materials and concentrates, it is recommended that a quality control setup be implemented. This will mitigate the high risk of inaccurate results, as well as false positives. When analysing materials in the sample bag, the analysis needs to be calibrated for the respective bag used. It is also imperative that all samples are in the same type/model bag. Some elements such as Ca, S, Ti, Zn might be part of the composition of the sample bag, which limits their detection in the sample.

For larger volumes of samples, SGS offers a customized matrix matched setup, which is site specific. This includes range-targeted Quality Control materials to allow for JORC compliance, as well as consistent input for geochemical modelling and machine learning.

These applications are also adjusted and continuously monitored to ensure the highest consistency and prompt reaction to any mineralogical change. Historical measurement data can also be reprocessed with the updated application, to further increase data quality and additional elements can also be added.

As part of the FAST offering, the on-site analytical techniques, including pXRF, can be deployed to the client site or a designated SGS preparation laboratory. The FAST project techniques are all set up to be matrix or site specific. The SGS Quality Control calibrations are traceable, with either matrix matched reference material (MMRM) or site specific reference material (SSRM). The application is continuously checked by performing confirmation analysis on 5-20% of the site samples at an SGS commercial laboratory. This confirmation analysis can also be used to improve a generic calibration to a site-specific calibration.

Please contact the Customer Service representative for your region for more information and advice on selecting the method and application for your project.

EXPLORATION/SOIL PXRF PACKAGE

GE_PXRF73GEO

Pulp based measurement for rocks, sediments, RC drill cuttings and crushed core for litho-geochemistry. Sediment samples are used as Quality Control.

ELEMENTS AND LIMIT(S)

Ag* 0.005 - 0.01 %	Hg* 0.005 - 0.1 %	Sn* 0.01 - 1 %
Al 0.2 - 45 %	K 0.02 - 5 %	Sr 0.0005 - 0.5 %
As 0.001 - 2 %	La* 0.02 - 0.4 %	Ta* 0.005 - 0.1 %
Ba 0.05 - 0.4 %	Mg 1.5 - 45 %	Th 0.002 - 0.1 %
Bi* 0.005 - 0.1 %	Mn** 0.01/0.06 - 3.2 %	Ti 0.02 - 2.5 %
Ca 0.05 - 32 %	Mo 0.005 - 0.05 %	Tl* 0.002 - 0.02 %
Cd* 0.005 - 0.5 %	Nb* 0.005 - 1 %	U 0.002 - 0.1 %
Ce* 0.02 - 1 %	Ni 0.005 - 1 %	V 0.01 - 0.2 %
Cl* 0.03 - 2 %	P 0.05 - 14.5 %	W* 0.005 - 0.1 %
Co 0.005 - 0.3 %	Pb 0.001 - 2 %	Y 0.0005 - 0.2 %
Cr 0.01 - 1.5 %	Rb 0.0005 - 0.05 %	Zn 0.002 - 0.8 %
Cu 0.0015 - 3 %	S 0.02 - 15 %	Zr 0.0005 - 1 %
Fe 0.01 - 28 %	Sb* 0.01 - 1 %	
Ga* 0.005 - 0.5 %	Se* 0.001 - 0.01 %	
Hf* 0.005 - 1 %	Si 0.5 - 47 %	



GE_PXRF73SOIL

Soil, sediments and till samples that are dried, delumped and screened at 180 micron. Till and Sediments are used for Quality Control.

ELEMENTS AND LIMIT(S)

Ag* 0.005 - 0.01%	Mo* 0.005 - 0.05%	U* 0.002 - 0.1%
Al 0.5 - 45%	Nb* 0.005 - 1%	V 0.01 - 0.2%
As 0.001 - 2%	Ni 0.005 - 1%	W* 0.005 - 0.1%
Ba 0.05 - 0.4%	P 0.05 - 14.5%	Y 0.0005 - 0.2%
Ca 0.1 - 32%	Pb 0.001 - 2%	Zn 0.002 - 0.8%
Cd* 0.005 - 0.5%	Rb 0.0005 - 0.05%	Zr*** 0.001 - 1%
Cl* 0.03 - 2%	S 0.05 - 15%	
Co*** 0.005 - 0.3%	Sb* 0.01 - 1%	
Cr 0.01 - 1.5%	Se* 0.001 - 0.01%	
Cu 0.0015 - 3%	Si*** 0.5 - 47%	
Fe 0.01 - 28%	Sr 0.0005 - 0.5%	
K 0.02 - 5%	Th* 0.002 - 0.1%	
Mg 2.5 - 45%	Ti 0.02 - 2.5%	
Mn** 0.01/0.06 - 3.2%	Tl* 0.002 - 0.02%	

* Optional elements may be available at select locations with an additional Quality Control setup cost. Please enquire.

** Site specific higher range (Vanta™)

*** Problematic element due to interference / inhomogeneity in soil fraction analysed

GE_PXRF73CONC MINING MATERIAL CONCENTRATES/PRODUCTS

Measured through a paper or plastic bag. Indicative results adjusted for attenuation of the bag. Elements common with bag material (i.e., Ca, Ti) are not reportable. Matrix matched Quality Control.

ELEMENTS AND LIMIT(S)

As 0.005 - 10%	Fe 0.5 - 77%	Sn* 0.1 - 89%
Ba* 0.1 - 10%	Mn 0.5 - 80%	Ta* 0.1 - 82%
Bi* 0.01 - 90%	Ni 0.2 - 80%	W* 0.1 - 80%
Ca* 0.5 - 35%	Pb 0.1 - 94%	Zn** 0.1 - 85%
Cr 0.5 - 69%	S** 0.5 - 30%	Zr 0.1 - 74%
Cu 0.1 - 85%	Sb* 0.1 - 56%	



GE_PXRF73MIN

Pulp based measurement for mineralized rocks and sediments, RC drill cuttings, crushed core, feeds, and concentrates in a loose powder setup.

ELEMENTS AND LIMIT(S)

Ag 0.001 - 0.600% Indic.***	Hf 0.001 - 72.000% Indic.***	Si 0.1 - 47% X
Al 0.1000 - 35.0000% X	Hg 0.002 - 86.000% Indic.***	Sn 0.005 - 88.000% Indic.***
As 0.0005 - 50.0000% X	K 0.0090 - 10.0000% X	Sr 0.0005 - 1.0000% X
Ba 0.003 - 10.000% X	La 0.004 - 0.700% Indic.***	Ta 0.003 - 82.000% Indic.***
Bi 0.0005 - 90.000% Indic.***	Mg 0.3000 - 35.0000% Indic.	Te 0.001 - 0.020% Indic.***
Ca 0.0040 - 31.0000% X	Mn 0.0020 - 45.0000% X	Th 0.001 - 0.500% Indic.***
Cd 0.001 - 0.700% Indic.***	Mo 0.001 - 67.000% Indic.***	Ti 0.0040 - 60.0000% X
Ce 0.0015 - 4.5000% Indic.***	Nb 0.001 - 42.000% Indic.***	Tl 0.0005 - 0.020% Indic.***
Cl 0.0100 - 4.0000% Indic.*	Ni 0.0010 - 80.0000% X	U 0.001 - 0.100% Indic.***
Co 0.0010 - 72.0000% Indic.**	P 0.0100 - 13.0000% X	V 0.0040 - 56.0000% X
Cr 0.0030 - 28.0000% X	Pb 0.0005 - 93.000% X	W 0.001 - 80.000% Indic.***
Cs 0.003 - 18.000% Indic.***	Rb 0.0005 - 0.0700% X	Y 0.0005 - 0.2000% X
Cu 0.0005 - 80.0000% X	S 0.0100 - 41.0000% X	Zn 0.0005 - 80.0000% X
Fe 0.0030 - 0.0000% X	Sb 0.005 - 19.000% Indic.***	Zr 0.0005 - 39.0000% X
Ga 0.0005 - 0.0500% Indic.***	Se 0.0005 - 0.0500% Indic.***	

X - QC'ed data with generic sediment/regolith based reference material

Indic - Indicative value is reported

Indic. * Indicative value with X-Ray tube line overlap

Indic.** Indicative value heavy Fe overlap with higher Limit of Detection

Indic.*** Optional elements as indicative values only may be available at select locations with an additional Quality Control setup cost. Please enquire.

CONTINUOUS EDXRF CORE OR CHIP TRAY SCANNING (CHEMISTRY / ELEMENTAL ANALYSIS + HIGH RESOLUTION IMAGERY)

Unlike hyperspectral imaging which provides a signal which can be correlated to certain mineralogical phases, XRF based scanning provides a chemical assay which compares well against the traditional complete digest assays of a commercial lab without any sample preparation directly from the core or chips.

As XRF analyses mostly the surface, integration of an area of 10cm or 1m will negate any inhomogeneity caused by the grainy assemblage of minerals and provide an assay close to the composite chemistry derived from cutting core and preparing it using traditional methods in a lab. Direct application of chemistry data in the logging process is well documented; this tool allows data integration at a very early stage of the process i.e. directly after the core has been taken.

Additional benefits include the ability to work on the data and use the deliverables to create a permanent record of the investment into the drill hole, especially when all material is slated for additional testing i.e. geo-metallurgical, pulp density or department analysis.

Unlike point/spot analysis using pXRF, continuous scanning is made possible by using the patented method of constant distance scanning by MINALYZE™ which in addition to chemical data also provides supplemental deliverables.

Scanning is performed at a constant distance from the sample surface, thus enabling correction for any air absorption. Integration intervals from 10cm to 1m or your custom requirements can be implemented. The analytical element range for this method is from Al to U. Rubble and cracks are skipped, ensuring that data is consistent for the quantification of the results and subsequent use in modelling.

Deliverables include:

- High resolution picture of dry core or chip trays (10 pixel/mm) under constant lighting conditions
- LIDAR based topography scan of the trays -> colorized with the picture to provide 3 D map of tray
- Chemistry as Quality Control CSV text file (weight %)
- Rock Quality Determination (RQD) index as cracks, rubble and scannable core are identified and tagged in the files
- Laser based accurate measuring of the core tray content

- Specific Gravity (XSG) : XRF measured proxy calibrated against laboratory pycnometer SG
- Cloud based visualization and logging software with export functions into iOGAS™ and Leapfrog™ as well as ability to:
 - Share across teams and manipulation of the data
 - Free manipulation/zoom of 3 D tray and images down to mm level
 - Ability to log with chemical information overlapping 3-D core image
 - Structural logging (alpha/beta) by user on aligned core

Core scanning is a FAST offering for logging core at your facility or library, but is also available in selected SGS laboratories as a service. Similar to our pXRF offering, we have a number of different setups ranging from generic screening to custom site specific setups including confirmation analysis on pulp derived from the ½ or ¼ core together with core slabbing and cutting all under one roof.

GE_EDX89G_AG GENERIC SETUP (AG EXCITATION)

	From (% wt)	to (% wt)	Info		From (% wt)	to (% wt)	Info
Al	3	52	QC	Pb	0.002	30	QC
As	0.0009	1	QC	Rb	0.0006	1	QC
Ba	0.008	10	Indic**	S	0.03	40	QC
Bi	0.002	1	Indic**	Sb	0.008	0.1	Indic**
Ca	0.01	70	QC	Se	0.004	1	Indic**
Cl	0.029	10	Indic**	Si	2.000	71	QC
Cr	0.002	68	QC	Sr	0.0008	1	QC
Cu	0.0012	10	QC	Ta	0.001	10	Indic**
Fe	0.001	69	QC	Te	0.008	0.1	Indic**
Ga	0.0009	1	Indic**	Ti	0.003	60	QC
K	0.030	70	*/QC	U	0.0012	1	Indic**
Mn	0.0018	77	QC	V	0.001	56	QC
Nb	0.001	10	QC	Y	0.001	1	QC
Ni	0.003	20	QC	Zn	0.0011	10	QC
P	0.100	40	QC	Zr	0.0008	10	QC

*Interference with tube line

Indic.** Optional elements as indicative values only may be available at select locations with an additional Quality Control setup cost. Please enquire.

GE_EDX89G_CR

	From (% wt)	to (% wt)		From (% wt)	to (% wt)
Al	0.0142	52.0	Pb	0.002	10.0
As	0.0005	5.0	Rb	0.001	1.0 Indic**
Ca	0.001	70.0	S	0.003	40.0
Cl	0.001	20.0 Indic**	Si	0.034	46.0
Cu	0.002	10.0	Sr	0.001	1.0 Indic**
Fe	0.01	69.0	Ti	0.0005	60.0
K	0.001	70.0	V	0.002	56.0 Indic**, *
Mn	0.01	77.0	Zn	0.002	10.0
Ni	0.005	20.0 Indic**, *			
P	0.004	40.0			

* Interference with tube line, spectral contamination

Indic.** Optional elements as indicative values only may be available at select locations with an additional Quality Control setup cost. Please enquire.

PNIR HYPERSPECTRAL SCREENING (SKALARS, MINERAL ID, MINERAL INDICATIVE WEIGHT%)

At selected SGS facilities, analysis of coarse material, pulp and solid samples (i.e. core) is offered, using pNIR instrumentation (i.e. ASD Terraspec™), covering the VNIR (380 – 1000nm) and SWIR1 and short wavelength infrared ranges 1001nm to 1800nm and 1800nm to 2500nm. A contact probe (solid/coarse) or diffuse reflectance probe (compacted pulp) is utilized. Stringent Quality Control of the unit and setup (regular white balance and polystyrene calibrations), as well as defined percentage of repeats are standard. Quality Controlled data is ready for processing by either client or as part of a customized project by SGS. These services are also available as part of our FAST offering, on site or at preparation labs. This high-quality data can be used directly (as spectra) for machine learning applications, correlating it to metallurgical or “feed” properties. Additional deliverables are a selection of standard Skalars as well as the 2 to 3 most abundant IR active minerals in the VNIR &SWIR range.

GE_PNIR73SCAN1	pNIR Scan on coarse (<2mm) material (i.e. sample prep crusher split) using a contact probe including standardized Quality Control
GE_PNIR73SCAN2	pNIR Scan on analytical grade pulp using a diffuse reflectance probe including standardized Quality Control
GE_PNIR79SCAN	pNIR Scan on solid core material using contact probe including standardized Quality Control

FTIR FOR QUANTITATIVE MINERALOGICAL SCREENING (MINERAL WEIGHT %)

Fourier-transform infrared spectroscopy (FTIR) is a technique used to obtain an infrared spectrum of absorption or emission of a solid, liquid or gas. The minerals that make up rocks and soils, each have a unique molecular structure. In minerals covalent bonding with i.e. C-H, O-H C=O etc., infrared radiation results in the vibration of the molecular bonds in the mineral. The intrinsic physiochemical property of these molecular bonds will provide a characteristic ‘finger print’ for the applicable minerals.

SGS has developed a set of FTIR applications using standard analytical pulp to determine the weight% of selected minerals using MID range FTIR and a fixed optical path Attenuated Total Reflection (ATR) setup.

This setup is ideal to screen large numbers of samples, as the analysis time is less than 2 minutes.

While the generic analysis will provide indicative results, the matrix specific setups for certain minerals offer more accurate analysis including additional non-mineralogical parameters.

For larger volume of samples, SGS offers customized matrix matched and site specific setups, which can include process specific parameters. SGS in-house expertise can add value with rapid results to assist with your project.

EXPLORATION FTIR PACKAGE

GE_FTIR73BULK

MINERALS AND LIMIT(S)

Apatite 1.0 - 70.0%	K Feldspar 1.0 - 50.0%	Smectite 1.0 - 100.0%
Biotite 1.0 - 60.0%	Kaolinite 1.0 - 100.0%	Spodumene 1.0 - 100.0%
Calcite 1.0 - 100.0%	Muscovite 1.0 - 40.0%	Tantalum 1.0 - 45.0 %
Chlorite 1.0 - 100.0%	Plagioclase 1.0 - 100.0%	Total Alumina 20.0 - 60.0%
Dolomite 1.0 - 100.0%	Petalite 1.0 - 40.0%	Total FeOxide 3.0 - 30.0%
Goethite 1.0 - 20.0%	Quartz 1.0 - 100.0%	Total Silica 1.0 - 35.0%
Illite 1.0 - 100.0%	Siderite 1.0 - 30.0	Total TiO2 1.5 - 3.5%

COMMERCIAL TESTING SERVICES

Most SGS laboratories provide exploration clients with dedicated sample preparation areas. Our Centres of Excellence dedicated to analytical 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-OES, ICP-MS and XRF.

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 track and plan for your shipment.

We strongly recommend that all sample submissions be clearly labeled. Sample submissions that are poorly labeled or packaged can incur additional sorting charges.

All sample shipments require a completed sample submittal form or letter with clear instructions to avoid delays. Sample submission forms can be found on our website at www.sgs.com/en/mining/analytical-services/geochemistry. Samples will not be analysed 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 / or storage 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 following these sample submission protocols.

PKP10	Sample collection / pick up
LOG10	Sample sorting and registration
WGH10	Sample weight as received
WGH11	Sample weight after drying
WGH12	Weigh Bullion samples

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 a SGS Centre of Excellence, analysed and reported. For more information about this process, please ask your local SGS laboratory.

SAMPLE RETURN, RETENTION, STORAGE AND DISPOSAL

Pulp samples will be discarded after three months unless you specifically request on the sample submittal form to return or store. Storage fees will apply.

RTN01	Return, pulp/rejects to client
RTR01	Retrieval and handling of samples for reanalysis
STO01	Store, cage, monthly rate
STO02	Store, bulka bag, monthly rate
STO03	Store, crate, monthly rate
STO04	Store, pallet, monthly rate
STO05	Retain coarse reject
STO06	Retain pulp residue
DIS10	Disposal via pallet, includes transfer of samples
DIS11	Disposal via skip, includes transfer of samples
DIS12	Disposal via steel cage, includes transfer of samples
DIS13	Disposal via bulka bag, includes transfer of samples
DIS14	Disposal of sample material, per kg rate
DIS15	Disposal of samples, incineration (soils)



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. 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 technical personnel 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 utilized 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.

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 enquire.

SAMPLE PREPARATION PROCEDURES

DRYING

DRY10	Sample Drying, 105°C, <3 kg
DRY11	Sample Drying, 105°C, 3-5 kg
DRY12	Sample Drying, 105°C, 5-7 kg
DRY13	Sample Drying, 105°C, 7-10 kg
DRY14	Sample Drying, 105°C, 10-15 kg
DRY27	Sample Drying, 105°C, >15 kg
DRY15	Microwave Sample Drying, 105°C, <3 kg
DRY16	Microwave Sample Drying, 105°C, 3-5 kg
DRY17	Microwave Sample Drying, 105°C, 5-7 kg
DRY18	Microwave Sample Drying, 105°C, 7-10 kg
DRY19	Microwave Sample Drying, 105°C, 10-15 kg
DRY28	Microwave Sample Drying, 105°C, >15 kg
DRY20	Sample Drying, 60°C, <3 kg
DRY21	Sample Drying, 60°C, >3kg, per kg
DRY22	Sample Drying, Room Temp, <3 kg
DRY23	Sample Drying, Room Temp, >3 kg, per kg
DRY24	Sample Drying, Excessively Wet Samples
DRY25	Oven Drying, 105°C, Carbon Samples

CRUSHING

CRU09	Coarse crush 3.36 mm
CRU10	Coarse crush 6 mm
CRU11	Crush <3 kg, 75% passing 2 mm
CRU12	Crush 3-5 kg, 75% passing 2 mm
CRU13	Crush 5-7 kg, 75% passing 2 mm
CRU14	Crush 7-10 kg, 75% passing 2 mm
CRU15	Crush 10-15 kg, 75% passing 2 mm per kg
CRU22	Crush >15 kg, 75% passing 2 mm per kg
CRU16	Crush <3 kg, 90% passing 2 mm
CRU17	Crush 3-5 kg, 90% passing 2 mm
CRU18	Crush 5-7 kg, 90% passing 2 mm
CRU19	Crush 7-10 kg, 90% passing 2 mm
CRU20	Crush 10-15 kg, 90% passing 2 mm per kg
CRU21	Crush >15 kg, 90% passing 2 mm per kg
CRM10	CRM Pulverize <3 kg, 90% passing 1 mm
CRM11	CRM Pulverize 3-5 kg, 90% passing 1 mm
CRM12	CRM Pulverize 5-7 kg, 90% passing 1 mm
CRM13	CRM Pulverize 7-10 kg, 90% passing 1 mm
CRM14	CRM Pulverize 10-15 kg, 90% passing 1 mm
CRM15	CRM Pulverize >15 kg, 90% passing 1 mm per kg

SPLITTING

SPL10	Manual Riffle Splitting, per kg
SPL11	Cone and Quarter Splitting, per kg
SPL12	Split additional representative samples
RSD10	Rotary Split <3 kg
RSD11	Rotary Split 3-5 kg
RSD12	Rotary Split 5-7 kg
RSD13	Rotary Split 7-10 kg
RSD14	Rotary Split 10-15 kg
RSD15	Rotary Split >15 kg
RSD16	Rotary Split, Micro Split <100 g

SCREENING - APPLICABLE TO SOILS AND SEDIMENTS

SCR10	Dry Screening to -80mesh (180µm) < 2kg
SCR11	Dry Screening to -80mesh (180µm) > 2kg
SCR12	Dry Screening, various micron particle sizes <2 kg
SCR13	Dry Screening, various micron particle sizes >2 kg
SCR14	Wet Screening, 75µm, evaluation of prep
SCR15	Wet Screening, various micron particle sizes <2 kg
SCR16	Wet Screening, various micron particle sizes >2 kg
SCR17	Cyclosizing
SCR18	Metallic/Screening Procedure 75 µm
SCR19	Metallic/Screening Procedure 106 µm
SCR20	Metallic/Screening Procedure 212 µm
SCR21	Wet Screening Desliming, various micron particle sizes per kg

PULVERIZING

PUL10	Pulv, Cr Steel, 85% 75µm 250g
PUL11	Pulv, Cr Steel, 85% 75µm 500g
PUL12	Pulv, Cr Steel, 85% 75µm 800g
PUL13	Pulv, Cr Steel, 85% 75µm 1,000g
PUL14	Pulv, Cr Steel, 85% 75µm 3000g
PUL25	Pulv, Cr Steel, 85% 75µm >3000g
PUL15	Pulv, Cr Steel, 90% 75µm 250g
PUL16	Pulv, Cr Steel, 90% 75µm 500g
PUL17	Pulv, Cr Steel, 90% 75µm 800g
PUL18	Pulv, Cr Steel, 90% 75µm 1,000g
PUL19	Pulv, Cr Steel, 90% 75µm 3,000g
PUL26	Pulv, Cr Steel, 90% 75µm >3,000g
PUL20	Pulv, Zirconia bowl, 50-80g
PUL21	Pulv, Tungsten Carbide Bowl <100g
PUL22	Pulv, Agate/Ceramic Mort & Pest <100g
PUL23	Pulv, Agate/Ceramic Ringmill <100g
PUL24	Pulv, Specified Mesh Size per kg
PUL27	Disc Grind, 106µm 500g-1.5kg
PUL28	Disc Grind, 106µm 1.5kg-3.5kg
PUL29	Disc Grind, 106µm >3.5kg per kg
PUL30	Ringmill Preparation, Carbon Sample(s)
PUL31	Hand Preparation, Carbon Sample(s)
PUL32	Pulverization of Concentrates

Note: Samples can also be pulverized at customer specified grain sizes (i.e. 106 or 120 microns) and % passing requirements. Please enquire.

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. All samples are crushed to <2mm and a maximum 3kg aliquot obtained from a linear splitting device (LSD) and pulverized to >85% passing 75µm. Pulp sub-sample is then obtained using a linear splitting device (LSD).

Automated sample preparation has several advantages in preparing samples in a consistent reproducible fashion independent of any human habits or variability. Pulverisers are cleaned between every sample using barren material to scour the bowl. All sample and associated parameters are tracked in milling time, sample weights at all stages of preparation and total sample loss per sample available. Quality reports per batch are also available.

Automated sample preparation is available at select sites. Please enquire.

RPREP - Robotic Prep (Boyd Elite 2mm, Mill, LSD)

MISCELLANEOUS PROCEDURES

CLN10	Barren wash after crushing stage
CLN11	Barren wash after pulverizing stage
COM10	Compositing samples
COM11	Compositing samples, per kg
RAD01	Radiation monitoring using scintillation counter
DPE10	Radioactive preparation environment
DPE11	Asbestos preparation environment
ADM11	Sample quarantine and handling
DIS09	Waste disposal fee

MOISTURE AND LOSS ON IGNITION (LOI)

Many materials contain volatile components and/or moisture. SGS has a variety of tests, including moisture (H₂O), loss on ignition (LOI) (at various temperatures) and thermogravimetric analysis (TGA), that provide reliable and quantitative analyses of these parameters.

MOISTURE (H₂O)

CODE	ELEMENT	LIMIT(S)	DESCRIPTION
G_PHY03V	H ₂ O-	0.1 - 100%	Gravimetric determination at 105°C
G_PHY05V	H ₂ O+	0.1 - 100%	Penfield tube

LOSS ON IGNITION (LOI)

CODE	ELEMENT	LIMIT(S)	DESCRIPTION
G_PHY01V	LOI	-10 - 100%	Gravimetric determination at 1000°C
G_PHY02V	LOI	-50 - 100%	Multi-point TGA determinations

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

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® or TIMA-X™. 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_PHY06V	Specific gravity - pycnometer
G_PHY08V	Specific gravity - volumetric
G_PHY17V	Bulk density – immersion, waxed
G_PHY18V	Bulk density - immersion, non-waxed

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/analysis. 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 separated (i.e. 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_PHY15V Particle size, sieve analysis (dry or wet)

G_PHY16V Particle size, laser diffraction



PRECIOUS METALS

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 enquire.

GOLD

EXPLORATION-GRADE ANALYSIS

FIRE ASSAY GOLD

CODE	ELEMENT	LIMIT(S)	DESCRIPTION
GE_FAA30V5	Au	5 - 10,000 ppb	30 g, Fire assay, AAS finish
GE_FAA50V5	Au	5 - 10,000 ppb	50 g, Fire assay, AAS finish
GE_FAI30V5*	Au**	1 - 10,000 ppb	30 g, Fire assay, ICP-OES finish
GE_FAI50V5*	Au**	1 - 10,000 ppb	50 g, Fire assay, ICP-OES finish
GE_FAI31V5	Au**	5 - 10,000 ppb	30 g, Fire assay, ICP-OES finish
GE_FAI51V5	Au**	5 - 10,000 ppb	50 g, Fire assay, ICP-OES finish
GE_FAM30V5	Au**	1 - 2,000 ppb	30 g, Fire assay, ICP-MS finish
GE_FAM50V5	Au**	1 - 2,000 ppb	50 g, Fire assay, ICP-MS finish

Note: *GE_FAI30V5/GE_FAI50V5 methods use new fire assay pots to achieve these lower limits.

** Pt and Pd can be included, refer to [page 34](#).

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.

GOLD BY ACID DIGESTION (AQUA REGIA)

CODE	ELEMENT	LIMIT(S)	DESCRIPTION
GE_ARE1V50	Au	1 - 800 ppb	50 g, Aqua regia digest, DIBK extraction, AAS finish
GE_ARE2V25	Au	0.01 - 100 ppm	25 g, Aqua regia digest, DIBK extraction, AAS finish
GE_ARE2V50	Au	0.01 - 100 ppm	50 g, Aqua regia digest, DIBK extraction, AAS finish
GE_ARMV25	Au*	1 - 500 ppb	25 g, Aqua regia digest, ICP-MS finish
GE_ARMV50	Au*	1 - 500 ppb	50 g, Aqua regia digest, ICP-MS finish

Note: Additional elements are available on request

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 analysed. 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_MBLA65V30	Au	0.1 - 1,000 ppm	Hot, 30 g, Mini cyanide leach, AAS finish
GE_BLE61K	Au	0.02 - 100 ppm	500 g, Active cyanide leach, Solvent extraction, AAS finish
GE_BLE61N	Au	1 - 100,000 ppb	2000 g, Active cyanide leach, Solvent extraction, AAS 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 analysed. 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_LWE69J	Au	0.01 - 1,000 ppm	200 g, Accelerated cyanide leach, AAS finish
GE_LWE69K	Au	0.01 - 1,000 ppm	500 g, Accelerated cyanide leach, AAS finish
GE_LWE69L	Au	0.01 - 1,000 ppm	800 g, Accelerated cyanide leach, AAS finish
GE_LWE69M	Au	0.01 - 1,000 ppm	1000 g, Accelerated cyanide leach, AAS finish
GE_LWE69N	Au	0.01 - 1,000 ppm	2000 g, Accelerated cyanide leach, AAS finish

ORE-GRADE ANALYSIS**INSTRUMENTAL AND GRAVIMETRIC ANALYSIS**

CODE	ELEMENT	LIMIT(S)	DESCRIPTION
GO_FAA30V10	Au	0.01 - 100 ppm	30 g, Fire assay, AAS finish
GO_FAA50V10	Au	0.01 - 100 ppm	50 g, Fire assay, AAS finish
GO_FAP30V10	Au	0.01 - 100 ppm	30 g, Fire assay, MP-AES finish
GO_FAP50V10	Au	0.01 - 100 ppm	50 g, Fire assay, MP-AES finish
GO_FAI30V10	Au **	0.01 - 100 ppm	30 g, Fire assay, ICP-OES finish
GO_FAI50V10	Au **	0.01 - 100 ppm	50 g, Fire assay, ICP-OES finish
GO_FAG30V	Au	0.5 - 10,000 ppm	30 g, Fire assay, gravimetric finish
GO_FAG50V	Au	0.5 - 10,000 ppm	50 g, Fire assay, gravimetric finish
GO_FAG32V	Au	0.01 - 100 ppm	30 g, Fire assay, AAS finish (Au) gravimetric finish (Ag)
	Ag	10 - 10,000 ppm	
GO_FAG52V	Au	0.01 - 100 ppm	50 g, Fire assay, AAS finish (Au) gravimetric finish (Ag)
	Ag	10 - 10,000 ppm	
GO_FAG33V	Au	0.5 - 10,000 ppm	30 g, Fire assay, gravimetric finish (Au, Ag)
	Ag	10 - 10,000 ppm	

** Pt and Pd can be included, refer to [page 34](#).

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 analysed using the screened metallics sample preparation and assaying procedure. This consists of:

- Screening 500g/1000g or client specified weight of the sample to a defined grain size, typically 75, 106 or 200 microns.
- Weighing the various fractions.
- Assaying the entire plus fraction.
- Weighing and analysing the undersize (typically 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-OES or gravimetric, depending upon concentration. Limits shown are based on instrument analysis. Gravimetric limits are higher, 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 Ag	≥ 0.01 ppm ≥ 10 ppm	Au, Ag, screen metallics* (75/106/212), 30 g. Fire assay, 500g AAS/ICP/Grav
GO_FAS50K	Au Ag	≥ 0.01 ppm ≥ 10 ppm	Au, Ag, screen metallics* (75/106/212), 50 g. Fire assay, 500g AAS/ICP/Grav
GO_FAS30M	Au Ag	≥ 0.01 ppm ≥ 10 ppm	Au, Ag, screen metallics* (75/106/212), 30 g. Fire assay, 1000g AAS/ICP/Grav
GO_FAS50M	Au Ag	≥ 0.01 ppm ≥ 10 ppm	Au, Ag, screen metallics* (75/106/212), 50 g. Fire assay, 1000g AAS/ICP/Grav
GO_FAS30V	Au Ag	≥ 0.01 ppm ≥ 10 ppm	Au, Ag, screen metallics* (75/106/212), 30 g. Fire assay, >1000g AAS/ICP/Grav
GO_FAS50V	Au Ag	≥ 0.01 ppm ≥ 10 ppm	Au, Ag, screen metallics* (75/106/212), 50 g. Fire assay, >1000g AAS/ICP/Grav

Note: *options for screen sizes available. Pt, Pd can be added. Finish technique is based on concentration.

CONTROL AND CONCENTRATE-GRADE ANALYSIS**INSTRUMENTAL AND GRAVIMETRIC ANALYSIS**

CODE	ELEMENT	LIMIT(S)	DESCRIPTION
GC_FAA30V10	Au	0.01 – 1,000 ppm	30 g, Fire assay, AAS finish
GC_FAA50V10	Au	0.01 – 1,000 ppm	50 g, Fire assay, AAS finish
GC_FAG32V	Au Ag	0.01 - 1,000 ppm ≥ 10 ppm	30 g, Fire assay, AAS finish (Au) 30 g, Fire assay, gravimetric finish (Ag)
GC_FAG33V	Au Ag	≥ 0.5 ppm ≥ 10 ppm	30 g, Fire assay, gravimetric finish (Au, Ag)

GOLD IN PROCESS SOLUTIONS

CODE	ELEMENT	LIMIT(S)	DESCRIPTION
GC_FSA84T	Au	≥0.01 mg/L	Solution, Fire assay, AAS finish
GC_FSI84T	Au	≥0.01 mg/L	Solution, Fire assay, ICP-OES finish

Note: These methods are also applicable to cyanide liquors

GOLD IN CYANIDE LIQUORS

CODE	ELEMENT	LIMIT(S)	DESCRIPTION
GC_AAS82T	Au	≥0.1 mg/L	CN solution, AAS finish
GC_AAS82X	Au	≥0.001 mg/L	Solvent extraction, DIBK, AAS finish

GOLD IN CARBON

CODE	ELEMENT	LIMIT(S)	DESCRIPTION
GC_FAA01V100	Au	5 - 20,000 ppm	1-2 g, Fire assay, AAS finish
GC_ACA22D100V	Au	5 - 250,000 ppm	1 g, Ash, acid digest, AAS finish
GC_FAG01V	Au	≥5 ppm	1-5 g, Fire assay, gravimetric finish

GOLD BULLION

CODE	ELEMENT	LIMIT(S)	DESCRIPTION
GC_BUL36V	Au Ag	0.5-99.5% 0.01-99.5%	100-500 mg, Fire assay, gravimetric finish 100-500 mg, Fire assay, gravimetric finish

SILVER

EXPLORATION-GRADE ANALYSIS

ACID DIGESTION - INSTRUMENTATION

CODE	ELEMENT	LIMIT(S)	DESCRIPTION
GE_AAS22E50	Ag	0.3 - 100 ppm	2 g, 2-Acid digest, AAS finish
GE_AAS33E50	Ag	0.3 - 100 ppm	2 g, 3-Acid digest, AAS finish
GE_AAS42E50	Ag	0.3 - 100 ppm	2 g, 4-Acid digest, AAS finish

Note: It is recommended that mineralized samples with Ag >30g/t are analysed using the GO_AAS21C50 method below. Silver (Ag) can also be analysed in many multi-element packages. Refer to [page 37](#).

ORE-GRADE ANALYSIS

ACID DIGESTION - INSTRUMENTATION

CODE	ELEMENT	LIMIT(S)	DESCRIPTION
GO_AAS21C50	Ag	1 - 300 ppm	0.5 g, 2-Acid digest, AAS finish

GRAVIMETRIC ANALYSIS

CODE	ELEMENT	LIMIT(S)	DESCRIPTION
GO_FAG32V	Au	0.01 - 100 ppm	30 g, Fire assay, AAS finish (Au) gravimetric finish (Ag)
	Ag	10 - 10,000 ppm	
GO_FAG33V	Au	0.5 - 10,000 ppm	30 g, Fire assay, gravimetric finish (Au, Ag)
	Ag	10 - 10,000 ppm	
GO_FAG52V	Au	0.01 - 100 ppm	50 g, Fire assay, AAS finish (Au), gravimetric finish (Ag)
	Ag	10 - 10000 ppm	

CONTROL AND CONCENTRATE-GRADE ANALYSIS

INSTRUMENTAL AND GRAVIMETRIC ANALYSIS

CODE	ELEMENT	LIMIT(S)	DESCRIPTION
GC_AAS43V100	Ag	1 - 1,000 ppm	Variable wt, 4-acid digest, AAS finish
GC_FAG32V	Au	0.01 - 1,000 ppm	30 g, Fire assay, AAS finish (Au) gravimetric finish (Ag)
	Ag	≥ 10 ppm	
GC_FAG33V	Au	≥ 0.5 ppm	30 g, Fire assay, gravimetric finish (Au, Ag)
	Ag	≥ 10 ppm	
GC_ACA22D100V	Ag	2 - 2,000 ppm	Carbon, 1 g, ash, acid digest, extract, AAS finish
GC_BUL36V	Ag	0.01 - 99.5%	100-500 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_FAI30V5*	Au	1 - 10,000 ppb	30 g, Fire assay, ICP-OES finish
	Pt	10 - 10,000 ppb	
	Pd	1 - 10,000 ppb	
GE_FAI50V5*	Au	1 - 10,000 ppb	50 g, Fire assay, ICP-OES finish
	Pt	10 - 10,000 ppb	
	Pd	1 - 10,000 ppb	
GE_FAM30V5	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_FAM50V5	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_FAI31V5	Au	5 - 10,000 ppb	30 g, Fire assay, ICP-OES finish
	Pt	10 - 10,000 ppb	
	Pd	5 - 10,000 ppb	
GE_FAI51V5	Au	5 - 10,000 ppb	50 g, Fire assay, ICP-OES finish
	Pt	10 - 10,000 ppb	
	Pd	5 - 10,000 ppb	

Note: *GE_FAI30V5 & GE_FAI50V5 methods use new fire assay pots to achieve lower limits.

ORE-GRADE ANALYSIS

GOLD, PLATINUM AND PALLADIUM

CODE	ELEMENT	LIMIT(S)	DESCRIPTION
GO_FAI30V10	Au	0.01 - 100 ppm	30 g, Fire assay, ICP-OES finish
	Pt	0.01 - 100 ppm	
	Pd	0.01 - 100 ppm	
GO_FAI50V10	Au	0.01 - 100 ppm	50 g, Fire assay, ICP-OES finish
	Pt	0.01 - 100 ppm	
	Pd	0.01 - 100 ppm	



CONTROL-GRADE ANALYSIS

GOLD, PLATINUM AND PALLADIUM

CODE	ELEMENT	LIMIT(S)	DESCRIPTION
GC_FAI35V10	Au	0.02 ppm - 20%	Variable wt, Fire assay, ICP-OES finish
	Pt	0.02 ppm - 20%	
	Pd	0.02 ppm - 20%	
GC_FAA35V10	Au	0.02 ppm - 20%	Variable wt, Fire assay, AAS finish
	Pt	0.02 ppm - 20%	
	Pd	0.02 ppm - 20%	

PLATINUM GROUP ELEMENTS

CODE	ELEMENT	LIMIT(S)	DESCRIPTION
GC_FAI41V10	Pt	≥ 0.02 ppm	30 g, Fire assay nickel sulphide collection, ICP-OES
	Pd	≥ 0.02 ppm	
	Rh	≥ 0.02 ppm	
	Ru	≥ 0.05 ppm	
	Ir	≥ 0.13 ppm	

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

CODE	ELEMENT	LIMITS	DESCRIPTION
GC_FAM42V10	Pt	0.02 ppm	30 g, Fire assay nickel sulphide collection, ICP-MS
	Pd	0.02 ppm	
	Rh	0.02 ppm	
	Ru	0.05 ppm	
	Ir	0.02 ppm	

Note: This method is not available in all SGS laboratories. Samples can be analysed for Osmium by neutron activation. Please contact us for more information.

EXPLORATION-GRADE ANALYSIS

MULTI-ELEMENT, TRACE ICP-OES AND ICP-MS PACKAGES

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.

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

Drill-core and rock samples are generally analysed 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-OES 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_3 and HCl). After the digestion, the solution is analysed by either ICP-OES or ICP-MS or both. We can also analyse these digestions by Hydride AAS to determine the hydride forming elements (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 "22B20" are based on a combination of 2:1 HNO_3 : HCl . This digest is recommended for samples with organic or high sulphide mineral content*.

The methods listed below with the designation "21B20" are based on a combination of 3:1 HCl : HNO_3 . 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 "21B20" and "22B20" digests.

NOTE: Requires a minimum sample weight of 0.5g. Lower 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 speak 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-OES PACKAGE (34 ELEMENTS)

GE_ICP21B20 or GE_ICP22B20

ELEMENTS AND LIMIT(S)

Ag 2 - 100 ppm*	Hg 1 - 10,000 ppm	Sb 5 - 10,000 ppm
Al 0.01 - 15%	K 0.01 - 15%	Sc 0.5 - 10,000 ppm
As 3 - 10,000 ppm	La 0.5 - 10,000 ppm	Sn 10 - 10,000 ppm
Ba 5 - 10,000 ppm	Li 1 - 10,000 ppm	Sr 0.5 - 10,000 ppm
Be 0.5 - 2,500 ppm	Mg 0.01 - 15%	Ti 0.01 - 15%
Bi 5 - 10,000 ppm	Mn 2 - 10,000 ppm	V 1 - 10,000 ppm
Ca 0.01 - 15%	Mo 1 - 10,000 ppm	W 10 - 10,000 ppm
Cd 1 - 10,000 ppm	Na 0.01 - 15%	Y 0.5 - 10,000 ppm
Co 1 - 10,000 ppm	Ni 1 - 10,000 ppm	Zn 1 - 10,000 ppm
Cr 1 - 10,000 ppm	P 0.01 - 15%	Zr 0.5 - 10,000 ppm
Cu 0.5 - 10,000 ppm	Pb 2 - 10,000 ppm	
Fe 0.01 - 15%	S 0.01 - 5%	

*Note: The upper limit of 100ppm for Ag is achieved with the **GE_ICP21B20** package only. **GE_ICP22B20** will not fully recover Ag in high concentrations. Refer to the Ag specific methods on [page 33](#).

TWO ACID / AQUA REGIA DIGESTION / ICP-MS PACKAGE (36 ELEMENTS)

GE_IMS22B20 or GE_IMS21B20

ELEMENTS AND LIMIT(S)

Ag 0.01 - 10 ppm	Ga 0.1 - 10,000 ppm	Sb 0.05 - 10,000 ppm
Al 0.01 - 10%	Hg 0.01 - 100 ppm	Sc 0.1 - 10,000 ppm
As 1 - 10,000 ppm	K 0.01 - 10%	Sn 0.3 - 1,000 ppm
Ba 5 - 10,000 ppm	La 0.1 - 10,000 ppm	Sr 0.5 - 10,000 ppm
Bi 0.02 - 10,000 ppm	Mg 0.01 - 15%	Th 0.1 - 10,000 ppm
Ca 0.01 - 15%	Mn 2 - 10,000 ppm	Ti 0.01 - 10%
Cd 0.01 - 10,000 ppm	Mo 0.05 - 10,000 ppm	Tl 0.02 - 10,000 ppm
Ce 0.05 - 1,000 ppm	Na 0.01 - 10%	U 0.05 - 10,000 ppm
Co 0.1 - 10,000 ppm	Ni 0.5 - 10,000 ppm	V 1 - 10,000 ppm
Cr 1 - 10,000 ppm	P 0.01 - 1%	W 0.1 - 10,000 ppm
Cu 0.5 - 10,000 ppm	Pb 0.2 - 10,000 ppm	Y 0.05 - 10,000 ppm
Fe 0.01 - 15%	Rb 0.2 - 10,000 ppm	Zn 1 - 10,000 ppm



TWO ACID / AQUA REGIA DIGESTION / COMBINED ICP-OES AND ICP-MS PACKAGE (51 ELEMENTS)

GE_ICM21B20 (ICP21B20 & IMS21B20) OR GE_ICM22B20 (ICP22B20 & IMS21B20)

ELEMENTS AND LIMIT(S)

Ag 0.01 - 100* ppm	Hg 0.01 - 10,000 ppm	Sc 0.1 - 10,000 ppm
Al 0.01 - 15%	In 0.02 - 500 ppm	Se 1 - 1,000 ppm
As 1 - 10,000 ppm	K 0.01 - 15%	Sn 0.3 - 1,000 ppm
Ba 5 - 10,000 ppm	La 0.1 - 10,000 ppm	Sr 0.5 - 10,000 ppm
Be 0.1 - 100 ppm	Li 1 - 10,000 ppm	Ta 0.05 - 10,000 ppm
Bi 0.02 - 10,000 ppm	Lu 0.01 - 1,000 ppm	Tb 0.02 - 10,000 ppm
Ca 0.01 - 15%	Mg 0.01 - 15%	Te 0.05 - 1,000 ppm
Cd 0.01 - 10,000 ppm	Mn 2 - 10,000 ppm	Th 0.1 - 10,000 ppm
Ce 0.05 - 1,000 ppm	Mo 0.05 - 10,000 ppm	Ti 0.01 - 15%
Co 0.1 - 10,000 ppm	Na 0.01 - 15%	Tl 0.02 - 10,000 ppm
Cr 1 - 10,000 ppm	Nb 0.05 - 1,000 ppm	U 0.05 - 10,000 ppm
Cs 0.05 - 1,000 ppm	Ni 0.5 - 10,000 ppm	V 1 - 10,000 ppm
Cu 0.5 - 10,000 ppm	P 0.01 - 15%	W 0.1 - 10,000 ppm
Fe 0.01 - 15%	Pb 0.2 - 10,000 ppm	Y 0.05 - 10,000 ppm
Ga 0.1 - 10,000 ppm	Rb 0.2 - 10,000 ppm	Yb 0.1 - 100 ppm
Ge 0.1 - 10,000 ppm	S 0.01 - 5%	Zn 1 - 10,000 ppm
Hf 0.05 - 500 ppm	Sb 0.05 - 10,000 ppm	Zr 0.5 - 10,000 ppm

*Note: The upper limit of 100ppm for Ag is achieved with the GE_ICP21B20 package only. GE_ICP21B20 will not fully recover Ag in high concentrations. Refer to the Ag specific methods on [page 33](#).

TWO ACID / AQUA REGIA DIGESTION / HYDRIDE AAS PACKAGE

GE_HAS21B20

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	

MULTI-ACID (FOUR ACID) DIGESTION PACKAGES

NITRIC, HYDROFLUORIC, PERCHLORIC AND HYDROCHLORIC ACID DIGEST

Multi-acid (Four 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 HNO₃ (nitric acid), HF (hydrofluoric acid), HClO₄ (perchloric acid) and HCl (hydrochloric acid). Because hydrofluoric acid dissolves silicate minerals, these digestions are often referred to as "near-total digestions". NOTE: Requires a minimum sample weight of 0.5g. Lower 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 (Four 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 (FOUR ACID) DIGESTION / ICP-OES PACKAGE (33 ELEMENTS)

GE_ICP40Q12

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 - 10,000 ppm
As 3 - 10,000 ppm	La 0.5 - 10,000 ppm	Sc 0.5 - 10,000 ppm
Ba 1 - 10,000 ppm	Li 1 - 10,000 ppm	Sn 10 - 10,000 ppm
Be 0.5 - 2500 ppm	Mg 0.01 - 15%	Sr 0.5 - 10,000 ppm
Bi 5 - 10,000 ppm	Mn 2 - 10,000 ppm	Ti 0.01 - 15%
Ca 0.01 - 15%	Mo 1 - 10,000 ppm	V 2 - 10,000 ppm
Cd 1 - 10,000 ppm	Na 0.01 - 15%	W 10 - 10,000 ppm
Co 1 - 10,000 ppm	Ni 1 - 10,000 ppm	Y 0.5 - 10,000 ppm
Cr 1 - 10,000 ppm	P 0.01 - 15%	Zn 1 - 10,000 ppm
Cu 0.5 - 10,000 ppm	Pb 2 - 10,000 ppm	Zr 0.5 - 10,000 ppm

Note: Additional elements can be added. Please enquire.

MULTI-ACID (FOUR ACID) DIGESTION / COMBINED ICP-OES AND ICP-MS PACKAGE (49 ELEMENTS)

GE_ICM40Q12 (GE_ICP40Q12 & GE_IMS40Q12)

ELEMENTS AND LIMIT(S)

Ag 0.02 - 100 ppm	K 0.01 - 15%	Sn 0.3 - 1,000 ppm
Al 0.01 - 15%	La 0.1 - 10,000 ppm	Sr 0.5 - 10,000 ppm
As 1 - 10,000 ppm	Li 1 - 10,000 ppm	Ta 0.05 - 10,000 ppm
Ba 1 - 10,000 ppm	Lu 0.01 - 1,000 ppm	Tb 0.05 - 10,000 ppm
Be 0.1 - 2,500 ppm	Mg 0.01 - 15%	Te 0.05 - 1,000 ppm
Bi 0.04 - 10,000 ppm	Mn 2 - 10,000 ppm	Th 0.2 - 10,000 ppm
Ca 0.01 - 15%	Mo 0.05 - 10,000 ppm	Ti 0.01 - 15%
Cd 0.02 - 10,000 ppm	Na 0.01 - 15%	Tl 0.02 - 10,000 ppm
Ce 0.05 - 1,000 ppm	Nb 0.1 - 1,000 ppm	U 0.05 - 10,000 ppm
Cs 1 - 1,000 ppm	Ni 0.5 - 10,000 ppm	V 2 - 10,000 ppm
Co 0.1 - 10,000 ppm	P 0.01 - 15%	W 0.1 - 10,000 ppm
Cr 1 - 10,000 ppm	Pb 0.5 - 10,000 ppm	Y 0.1 - 10,000 ppm
Cu 0.5 - 10,000 ppm	Rb 0.2 - 10,000 ppm	Yb 0.1 - 1,000 ppm
Fe 0.01 - 15%	S 0.01 - 5%	Zn 1 - 10,000 ppm
Ga 0.1 - 500 ppm	Sb 0.05 - 10,000 ppm	Zr 0.5 - 10,000 ppm
Hf 0.02 - 500 ppm	Sc 0.5 - 1,000 ppm	
In 0.02 - 500 ppm	Se 2 - 1,000 ppm	

Note: Select packages for rare earth elements can be found on [page 57](#).

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.

NOTE: Lower 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-OES PACKAGE (29 ELEMENTS)

GE_ICP90A50

ELEMENTS AND LIMIT(S)

Al 0.01 - 25%	K 0.1 - 25%	Sc 5 – 50,000 ppm
As 30 – 10,000 ppm	La 10 – 50,000 ppm	Si 0.1 - 30%
Ba 10 – 50,000 ppm	Li 10 – 50,000 ppm	Sn 50 – 50,000 ppm
Be 5 – 25,000 ppm	Mg 0.01 - 25%	Sr 10 – 5,000 ppm
Ca 0.1 - 25%	Mn 10 – 100,000 ppm	Ti 0.01 - 25%
Cd 10 – 50,000 ppm	Mo 10 – 50,000 ppm	V 10 – 50,000 ppm
Co 10 – 50,000 ppm	Ni 10 – 100,000 ppm	W 50 – 40,000 ppm
Cr 10 – 50,000 ppm	P 0.01 - 25%	Y 5 – 25,000 ppm
Cu 10 – 50,000 ppm	Pb 20 – 100,000 ppm	Zn 10 – 50,000 ppm
Fe 0.01 - 25%	Sb 50 – 100,000 ppm	

SODIUM PEROXIDE FUSION / COMBINED ICP-OES AND ICP-MS PACKAGE (54 ELEMENTS)

GE_ICM90A50 (GE_ICP90A50 & GE_IMS90A50)

ELEMENTS AND LIMIT(S)

Ag 1 - 200 ppm	Ge 1 – 1,000 ppm	Sc 5 – 50,000 ppm
Al 0.01 - 25%	Ho 0.05 – 1,000 ppm	Si 0.1 - 30%
As 3 – 10,000 ppm	In 0.2 – 1,000 ppm	Sm 0.1 – 1,000 ppm
Ba 10 – 50,000 ppm	K 0.1 - 25%	Sn 1 – 10,000 ppm
Be 5 – 25,000 ppm	La 0.1 – 10,000 ppm	Sr 10 – 5,000 ppm
Bi 0.1 – 1,000 ppm	Li 10 – 50,000 ppm	Ta 0.5 – 10,000 ppm
Ca 0.1 - 25%	Lu 0.05 – 1,000 ppm	Tb 0.05 – 1,000 ppm
Cd 0.2 – 10,000 ppm	Mg 0.01 - 25%	Th 0.1 – 1,000 ppm
Ce 0.1 – 10,000 ppm	Mn 10 – 100,000	Ti 0.01 - 25%
Co 0.5 – 10,000 ppm	Mo 2 – 10,000 ppm	Tl 0.5 – 1,000 ppm
Cr 10 – 50,000 ppm	Nb 2 – 10,000 ppm	Tm 0.05 – 1,000 ppm
Cs 0.1 – 10,000 ppm	Nd 0.1 – 10,000 ppm	U 0.05 – 10,000 ppm
Cu 10 – 50,000 ppm	Ni 5 – 50,000 ppm	V 10 – 50,000 ppm
Dy 0.05 – 1,000 ppm	P 0.01 - 25%	W 5 – 10,000 ppm
Er 0.05 – 1,000 ppm	Pb 2 – 50,000 ppm	Y 0.5 – 10,000 ppm

Eu 0.05 – 1,000 ppm	Pr 0.05 – 1,000 ppm	Yb 0.1 – 1,000 ppm
Fe 0.01 - 25%	Rb 2 – 10,000 ppm	Zn 10 – 50,000 ppm
Ga 1 – 1,000 ppm	Sb 1 – 10,000 ppm	
Gd 0.05 – 1,000 ppm		

GE_HAS90A20**ELEMENTS AND LIMIT(S)**

As 0.5 - 1,000 ppm	Bi 0.5 - 1,000 ppm	Sb 0.5 - 1,000 ppm
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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 analysed by ICP-OES, ICP-MS or both ICP-OES and ICP-MS. This technique requires a minimum sample weight of 0.2 g.

LITHIUM METABORATE FUSION / ICP-MS PACKAGE (32 ELEMENTS)**GE_IMS95A50****ELEMENTS AND LIMIT(S)**

Ag 1 - 200 ppm	Ho 0.05 - 1,000 ppm	Ta 0.5 - 10,000 ppm
Ce 0.1 - 10,000 ppm	La 0.1 - 10,000 ppm	Tb 0.05 - 1,000 ppm
Co 0.5 - 10,000 ppm	Lu 0.05 - 1,000 ppm	Th 0.1 - 1,000 ppm
Cs 0.1 - 10,000 ppm	Mo 2 - 10,000 ppm	Tm 0.05 - 1,000 ppm
Cu 5 - 10,000 ppm	Nb 1 - 10,000 ppm	U 0.05 - 10,000 ppm
Dy 0.05 - 1,000 ppm	Nd 0.1 - 10,000 ppm	V 5 - 10,000 ppm
Er 0.05 - 1,000 ppm	Ni 5 - 10,000 ppm	W 1 - 10,000 ppm
Eu 0.05 - 1,000 ppm	Pr 0.05 - 1,000 ppm	Y 0.5 - 1,000ppm
Ga 1 - 1,000 ppm	Rb 0.2 - 10,000 ppm	Yb 0.1 - 1,000 ppm
Gd 0.05 - 1,000 ppm	Sm 0.1 - 1,000 ppm	Zr 0.5 – 1,000 ppm
Hf 1 - 10,000 ppm	Sn 1 - 10,000 ppm	

Note: Lithium metaborate fusion ICP-OES package GO_ICP95A50 can be found on [page 51](#).

EXPLORATION GRADE XRF ANALYSIS

PXRF on exploration grade pulp can be readily added to acid partial digest ICP methods (as above) to include resistive minerals and total recovery of Ti, Zr, Sn, W, Nb, and Ta.

EXPLORATION/SOIL PXRF PACKAGE GE_PXRF73GEO

Pulp based measurement for rocks, sediments, RC drill cuttings and crushed core for litho geochemistry. Sediment samples are used as Quality Control.

ELEMENTS AND LIMIT(S)

Ag* 0.005 - 0.01%	Hg* 0.005 - 0.1%	Sn* 0.01 - 1%
Al 0.2 - 45%	K 0.02 - 5%	Sr 0.0005 - 0.5%
As 0.001 - 2%	La* 0.02 - 0.4%	Ta* 0.005 - 0.1%
Ba 0.05 - 0.4%	Mg 1.5 - 45%	Th 0.002 - 0.1%
Bi* 0.005 - 0.1%	Mn** 0.01/0.06 - 3.2%	Ti 0.02 - 2.5%
Ca 0.05 - 32%	Mo 0.005 - 0.05%	Tl* 0.002 - 0.02%
Cd* 0.005 - 0.5%	Nb* 0.005 - 1%	U 0.002 - 0.1%
Ce* 0.02 - 1%	Ni 0.005 - 1%	V 0.01 - 0.2%
Cl* 0.03 - 2%	P 0.05 - 14.5%	W* 0.005 - 0.1%
Co 0.005 - 0.3%	Pb 0.001 - 2%	Y 0.0005 - 0.2%
Cr 0.01 - 1.5%	Rb 0.0005 - 0.05%	Zn 0.002 - 0.8%
Cu 0.0015 - 3%	S 0.02 - 15%	Zr 0.0005 - 1%
Fe 0.01 - 28%	Sb* 0.01 - 1%	
Ga* 0.005 - 0.5%	Se* 0.001 - 0.01%	
Hf* 0.005 - 1%	Si 0.5 - 47%	

GE_PXRF73SOIL

Soil, sediments and till samples that are dried, delumped and screened at 180 micron. Till and Sediments are used for Quality Control.

ELEMENTS AND LIMIT(S)

Ag* 0.005 - 0.01%	Mo* 0.005 - 0.05%	U* 0.002 - 0.1%
Al 0.5 - 45%	Nb* 0.005 - 1%	V 0.01 - 0.2%
As 0.001 - 2%	Ni 0.005 - 1%	W* 0.005 - 0.1%
Ba 0.05 - 0.4%	P 0.05 - 14.5%	Y 0.0005 - 0.2%
Ca 0.1 - 32%	Pb 0.001 - 2%	Zn 0.002 - 0.8%
Cd* 0.005 - 0.5%	Rb 0.0005 - 0.05%	Zr*** 0.001 - 1%
Cl* 0.03 - 2%	S 0.05 - 15%	
Co*** 0.005 - 0.3%	Sb* 0.01 - 1%	
Cr 0.01 - 1.5%	Se* 0.001 - 0.01%	
Cu 0.0015 - 3%	Si*** 0.5 - 47%	
Fe 0.01 - 28%	Sr 0.0005 - 0.5%	
K 0.02 - 5%	Th* 0.002 - 0.1%	
Mg 2.5 - 45%	Ti 0.02 - 2.5%	
Mn** 0.01/0.06 - 3.2%	Tl* 0.002 - 0.02%	

* Optional elements may be available at select locations with an additional Quality Control setup cost. Please enquire.

** Site specific higher range (Vanta™)

*** problematic element due to interference / inhomogeneity in soil fraction analysed.

GE_PXRF73CONC MINING MATERIALS CONCENTRATES/PRODUCT

Measured through a paper or plastic bag. Indicative results adjusted for attenuation of the bag. Elements common with bag material (i.e., Ca, Ti) are not reportable. Matrix matched Quality Control.

ELEMENTS AND LIMIT(S)

As 0.005 - 10%	Fe 0.5 - 77%	S(**) 0.5 - 30%
Ba(*) 0.1 - 10%	Mn 0.5 - 80%	W(*) 0.1 - 80%
Bi(*) 0.01 - 90%	Ni 0.2 - 80%	Ta(*) 0.1 - 82%
Ca(**) 0.5 - 35%	Pb 0.1 - 94%	Zr 0.1 - 74%
Cr 0.5 - 69%	Sb(*) 0.1 - 56%	Zn (**) 0.1 - 85%
Cu 0.1 - 85%		

PRESSED PELLET / XRF PACKAGE (26 ELEMENTS)

GE_PXRF73MIN

Pulp based measurement for mineralized rocks, sediments, RC drill cuttings, crushed core, feeds and concentrates in a loose powder setup.

ELEMENTS AND LIMIT(S)

Ag 0.001 - 0.600 Indic.***	Hf 0.001 - 72.000 Indic.***	Si 0.1 - 47 X
Al 0.1000 - 35.0000 X	Hg 0.002 - 86.000 Indic.***	Sn 0.005 - 88.000 Indic.***
As 0.0005 - 50.0000 X	K 0.0090 - 10.0000 X	Sr 0.0005 - 1.0000 X
Ba 0.003 - 10.000 X	La 0.004 - 0.700 Indic.***	Ta 0.003 - 82.000 Indic.***
Bi 0.0005 - 90.000 Indic.***	Mg 0.3000 - 35.0000 Indic.	Te 0.001 - 0.020 Indic.***
Ca 0.0040 - 31.0000 X	Mn 0.0020 - 45.0000 X	Th 0.001 - 0.500 Indic.***
Cd 0.001 - 0.700 Indic.***	Mo 0.001 - 67.000 Indic.***	Ti 0.0040 - 60.0000 X
Ce 0.0015 - 4.5000 Indic.***	Nb 0.001 - 42.000 Indic.***	Tl 0.0005 - 0.020 Indic.***
Cl 0.0100 - 4.0000 Indic.*	Ni 0.0010 - 80.0000 X	U 0.001 - 0.100 Indic.***
Co 0.0010 - 72.0000 Indic.**	P 0.0100 - 13.0000 X	V 0.0040 - 56.0000 X
Cr 0.0030 - 28.0000 X	Pb 0.0005 - 93.000 X	W 0.001 - 80.000 Indic.***
Cs 0.003 - 18.000 Indic.***	Rb 0.0005 - 0.0700 X	Y 0.0005 - 0.2000 X
Cu 0.0005 - 80.0000 X	S 0.0100 - 41.0000 X	Zn 0.0005 - 80.0000 X
Fe 0.0030 - 70.0000 X	Sb 0.005 - 19.000 Indic.***	Zr 0.0005 - 39.0000 X
Ga 0.0005 - 0.0500 Indic.***	Se 0.0005 - 0.0500 Indic.***	

X Quality Controlled data with generic sediment/regolith based reference material

Indic. - Indicative value is reported

Indic.* indicative value with X-Ray tube line overlap

Indic.** indicative value heavy Fe overlap with higher Limit of Detection

Indic.*** Optional elements as indicative values only may be available at select locations with an additional Quality Control setup cost. Please enquire.

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

GE_XRF71SQ

Ag 0.005-50%	I 0.005-50%	Sn 0.001-50%
Al 0.1-80%	K 0.001-50%	S 0.01-75%
Ba 0.001-40%	La 0.001-25%	Sr 0.001-50%
Bi 0.001-20%	Mn 0.01-50%	Ta 0.001-50%
Br 0.005-50%	Mo 0.01-50%	Te 0.005-25%
Ca 0.001-50%	Na 0.01-50%	Th 0.001-5%
Ce 0.001-20%	Nb 0.01-15%	U 0.001-5%
Cl 0.001-2%	Nd 0.01-15%	V 0.001-25%
Co 0.001-20%	Ni 0.001-50%	W 0.001-50%
Cr 0.001-100%	P 0.001-50%	Y 0.001-50%
Cu 0.001-100%	Pb 0.001-50%	Zn 0.001-50%
Fe 0.001-100%	Rb 0.001-50%	Zr 0.001-50%
Ga 0.001-5%	Sb 0.001-50%	LOI*
Ge 0.001-5%	Se 0.001-10%	
Hf 0.001-5%	Si 0.1-100%	

*G_PHY01V or G_PHY02V

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 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 or cell-based ICP-MS.

There are many benefits to using MMI™ Technology for soil geochemistry, including:

- Few false anomalies
- Focused anomalies
- Minimal nugget effects

EXPERTISE
IS
GUARANTEED

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 g sample and the extracted solution is analysed via ICP-MS, providing determinations in the part per billion range. For detailed instructions for the MMI™ sampling protocols and orientation surveys, please visit <https://www.sgs.com/en/mining/analytical-services/geochemistry/mobile-metal-ions-mmi> or contact us at minerals@sgs.com.

ICP-MS UNIVERSAL CELL TECHNOLOGY

SGS is committed to the MMI™ Technology. With the development of the ICP-MS combined with reaction cell technology we are able to further enhance this analytical approach. The lower detection limits provided by the removal of interferences using cell based technology inside the ICP-MS means 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 analyse your samples using the MMI-ME package.

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

GE_MMIM

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	

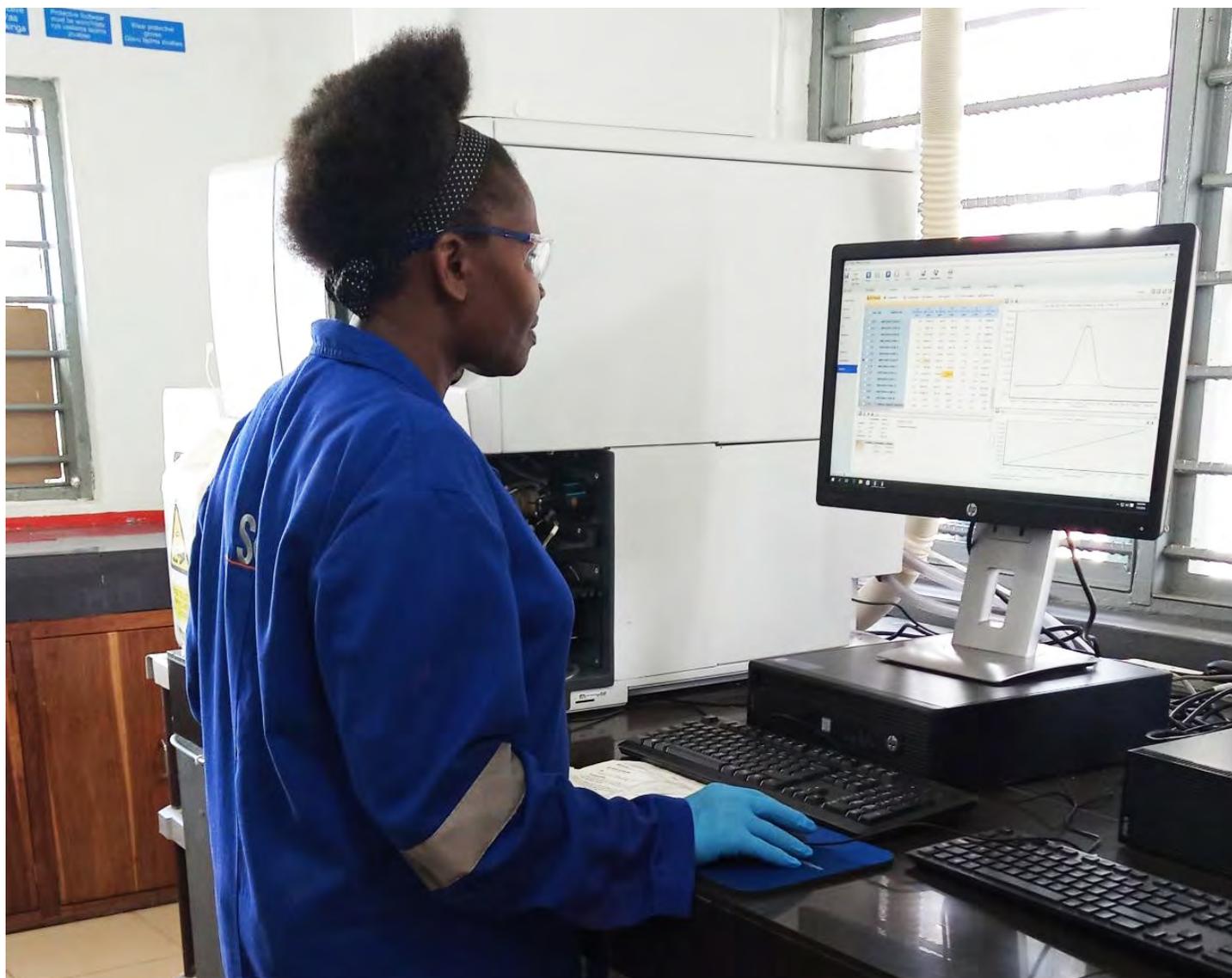
MOBILE METAL ION ENHANCED PACKAGE / ICP-MS (55 ELEMENTS)

GE_MMIME

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: Sulphur, bromine, iodine and lead isotopes can be added to the MMI-ME package by request.



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-OES and ICP-MS.

GE_ICP23D50

ELEMENTS AND LIMITS

Al 12 – 150,000 ppm	K 7 - 250,000ppm	Sr 0.5 – 10,000 ppm
B 10 – 10,000 ppm	Li 7 – 250,000 ppm	Ti 1 – 150,000 ppm
Ba 1 – 10,000 ppm	Mg 9 – 150,000 ppm	S 42 – 410,000 ppm
Ca 30 – 150,000 ppm	Mn 2 – 10,000 ppm	V 20 – 10,000 ppm
Cr 10 – 10,000 ppm	Na 12 – 150,000 ppm	Zn 1 – 10,000 ppm
Cu 0.5 – 10,000 ppm	Ni 1 – 10,000 ppm	Zr 0.05 – 10,000 ppm
Fe 7 – 150,000 ppm	P 18 – 250,000 ppm	

GE_IMS23D50

ELEMENTS AND LIMITS

Ag 0.01 – 10 ppm	Ga 1 – 10,000 ppm	Pd 0.01 – 500 ppm	Tb 0.002 – 10,000 ppm
As 10 – 10,000 ppm	Gd 0.01 – 1,000 ppm	Pr 0.005 – 1,000 ppm	Te 0.1 – 1,000 ppm
Au 0.005 – 5 ppm	Hf 0.5 – 500 ppm	Pt 0.005 – 350 ppm	Th 0.002 – 10,000 ppm
Bi 0.005 – 10,000 ppm	Hg 0.02 – 10,000 ppm	Rb 0.2 – 10,000 ppm	Tl 0.002 – 1,000 ppm
Cd 0.03 – 10,000 ppm	Ho 0.002 – 500 ppm	Rh 0.001 – 500 ppm	Tm 0.002 – 1,000 ppm
Ce 0.01 – 1,000 ppm	In 0.005 – 500 ppm	Sb 0.04 – 10,000 ppm	U 0.001 – 10,000 ppm
Co 0.01 – 10,000 ppm	Ir 0.002 – 500 ppm	Sc 0.3 – 10,000 ppm	W 0.01 – 10,000 ppm
Cs 0.005 – 1,000 ppm	La 0.01 – 10,000 ppm	Se 5 – 1,000 ppm	Y 0.01 – 10,000 ppm
Dy 0.005 – 1,000 ppm	Lu 0.002 – 10,000 ppm	Sm 0.005 – 1,000 ppm	Yb 0.002 – 100 ppm
Er 0.005 – 1,000 ppm	Mo 0.05 – 10,000 ppm	Sn 0.4 – 1,000 ppm	
Eu 0.002 – 1,000 ppm	Nd 0.02 – 10,000 ppm	Ta 0.2 – 10,000 ppm	

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 limits can increase. Requests for environmental services will be forwarded to an SGS Environmental Services Laboratory.

GROUND WATER ANALYSIS / ICP-OES PACKAGE (31 ELEMENTS)

GE_ICP80T GE_ICP80T

ELEMENTS AND LIMIT(S)

Ag ≥0.001 ppm	Co ≥0.01 ppm	Mn ≥0.005 ppm	Sn ≥0.05 ppm
Al ≥0.05 ppm	Cr ≥0.01 ppm	Mo ≥0.01 ppm	Sr ≥0.001 ppm
As ≥0.03 ppm	Cu ≥0.005 ppm	Na ≥0.05 ppm	Ti ≥0.01 ppm
Ba ≥0.01 ppm	Fe ≥0.05 ppm	Ni ≥0.01 ppm	V ≥0.01 ppm
Be ≥0.005 ppm	K ≥0.1 ppm	P ≥0.05 ppm	W ≥0.05 ppm
Bi ≥0.05 ppm	La ≥0.01 ppm	Pb ≥0.03 ppm	Y ≥0.005 ppm
Ca ≥0.05 ppm	Li ≥0.01 ppm	Sb ≥0.05 ppm	Zn ≥0.005 ppm
Cd ≥0.01 ppm	Mg ≥0.05 ppm	Sc ≥0.001 ppm	Zr ≥0.01 ppm

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
Co ≥0.1 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
Cs ≥0.01 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
G_PHY14V	Total dissolved solids (TDS)	Gravimetric
GC_ISE10T	pH	Ion selective electrode (ISE)
GE_ISE21T	Fluoride F ⁻	Ion selective electrode (ISE)
GE_ISE30T	Chloride Cl ⁻	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_CSA07D	SO ₄ ²⁻	0.01-30%	Leach/ICP-OES	1.0
GE_CSA08Q	S ²⁻	≥0.05	Leach/ IR combustion	2.0
GE_CSA02Q	C (Carbonate)	≥0.01%	Leach/IR combustion	0.2
GE_CSB02V	CO ₂ (Carbonate)	≥0.05%	Coulometry	0.02 - 0.1
GE_CSA03B	C (organic)	0.01-40%	Leach/IR combustion	0.25
	C (inorganic)	0.01-30%		
GE_CSB03V	C (organic)	≥0.01%	Coulometry	1.0
	C (inorganic)	≥0.05%		
GE_CSA05V	C (graphitic)	≥0.05%	Leach/IR combustion	0.05
GE_CSB05V	C (graphitic)	≥0.05%	Coulometry	1.0

ADDITIONAL SINGLE ELEMENTS

CODE(S)	ELEMENT	LIMIT(S)	DESCRIPTION	MIN. SAMPLE WT.(g)
GE_CVA37A25	Hg	0.005 - 100 ppm	Cold vapour AAS	0.2
GE_ISE20V	F	25 - 100,000 ppm	Ion selective electrode	0.1
GE_ISE30V	Cl	50 - 5,000 ppm	Ion selective electrode	0.2

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

ORE-GRADE ANALYSIS

OVER RANGE METHODS

AQUA REGIA DIGESTION / ICP-OES

GO_ICP21B100

ELEMENTS AND LIMIT(S)

Ag 0.01 - 0.1%	Cu 0.01 - 30%	Ni 0.001 - 10%
As 0.01 - 10%	Fe 0.01 - 30%	Pb 0.001 - 10%
Cd 0.001 - 10%	Mn 0.01 - 10%	S 0.01 - 30%
Co 0.001 - 10%	Mo 0.001 - 10%	Zn 0.01 - 10%

MULTI-ACID (FOUR ACID) DIGESTION / ICP-OES PACKAGE

GO_ICP42Q100

ELEMENTS AND LIMIT(S)

Ag 0.01 - 0.1%	Fe 0.1 - 30%	Ni 0.001 - 10%
As 0.01 - 10%	Li 0.01 - 10%	Pb 0.01 - 30%
Cd 0.001 - 10%	Mn 0.001 - 10%	S 0.01 - 10%
Co 0.001 - 10%	Mo 0.001 - 10%	Zn 0.01 - 30%
Cu 0.01 - 30%		

Note: Additional elements can be added upon request.

SODIUM PEROXIDE FUSION / ICP-OES PACKAGE

GO_ICP90Q100

ELEMENTS AND LIMIT(S)

As 0.01 – 20%	Mg 0.01 – 30%	Sb 0.01 – 20%
Bi 0.01 – 10%	Mn 0.01 – 30%	Zn 0.01 - 30%
Co 0.01 - 30%	Mo 0.01 - 30%	
Cu 0.01 - 30%	Ni 0.01 - 30%	
Fe 0.05 - 50%	Pb 0.01 - 30%	

Requires a minimum sample weight of 0.5 g. For samples containing these elements at greater than the upper limit an alternative technique will be used for full recovery.



FUSION-ICP PACKAGES

LITHIUM METABORATE FUSION / ICP-OES (LITHOLOGIC) PACKAGE (13 ELEMENTS)

GO_ICP95A50

ELEMENTS AND LIMIT(S)

Al ₂ O ₃ 0.01 - 75%	MnO 0.01 - 10%	LOI -10 - 100%
CaO 0.01 - 60%	Na ₂ O 0.01 - 30%	
Cr ₂ O ₃ 0.01 - 10%	P ₂ O ₅ 0.01 - 25%	
Fe ₂ O ₃ 0.01 - 75%	SiO ₂ 0.01 - 90%	
K ₂ O 0.01 - 25%	TiO ₂ 0.01 - 25%	
MgO 0.01 - 30%	V ₂ O ₅ 0.01 - 10%	

Requires a minimum sample weight of 0.5g. Note: Ba, Nb, Sr, Y, Zn and Zr can be added upon request.



FUSION-XRF PACKAGES

BORATE FUSION / XRF WHOLE ROCK PACKAGE

GO_XRF72

Analyte	Calibrated as Compound	Package Majors	Package	Package Maj/Min	Range
Al	Al ₂ O ₃	X	X	X	0.01-100%
As	As ₂ O ₃		X	X	0.01-5%
Ba	BaO	X	X	X	0.01-60%
Bi	Bi ₂ O ₃			Extension/ Optional Oxide	0.01-5%
Ca	CaO	X	X	X	0.01-60%
Cl	Cl		X	X	0.01-30%
Co	Co ₃ O ₄		X	X	0.01-5%
Cr	Cr ₂ O ₃		X	X	0.01-5%
Cu	CuO		X	X	0.01-5%
Fe	Fe ₂ O ₃	X	X	X	0.01-100%
Hf	HfO ₂			Extension/ Optional Oxide	0.01-5%
K	K ₂ O	X	X	X	0.01-70%
Mg	MgO	X	X	X	0.01-100%
Mn	Mn ₃ O ₄	X	X	X	0.01-100%
Mo	MoO ₃			Extension/ Optional Oxide	0.01-5%
Na	Na ₂ O	X	X	X	0.01-60%
Ni	NiO		X	X	0.01-5%
P	P ₂ O ₅	X	X	X	0.01-55%
Pb	PbO		X	X	0.01-5%
Rb	Rb ₂ O			Extension/ Optional Oxide	0.01-5%
Sb	Sb ₂ O ₃			Extension/ Optional Oxide	0.01-5%
Si	SiO ₂	X	X	X	0.01-100%
Sn	SnO ₂		X	Extension/ Optional Oxide	0.01-5%
S	SO ₃	X	X	X	0.01-10%
Sr	SrO		X	X	0.01-5%
Ta	Ta ₂ O ₅			Extension/ Optional Oxide	0.01-5%
Th	ThO ₂			Extension/ Optional Oxide	0.01-1%
Ti	TiO ₂	X	X	X	0.01-100%
U	U ₃ O ₈			Extension/ Optional Oxide	0.01-5%
V	V ₂ O ₅	X	X	X	0.01-10%
W	WO ₃			Extension/ Optional Oxide	0.01-5%
Zn	ZnO		X	X	0.01-5%
Zr	ZrO ₂		X	X	0.01-5%
LOI (1000°C)*		X	X	X	-10 – 100%
Moisture (as received)		Optional	Optional	Optional	≥0.01 %

*G_PHY01V or G_PHY02V

Umineralized whole rock analysis; for commodities and specific matrices refer to commodity section

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 enquire.

ADDITIONAL SINGLE ELEMENTS

CODE(S)	ELEMENT	LIMIT(S)	DESCRIPTION	MIN. SAMPLEWT.(g)
GO_CVA38B50	Hg	≥0.3 ppm	Cold vapour AAS	0.25
GO_CLA31V	Cl	20 – 5000 ppm	Titration	10

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

CONTROL-GRADE ANALYSIS

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 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-OES (30 ELEMENTS)**GC_ICP21C50****ELEMENTS AND REPORTING LIMIT(S)**

Ag 0.8ppm – 0.1%	Co 3ppm - 50%	Mo 6ppm - 50%	Sr 0.02ppm - 50%
Al 2ppm – 50%	Cr 1ppm - 50%	Na 20ppm - 50%	Ti 0.2ppm - 50%
As 30ppm – 50%	Cu 1ppm - 50%	Ni 6ppm - 50%	Tl 30ppm - 50%
Ba 0.07ppm – 50%	Fe 2ppm - 50%	P 50ppm - 50%	V 2ppm - 50%
Be 0.02ppm – 50%	K 10ppm - 50%	Pb 20ppm - 50%	Y 0.2ppm - 50%
Bi 10ppm - 50%	Li 20ppm - 50%	Sb 10ppm - 50%	Zn 7ppm - 50%
Ca 9ppm - 50%	Mg 0.7ppm - 50%	Se 30ppm - 50%	
Cd 0.9ppm - 50%	Mn 0.4ppm - 50%	Sn 20ppm - 50%	

Additional elements can be added. An ICP-MS option is available. Requires a minimum sample weight of 1.0 g.

MULTI-ACID (FOUR ACID) DIGESTION PACKAGES

MULTI-ACID DIGESTION PACKAGE / ICP-OES (30 ELEMENTS)

GC_ICP42C100

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.

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

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

GC_ICP46C100

ELEMENTS AND REPORTING LIMIT(S)

Ag 0.8 ppm – 0.1%	Co 3 ppm - 50%	Mo 6 ppm - 50%	Sr 0.02ppm - 50%
Al 2 ppm – 50%	Cr 1 ppm - 50%	Na 20 ppm - 50%	Ti 0.2 ppm - 50%
As 30 ppm – 50%	Cu 1 ppm - 50%	Ni 6 ppm - 50%	Tl 30 ppm - 50%
Ba 0.07 ppm – 50%	Fe 2 ppm - 50%	P 50 ppm - 50%	V 2 ppm - 50%
Be 0.02 ppm – 50%	K 10 ppm - 50%	Pb 20 ppm - 50%	Y 0.2 ppm - 50%
Bi 10 ppm - 50%	Li 20 ppm - 50%	Sb 10 ppm - 50%	Zn 7 ppm - 50%
Ca 9 ppm - 50%	Mg 0.7 ppm - 50%	Se 30 ppm - 50%	
Cd 0.9 ppm - 50%	Mn 0.4 ppm - 50%	Sn 20 ppm - 50%	

Additional elements can be added. An ICP-MS option is available. Requires a minimum sample weight of 1.0 g. Recoveries for volatiles (i.e., As, Sb) may be incomplete.

FUSION PACKAGES

FUSION / ICP-OES PACKAGE (28 ELEMENTS)

GC_ICP93A50V

ELEMENTS AND REPORTING LIMIT(S)

Ag 200 ppm - 1%	Co 200 ppm - 50%	Mo 300 ppm - 50%	Tl 2,000 ppm - 50%
Al 0.04% - 50%	Cr 40 ppm - 50%	Ni 300 ppm - 50%	V 80 ppm - 50%
As 1,200 ppm - 50%	Cu 40 ppm - 50%	Pb 800 ppm - 50%	Y 8 ppm - 50%
Ba 3 ppm - 50%	Fe 0.05% - 50%	Sb 400 ppm - 50%	Zn 300 ppm - 50%
Be 0.8 ppm - 50%	K 0.04% - 50%	Se 2,000 pm - 50%	
Bi 400 ppm - 50%	Li 800 ppm - 50%	Sn 800 ppm - 50%	
Ca 0.08% - 50 %	Mg 0.003% - 50%	Sr 10 ppm - 50%	
Cd 40 ppm - 50%	Mn 0.002% - 50%	Ti 0.0008% - 50 %	

Additional elements can be added. An ICP-MS option is available. Requires a minimum sample weight of 0.2 g.

FUSION / AAS**GC_AAS93A50V****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_XRF72	Same available range and elements as GO_XRF72, refer to ore grade analysis section	Borate fusion / XRF
GC_XRF70V	Same available range and elements as GO_XRF70V, refer to ore and commodities section	Pyrosulphate fusion / XRF
GC_XRF75	Refer to pages 55 for elements and ranges	Internal standard / XRF

PROCESS SOLUTION PACKAGES**PROCESS SOLUTION PACKAGE / ICP-OES / NON-CYANIDE BASED (30 ELEMENTS)****GC_ICP84T****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 enquire.

**QUALITY ANALYSIS
MEANS
QUALITY RESULTS**

PROCESS SOLUTION PACKAGE / ICP-OES / CYANIDE BASED (30 ELEMENTS)**GC_ICP82T****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 enquire.

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

CODE(S)	ELEMENT	LIMIT(S)	DESCRIPTION	MIN. SAMPLE WT.(g)
GC_CSA06V	S	≥0.01%	IR combustion	0.2
	C	≥0.01%		0.2
GC_CSA08V	S ²⁻	≥0.05%	Leach/Digest/IR	2.0
GC_CLA01V	Fe ²⁺	≥0.5%	Ferrous iron titration	0.25

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

ADDITIONAL SINGLE ANALYTES

CODE(S)	ANALYTES	LIMITS	DESCRIPTION	MIN. SAMPLE WT.(g)
GC_CLA04V	Insolubles (acid)	≥0.05%	Gravimetric	5
GC_CLA03V	CaO	≥5%	Available lime	2
GC_ISE10V	pH (soils/sediments)	0.1 - 14	Ion selective electrode	20

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

VOLUMETRIC AND GRAVIMETRIC METHODS FOR CONCENTRATES

CODE(S)	ELEMENT	LIMIT(S)	DESCRIPTION	MIN. SAMPLE WT.(g)
GC_CON13V	Cu	15 - 60%	Titration	0.25
GC_CON03V	Cu	5 - 100%	Electroplating	1.0
GC_CON07V	Ni	5 - 100%	Electroplating	1.0
GC_CON11V	Pb	1 - 80%	Titration	2.0
GC_CON12V	Zn	10 - 80%	Titration	0.5
GC_CON08V	Fe	10 - 80%	Titration	0.25

Note: these elements can be analysed to party or umpire quality standards (GT). Additional elements can be determined on concentrate samples in some SGS laboratories. Please enquire. Trade sample analyses typically require moisture analysis and may require a larger minimum sample weight.

SELECT METHODS

SGS offers a wide variety of select methods to analyse 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 enquire.

RARE EARTH ELEMENT ANALYSIS

Rare earth element (REE) samples can be analysed 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 enquire to ensure we meet your requirements.

The following exploration packages contain REEs or can have additional REE elements requested.

RARE EARTH ELEMENT ADD ON TRACE PACKAGES

CODE(S)	ADDITIONAL ELEMENTS*	DESCRIPTION
GE_IMS40Q12	Pr, Nd, Sm, Eu, Gd, Dy, Ho, Er, Tm	4-Acid digest / ICP-MS

* REE elements that can be added to existing package

RARE EARTH ELEMENT INCLUSIVE TRACE PACKAGES

CODE(S)	ELEMENTS	DESCRIPTION
GE_ICM90A50	Refer to pg.40	Sodium peroxide fusion / ICP-OES / ICP-MS
GE_IMS95A50	Refer to pg.41	Lithium metaborate fusion / ICP-MS

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

GO_IMS91Q100

ELEMENTS AND LIMIT(S)

Ce 50 - 15,000 ppm	Ho 0.1 - 200 ppm	Sm 10 - 20,000 ppm	Y 5 - 10,000 ppm
Dy 1 - 5,000 ppm	La 50 - 50,000 ppm	Tb 1 - 500 ppm	Yb 1 - 200 ppm
Er 0.5 - 200 ppm	Lu 0.2 - 200 ppm	Th 5 - 50,000 ppm	
Eu 1 - 5,000 ppm	Nd 50 - 50,000 ppm	Tm 0.1 - 200 ppm	
Gd 5 - 5,000 ppm	Pr 10 - 20,000 ppm	U 1 - 200 ppm	

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

EXPLORATION-GRADE COPPER METHODS

CODE(S)	LIMIT(S)	DESCRIPTION
GE_ICP22B20 / GE_ICP21B20	0.5 ppm - 1 %	2-Acid digest / Aqua regia – ICP-OES
GE_IMS22B20 / GE_IMS21B20	0.5 ppm - 1 %	2-Acid digest / Aqua regia – ICP-MS
GE_ICP40Q12	0.5 ppm - 1 %	4-Acid digest – ICP-OES
GE_ICP90A50	10 ppm - 5 %	Fusion – ICP-OES

ORE-GRADE COPPER METHODS

CODE(S)	LIMIT(S)	DESCRIPTION
GO_ICP21B100	0.01 - 30 %	Aqua regia digest – ICP-OES
GO_ICP42Q100	0.01 - 30 %	4-Acid digest – ICP-OES
GO_ICP90Q100	0.01 - 30 %	Fusion – ICP-OES

CONCENTRATE-GRADE COPPER METHODS

CODE(S)	LIMIT(S)	DESCRIPTION
GC_CON13V*	15 - 60 %	Short iodide titration
GC_CON03V*	5 - 100 %	Electrogravimetry

* These methods can be done at party or umpire quality.

MINERAL SELECTIVE COPPER METHODS

CODE(S)	LIMIT(S)	DESCRIPTION
GC_AAS70D200	≥0.002 %	Cu oxide method, citric acid leach, AAS
GC_AAS71C50	≥0.001 %	Cu H ₂ SO ₄ soluble, AAS
GC_AAS74C50	≥0.001 %	Cu acetic acid soluble, AAS
GC_AAS75D100	≥0.001 %	CN soluble Cu, AAS
GC_AAS01D250	≥0.001 %	Metallic Cu, AgNO ₃ digest, AAS
GC_ASQ01D50	≥0.001 %	Sequential Cu leach (H ₂ SO ₄ soluble Cu, Cyanide soluble Cu, residual Cu), AAS
GC_ASQ02D100		
GC_ASQ03D50		

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 GE_ICP21B20, GE_ICP22B20, GE_ICP40Q12, GE_ICP90A50 digestion techniques. For description of the GO_ICP21B100, GO_ICP42Q100 and GO_ICP90Q100 techniques, please see the Ore-Grade Analysis section.

EXPLORATION-GRADE NICKEL METHODS

CODE(S)	LIMIT(S)	DESCRIPTION
GE_ICP22B20 / GC_ICP21B20	1 ppm - 1%	2-Acid digest / Aqua regia – ICP-OES
GE_IMS22B20 / GE_IMS21B20	0.5 ppm - 1%	2-Acid digest / Aqua regia – ICP-MS
GE_ICP40Q12	1 ppm - 1%	4-Acid digest – ICP-OES
GE_ICP90A50	10 ppm - 10%	Fusion – ICP-OES
GE_IMS90A50	5 ppm - 5%	Fusion – ICP-MS

ORE-GRADE NICKEL METHODS

CODE(S)	LIMIT(S)	DESCRIPTION
GO_ICP21B100	0.001 - 10%	Aqua regia digest – ICP-OES
GO_ICP42Q100	0.001 - 10%	4-Acid digest – ICP-OES
GO_ICP90Q100	0.01 - 30%	Fusion – ICP-OES

CONCENTRATE-GRADE NICKEL METHODS

CODE(S)	LIMIT(S)	DESCRIPTION
GC_CON06V*	0.1 - 60%	DMG separation / EDTA titration
GC_CON07V*	5 - 100%	DMG separation / electroplating

* These methods can be done at party or umpire quality (GT).

MINERAL SELECTIVE NICKEL METHODS

CODE	LIMIT(S)	DESCRIPTION
GC_AAS03D250	≥0.002%	Metallic & sulphide nickel by bromine-methanol leach, AAS finish

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

ORES AND COMMODITIES

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

- Manganese ores.
- Aluminium ores (bauxite, including extractable SiO_2 , Al_2O_3 , reactive Si, available Al).
- Tantalum ores.
- Industrial minerals (limestone, chromite, borate).
- Fertilizers products (phosphate, sulphur, potash).
- Concentrates and metals.
- Mineral sands.
- 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.

GENERIC / MULTI-ELEMENT ORES

Generic Ore compatible analytical methods with a wide dynamic range using XRF.

PYROSULPHATE FUSION / XRF BASE METAL PACKAGE (10 ELEMENTS)

GO_XRF70

ELEMENTS AND LIMITS

Co 0.01 - 100%	Fe 0.05 - 100%	Ni 0.01 - 100%	Zn 0.01 - 100%
Cr 0.01 - 100%	Mn 0.01 - 100%	Pb 0.01 - 100%	
Cu 0.01 - 100%	Mo 0.01 - 100%	W 0.05 - 100%	

WIDE RANGE ORE METHOD BASED ON PRESSED PELLET; USE OF AN INTERNAL STANDARD TO ALLOW FOR MATRIX CORRECTION

GO/GC_XRF75

As 0.001-100%	Sb 0.002-100%	Nb 0.001-100%	U_3O_8 0.002-10%
Sn 0.002-100%	Ta 0.002-100%	ThO_2 0.005-10%	W 0.002-50%

Wide range borate fusion for sulphide, concentrates and metallurgical samples using oxidizing borate fusion (NaNO_3). Upon special request and at some sites LiNO_3 as oxidizer is available allowing to report Na_2O . This method can be used for FeCr, FeMn. FeSi requires a dedicated method. Please enquire on availability.

GO_XRF76

Analyte	Calibrated as Compound	Package Majors	Package	Package Maj/Min	Range
Al	Al ₂ O ₃	X	X	X	0.01-100%
As	As ₂ O	X	X	X	0.01-10%
Ba	BaO	X	X	X	0.01-10%
Bi	Bi ₂ O ₃		X		0.01-40%
Ca	CaO	X	X	X	0.01-80%
Co	Co ₃ O ₄	X	X	X	0.01-40%
Cr	Cr ₂ O ₃	X	X	X	0.01-40%
Cu	CuO	X	X	X	0.01-40%
Cs	Cs ₂ O			X	0.01-10%
Dy	Dy ₂ O ₃			X	0.01-10%
Eu	Eu ₂ O ₃			X	0.01-10%
F	F	addOn	addOn	addOn	0.5-50%
Fe	Fe ₂ O ₃	X	X	X	0.01-100%
Gd	Gd ₂ O ₃			X	0.01-10%
Hf	HfO ₂		X		0.01-10%
K	K ₂ O	X	X	X	0.01-70%
La	La ₂ O ₃			X	0.01-10%
Mg	MgO	X	X	X	0.05-100%
Mn	Mn ₃ O ₄	X	X	X	0.01-100%
Mo	MoO ₃		X		0.01-30%
Na	Na ₂ O	N.A.	N.A.	N.A.	0.05-50%
Nb	Nb ₂ O ₃		X		0.01-25%
Nd	Nd ₂ O ₃			X	0.01-30%
Ni	NiO	X	X	X	0.01-5%
P	P ₂ O ₅	X	X	X	0.01-55%
Pb	PbO	X	X	X	0.01-64%
Pr	Pr ₆ O ₁₁			X	0.01-10%
Sb	Sb ₂ O ₃		X		0.01-50%
Si	SiO ₂	X	X	X	0.05-100%
Sm	Sm ₂ O ₃			X	0.01-10%
Sn	SnO ₂		X		0.01-40%
S	SO ₃	X	X	X	0.01-92%
Sr	SrO	X	X	X	0.01-5%
Ta	Ta ₂ O ₅		X		0.01-50%
Th	ThO ₂		X		0.01-1%
Ti	TiO ₂	X	X	X	0.01-100%
U	U ₃ O ₈		X		0.01-10%
V	V ₂ O ₅	X	X	X	0.01-10%
W	WO ₃		X		0.01-60%
Zn	ZnO	X	X	X	0.01-50%
Zr	ZrO ₂		X		0.01-10%
LOI (1000°C)*		Optional	Optional	Optional	-10 – 100%
Moisture (as received)		Optional	Optional	Optional	≥0.01%

*G_PHY01V or G_PHY02V

IRON ORE

Lithium borate fusion and WD XRF analysis is the industry method of choice for the analysis of oxide iron ores. Single or multi-temperature LOI is available, customizable as required. Borate Fusion ranges are available to accommodate ore grade, grade control and commercial analysis.

BORATE FUSION / XRF IRON ORE PACKAGE

GO_XRF72FE1

Al ₂ O ₃ 0.01 - 100%	K ₂ O 0.01 - 10%	Zn 0.01 - 1%
As 0.01 - 1%	Pb 0.01 - 10%	Zr 0.01 - 1%
Ba 0.01 - 1%	SiO ₂ 0.01 - 100%	LOI -20 – 100% *
CaO 0.01 - 40%	Sn 0.01 - 1%	
Cr ₂ O ₃ 0.01 - 10%	S 0.01 - 2%	
Cu 0.01 - 5%	TiO ₂ 0.01 - 50%	
Fe 0.01 - 70%	V 0.01 - 5%	

*G_PHY01V or G_PHY02V

GO_XRF72FE2

ELEMENTS AND LIMIT(S)

Al ₂ O ₃ 0.01 - 100%	Mn 0.001 - 28%	Zn 0.01 - 1%
As 0.001 - 1%	Na ₂ O 0.01 - 2%	Zr 0.001 - 1%
Ba 0.001 - 1%	Ni 0.01 - 10%	LOI (1000°C) REQ*
CaO 0.01 - 40%	P 0.001 - 10%	LOI (650°C) Optional*
Cl 0.001 - 1%	Pb 0.001 - 10%	LOI (425°C) Optional*
Co 0.001 - 5%	SiO ₂ 0.01 - 100%	LOI (371°C) Optional*
Cr ₂ O ₃ 0.001 - 10%	Sn 0.001 - 1%	LOI (105°C) REQ*
Cu 0.001 - 5%	S 0.01 - 2%	
Fe 0.01 - 70%	Sr 0.01 - 1%	
K ₂ O 0.001 - 10%	TiO ₂ 0.01 - 50%	
MgO 0.01 - 100%	V 0.01 - 5%	

*G_PHY01V or G_PHY02V

VOLUMETRIC METHOD FOR IRON ORE

CODE	ELEMENT	LIMIT(S)	DESCRIPTION	MIN. SAMPLEWT.(g)
GC_CON08V	Fe	10 - 80%	Titration	0.25

Note: this method can be analysed to party or umpire quality standards (GT).

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
G_PHY20V	Satmagan	Measures the total magnetic moment in a saturated magnetic field to determine the percentage of magnetic material present
G_PHY19V	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_IMS22B20 / GE_IMS21B20	0.05 - 10,000 ppm	2-Acid / aqua regia digest / ICP-MS
GE_IMS95A50	0.05 - 10,000 ppm	Lithium metaborate fusion / ICP-MS
GE_MMIME	≥0.5ppb	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_IMS91Q100	1 - 200 ppm	Sodium peroxide fusion / ICP-MS
GO_XRF71	0.002 - 3%	Pressed pellet/powder XRF
GO_XRF72	0.01 - 10%	Borate fusion / 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_IMS22B20 / GE_IMS21B20	1 - 10,000 ppm	2-Acid / aqua regia digest / ICP-OES
GE_ICP40Q12	1 - 10,000 ppm	4-Acid digest / ICP-OES
GE_ICP92A50	10 - 50,000 ppm	Sodium peroxide fusion / ICP-OES
GE_IMS90A50	5 - 10,000 ppm	Sodium peroxide fusion / ICP-MS

LITHIUM PACKAGES FOR HIGHER GRADE MINERALIZATION

CODE(S)	ELEMENTS/ LIMIT(S)	DESCRIPTION
GE_ICP92A50	≥10ppm	Sodium peroxide fusion / ICP-OES

FLUORSPAR

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

SOLUBLE FLUORSPAR PACKAGE

CODE(S)	ELEMENTS/ LIMIT(S)	DESCRIPTION
GC_CLA27V	CaCO ₃ (≥0.1%)	EDTA Titration
	CaF ₂ (≥10%)	Calculation

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BAUXITE

GO/GT_XRF72BX

ANALYTE	REPORTED AS	RANGE
Al	Al ₂ O ₃	0.01 - 100%
Ba	BaO	0.01 - 5%
Ca	CaO	0.01 - 5%
Cr	Cr ₂ O ₃	0.01 - 1%
Fe	Fe ₂ O ₃	0.01 - 50%
K	K ₂ O	0.001 - 1%
Mg	MgO	0.01 - 10%
Mn	MnO	0.01 - 10%
Na	Na ₂ O	0.01 - 10%
P	P ₂ O ₅	0.01 - 10%
Si	SiO ₂	0.05 - 100%
S	SO ₃	0.01 - 1%
Ti	TiO ₂	0.01 - 5%
V	V ₂ O ₅	0.01 - 1%
Zr	ZrO ₂	0.01 - 1%
Ga	Ga ₂ O ₃ option	0.01 - 5%
LOI (1000°C)*	LOI	-10 – 100%

*G_PHY01V or G_PHY02V

Dried sample only.

Additional characterizations available include:

Reactive Silica and Available Alumina, 0.01-100%. With standard digestion temperature 145°C and standard digestion temperature 235°C respectively .

Standard Bomb digest followed by ICP-OES analysis (GO_ICP10V500)

Total Organic Carbon (non Carbonate) TOC using combustion refer to [page 49](#).

Total Carbon by combustion TC using IR combustion refer to [pages 49, 53, 56](#).

FTIR based characterization GE_FTIR73BX (below) which includes the typical Bauxite minerals as well as phases correlated to chemistry.

GE_FTIR73BX

Total Alumina 20.0 - 60.0%	Quartz 1.0 - 100.0%	Calcite 1.0 - 100.0%
Reactive Alumina 20.0 - 60.0%	K-Felspar 1.0 - 50.0%	Dolomite 1.0 - 100.0%
Total Silica 1.0 - 35.0%	Kaolonite 1.0 - 100.0%	Goethite 1.0 - 20.0%
Reactive Silica 1.0 - 356.0%	Smectite 1.0 - 100.0%	Siderite 1.0 - 30.0%
Total Iron Oxides 3.0 - 30.0%	Plagioclase 1.0 - 100.0%	
Total Titanium Oxides 1.5 - 3.5%	Illite 1.0 - 100.0%	

Obtain quantitative infra-red spectral data using an ATR based system includes total oxide weight % calibrated against borate fusion XRF and reactive silica and aluminium calibrated against classical bomb digest.



NICKEL LATERITE

Industry standard XRF multielement method based on dried sample due to hygroscopic nature of the ore. LOI (PHY02V) required.

GO_XRF72NL

ANALYTE	REPORTED AS	RANGE
Al	Al ₂ O ₃	0.01-100%
As	As optional	0.01-1%
Ba	BaO	0.01-1%
Ca	CaO	0.01-40%
Co	Co	0.001-5%
Cr	Cr ₂ O ₃	0.005-10%
Cu	Cu	0.01-1%
Fe	Fe ₂ O ₃	0.01-100%
K	K ₂ O	0.01-10%
Mg	MgO	0.01-50%
Mn	MnO	0.01-40%
Na	Na ₂ O	0.01-5%
Ni	Ni	0.005-8%
P	P ₂ O ₅	0.01-5%
Pb	Pb	0.005-1%
Si	SiO ₂	0.05-100%
Sc	Sc ₂ O ₃ option	0.01-1%
S	SO ₃	0.01-1%
Ti	TiO ₂	0.01-1%
Zn	Zn	0.001-2%
LOI (1000°C)*	LOI	-10 – 100%

Dried sample only.

*G_PHY01V or G_PHY02V

MANGANESE ORE

Industry standard XRF borate fusion method with (76) and without (72) oxidation. LOI (G_PHY01V or G_PHY02V) required. Oxidation method (76) recommended for ores with variable oxidation states.

GO_XRF72MN /GO_XRF76MN

ANALYTE	REPORTING AS	RANGE
Al	Al ₂ O ₃	0.01-100%
As	As	0.01-1%
Ba	Ba	0.01-5%
Ca	CaO	0.01-40%
Cl	Cl	0.01-1%
Co	Co	0.01-5%
Cr	Cr	0.01-10%
Cu	Cu	0.01-5%
Fe	Fe ₂ O ₃	0.05-100%
K	K ₂ O	0.01-10%
Mg	MgO	0.01-100%
Mn	Mn ₃ O ₄	0.01-100%
Na	Na ₂ O (only on 72)	0.01-10%
Ni	Ni	0.01-10%
P	P ₂ O ₅	0.01-10%
Pb	Pb	0.01-5%
Si	SiO	0.05-10%
Sn	Sn	0.01-1%
S	SO ₃	0.01-2%
Sr	SrO	0.01-1%
Ti	TiO ₂	0.01-50%
V	V ₂ O ₅	0.01-5%
Zn	ZnO	0.01-1%
Zr	ZrO ₂	0.01-1%
LOI (1000°C)*	LOI	-10 – 100%

Dried only

*G_PHY01V or G_PHY02V

CHROMITE ORE

XRF method for analysis of chromite ores in a high dilution borate fusion setup.

GO_XRF72CR

Minimum sample 1g.

ANALYTE	REPORTING AS	RANGE
Al	Al ₂ O ₃	0.01-100%
As	As ₂ O ₃ optional	0.01-1%
Ba	BaO	0.01-20%
Ca	CaO	0.01-40%
Cr	Cr ₂ O ₃	0.01-60%
Cu	CuO optional	0.01-5%
Fe	Fe ₂ O ₃	0.05-100%
K	K ₂ O	0.01-10%
Mg	MgO	0.05-50%
Mn	MnO	0.01-50%
Na	Na ₂ O	0.1-10%
Ni	NiO optional	0.01-10%
P	P ₂ O ₅	0.01-10%
Pb	PbO optional	0.01-5%
Si	SiO ₂	0.05-100%
S	SO ₃	0.01-1%
Ti	TiO ₂	0.01-50%
LOI (1000°C)*	LOI	-10 – 100%

Dried only

*G_PHY01V or G_PHY02V

RESISTIVE MINERALS / TUNGSTEN TIN ORES/CONCENTRATES

XRF method with high dilution borate fusion digest. Use GO_XRF76WSN for any sulphide, or metal containing samples.

GO_XRF72WSN/GO_XRF76WSN

Minimum sample 1g.

ANALYTE	REPORTING AS	RANGE
Al	Al ₂ O ₃	0.01-100%
As	As	0.01-1%
Ba	Ba	0.01-20%
Ca	CaO optional	0.01-40%
Co	Co	0.01-5%
Cr	Cr ₂ O ₃	0.01-60%
Cu	CuO optional	0.01-5%
Fe	Fe ₂ O ₃	0.05-100%
K	K ₂ O	0.01-10%
Mg	MgO	0.05-50%
Mn	MnO	0.01-15%
Na	Na ₂ O	0.1-10%
Nb	Nb ₂ O ₃	0.01-25%
Ni	NiO optional	0.01-10%
P	P ₂ O ₅	0.01-10%
Pb	PbO	0.01-5%
Si	SiO ₂	0.05-10%
Sn	SnO ₂	0.01-100%
S	SO ₃	0.01-2%
Sr	SrO	0.01-1%
Ta	Ta ₂ O ₅	0.01-50%
Th	ThO ₂ optional	0.01-1%
Ti	TiO ₂	0.01-50%
U	U ₃ O ₈ optional	0.01-5%
V	V ₂ O ₅ optional	0.01-5%
W	WO ₃	0.01-100%
Zn	ZnO	0.01-1%
Zr	ZrO ₂	0.01-1%
LOI (1000°C)*	LOI	-10 – 100%

Dried only

*G_PHY01V or G_PHY02V

LIMESTONE/ LIME / INDUSTRIAL MINERALS

Industry standard borate fusion XRF multielement method based on dried sample. LOI (G_PHY01V or G_PHY02V) required.

GC_XRF72LS

ANALYTE	REPORTING AS	RANGE
Al	Al ₂ O ₃	0.01-100%
As	As ₂ O ₃ Option E	0.01-5%
Ba	BaO	0.01-5%
Ca	CaO	0.01-100%
Cl	Cl	0.01-1%
Co	Co ₃ O ₄ Option E	0.01-1%
Cr	Cr ₂ O ₃	0.01-1%
Cu	CuO	0.01-1%
Fe	Fe ₂ O ₃	0.01-50%
K	K ₂ O	0.01-5%
Mg	MgO	0.01-100%
Mn	MnO	0.01-10%
Na	Na ₂ O	0.05-60%
Ni	NiO Option E	0.01-1%
P	P ₂ O ₅	0.01-55%
Pb	PbO Option E	0.01-5%
Si	SiO ₂	0.01-100%
Sn	SnO ₂ Option E	0.01-5%
S	SO ₃	0.01-50%
Sr	SrO	0.01-5%
Ti	TiO ₂	0.01-50%
V	V ₂ O ₅	0.01-5%
Zn	ZnO	0.01-5%
Zr	ZrO ₂	0.01-5%
LOI (1000°C)*	LOI	-10 – 100%
Moisture (as received)		≥0.01%

Option E: Extension package

*G_PHY01V or G_PHY02V

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_CSB05A	C graphitic (0.05%)	Coulometry	0.2
GC_CSA05V	C graphitic (0.05%)	Leach; IR Combustion	0.2
GC_CSA06V	Total Carbon (0.01%)	IR Combustion	0.2
TM_AMC561_M	*Ash content (0.01-10%)	Gravimetric	20

Note: High temperature carbon analyser available at some sites for carbon concentrates requiring greater precision. Contact your local representative.

*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_ICP95V100

ELEMENTS AND LIMIT(S)

Al 10 ppm	K 8 ppm	Si 30 ppm
Ba 0.3 ppm	Mg 3 ppm	Ti 0.8 ppm
Ca 10 ppm	Mn 0.4 ppm	Ti 0.8 ppm
Co 2 ppm	Mo 4 ppm	V 1 ppm
Cr 4 ppm	Na 5 ppm	Zn 20 ppm
Fe 20 ppm	P 20 ppm	Zr 0.3 ppm

Requires a minimum sample weight of 20 g.

Note: Trace impurities are determined by lithium metaborate fusion with ICP-OES analysis on residue obtained by ashing (TM_AMC561_M). Additional impurity elements are available upon request. Graphitic carbon and impurity analysis are not available at all SGS locations, please enquire.



CONVERSION FACTORS

US STANDARD TEST SIEVE SERIES

AMERICAN ASTM	INTERNATIONAL
INCH OR SIEVE	MILLIMETERS OR MICRONS
1.06 inch	26.50mm
1	25.00
7/8	22.40
3/4	19.00
5/8	16.00
0.53	13.20
1/2	12.50
7/16	11.20
3/8	9.50
5/16	8.00
0.265	6.70
1/4	6.30
3 1/2 sieve	5.60
4	4.75
5	4.00
6	3.35
7	2.80
8	2.36
10	2.00
12	1.70
14	1.40
16	1.18
18	1.00
20	850µm
25	710
30	600
35	500
40	425
45	355
50	300
60	250
70	212
80	180
100	150
120	125
140	106
170	90
200	75
230	63
270	53
325	45
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

FCHEMICAL CONVERSION FACTORS

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

DRILL CORE SPECIFICATION

	DIAMETER		VOLUME LENGTH	
	(MM)	(INCH)	M ³ X10 ⁻³ / M	INCH ³ / 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

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