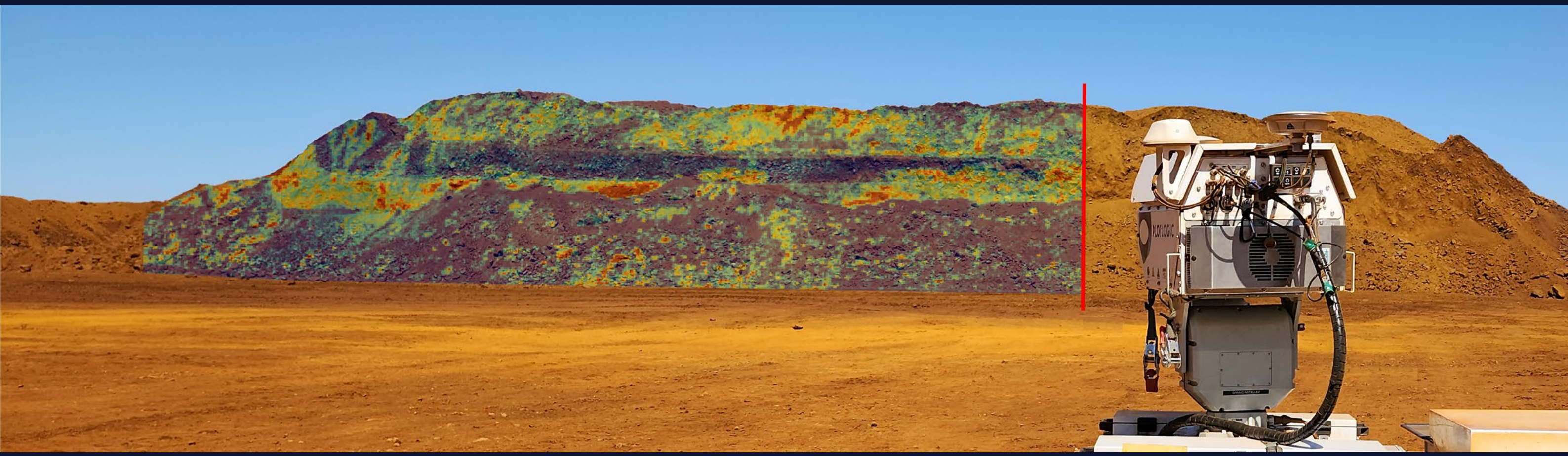
PLOTLOGIC

CASE STUDY



MEASURE AND MANAGE PROBLEM CLAYS BEFORE THEY DISRUPT PROCESSING WITH ORESENSE®

EXECUTIVE SUMMARY

Clay minerals, including Kaolinite, Illite, Smectite, and Chlorite, are critical in mining due to their influence on ore processing, swelling behaviour, and moisture retention. Traditional XRD methods often misidentify clay species, leading to inaccuracies in assay results. In contrast, analysis through OreSense® has consistently delivered superior accuracy, reliability and speed, making it a preferred tool for identification of clays. Fast, accurate clay analysis helps miners cut unnecessary drilling, avoid processing bottlenecks, and better manage stockpiles - saving time and money while improving recovery.

Across deployments in nickel laterites, iron ore, copper porphyry, and iron-oxide-copper-gold systems, OreSense® demonstrated:

- **High Accuracy** – Strong correlation with laboratory assays (e.g., R^2 = 0.969 for sericite in IOCG deposits)
- **Real-Time Results** – Turnaround within minutes instead of weeks, enabling faster operational decisions
- **Operational Benefits** – Drill metre savings in nickel laterites, selective stockpile management in iron ore, and continuous monitoring over conveyors in porphyry copper systems
- **Versatility** – Reliable performance across major clay groups, including challenging swelling clays such as smectites
- **Sample Representivity** – The optical nature of OreSense® provides a step change in sample representativity with a single 170m x 16m stockpile scan taken in 3 minutes providing 300,000 independent measurements

Overall, OreSense® has proven to be a more accurate, efficient, and versatile solution for clay mineralogy detection, directly improving decision-making in exploration, grade control, and production environments.

This case study contains a summary of multiple clay mineralogy case studies taken from OreSense® projects delivered to Plotlogic clients. Detailed operational context is excluded to focus on raw performance results of each project. Additional information on any results can be provided on request.

CLAY MINERALOGY

Clay minerals are hydrous aluminium phyllosilicates, characterised by sheet-like structures and a very small particle size. Their structures are based on composite layers formed from two-dimensional sheets of tetrahedral (SiO4) and octahedrally (Al_2O_3) coordinated cations.

Clay types can be classified based on the arrangement of layers within their structure:

- **Kaolinite:** Comprises a 1:1 ratio of tetrahedral to octahedral layers. Non-swelling clay
- **Illite:** Comprises of 2:1 ratio of tetrahedral to octahedral layers. Non-swelling clay
- **Smectite:** Features a 2:1 ratio of tetrahedral to octahedral layers. Swelling clay
- **Chlorite:** Consists of a 2:1:1 ratio of tetrahedral, octahedral, and additional octahedral layers. Non-swelling clay

Clay structures are shown in Figure 1.

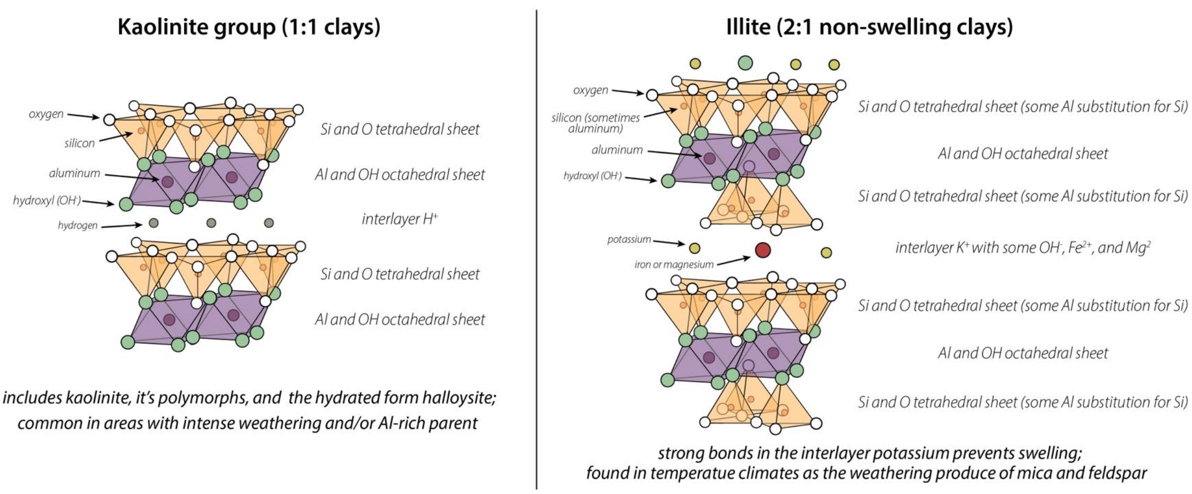


Figure 1 Clay Structures (1)

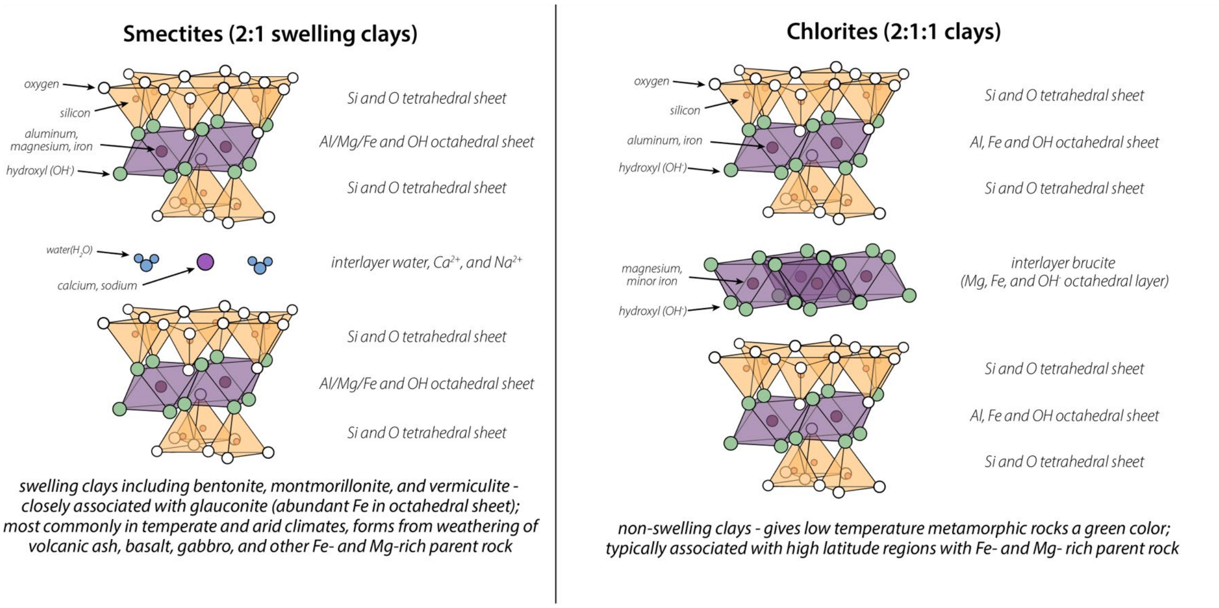


Figure 1 Clay Structures (2)

Typically, clay minerals possess a particle size of less than 2 microns and exist as platy particles within fine-grained aggregates. When mixed with water, these aggregates produce materials that exhibit varying degrees of plasticity.

The small particle size and unique crystal structures also give clay minerals several special properties, including a high cation exchange capacity, swelling behaviour, specific surface area, and adsorption capacity.

In Plotlogic's experience, for most applications it is more effective to deal with clays at the group level, shown in Table 1. At this level, the key properties, especially swelling, are discriminated, along with broad position in the geological model for the mine. There is often no evident benefit in attempting to identify the myriad and complex clay species.

Table 1 Major Clay Groups

CLAY GROUPS	INDIVIDUAL SPECIES	GEOLOGICAL CONTEXT AND SIGNIFICANCE
Kaolinite Group (Non-Swelling)	Kaolinite Dickite (polymorph of Kaolinite)	• Forms through intense chemical weathering or acidic hydrothermal alteration • Indicates leaching, low pH, and low-temperature alteration conditions • Common in weathering profiles and advanced argillic alteration zones • Impacts comminution, beneficiation and acid consumption in leaching processes **Ore deposit associations** Nickel Laterites: Kaolinite forms in the upper oxidized zone Epithermal Gold: Dickite forms in advanced argillic zones, often associated with high-sulphidation systems Iron Ore: In weathered iron formations
Illite/Mica Group (Non-swelling)	Illite Sericite Muscovite Phengite Phlogophite	• Forms in moderate to high temperature hydrothermal systems and occurs in hydrothermal veins • Associated with phyllic alteration • Commonly a major component of metamorphic rocks **Ore deposit associations** Porphyry Copper: Illite and phengite in phyllic alteration zones Iron Ore: Muscovite, Phengite occurs in metamorphosed BIFs
Smectite Group (Swelling)	Montmorillonite Beidellite Nontronite Saponite	• Forms in alkaline, low-temperature environments; common in argillic alteration and volcanic soils • Indicates early-stage alteration or weathering • Highly reactive and swelling which can add to complication with processing. Presence of Montmorillonite affects ore handling and moisture control **Ore deposit associations** Nickel Laterites: Nontronite forms in the lower saprolite zone which hosts nickel in some deposit types Volcanic-hosted deposits: Smectite in altered tuffs
Chlorite Group (Non-Swelling)	Mg-Chlorite Fe-Chlorite Corrensite (Interlayered chlorite and smectite)	• Forms in propylitic alteration zones of hydrothermal systems. Indicates low to moderate temperature alteration • Common in Metamorphic rocks, hydrothermal systems and mafic volcanic rocks **Ore deposit associations** Porphyry Copper (outer zones): Vector mineral in porphyry systems to characterise mineral zoning

There exist inherent challenges in XRD methodology distinguishing between clay species. Plotlogic has numerous examples of XRD methods misidentifying clay species and this error source forms the largest component of inaccuracies seen between hyperspectral predictions and laboratory assay. Hyperspectral methods are frequently a significantly better analytical method for determining clay types which is seen in practice across client sites requiring reliable clay identification.

ORESENSE® CASE STUDIES – SPLIT BY CLAY GROUP

Kaolinite Group

Kaolinite is a commonly requested clay species and multiple Plotlogic projects have focused on this clay group. To enable simple integration into existing workflows, Al2O3 is commonly reported as a chemical proxy. In both cases OreSense® is measuring Kaolinite and inferring Al2O3 stoichiometrically to correlate to available data source (e.g Inductively Coupled Plasma (ICP)).

Indonesian Nickel Laterite

Rapid detection of clay mineralogy has proven useful for accelerating grade control drilling in nickel laterite operations. By utilising the rapid turnaround of results, mines are able to identify bottom of ore faster than traditional methods. In turn, unnecessary drilling past bottom of ore can be avoided and the total campaign accelerated. The integrated workflow used for a successful OreSense® nickel laterite project is shown in Figure 2.

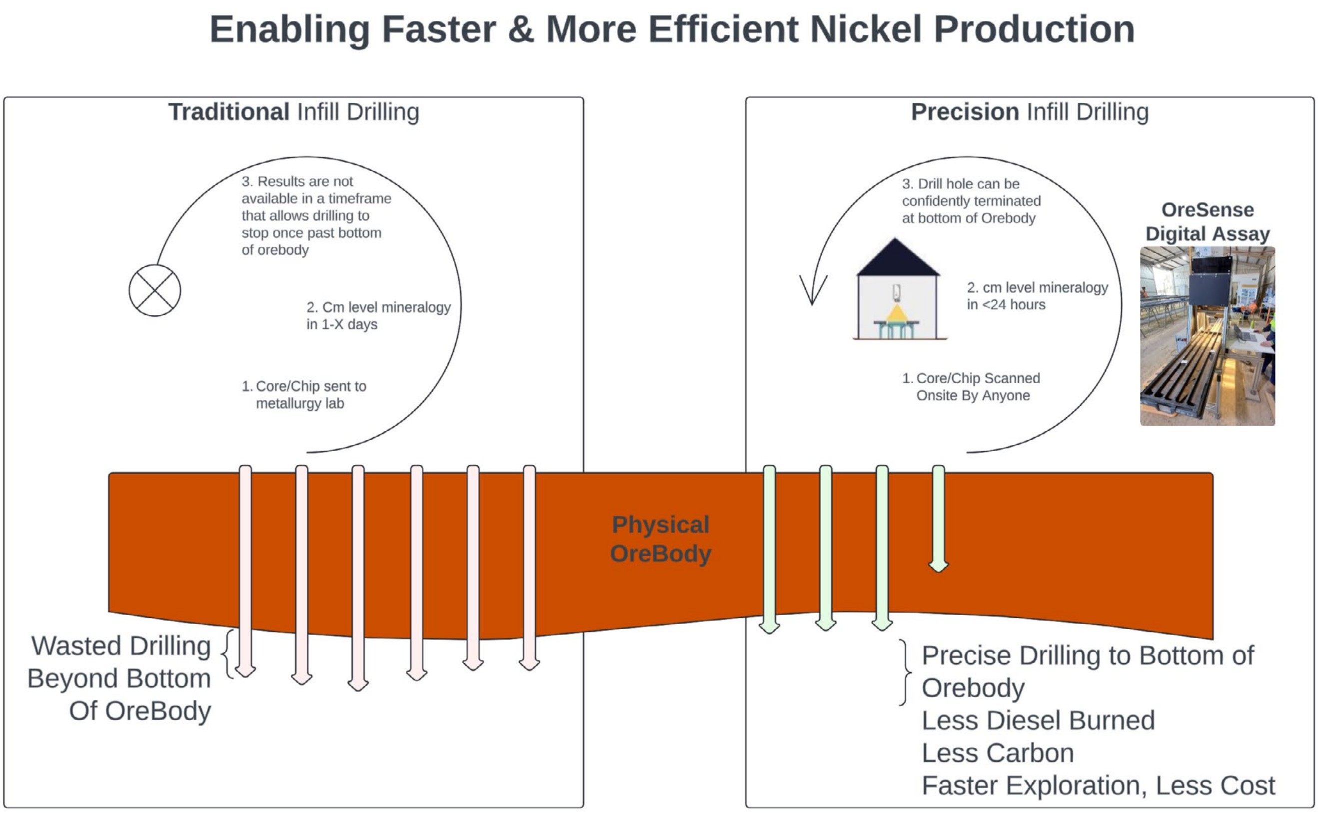


Figure 2 Integrated Workflow at Client Nickel Laterite Operations

Scatter plots shown comparing OreSense® Al_2O_3 prediction against laboratory assay for the same sample are shown in Figure 3.

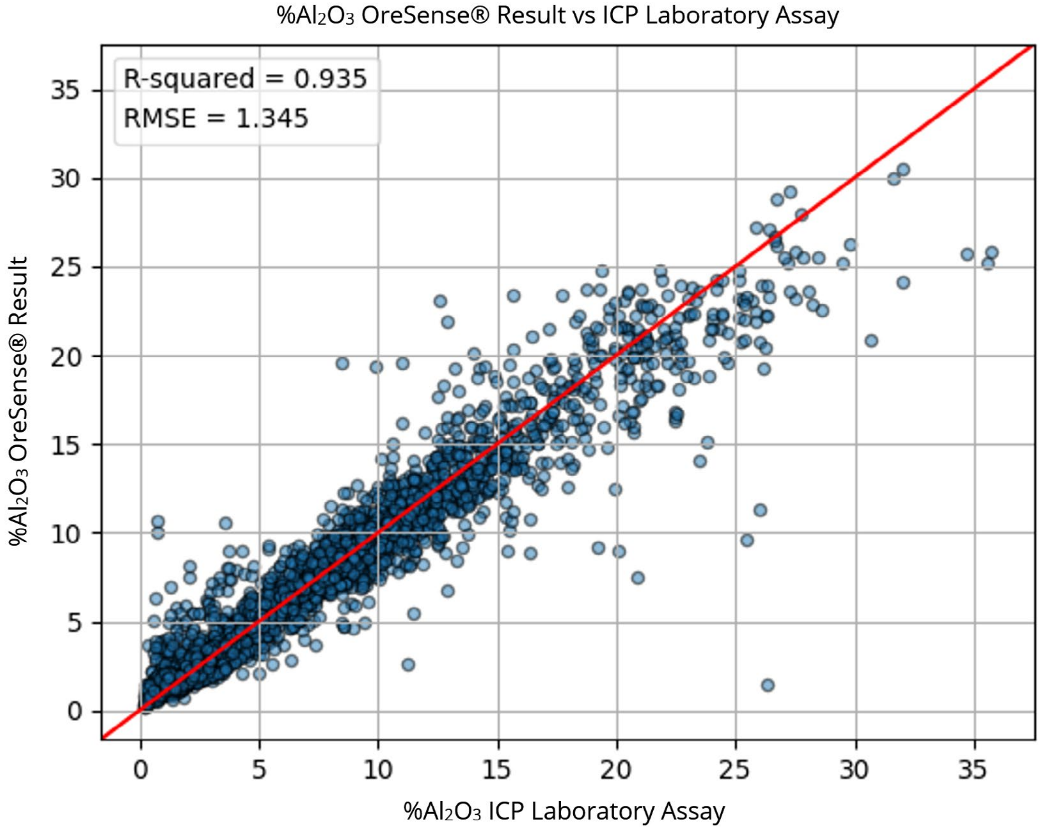


Figure 3 Al_2O_3 OreSense® Predicted vs ICP Laboratory Assay

OreSense® field deployment images for this particular project are shown in Figure 4 and Figure 5.

Figure 4 OreSense® Digital Assay Deployment – Indonesia

Figure 5 OreSense® Stockpile Sample Collections

Australian (WA) Iron Ore

Clay minerals are of interest in iron ore to mitigate production delays related to material handling issues through the plant and rail infrastructure. Field validation for this project involved collecting a grab sample for laboratory analysis. Before sampling, the area was measured using OreSense®. To facilitate this, a square target was positioned on a dedicated stockpile. OreSense® predictions within the target area were then compared to the results from the grab sample taken inside the target. Some level of error is expected with this method, as the material measured by OreSense® may differ slightly from the material physically collected. Stockpiles were selected to be as homogenous as practical to minimise this error.

Scatter plots shown compare OreSense® Al_2O_3 prediction of the target against the laboratory XRF assay of the grab sample. Plots shown in Figure 6 were generated by the client as a blind reconciliation. Example outputs of the tested model are shown in Figure 8.

- Each point in the 'Per Sample' plot is from an individual ROI created on a stockpile.
- Each point in the Per Scan Time is the average of the ROI's of that stockpile at its scan time. So, for example WMAT3 was scanned 7 different times.
- Each point in the Per Stockpile is the average of the ROI's for that stockpile across all scan times. So, from the example above the 7 WMAT3 samples are compressed into a singular stockpile value.

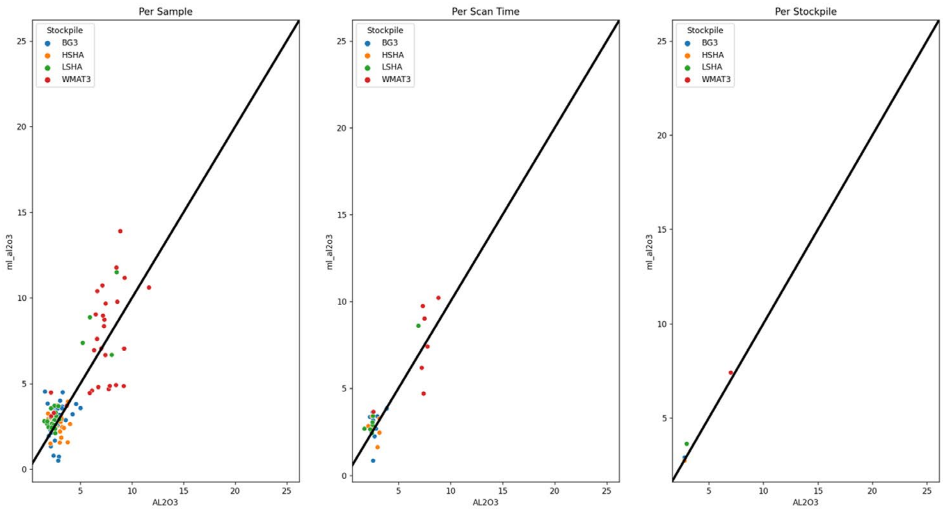


Figure 6 Blind Reconciliation Results – OreSense® Predicted (y-axis) vs Lab Assay (x-axis)

Figure 7 OreSense® Ranger – Field Operations

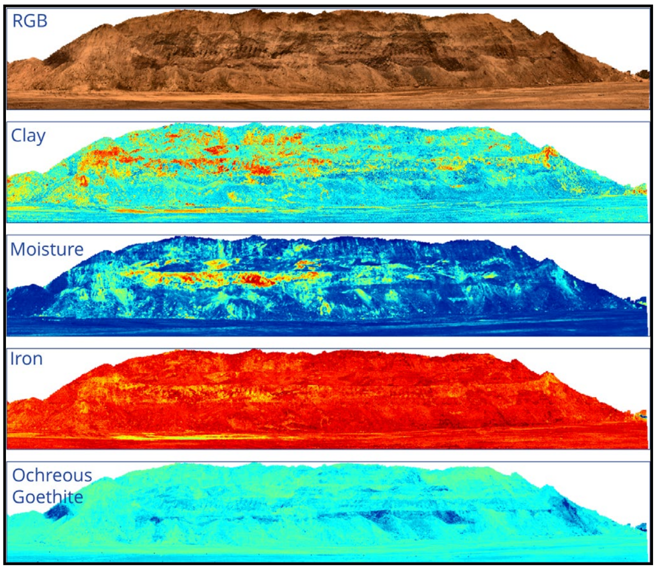


Figure 8 OreSense® Ranger – Production Outputs

Kaolinite & Chlorite Group

Australian (NSW) Porphyry Copper

Kaolinite and Chlorite clay minerals are of interest to many copper porphyry mills due to their varied and significant impact on process operations. This can include material handling, rheology and flotation performance issues. Validation of OreSense® Over the Conveyor (OTC) was completed at a large porphyry copper mine via belt cut method. Real time measurement of total clay on the conveyor via OreSense® is shown in Figure 9. The measured belt was crash stopped at 6AM (far right-hand side of series) and the corresponding belt cut sample taken. Total clay at this site consists of Kaolinite + Chlorite Clay Species.

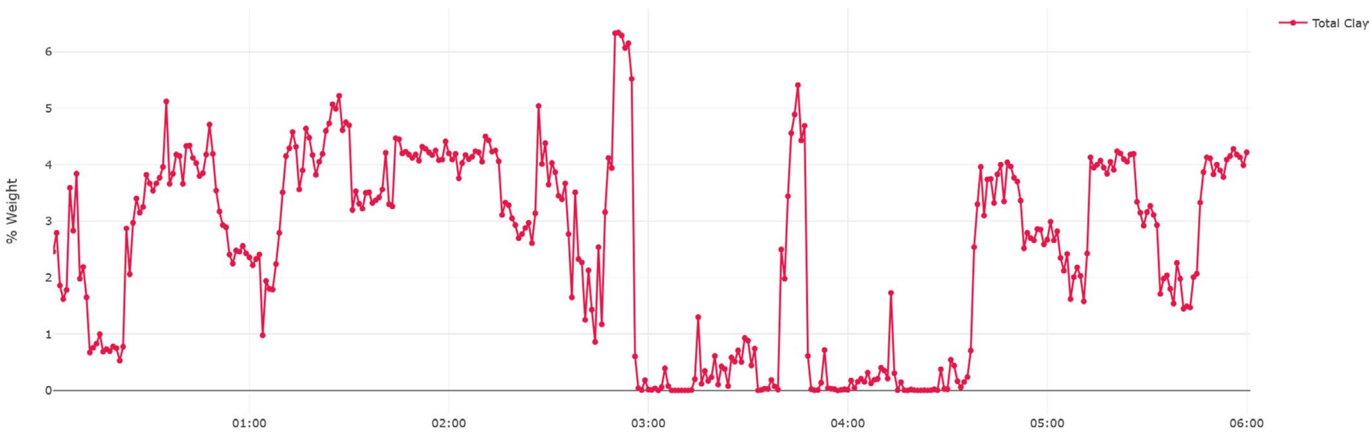


Figure 9 OreSense® Total Clay Output Prior to Belt Cut

Comparison of OreSense® readings compared to belt cut laboratory QXRD results are shown in Table 2.

Table 2 Belt Cut Validation Result

ORESENSE® MEASUREMENT		VALIDATION BELT CUT			
Time Stamp	Total Clay	Sample	Chlorite	Kaolinite	Total Clay
4/09/2024 6:00	4.2	Cut 1	3.9	0.7	4.5
4/09/2024 5:59	4.0	Cut 2	3.3	0.9	4.2
4/09/2024 5:58	4.1	Cut 3	3.1	0.6	3.7
4/09/2024 5:57	4.2	Cut 4	3.3	0.6	3.9
4/09/2024 5:56	4.3	Cut 5	2.8	0.6	3.3
4/09/2024 5:55	4.1	Cut 6	3.3	0.8	4.1
4/09/2024 5:54	4.1	Cut 7	2.7	0.7	3.4
4/09/2024 5:53	3.8	Cut 8	3.1	0.6	3.7
4/09/2024 5:52	3.9	Cut 9	3.4	0.8	4.2
4/09/2024 5:51	4.0	Cut 10	2.5	0.5	3.0
Average	4.1	Average	3.1	0.7	3.8

OreSense® total clay measured 4.1% compared to a belt cut average of 3.8% demonstrating accurate real time detection of clay minerals directly on the conveyor.

Example images of the associated deployments are shown in Figure 10 and Figure 11.

Figure 10 OreSense® OTC at a Large Copper Porphyry Mine in Australia

Figure 11 OreSense® OTC at a Large Broken Hill Type Lead/Zinc Mine in Australia

Illite/Mica Group

Australian (SA) Iron-Oxide-Copper-Gold

Illite/mica clay groups are of interest in geotechnical applications to serve as clear identifiers of joints and faults in underground mining operations. This in turn can be used to improve identification certainty, upskill geologists and enable increased remote monitoring of development drives. The speed and simple operation of an OreSense® unit enables miners to remove people from the face and optimise the use of technical resources by enabling field technicians to collect relevant geotechnical data on behalf of geologists. In some mines, OreSense® has enabled site geologists to remove the need to travel underground for inspection unless in response to a remotely identified issue. Figure 12 shows an OreSense® Recon in operation by a field technician.

Figure 12 Field Technician Collecting OreSense Data on Behalf of Geologists

Validation of OreSense® performance for Sericite (very fine, ragged grains and aggregates of white (colourless) micas, typically made of muscovite, illite, or paragonite) was completed at a large Iron Oxide-Copper-Gold mine. Approximately 6,000 samples were scanned by OreSense® Digital Assay and the measurement compared to normative mineralogy. Results are shown in Figure 13.

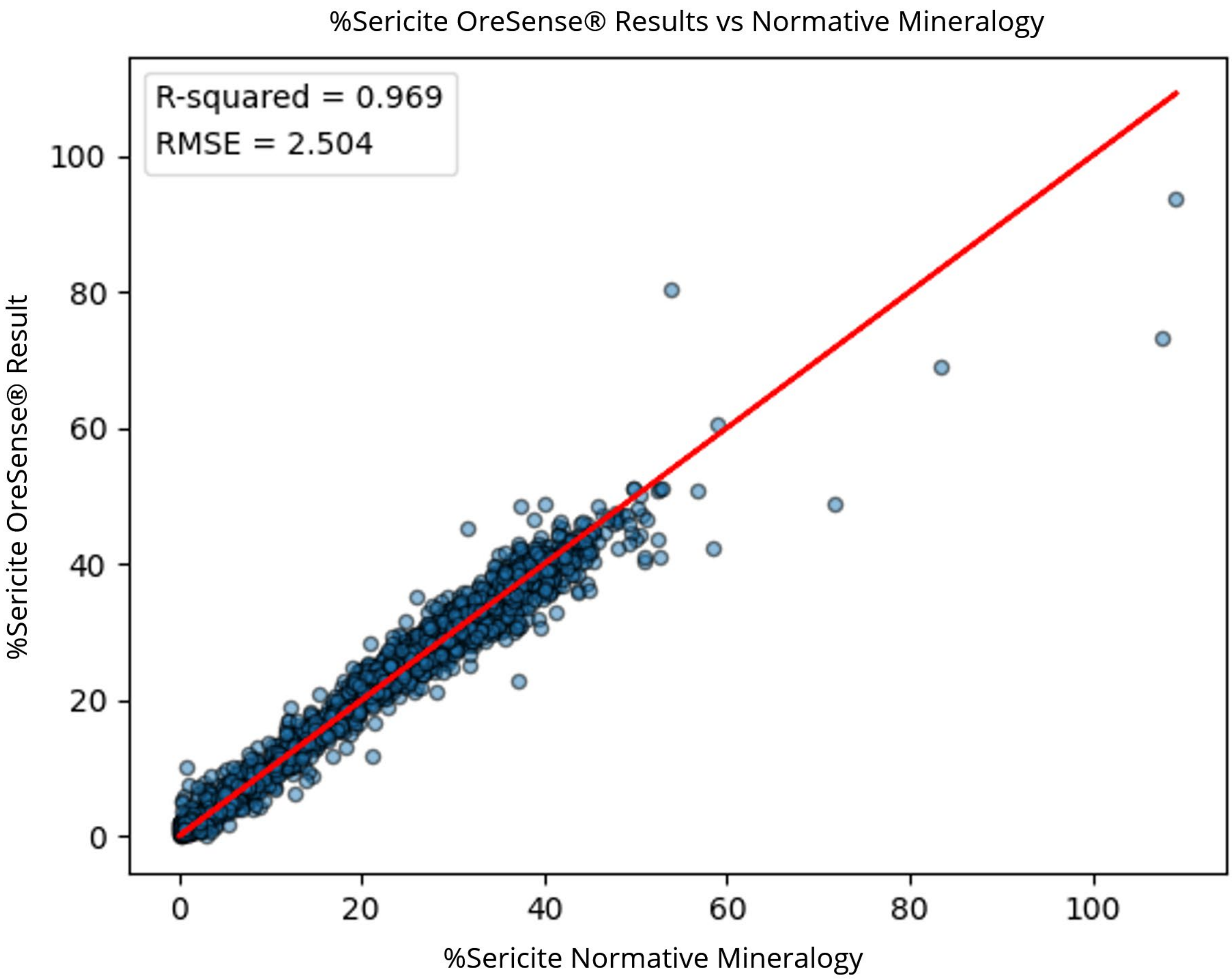


Figure 13 Sericite OreSense® Result vs Normative Mineralogy

Correlation to laboratory prediction was excellent across the data set with an achieved R^2 of 0.969.

Montmorillonite Smectite Clay Group

Digital Assay Application – Mixed Sources

Montmorillonite/smectite clay groups are a commonly requested application for detection and characterisation by OreSense®. This clay group is often miscategorised by XRD laboratory methods resulting in many smectite applications investigated by Plotlogic resulting in identification and characterisation of other clay groups. As a result, only a small number of actual montmorillonite clay samples have been analysed by an OreSense® system. Regardless, the spectral features of this clay group are distinct and despite the small data set, correlation to laboratory prediction has proven reasonable. Results are shown in Figure 14.

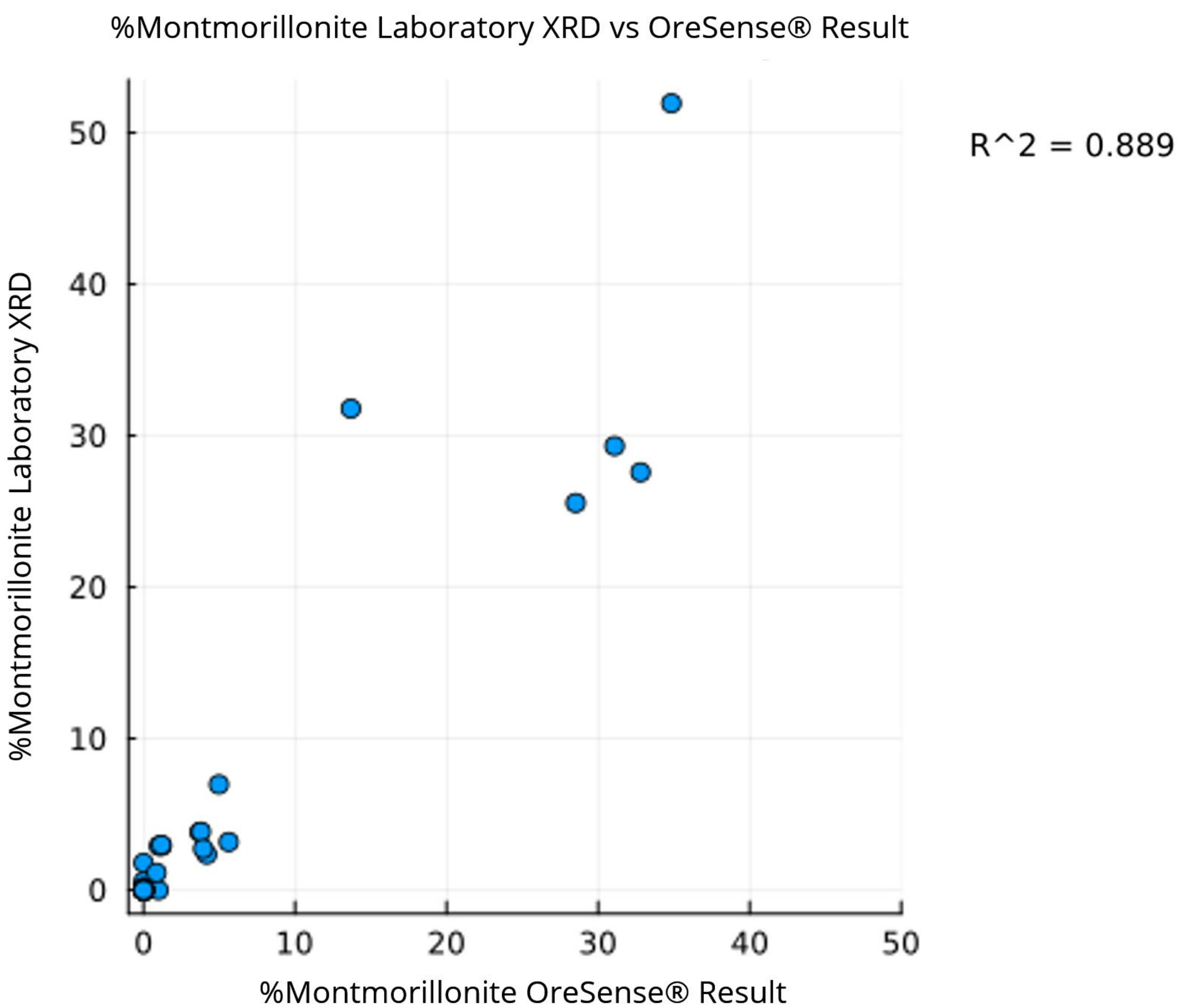


Figure 14 Montmorillonite Laboratory XRD vs OreSense® Result

CONCLUSION

The presented case studies demonstrate that Plotlogic's OreSense® system provides a consistent and reliable method for clay mineral identification across a variety of geological settings. In applications spanning nickel laterites, iron ore, porphyry copper, and iron-oxide-copper-gold systems, OreSense® showed high correlation with laboratory assays, rapid data acquisition, and robust performance across all major clay groups. Notably, the system performed well in detecting both non-swelling and swelling clays, a known limitation for many traditional analytical approaches.

Beyond accuracy, the capacity to generate near real-time results has clear implications for operational workflows. Case studies illustrate how reduced assay turnaround times enable quicker feedback loops for exploration and grade control, while continuous monitoring in production contexts supports more informed decision-making. Many operations have investigated the impact of geometallurgical parameters on mine and mill performance, however, the impracticality of existing analytical methods to collect and action data in a timely manner has limited effectiveness.

The evidence suggests that hyperspectral analysis, as implemented through OreSense®, represents a valuable complement - and in some cases, a superior alternative - to conventional methods such as XRD, particularly where speed and sample representativity constraints are critical. Removing the need to physically sample enables a step change in the practically of geometallurgical sampling campaigns and allows for the implementation of workflows that leverage this data to generate meaningful improvements across an operation.

Additional detail on specific case studies, validation processes, and site-based deployments can be made available to interested stakeholders. For operations where clay mineralogy presents a material challenge, further technical discussions may help identify opportunities to adapt OreSense® workflows to local requirements. The data presented here indicates that OreSense® can play a valuable role in operations constrained by the speed, cost and representivity of available clay detection methods. Through tight workflow integration and clear decision-oriented outputs, previously unachievable use cases are practically achievable, enabling significant value to be unlocked.

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