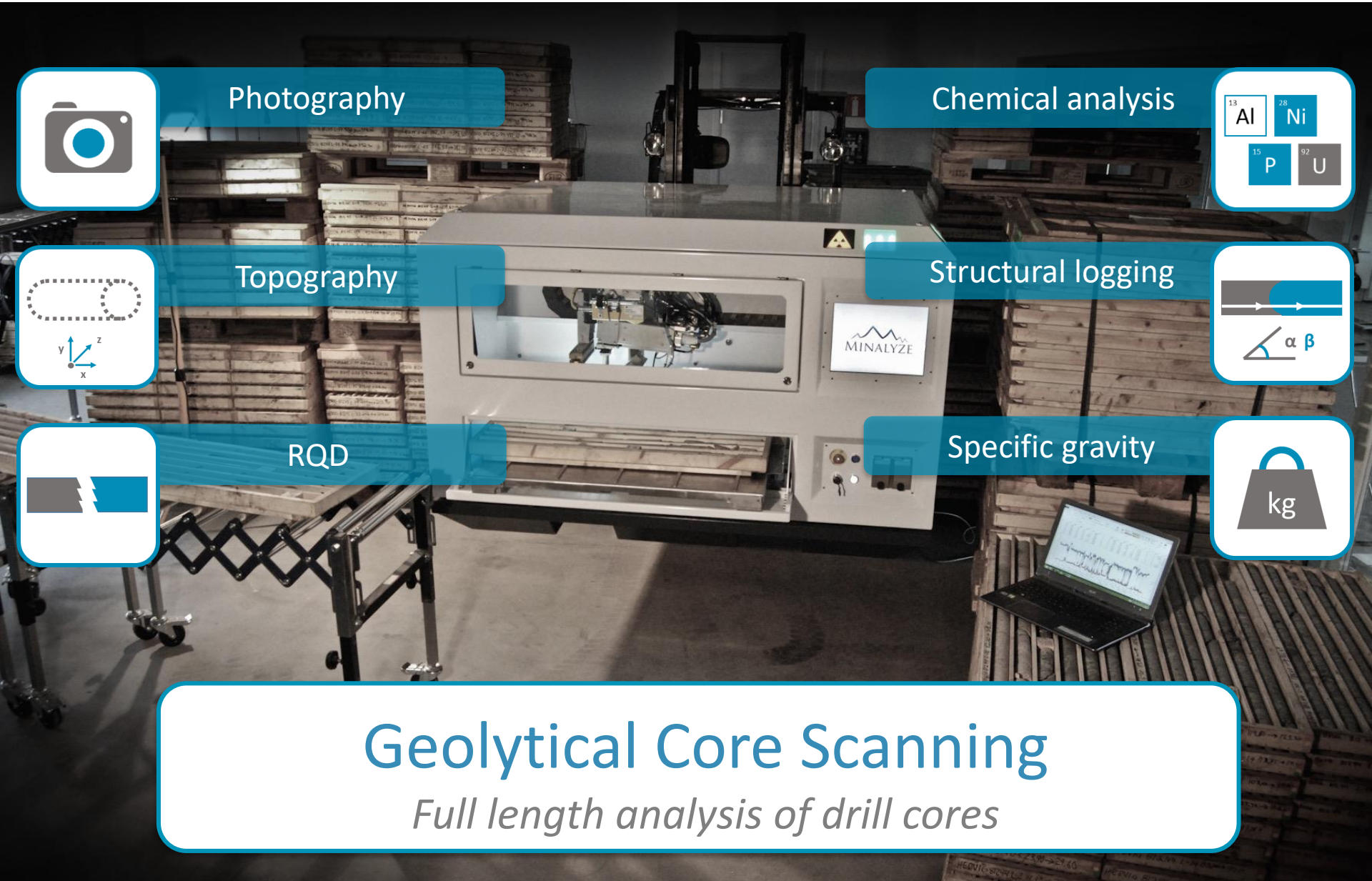
New Discovery Program Industry Consultation and Knowledge Transfer Workshop

Mikael Arthursson, CTO, Minalyze Pty Ltd

*Pioneering the **mining** industry by shaping tomorrow's **exploration** process*

Minalyzer CS



Geolytical Core Scanning

Full length analysis of drill cores

High-Resolution Photography

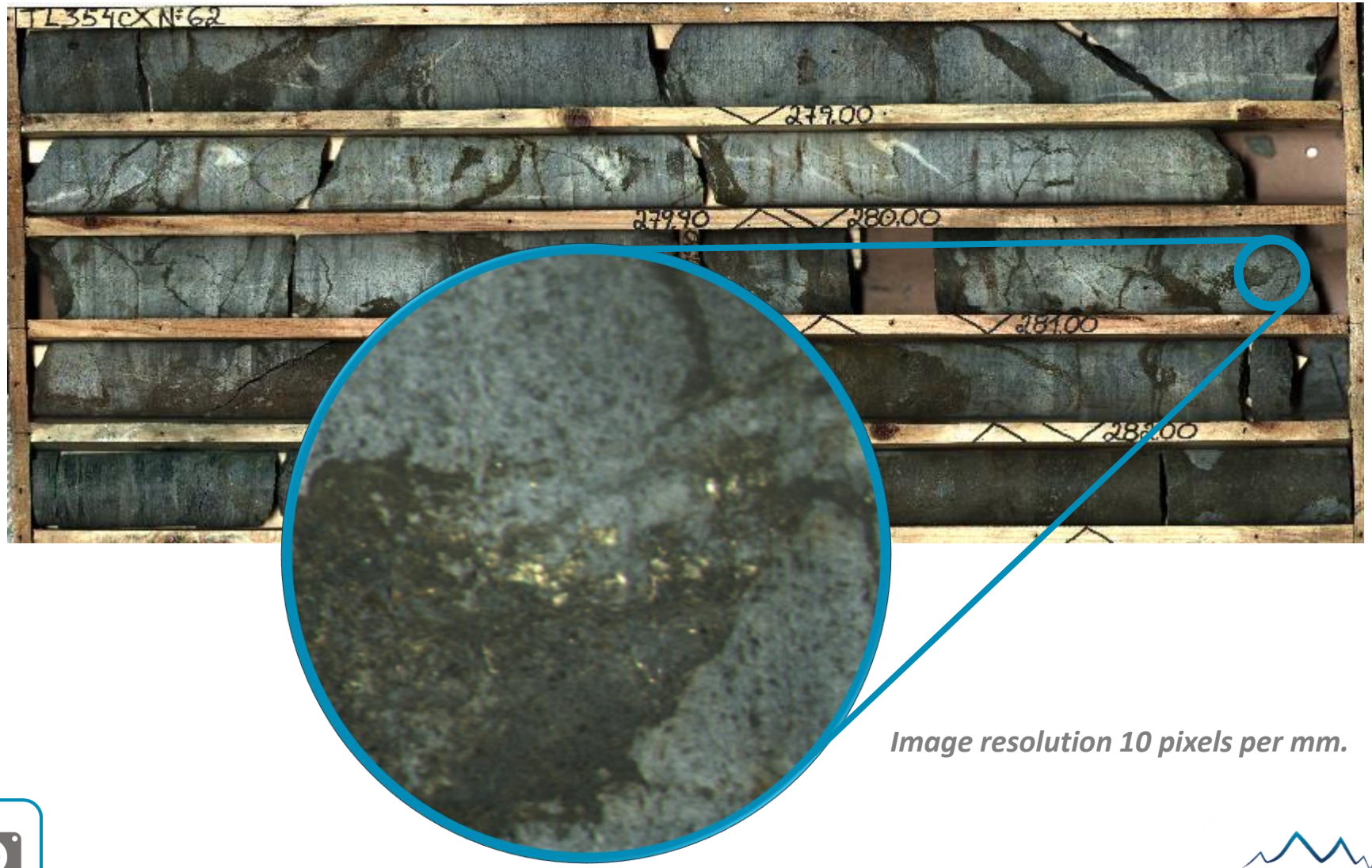


Image resolution 10 pixels per mm.

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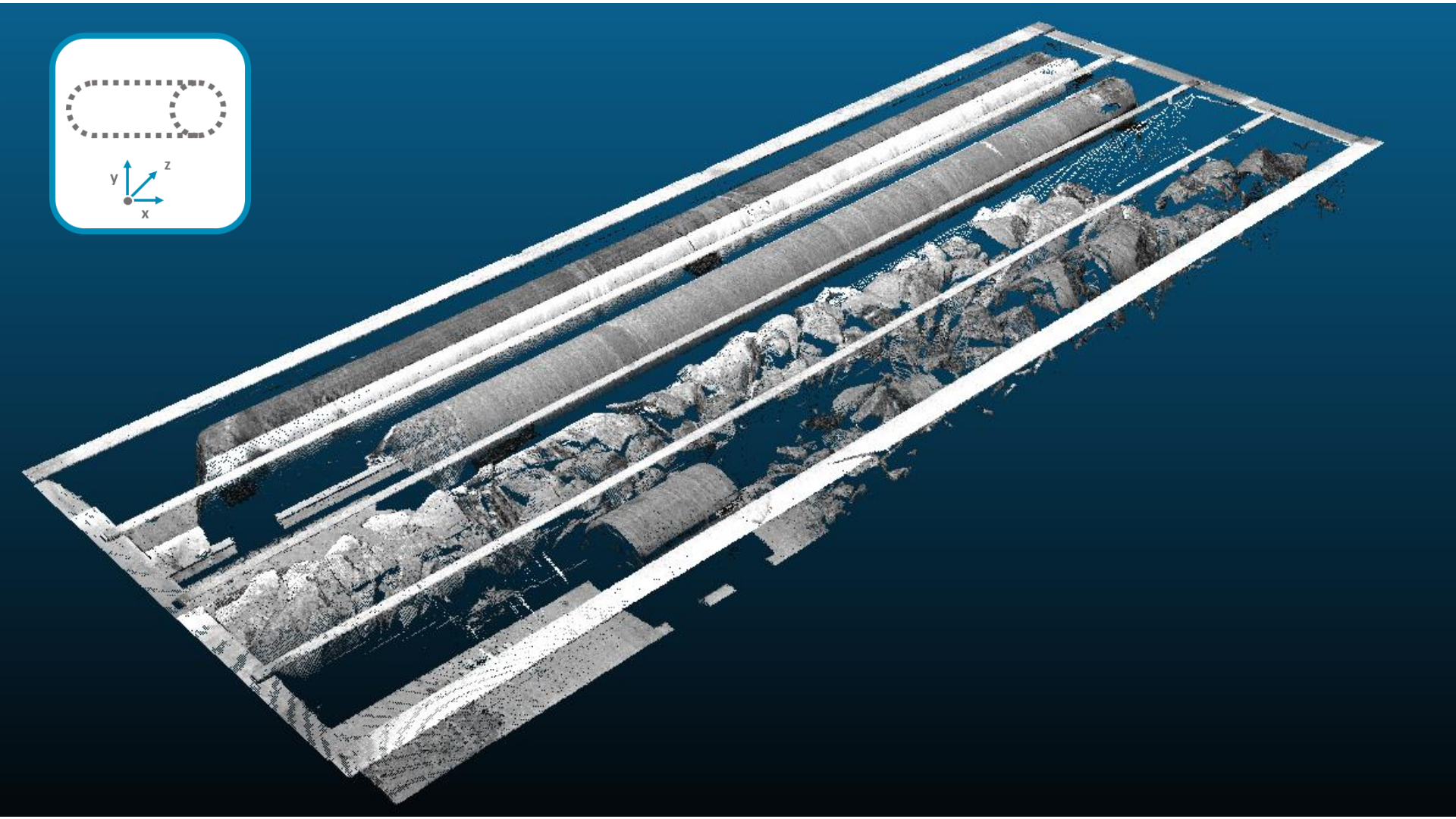
Topography Scan



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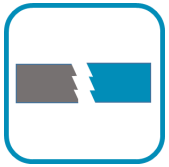
High-Resolution Topography

Point cloud model **resolution** 1 mm spatially and 0.2 mm across and vertically. Each point records an **intensity** reading allowing grey scale visualization of the core tray.

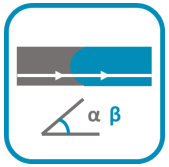
At this resolution **physical properties** of the core become apparent, fractures, dimensions, lengths and roughness.

In addition the intensity values makes it possible to distinguish veins and other **visual features** from the core.

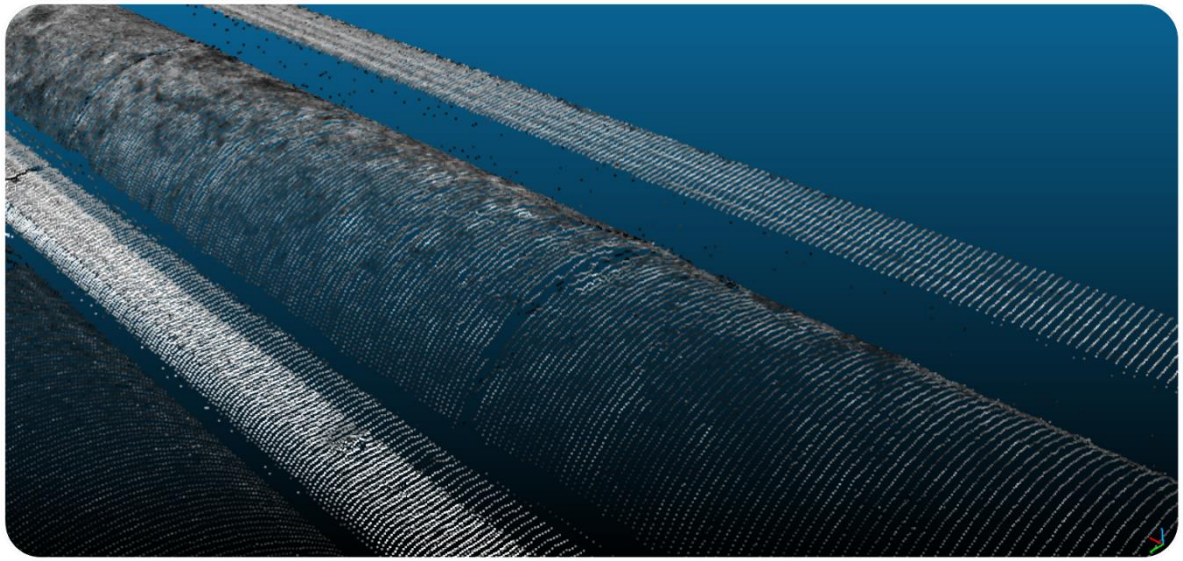
Enables:

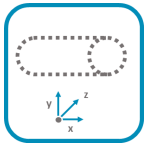


RQD



Structural Logging





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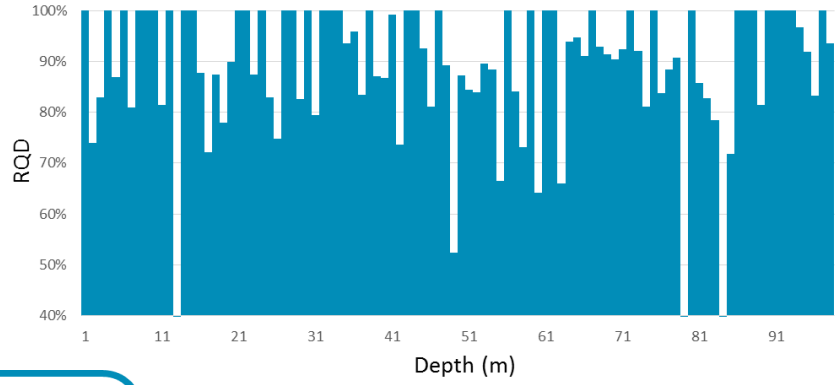
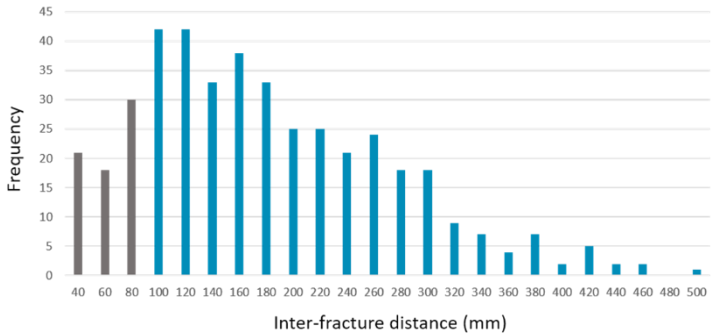
Semi-Automatic RQD

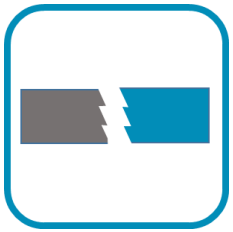
Determining the Rock Quality Designation is a **time consuming** but important task especially regarding **safety** in underground operations.

The Minalyzer CS acquires topography information of the core enabling **semi-automatic** RQD calculations on **any interval**, **reducing the time** and **subjectivity** of determining RQD values.

Since all inter-fracture distances are measured it is also possible to **enhance** the analysis by introducing a Histogram on desired groups designated by inter-fracture length intervals. This is one way to utilize the extensive data set provided through Minalyze.







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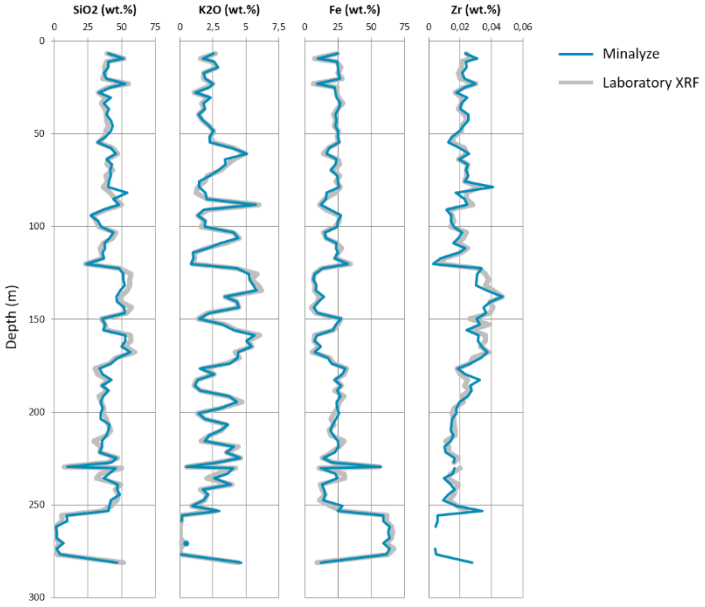
Geochemical XRF Assays

The Minalyzer CS aquires **XRF** spectral data by a **continuous** movement along the **complete** length of the core.



The XRF footprint is 20mm x 1 mm. Analysis is less subjective, very repeatable and **highly representative**.

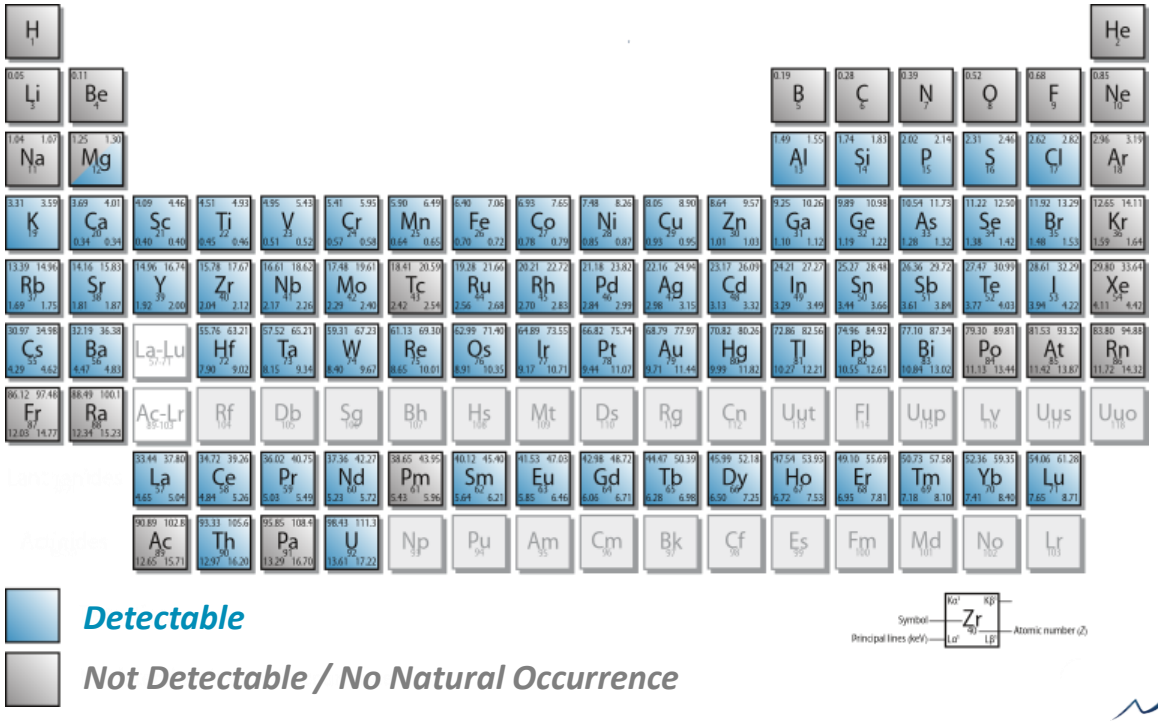
- Provides **overview** and **continuity**
- **Removes bias** in sampling
- Allows for geochemical logging with **objective** data

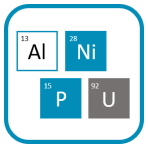
Multi-Elemental

The elemental range spans in general from **Al to U**, allowing **whole rock** analyses.

Allows you to find correlations between elements that previously were not included in your analytical suite for the full length of core.

Detection limits can be optimized through parameters such as anode type, scanning speed and interval length.





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Non-Destructive

Scanning samples is completely non-destructive and minimal sample preparation is required.

The sample surface should be **visually clean** from dust, mud and other contaminants.

Keeping your samples intact enables for subsequent **mechanical testing** and saves time on time consuming tasks of **sample preparation** such as **splitting**, **cutting**, **crushing** and **grinding** samples.

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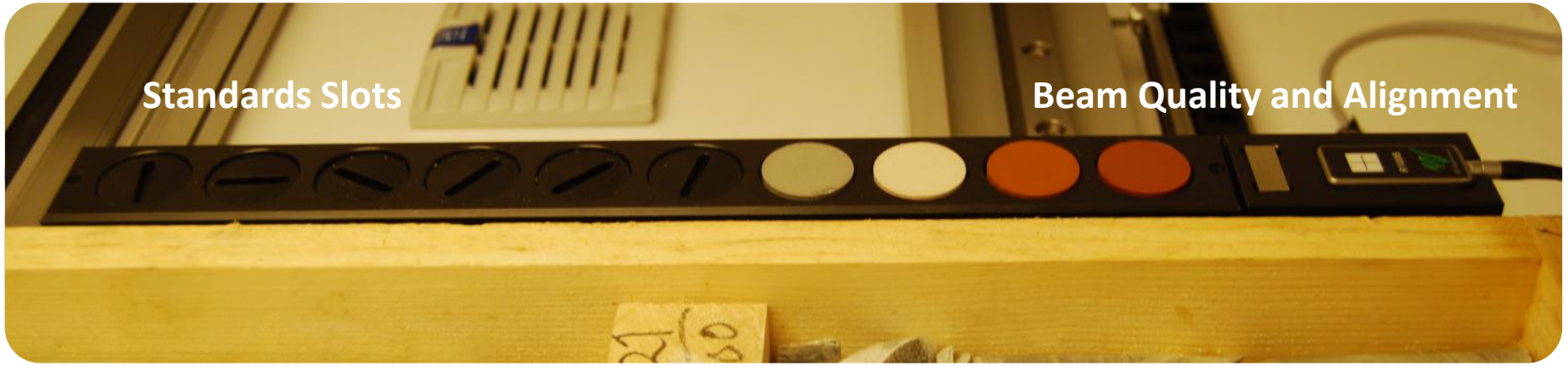
Instrument Calibration & QA/QC

The Minalyzer CS is equipped with a **calibration station** that hosts features to cover instrument QA/QC in an automated routine.

- a sensor for checking the X-ray beam **intensity**, **shape** and **position**.
- standard samples to calibrate the X-ray detector and check for drift. Slots for up to **ten** pressed **pellets** which could be either standard reference materials or deposit specific material that allows for calibration of the chemical data.



Calibration station integrated in Minalyzer CS for routine drift check and calibration.

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High Resolution Geochemistry

The spectral **data is stored in cm intervals** but can be processed on **any interval** from cm to several meters.

- Assists in **geological logging**
- **Fast turnaround** and **objective**
- Assists in **sample selection**
- **Reduce need for traditional destructive sampling**

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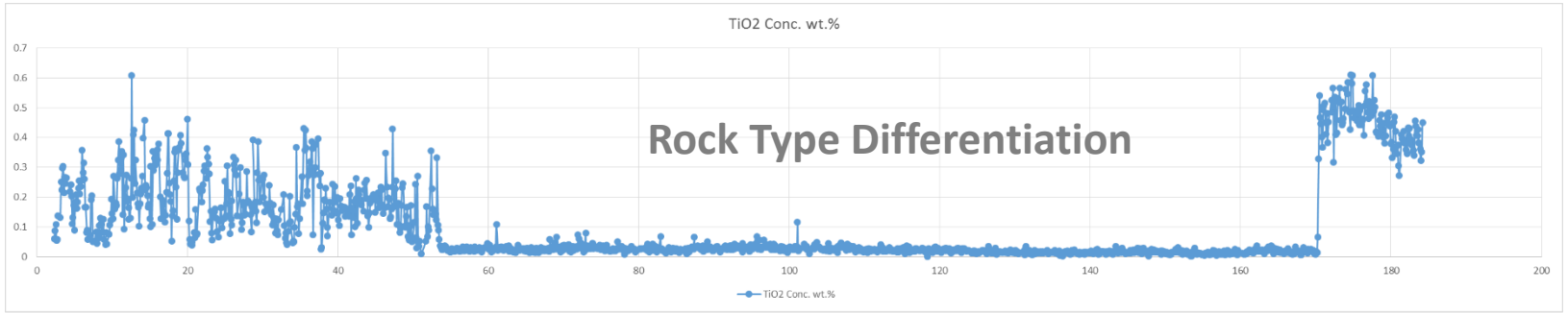
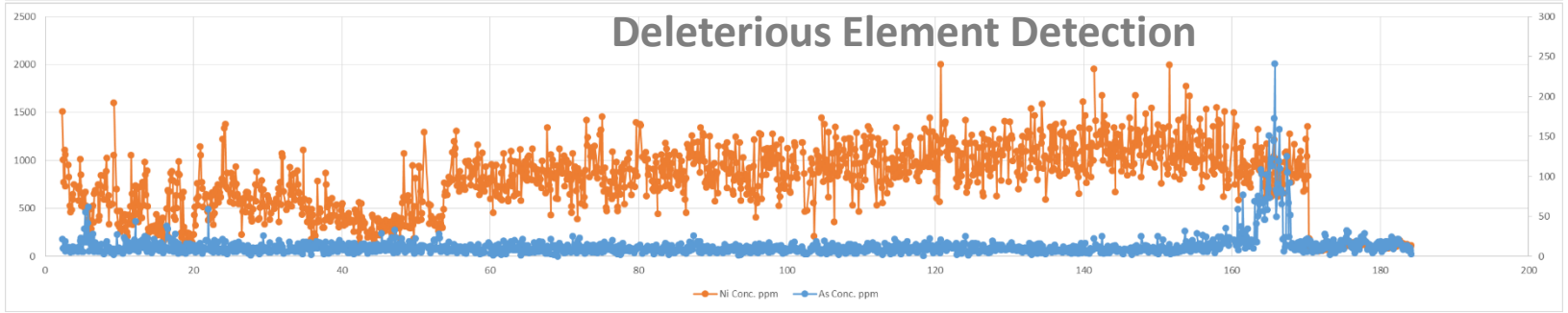
Improves Geological Logging

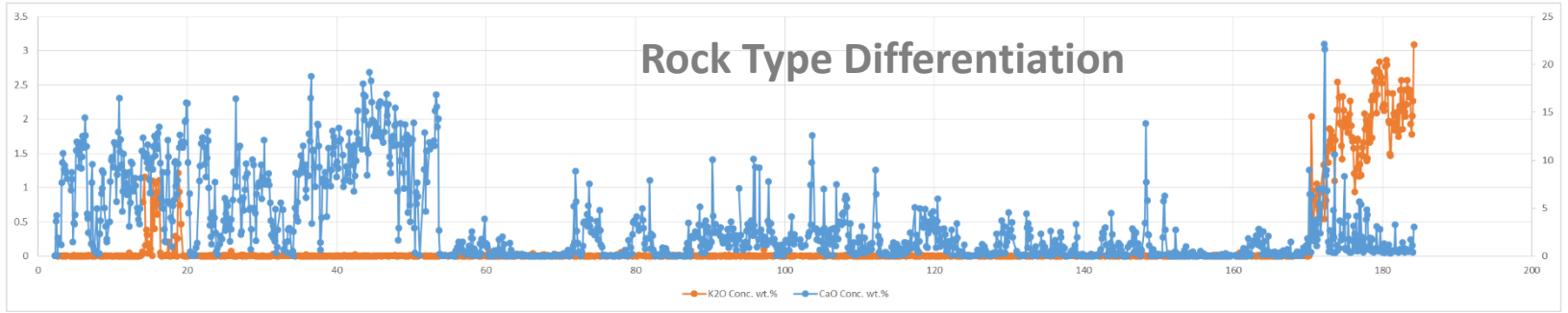


TiO2



Ni

As



K2O

CaO

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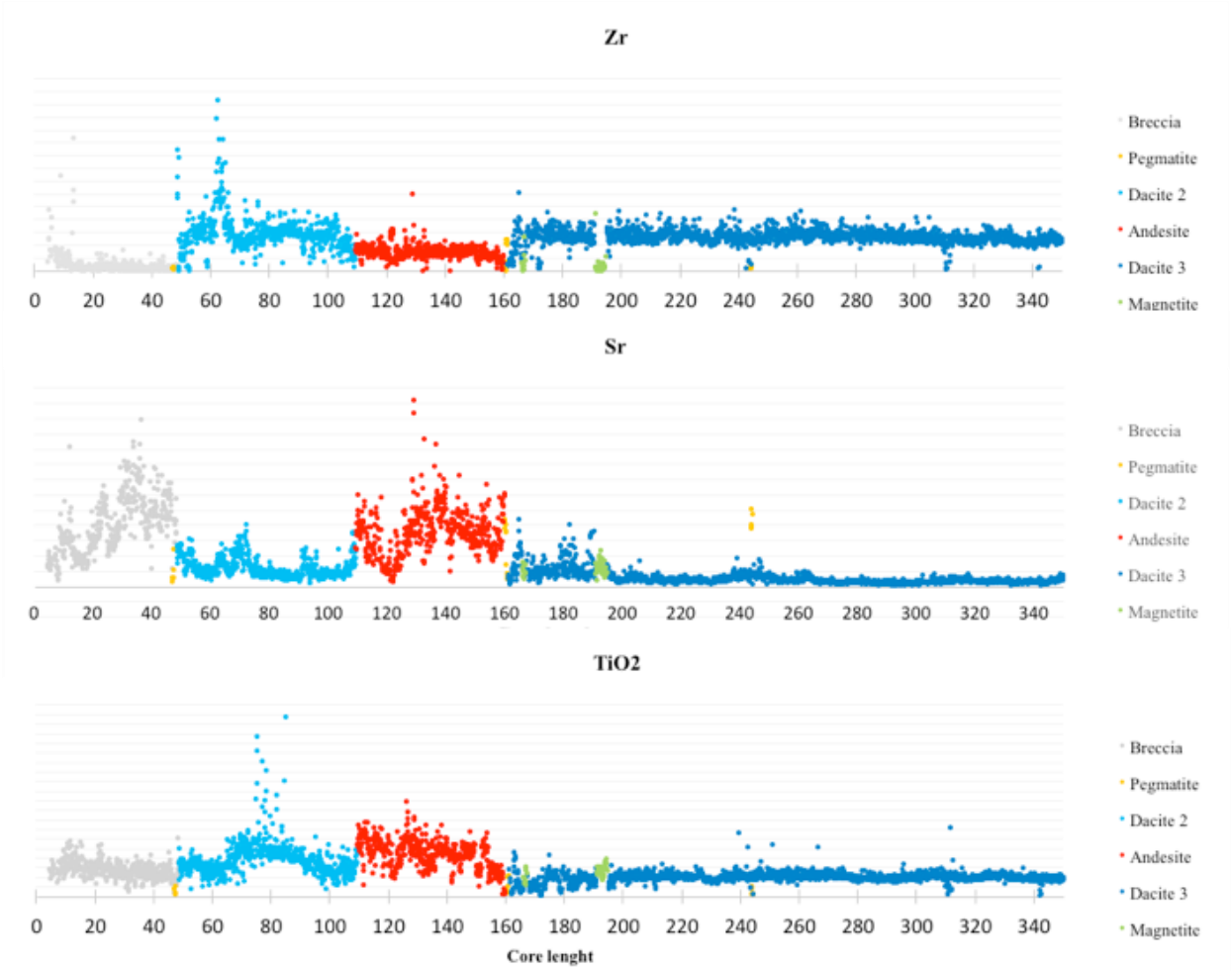
Geochemical Core Logging

The geochemical XRF data provides the logger with **objective** and **quantifiable** information about the core, such as chemical data which can improve the **consistency** & **quality** of the log.



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Geochemical Core Logging

- Geology can be complicated.
- Lithologies can be altered.
- Identifying the original rock units can be challenging.
- Correctly recording geology is critical for a geological model and resource estimation.
- Drill holes are often logged by the least experienced.
- Geochemical data generated by the Minalyzer CS can be used to distinguish rocks.

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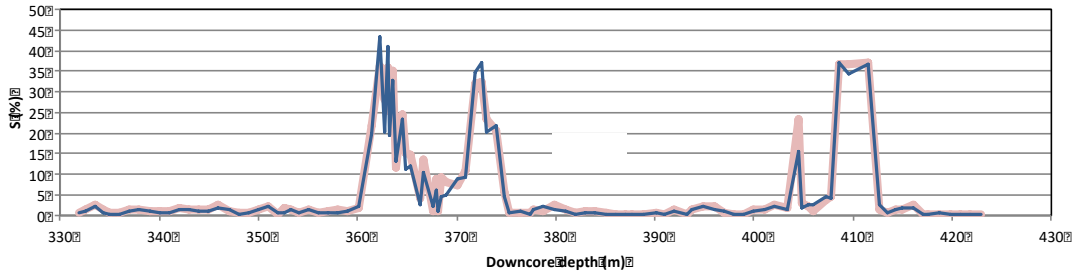
Representativity in Practice

One half of the core destructively sampled the other half scanned by Minalyze.

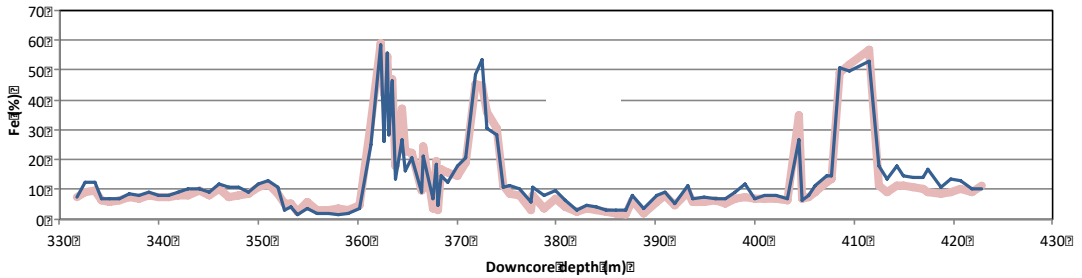
S IGO

S MLZ



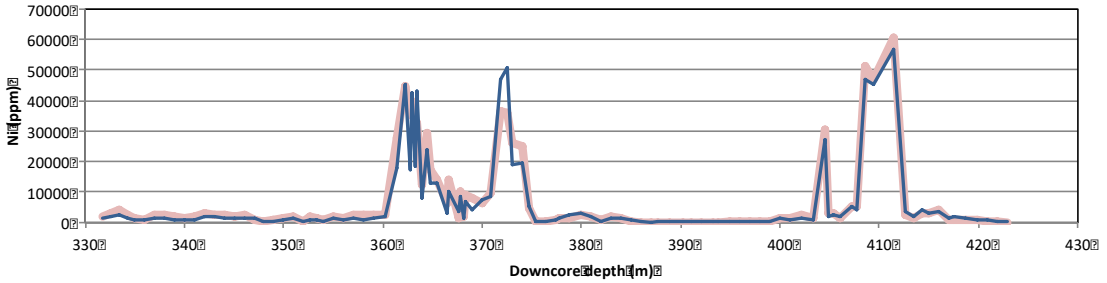
Fe IGO

Fe MLZ



Ni IGO

Ni MLZ



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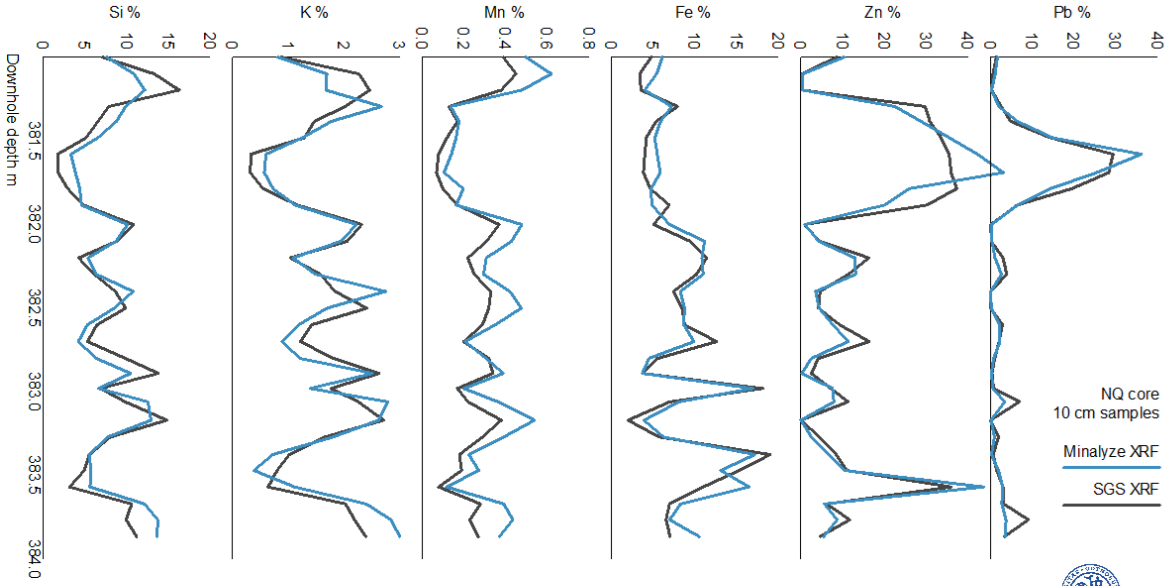
Representativity in Practice

Continuous XRF scan

SGS GLENCORE

Collaborative laboratory comparison

Surface scan vs. Full core



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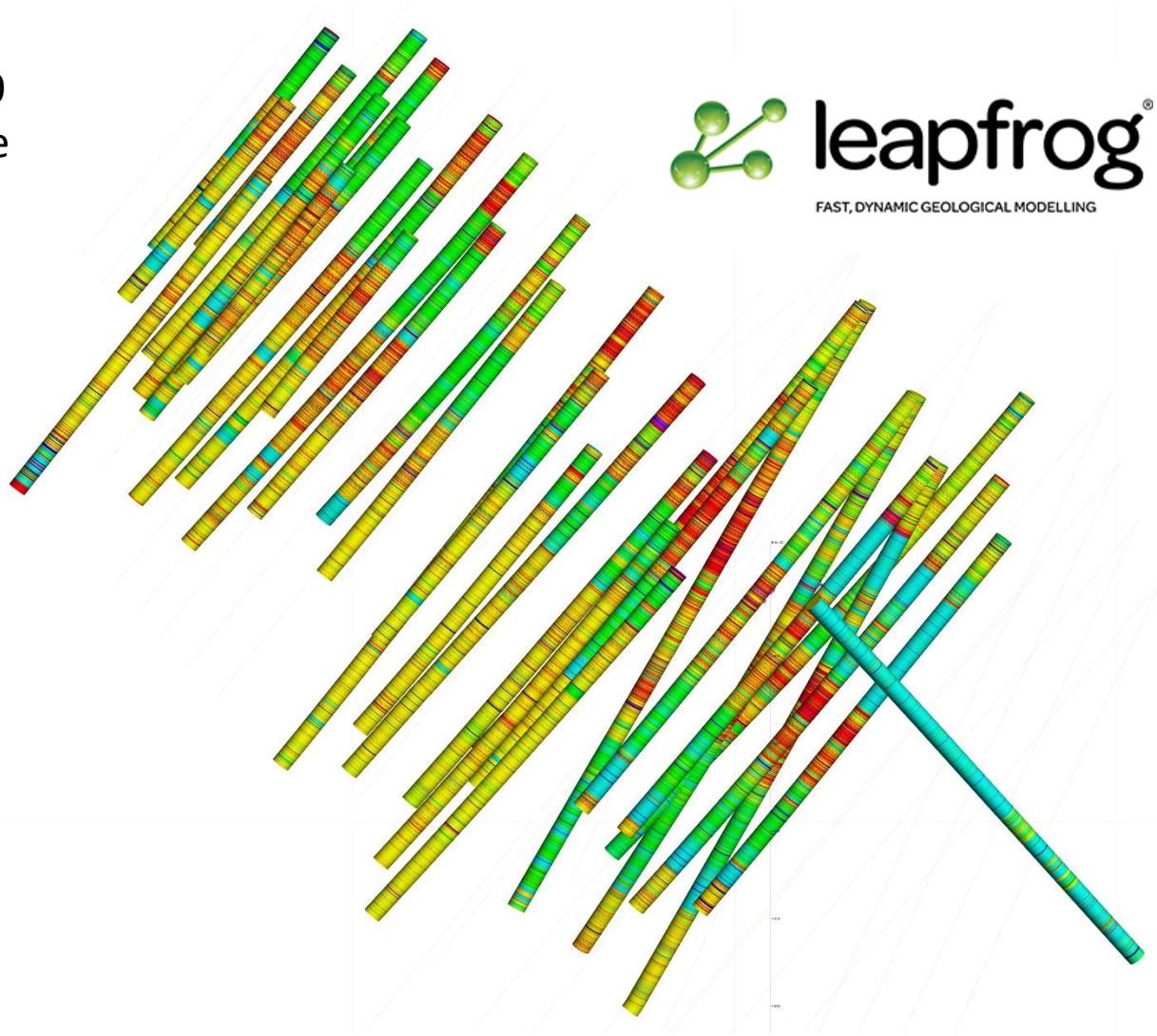
Compatible Data Set

- High-resolution analyses (10 cm) of zirconium in drill core
- Results compatible with Leapfrog Geo and other 3D modelling software
- Variations in zirconium content dependent on distinct rock types in a metavolcanic stratigraphy.



Minalyze is in a partnership with Leapfrog and other companies in the data value chain.

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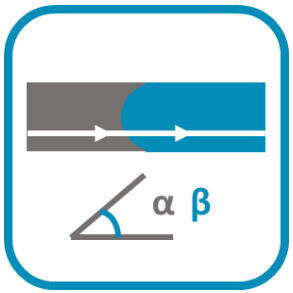
Structural Logging

Oriented drill core provides a lot of detailed structural information about the geology of a project.

Drillers mark the side of the drill core that either points down or up by using a special orientation device. Structural features, such as fractures, veins, and foliation, can be measured relative to the orientation line by measuring the so-called **alpha** and **beta** angles.

There are major issues with these measurements, which are a tedious and **time-consuming** task. The risk for **erroneous** and **inconsequent** measurements is large and it is very difficult to do a proper **quality check** or to verify how a measurement was taken.



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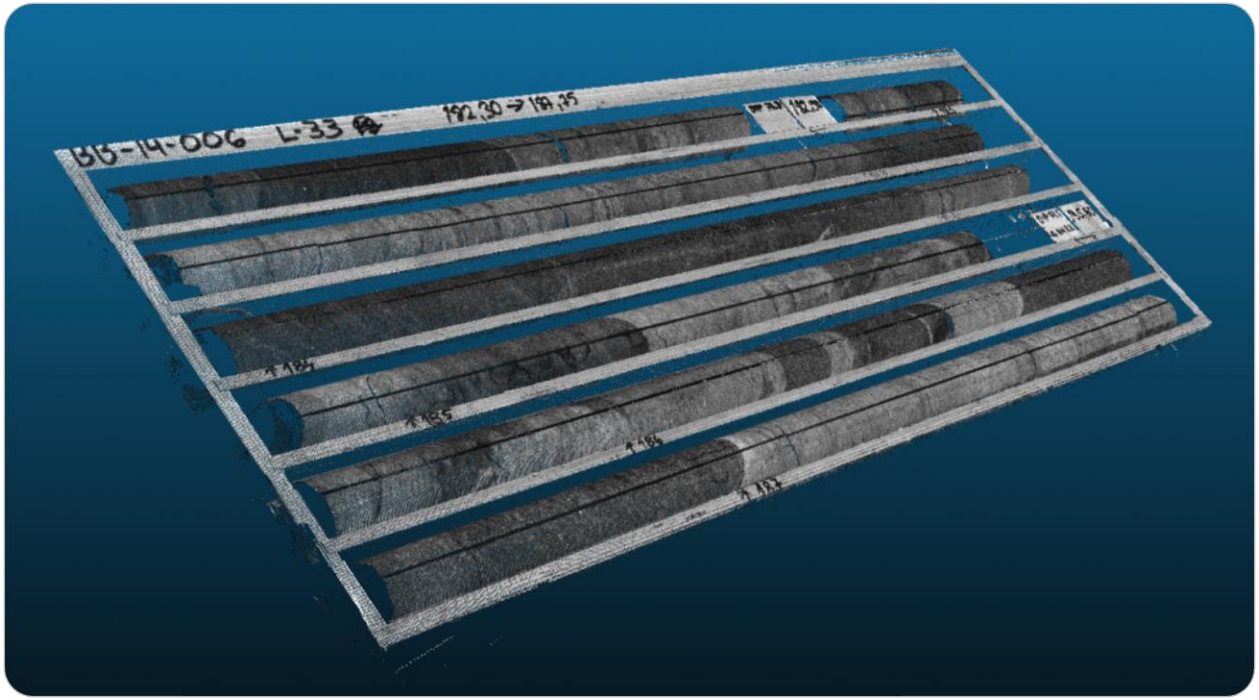
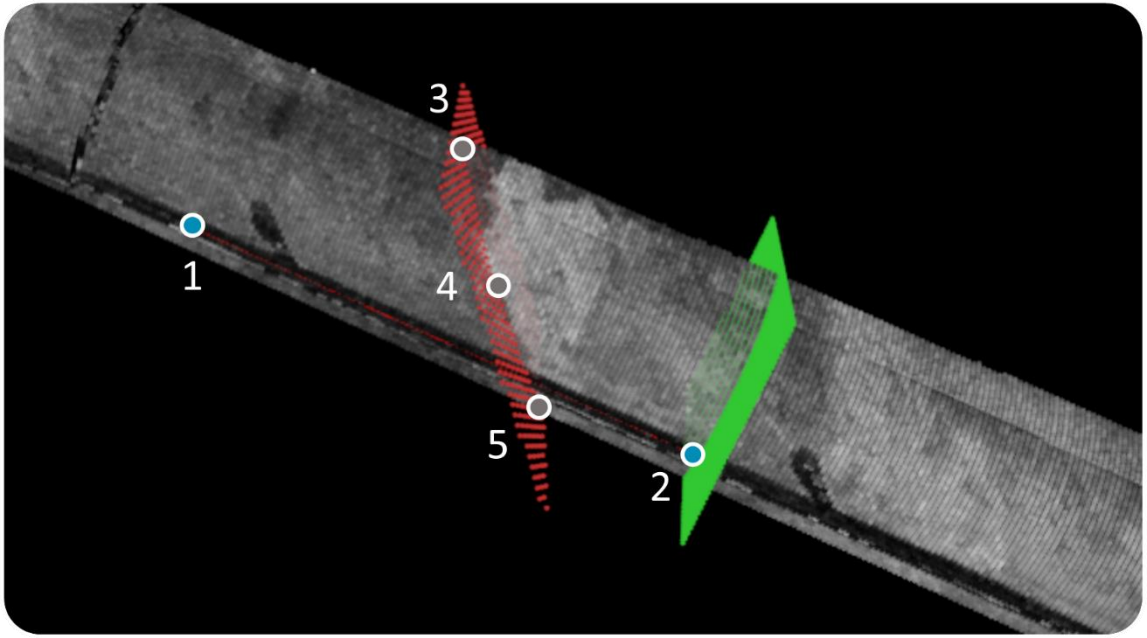
3D Model of Oriented Core

3D Topography model of the core tray is acquired during the Pre-Scanning step in the Minalyzer CS. If the core have been oriented and marked prior to the Pre-Scan with the orientation line facing upwards this data set enables digital structural logging.

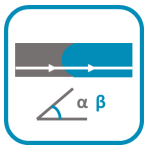


3D Model of Oriented Core

Alpha and **beta** angles of planar structural features can be measured in the tray without manual handling, quickly and accurately directly from this digital version of the drill core using software developed by Minalyze. The method is in general faster and **less labour-intensive** than conventional methods, while also significantly **reducing the risk of incorrect measurements**. The method works for all sizes of drill core and even cut cores, such as half core, can be measured.



The structural feature is logged by clicking two points on the orientation line and three points on the feature to be logged.



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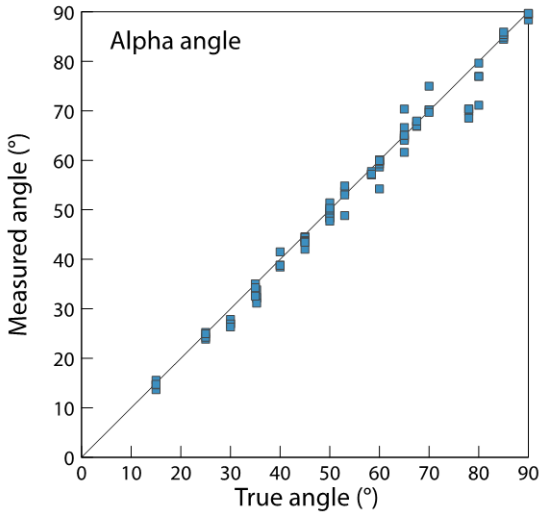
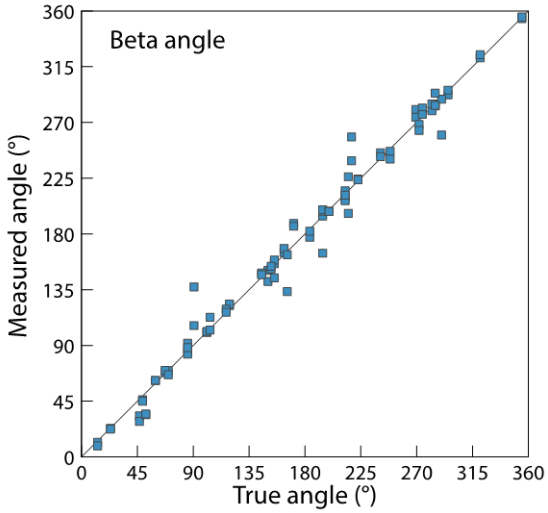
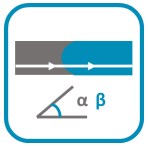
Works for All Angles

Alpha and **beta** angles of planar structural features can now be measured **quickly** and **accurately**, **saving time** on time-consuming manual measurements, while also significantly **reducing the risk** of incorrect measurements. Measurements are stored **digitally** in direct relation to the drill core, eliminating the risks of **erroneous** recording of measurements. Adjustments can be made to the measurements if necessary, long after the cores have been sampled and sent to the archive without needing to physically retrieve the core trays. Senior geologists can easily perform a quality check of the measurements.







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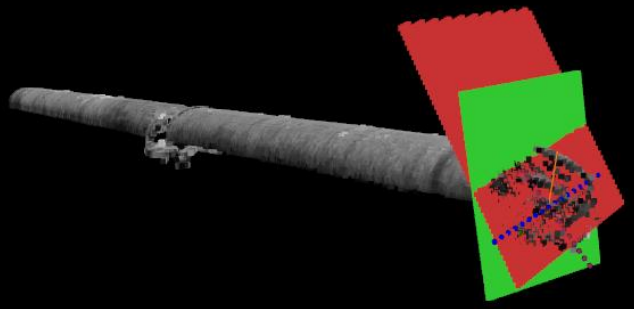
Digital Measurement in Practice



Angles:
Alpha_= 59.55
Beta = 34.98

Time and cost savings

Example

Core length: 500 meters

Core features: 600

Traditional: average 2.5 minutes/feature

Minalogger: average 0.5 minutes/feature

➔ **Saved 20 hours manual work**

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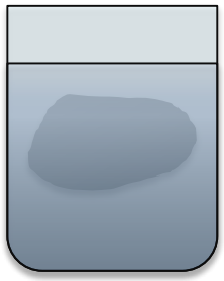
Specific Gravity

Measure SG to convert volume to weight.

Traditionally done by:

- **Hydrostatic weighing** in air and water.
- **Gamma-ray densitometry** for core and downhole tools.
- **Gas Pycnometry** on pulps.

36.2 g



14.2 g

= **2.55** g/cm^3

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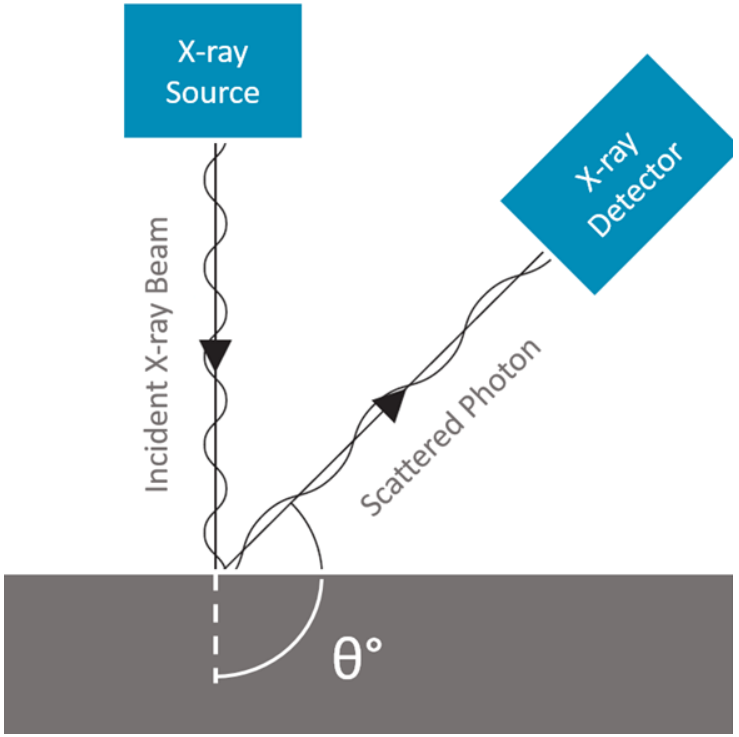
Specific Gravity

X-SG is a method developed, tested and applied by Minalyze for estimating the SG on a geological sample **based on the interaction between X-rays and the sample**.

X-SG works with a backscatter setup.

X-SG™



kg

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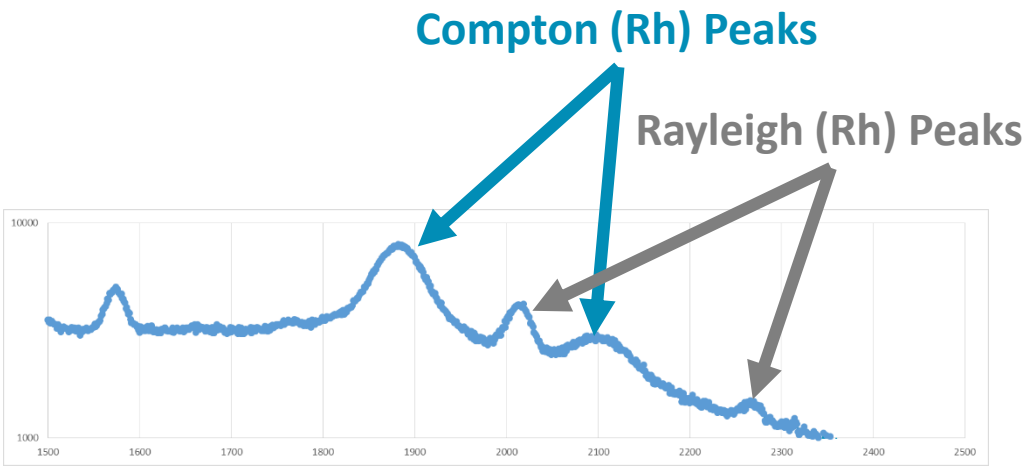
Rayleigh & Compton Peaks

Apart from the characteristic X-rays there are incident X-rays that are **scattered** by the sample, known as **Rayleigh** and **Compton** scattering. The intensity of the scattered X-rays depends on the physical properties of the sample, including the density.

SG is estimated on the same intervals as the chemistry as it is derived from the same data just looking at a different part of the spectra.

This effect is used in healthcare applications to measure bone density.

Rayleigh and Compton peaks have a direct correlation to the density of the material.



kg

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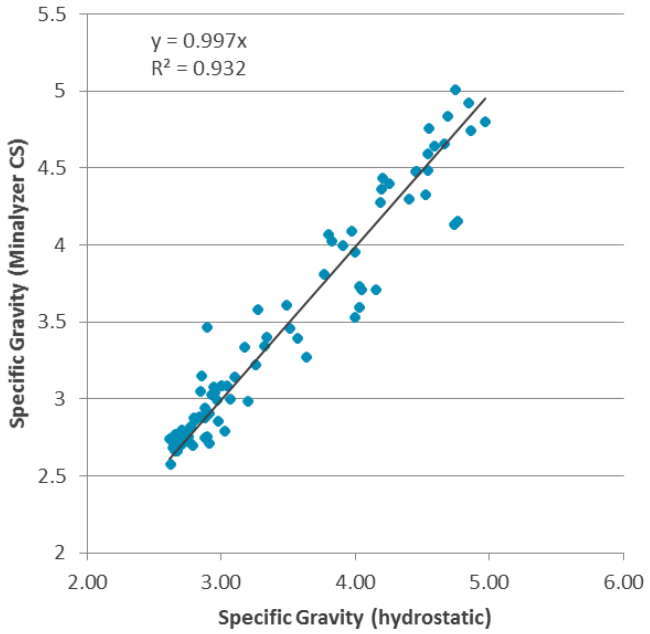
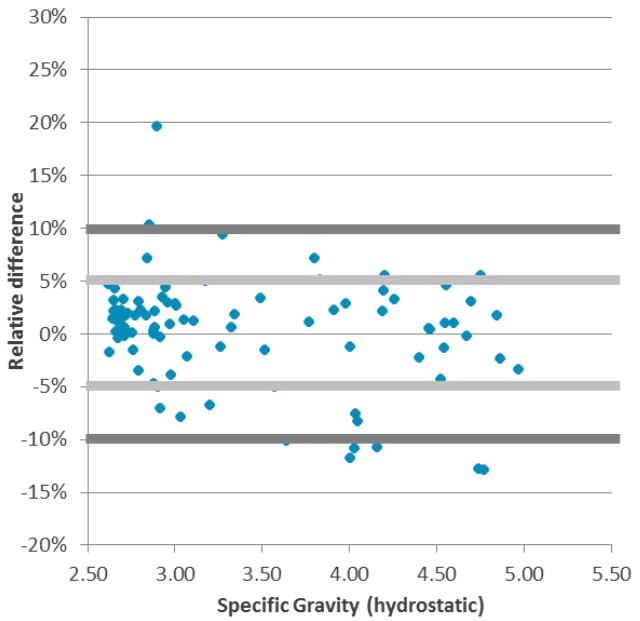
Reliable Results

Trials show the relation between the hydrostatic specific gravity and Minalyzer CS specific gravity is close to a 1 : 1 ratio.

The relative differences between the hydrostatic specific gravity and the estimated specific gravity by Minalyzer CS are generally less than ±10 %.





kg

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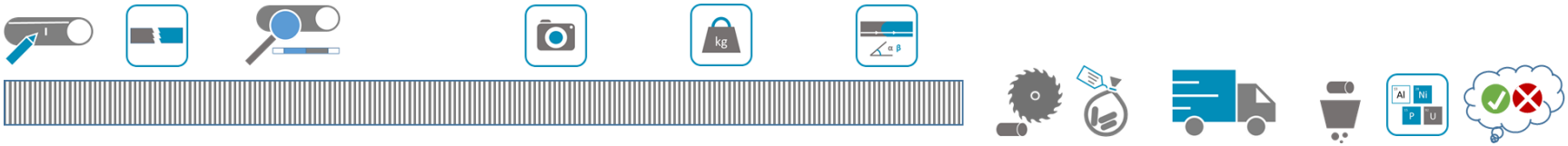
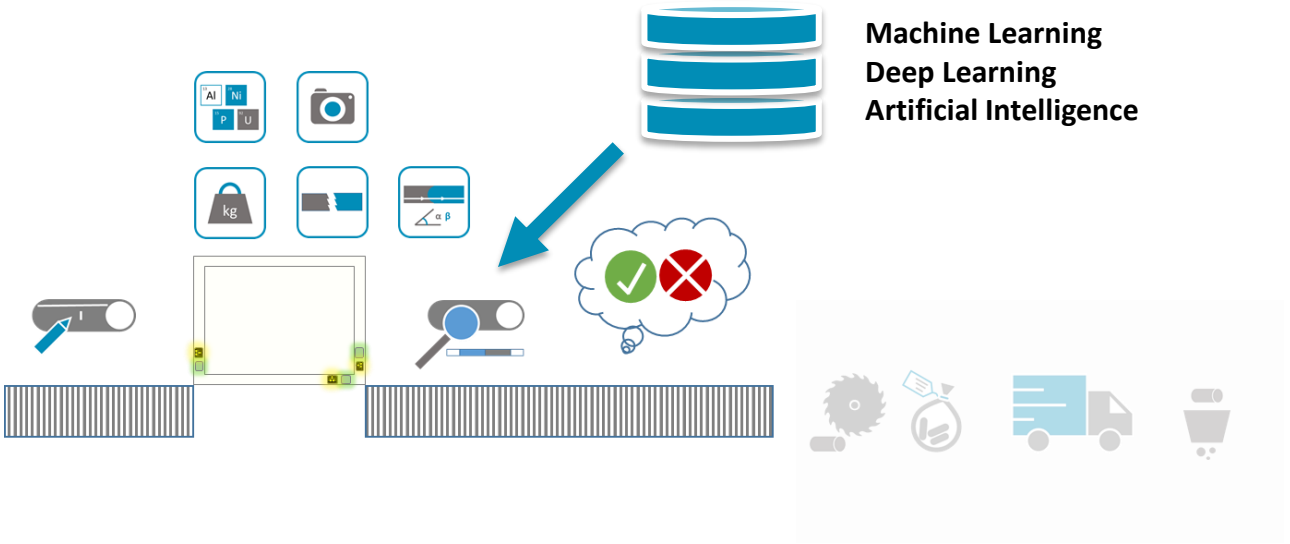
Workflow

Traditional Workflow



New Workflow



Machine Learning
Deep Learning
Artificial Intelligence

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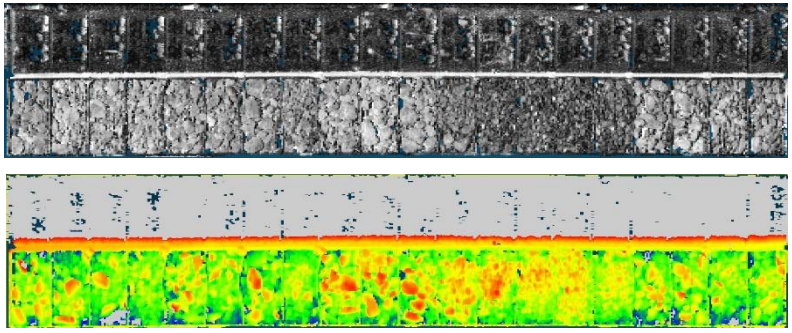
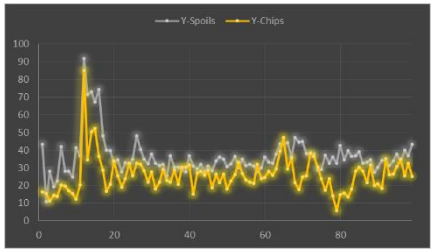
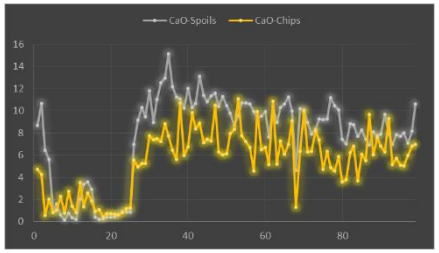
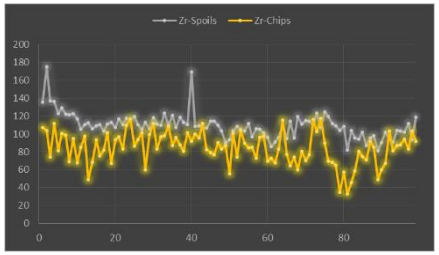
RC Chip Tray Scanning

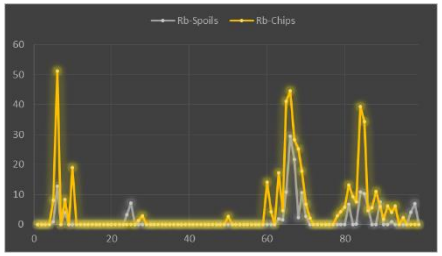
Possibility to scan **around 1000** samples per shift depending on desired analysis time and quality. Also enables scanning of **pulps**.

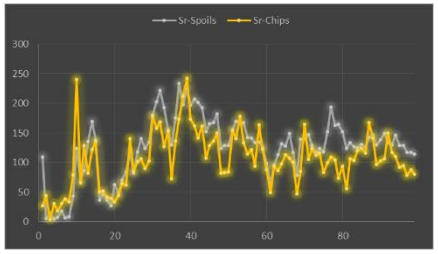


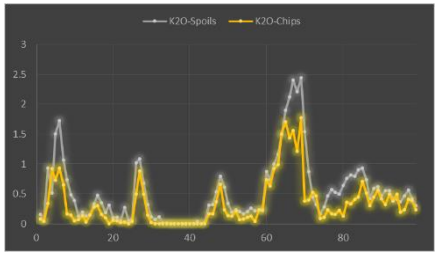


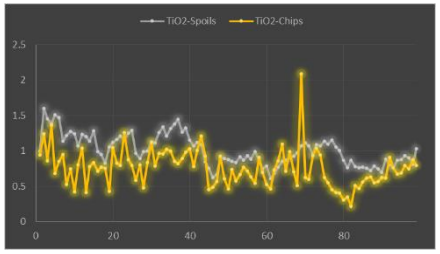


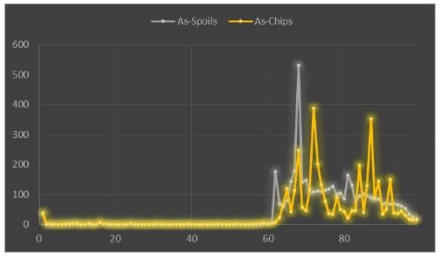












Minalyzer CS is Mobile

Decreasing waiting time

Preparation and transport of samples not needed

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Minalyzer CS is Mobile

Application – Remote Exploration

MINALYZER CS

MINALYZE

Application – Core Shed

Application - Mine Site

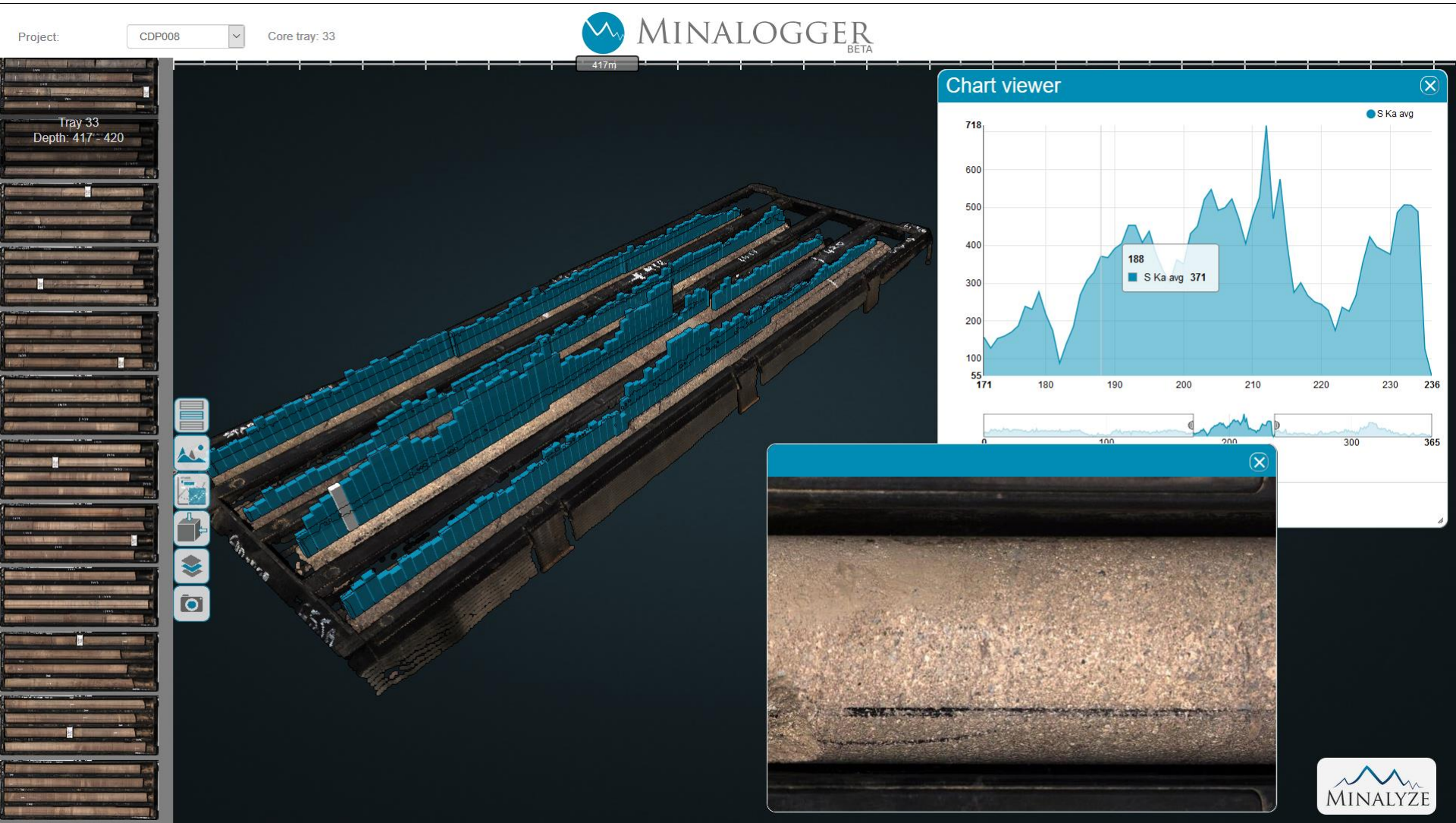
Application - Mine Site

Application – Government Core Library

Application – Research and Academia

Minalogger – Cloud Software

World unique cloud based web software for 3D visualization of all generated datsets in a PC, Mac, Phone or Tablet on the go. Can also load other externally generated depth related data.



Workshop Tasks

MSDP 02

- Is there information in this drill hole that could drive economic mineral exploration?
- What elements would potentially be of economic value?
- At what depth is metals of potential economic value introduced?

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Workshop Tasks

CDP 008

- This hole passes through a sedimentary sequence of mud and siltstones before entering a basalt. Which elements are helpful when identifying these changes in lithology?
- At what depth is the basalt introduced?
- What happens around depth 600m?

Customer Value

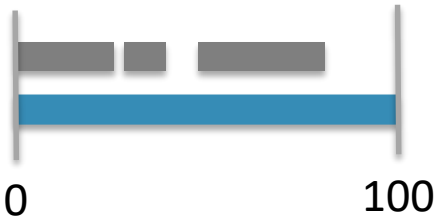
Direct Effects

Cost of analysis

- 46%

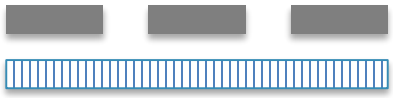
Time for analysis

- 4 weeks



Sample volume

100 %
(68%)



Resolution

10 cm
(300 cm)

Based on a 18 800 m exploration project

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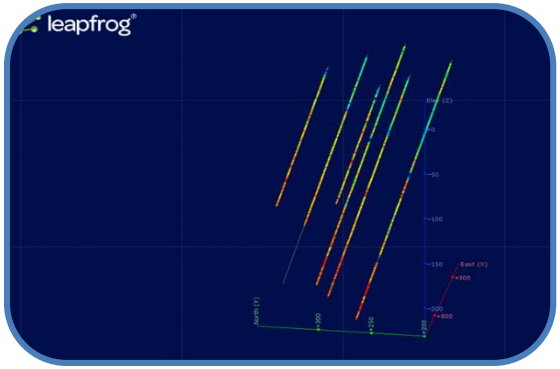
Customer Value

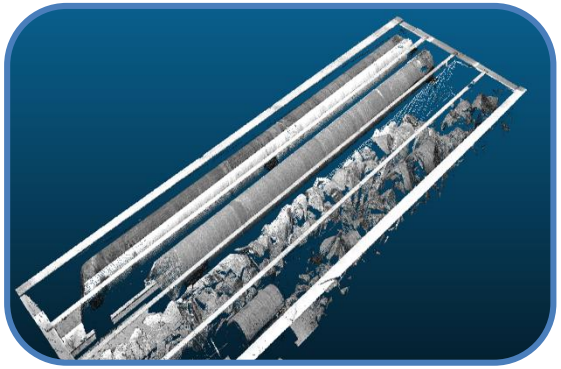
Indirect effects

Drilling optimization



Data direct to model

Logistic solution
- Less need for transportation



Digital core archive
- easy access to results

Saves **time**, **money** and reduce **risk**

Consistent data in one system

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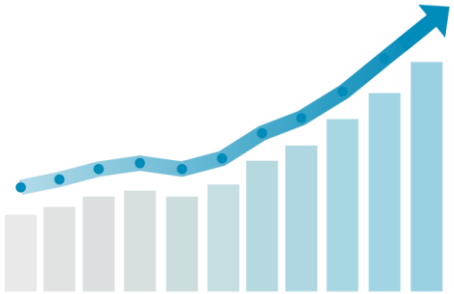
Enhance Revenue

•**Faster discoveries** - Detailed information delivered quickly will shorten and refine the exploration process and time to operating mine.

•**More discoveries per dollar invested** - Critical information delivered in real-time to optimize decision making.

•**CAPEX efficient** - A service-based business model for Minalyzer allows you to direct investment to operations optimization.



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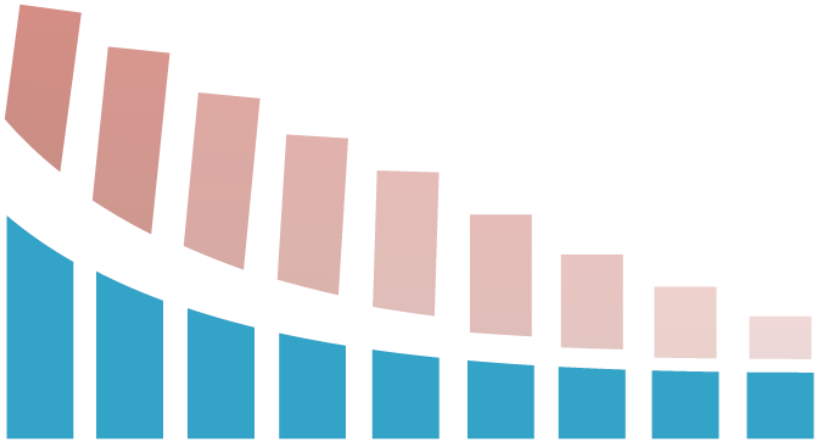
Reduce Cost

•**Efficient utilization of personnel** - Semi-automation of time consuming and repetitive work allows more time for qualitative assignments.

•**Decreased risk for investments** - More information earlier, provides improved decision basis.

•**Resource optimization** - Benefit from short lead times and optimize the exploration process or mine operations.



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Increase Efficiency

•**Analysis while the rig is still on site** – means drill program, **logistics and data management** can be improved, leading to better budget utilization.

•**Remote access** - retrieve results from the scan regardless of location. Experienced geological team at **HQ can collaborate with the field geologist**.

•**Complete information** - The continuous scan reveals more than what is visible to the eye providing a confident basis for **efficient logging**.

Example Clients and Partners

LKAB

BOLIDEN

icdp

Nordic Iron Ore

NickelMountain

TASMAN METALS AB

MINALYZE

igo

CSIRO

Challenger Geological Services

Evolution MINING

Government of South Australia

This list provide an idea on the width of application and is not exhaustive, more clients and partners are available for reference upon request.