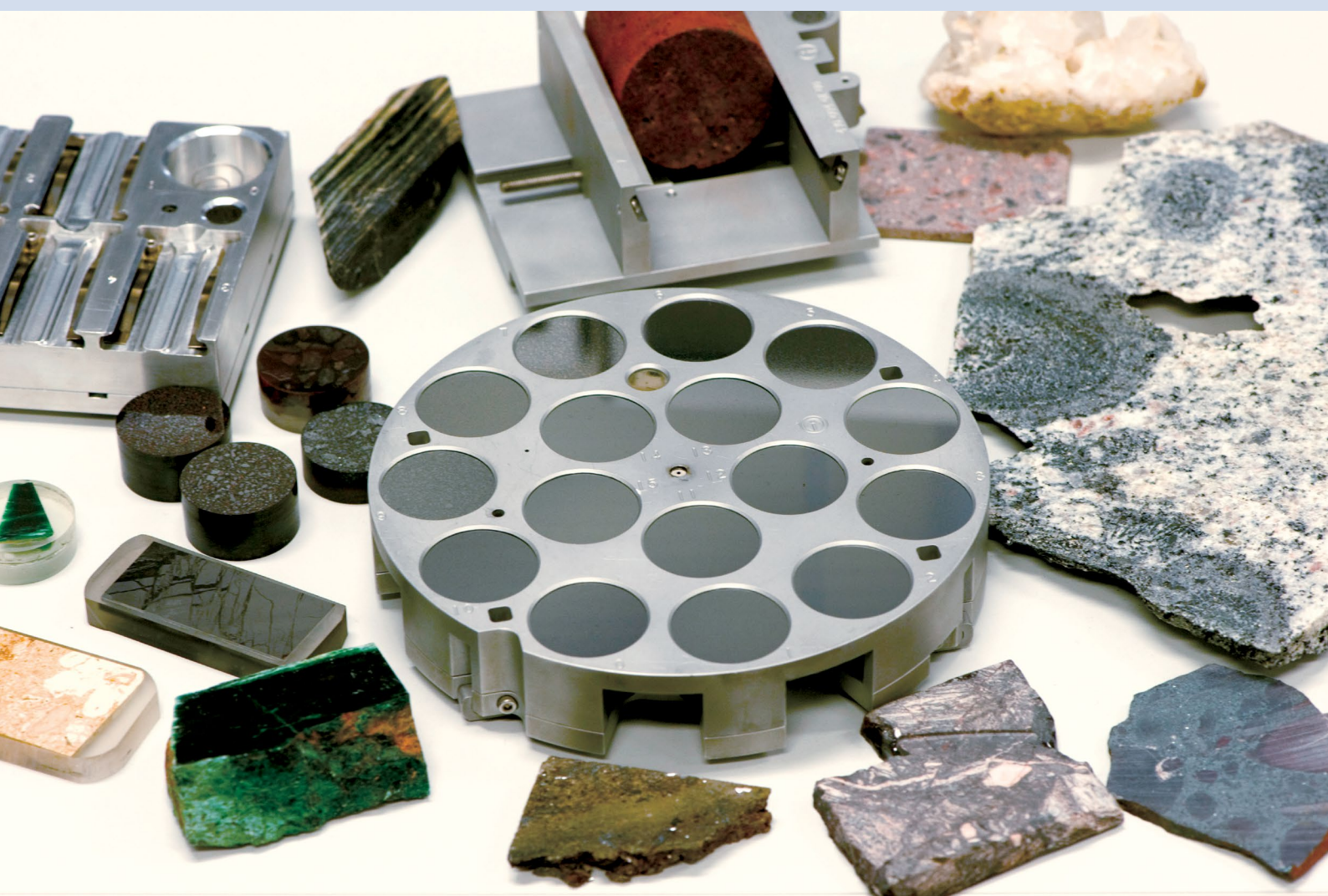




Santiago Mineral Services Centre

*A full range of Geochemistry, Metallurgical
and Environmental Testing with specialized
expertise in Copper and Gold ores.*

Mineralogy Services



RIGHT SOLUTIONS | RIGHT PARTNER



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Mineralogy Services Overview

Know more about your ore with ALS integrated analytical, mineralogical and metallurgical services. This combination will maximize productivity and efficiency of exploration and mineral processing plant design whilst optimizing, mining, production, marketing and rehabilitation processes.

Mineralogy is an important component of resource evaluation and metallurgical testwork development. Analysis is conducted to determine the relative proportions of valuable and gangue minerals, and their degree of liberation in the ore. Data is then used to predict or explain, the subsequent behaviour of the various classes of mineral particles in real or simulated mineral processing operations.

ALS Metallurgy has a market leading position in the range and capabilities of automated mineralogy equipment, with analysis carried out using a range of cutting edge technologies including MLA (Mineral Liberation Analyzer), QEMSCAN®, X-ray diffraction, ParticleSCAN, and HyLogging™.

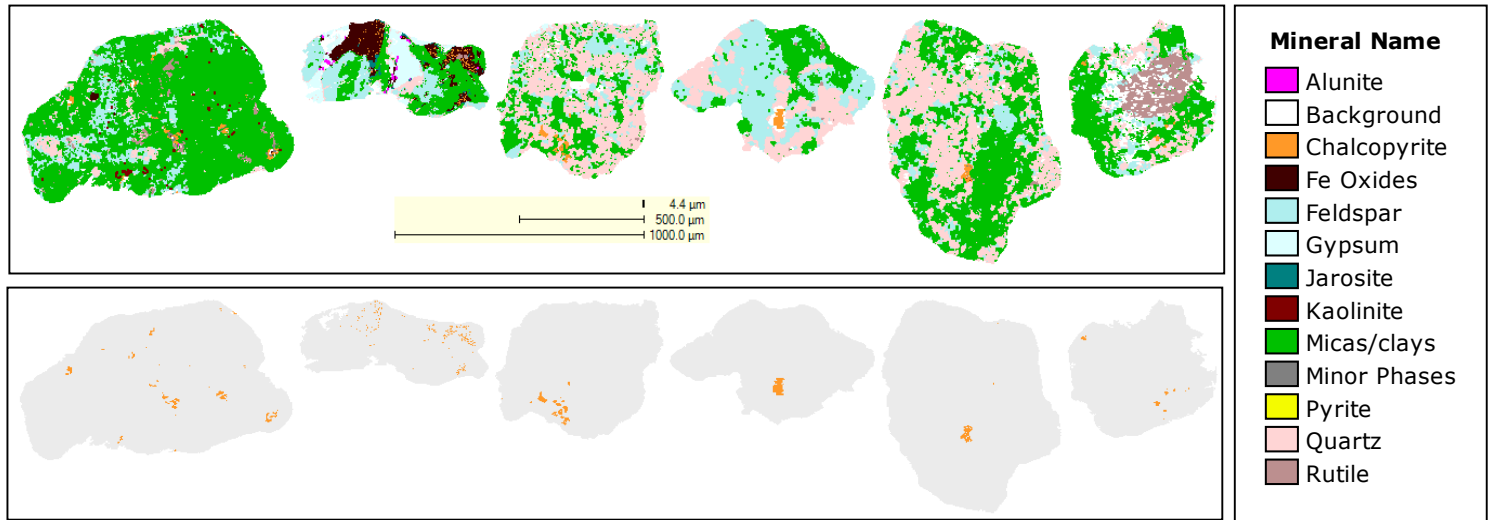
Our global team of highly experienced professional and technical staff integrate these various analytical techniques to provide clients with accurate, quantitative and traceable understanding of the mineralogical variability within a deposit.

ALS technical experts integrate assay data with quantitative mineralogy and bankable metallurgy to provide critical information for mineral process flowsheet development or optimisation. Working together with the Santiago team, ALS highly experienced mineralogists and metallurgists can provide complete ore characterisation and extractive nature.

Mineralogical data available from our range of technologies include:

Mineralogical data	
• Mineral species & compositions	• Liberation & locking
• Mineral distribution & associations	• Textural information
• Mineral grain & particle size distribution	• Colour coded particle images
• Elemental distributions of key minerals	• Bulk mineral species & distributions
• Mineralogical limiting grade recovery curve	• Trace mineral identification

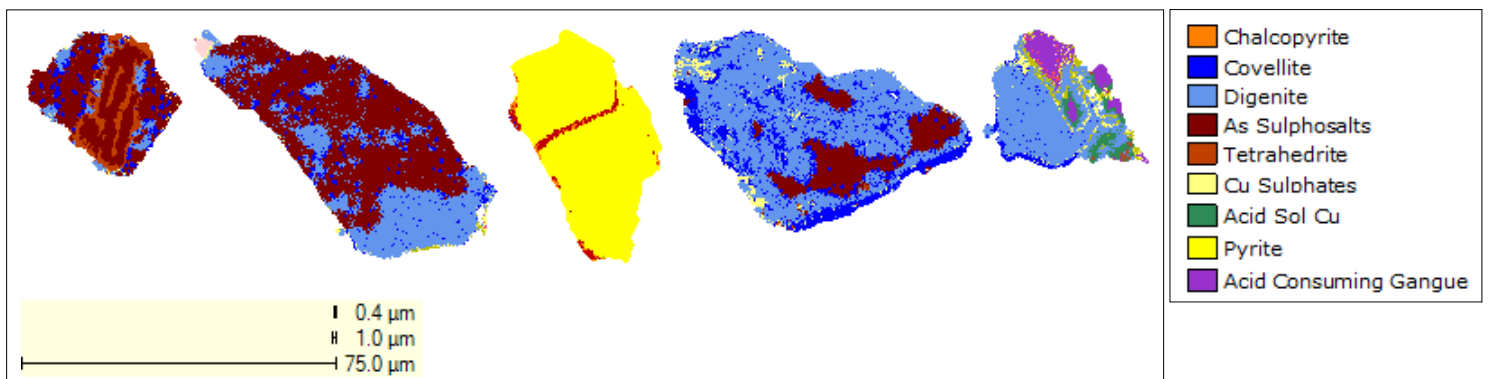
Across the total life cycle of your mining project:	
• Exploration	• Pilot plant testwork support
• Prefeasibility & feasibility studies	• Plant control & troubleshooting
• Resource & reserve determination	• Plant audits & monthly surveys
• Geometallurgy	• Smelter management
• Mine planning & production scheduling	• Environmental assessment
• Concentrator process design & optimisation	• Mine rehabilitation analysis



Automated Mineralogical Analysis using QEMSCAN® and MLA provides accurate, fast, repeatable, quantitative mineralogical analysis of core, process feed, concentrate and residue samples, and smelter products. The analysis maximises productivity and efficiency of exploration and process design, whilst assisting optimization of mining, production and rehabilitation processes.

ALS can add value throughout the life cycle of copper or gold projects:

- Prediction of leach parameters such as leach rates, acid consumption, acid generation and heat generation using quantitative mineralogical data
- Elemental deportment of valuable, deleterious and penalty elements between minerals
- Mineral liberation and locking analysis per size fraction with specific emphasis on surface exposure
- Grain size and particle size data (down to less than 1µm)
- Mineral associations especially to characterise complex relationships between minerals that might influence leach behaviour
- Textural information illustrating the complex relationships between the component minerals
- When presented in tables and as digital particle maps, the data is a powerful communication tool during team discussions





Mineralogy Services

Copper and other base metal mineralogy

Unlock the value within copper and other base metal resources by using automated mineral analysis to determine ore mineralogy, flotation recovery and leaching efficiency.

A thorough understanding of the mineralogical composition of an ore is critical when using hydrometallurgical processes to extract copper, molybdenum, nickel, cobalt and other base metals from ores.

Deposits currently being considered for exploitation are becoming increasingly more complex and, in response, so are the extractive metallurgical processes. It is therefore critical to obtain information on all factors that might affect eventual profitable mining and processing of the deposit. This is especially important in the case of:

- Complex and/or highly variable ore bodies
- Low grade ores
- Ores containing high proportions of deleterious minerals and/or elements

Understanding the mode of occurrence of the value elements as well as any deleterious elements and minerals in these ores is critical to achieving optimum extraction of the base metals from the ore and therefore maximizing profitability.

Ore Characterisation

Geometallurgical challenges presented by copper, molybdenum, nickel, cobalt, zinc and lead deposits at lower grades make access to reliable quantitative mineralogical data essential for comprehensive ore characterisation.

A comprehensive geometallurgical characterisation of base metal ores using SEM-base mineralogical analyses offers an opportunity to make a detailed assessment of ore body potential. Along with information on the valuable minerals in an ore body, important deleterious mineral data can be obtained during the analytical process.

In-situ ore textures can be characterized using the automated mineral analysis of coarse ore particles (<800µm). Polished blocks, standard thin sections or polished slabs can also be analyzed using automated mineral analysis to capture in situ grain sizes and mineral associations within micro textures. The abundance, locking and deportment of minerals containing arsenic in copper ores give valuable insight into potential processing challenges.

Leaching of low grade base metal sulphide and oxide ores

The efficiency of hydrometallurgical and bacterial leaching of base metal ores can also be improved by mineralogical analyses. Acid consumption and heat generation can be calculated using high precision and high resolution modal mineralogy data on all minerals influencing these factors in the leaching process.

Free surface area and locking information on acid consumers can indicate the efficiency of leaching and similar information on acid generators, such as pyrite, indicates their influence on acid consumption rates.

Mineral association tables derived from automated mineral analyses quantify intimate associations and help characterize base metal deportment for general leachability assessment.



Gold mineralogy

Gold deposits are becoming increasingly lower in grade and higher in complexity as are the extractive metallurgical processes. It is therefore critical to obtain information on all factors that may affect eventual profitable mining and processing of the deposit.

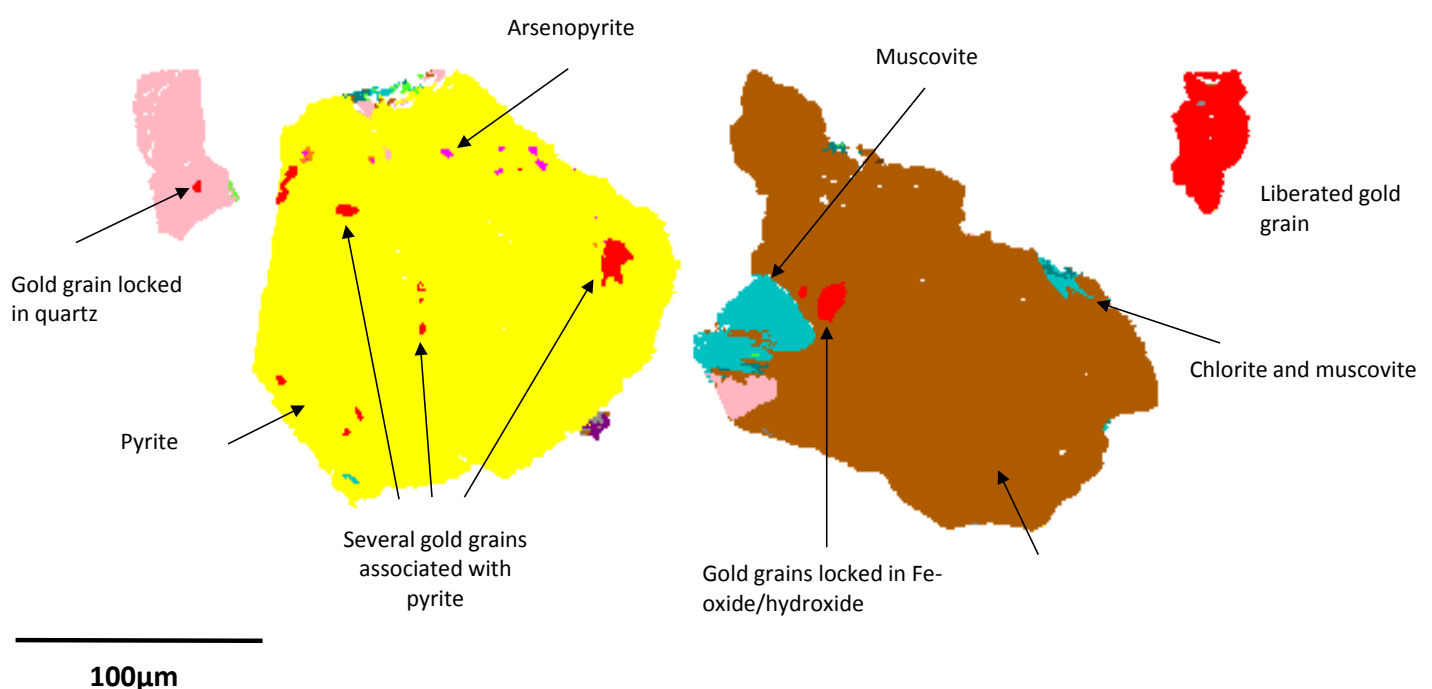
ALS can fully characterize gold ores through comprehensive programmes including multi-stage diagnostic leaching, pre-concentration, process mineralogy and other complementary testwork.

Our highly experienced global team of mineralogists and technicians works closely with dedicated gold metallurgists to provide the highest quality results and fast-turnaround times.

Process mineralogical studies include identification of the gold minerals (for example, size, shape, composition of the gold) and also the associated host rock minerals since their composition could have a significant effect on the efficiency of the extraction process and the overall viability of the operation.

ALS is able to characterize all gold-bearing grains larger than about $0.5\mu\text{m}$ in size and can discriminate between the gold species such as native gold, electrum, maldonite, calaverite, hessite, petzite, sylvanite, aurostibite, aurocuprite and others. This knowledge is important since gold alloyed with elements such as antimony, bismuth and tellurium and even silver is less soluble than native gold.

The importance of the identification of potentially deleterious minerals such as preg-robbars (for example, active carbon and pyrrhotite), environmentally undesirable elements (for example, arsenic and lead), and minerals that could potentially consume acid, alkali or oxygen should not be overlooked.





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Industry leading minerals focused testing, inspection and certification services across the total mine life cycle is now available at the ALS Santiago Minerals Service Centre:

Exploration Services

- | | |
|---------------------------------------|--|
| • Geochemical exploration services | • Onsite sample preparation facilities |
| • Geometallurgy | • Advanced mineralogy |
| • Scoping stage metallurgical testing | |

Process Optimisation, Pre-Feasibility & Feasibility Services

- | | |
|---|-------------------------------------|
| • Metallurgical testwork for flowsheet development & optimisation | • Continuous, bankable pilot plants |
| • Ore variability studies | • Geometallurgy |
| • Advanced mineralogy | • Marketing sample preparation |

Production Support

- | | |
|---|--|
| • Mine site laboratories for grade and mill process control | • Inspection of concentrate, cathode or bullion |
| • Oil condition monitoring for the mining fleet | • Environmental analysis for water, soil, tailings |
| • Routine process mineralogy | |

Contact Us

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