HyLogging™
Capability Statement
HyLogging™ Systems

2000–3000 CHIP/PULP SAMPLES PER SHIFT

500–900m CORE PER DAY

10–25mm SAMPLING STEPS (SELECTABLE)
Introduction

ALS Minerals has partnered with AusSpec International to provide a complete hyperspectral mineralogical service for measuring and interpreting drill core, chips and pulp specimens to assist with exploration and mining activities. AusSpec International is a key player in the global exploration and mining environment with expertise in the interpretation of spectral data from field and laboratory based instruments. ALS Minerals is an industry leader in laboratory services including acquisition of spectral data and was the first commercial laboratory to install HyLogging™ Technology.

HyLogging™ is a fast, inexpensive, non-destructive laboratory technique for determining sample mineralogy. The technology is used for a range of applications including mineral exploration, mine planning, grade control, geometallurgy and mineral processing. It works by collecting high quality spectral data and continuous high resolution colour imagery from drill core, chips and powders.

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Technology

The HyLogging™ system facilitates the rapid collection of high density spectral reflectance measurements and continuous high resolution colour imagery of drill core, chips and powders. The service operates using a step and measure procedure which allows it to measure a range of sample materials from continuous core to chips and pulps. The instrument operates at a wavelength range of 400–2500nm and is suitable for detection and analysis of an extensive list of minerals:

- Clay minerals:
  - Kaolinite, dickite, nacrite and halloysite from the kandite group
  - Montmorillonite, nontronite, saponite and others from the smectite group
  - Palygorskite-sepiolite group minerals
- Micas:
  - Muscovite, sericite, illite, paragonite, celadonite and other micas from the muscovite group
  - Biotite, phlogopite, annite and other micas from the biotite group
- Chlorites:
  - Clinochlore, chamosite, sudoite and other minerals from the chlorite group
- Serpentines
- Pyrophyllite – talc group minerals like pyrophyllite, talc and minnesotaite
- Amphiboles like actinolite, tremolite, edenite, hornblende
- Tourmaline group minerals like dravite and shorl
- Other metamorphic and alteration silicates like epidote group minerals, prehnite, topaz, etc.
- Opaline silica
- Selected zeolites, mostly Na- and Ca-bearing like analcime, laumontite
- Mg- and Al-oxide and hydroxide minerals like brucite, gibbsite, and diasporo
- Fe-oxide and -hydroxide minerals like goethite and hematite
- Carbonates like calcite, dolomite, ankerite, siderite, magnesite
- Sulphates, for example alunite, jarosite, gypsum
- Some REE-bearing phosphates and carbonates like monazite and bastnaesite group minerals.

![HyLogging™ system diagram](image-url)
Iron Ore

The principle commodity currently utilising the HyLogger™ technology is iron ore, however it has applications for other mineral commodities such as uranium, gold and base metals.

The visible near infra-red (vis-NIR) sensors provide a detailed, objective way of differentiating the main iron oxides such as hematite and goethite. The short wave infra-red (SWIR) region of the spectra can be used to identify clay bands, gibbsite, amphiboles and other associated minerals. The results can be correlated with analytical data to improve resource modelling.

Digital mineral indices (also known as spectral parameters) can also be extracted from the HyLogging™ data to represent changes in relative proportions (such as the hematite:goethite ratio or relative clay proportion) as well as changes in the chemistry of key minerals. These indices are numerical values which can be analysed and plotted in a similar way to geochemical data.

In addition the HyLogging™ system also collects high resolution photographs of the core trays, providing a detailed digital archive of colours and textures in the core samples to compare with the spectral data. A digital munsell colour value can also be calculated directly from the visible spectral data.

> objectively map hematite and goethite
> calculate hematite:goethite ratio
> assess relative clay proportion
> identify other secondary minerals
Uranium

HyLogging™ analysis is ideal for Uranium exploration applications in a range of geological settings including unconformity and Olympic dam style settings and in calcrete hosted uranium deposits. Analysis has been previously applied to deposits in the Northern Territory, Western Australia and the Athabasca Basin, Canada.

With HyLogging™, the mineral assemblages observed in association with many deposits are easily identified, which can assist in vectoring toward mineralisation. The down hole (figure adjacent) shows how mineral indices of chlorite proportion and chemistry can be plotted down hole to illustrate a distinct change in chlorite chemistry to a magnesian chlorite in proximal samples.

Mineral indices can be further integrated with geochemical and logging data to assess the spatial and statistical relationships between alteration and mineralisation in a project area. Ultimately the mineral indices can be used to plot key mineral characteristics in 3D to allow modeling of an alteration system to aid improved targeting. A 3D mineral distribution Leapfrog™ image is shown here of the Lake Maitland calcrete hosted uranium deposit. In green is a horizon of saponite (Mg smectite) and carbonate, and in blue (in the basement) is a horizon dominated by kaolinite and hematite. The uranium mineralisation is shown in dark red. The calcrete and uranium mineralisation appears to concentrate at the boundary between these two different clay mineral assemblages (see the cross section).

> identify alteration minerals
> assess chlorite and illite chemistry
> evaluate clay mineral and carbonate distribution

All figures courtesy of AusSpec International.
Regolith Logging

The spectral data collected by the HyLogger™ can be used to assess the clay type and crystallinity as well as depth of oxidation, when drilling through deep weathered lateritic regolith profiles as seen in locations such as Australia, Africa and parts of Brazil.

The clay assemblage and crystallinity allows the geologist to determine what part of the profile the sample is from. For example the upper saprolite samples are dominated by highly crystalline kaolinite with minimal smectite. In contrast the lower saprolite is characterised by a strong smectite signature with minor kaolinite. In addition, the smectite phase can give an indication of what the primary rock type was before weathering, for example:

- montmorillonite (Al-smectite) typically results from weathering of felsic rocks
- nontronite (Fe-smectite) typically results from weathering of mafic rocks
- saponite (Mg-smectite) is typically a weathering product of ultramafic rocks

The characteristics of the clay minerals in transported overburden are often distinct to the residual basement clays. For example, the kaolinite in the transported profiles is typically significantly lower crystallinity than the kaolinite observed in the upper saprolite intervals. This capability can allow a more objective determination of the base of the transported overburden in cases where this is difficult to log visually and therefore assists with selecting suitable geochemical samples.

> kaolinite crystallinity
> smectite proportion and type
> define base of transported overburden
> base of oxidation

A spectral parameter can be calculated from the spectra to represent intensity of iron oxide down hole which can provide useful information on depth of oxidation.

All figures courtesy of AusSpec International.
General Exploration

Geological spectral data has many levels of information that can be utilised. At the fundamental level the data provides information for mineral assemblages be it from core, chip, geochemical pulp or soil. In addition, information on mineral chemistry on key alteration minerals, such as white mica and chlorite, can be acquired from the spectral data. These types of data can allow exploration companies to rapidly map out alteration zoning, to build alteration models of a system based on the mineral assemblage and chemistry data, thus directing exploration efforts to more promising parts of a project area.

Webtrieve™

ALS Minerals provides clients with secure access over the Internet to Webtrieve™, a sample information and geochemistry results showcase.

Full audit trails and quality control reports are available along with work order status, sample flow statistics, method descriptions, and data export in various formats. Webtrieve™ also provides a platform to link geochemistry results and HyLogger™ photos and spectral mineralogy together for clear visualisation, through ALS Minerals’ CoreViewer™ software.
CoreViewer™ archives core or chip box photos captured by the HyLogger™ system for easy retrieval and viewing.

Depth start and end information is stored for each photograph, allowing a search on depth for specific boxes. Most importantly, the CoreViewer™ software creates a continuous photographic core strip allowing uninterrupted graphical comparison of depth-registered data with the core itself.

Any type of depth-registered data may be added into CoreViewer™, including geochemistry, mineralogy, and down-hole geophysics. A secure key is required to link all data and the core strip in each CoreViewer™ session. Once the data are linked to the core strip by depth, up to three types of results may be displayed below the core strip, such as mineral abundance from HyLogger™, total Fe results and down-hole magnetic susceptibility. Above, a section of core from an iron ore project is displayed above HyLogger™ mineralogy data; hematite and goethite dominate the results, while minor kaolinite is detected on a fracture with a white mineral coating.
Data option pathways to the client

ALS understands the value of data quality and integrity to exploration and mining companies. Our processes are designed to ensure clients receive the best quality assay data to assist informed decision making. The ALS quality program consists of a series of checks and balances with monitoring at senior management levels. Our global information management system provides oversight and access to all processes. The online Webtrieve™ tool provides client access to this quality information.

All ALS Geochemistry facilities are accredited to the higher of ISO 9001-2008 or ISO 17025 standards as appropriate to the services offered at each location.

Quality

*ALS Mineralogists will interpret data that is not recognised by the AusSpec Software Data Interpretation.
Health, Safety and Environment

Being an employee of ALS is about putting safety first. Globally, ALS is committed to a safe work culture.

Safety Management
As part of this global approach, ALS has developed an industry leading standard for managing health, safety and environmental issues.

At a local level, safety is a part of all work instructions however, some are specifically set to achieve policy objectives. The focus of the Safety Management System is to continually improve HSE performance and therefore documentation is constantly reviewed. Procedures and policies are specifically targeted toward safety in laboratories and related activities and as such are designed to comply with the requirements of industry best practice. Procedures are available upon request.

ALS is very proactive with respect to safety reporting. Real time reporting of NMI, MTI, FAI and LTI with a series of automated alerts is available to staff, HSE operatives and management alike.

Assessment of Safety Performance
Not satisfied with an improved performance in HSE ‘lag’ statistics, ALS launched a program of Positive Performance Indicators (PPI) in 2010. The PPI program assesses and actively reports the performance of individuals and operations from a proactive HSE perspective with respect to Leadership, Training, Injury Management and Process Compliance. The program and web based reporting tool encourages and rewards ownership and transparency of HSE issues.

Protection of the Environment
ALS has Extensive procedures and policies to ensure Protection of the Environment. Specific procedures and policies address the following issues:

• Waste Management, Monitoring and Maintenance;
• Disaster Management plans for spills;
• Management of Solid waste, with recycling where possible.