Fugro´s Innovation for the Mining Market

Uta Alisch, German Day at Mining Indaba, 6 February 2018

Remining of Tailings

Economic pressure leads to opportunities through innovation:

- Million tons of rock have been mined and discharged after processing creating huge tailings
- **Processing old tailings (Remining) can gain back raw materials**
- Material in tailings is fine grained = **easy to process**
- Tailings are **easy accessible**

Some Pros about Tailings:

- At the surface
- Processing plants are mostly already there (need just some adaption, improvements)
- Processing technologies has been improved (more efficient)
- Logistics are there
- Tailing dam safety and environmental issues can be addressed simultaneously

Remining of Tailings

Challenges for mining the tailings

- **Fast** and **cost effective screening technologies** for tailings are required
- Design for remining requires new efficient characterization
- Innovative (in-situ) mining and processing technologies required

Characterization of tailings: Metal contend and soil type

- Metal concentration and distribution for qualified resource estimation
- Geotechnical characterization for design of remining activities
- Soil type and grain size for processing

Tailing Planta Matta in Copiapo, Chile

Tailing Requinoa, Chile – Reprocessing Cu and Mo

CPT-XRF probe for tailings characterization

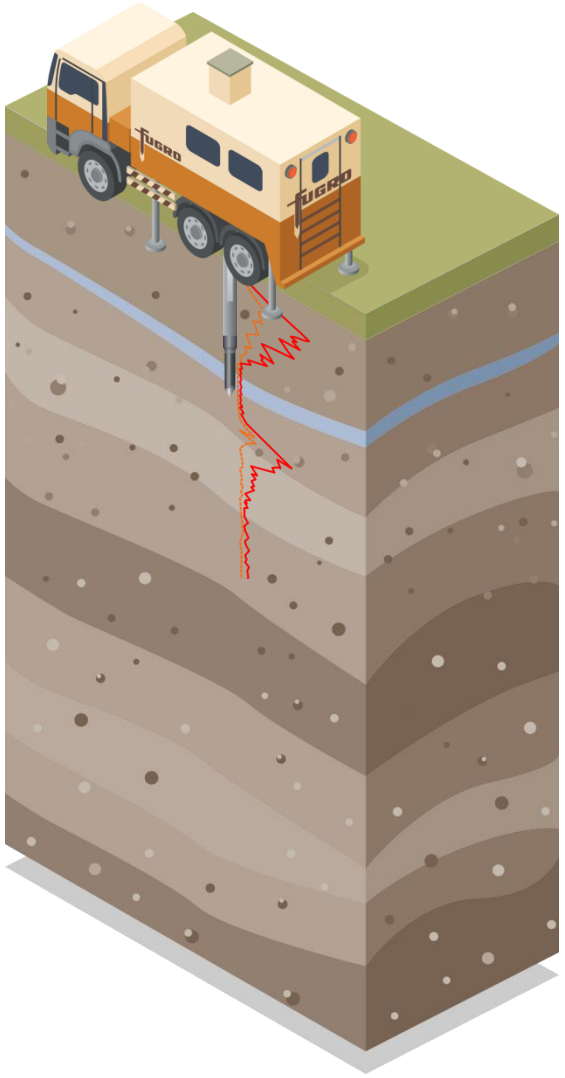
Multiparameter probe:

Metal concentration and soil classification in one push

XRF Window

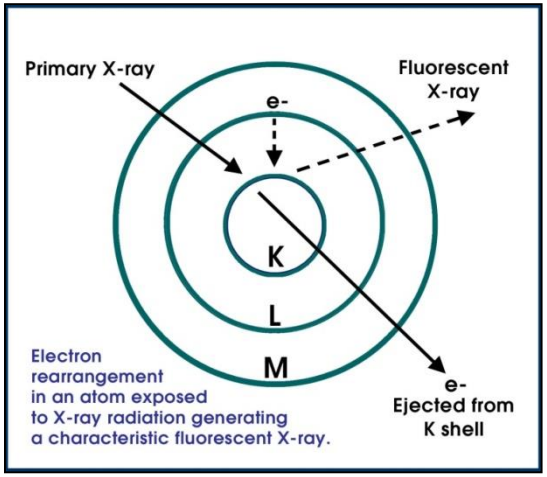
CPTU

- Tip resistance
- Sleeve friction
- Porewater pressure



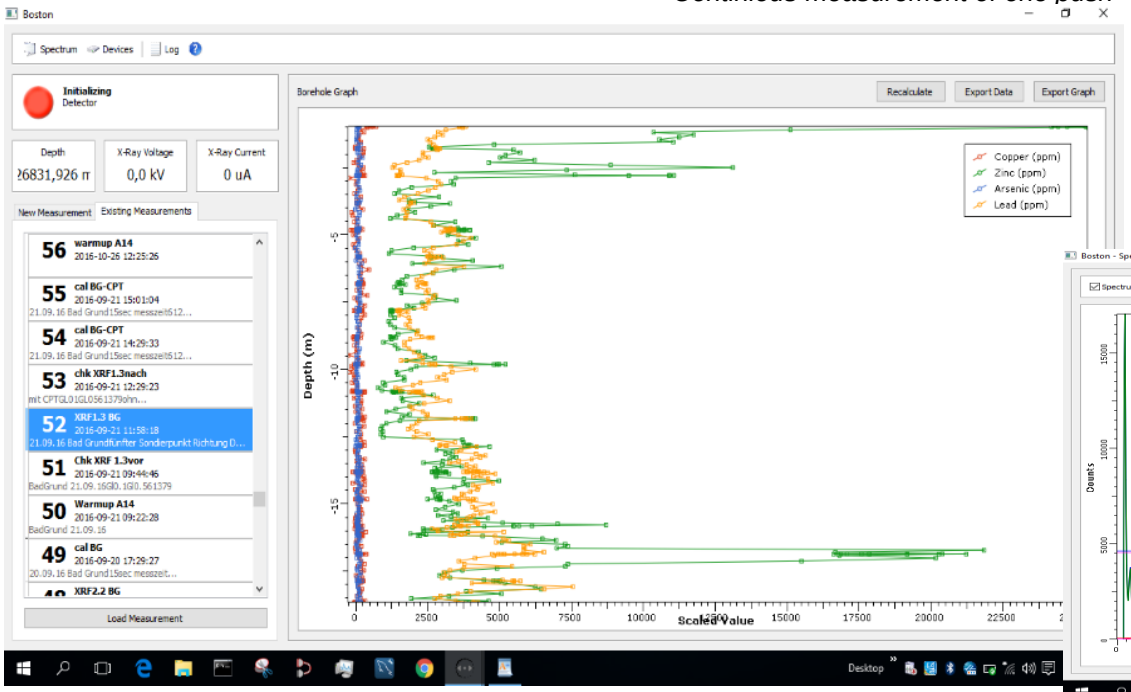
The XRF-CPT Technology

- Based on X-Ray Fluorescence
- Measures energy spectra for certain intervals (10-30 cm)
- Records data (concentration values of elements) in real time
- Provides high resolution data
- Very fast (100 – 150 m / day)
- Cost effective

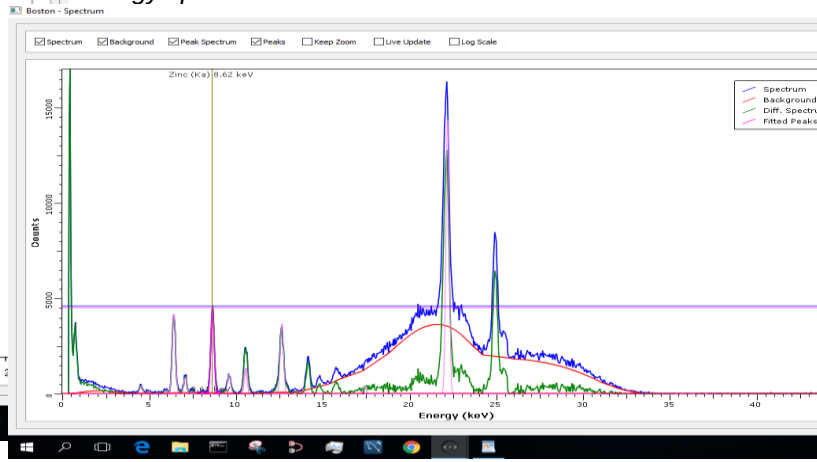


Principle

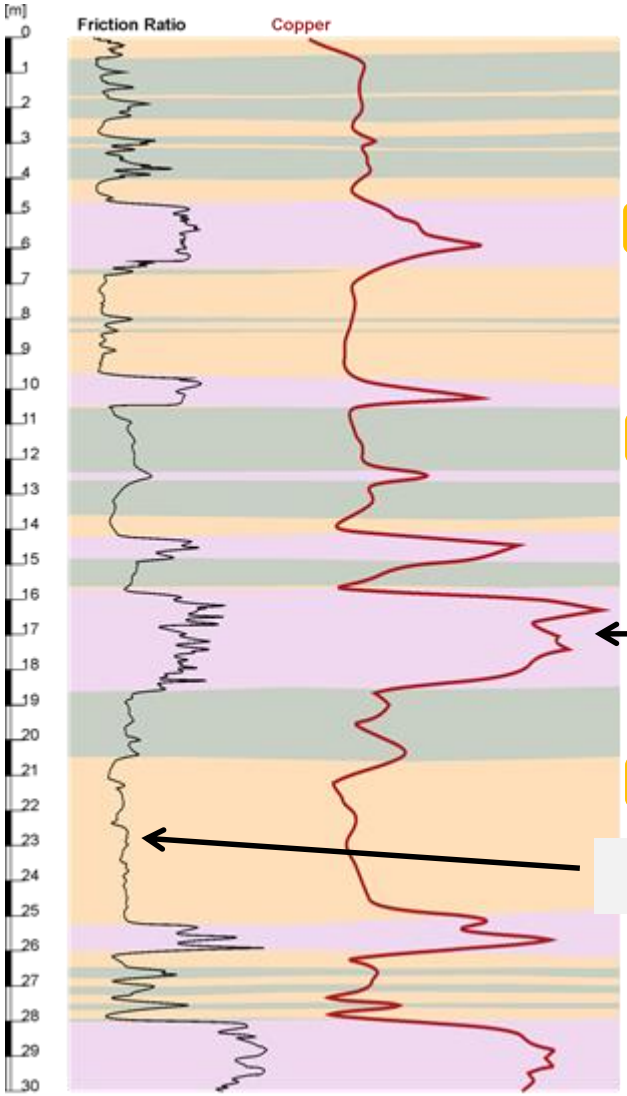
Continious measurement of one push



Energy spectra of elements



XRF-CPT Tailings Investigation



CLAY

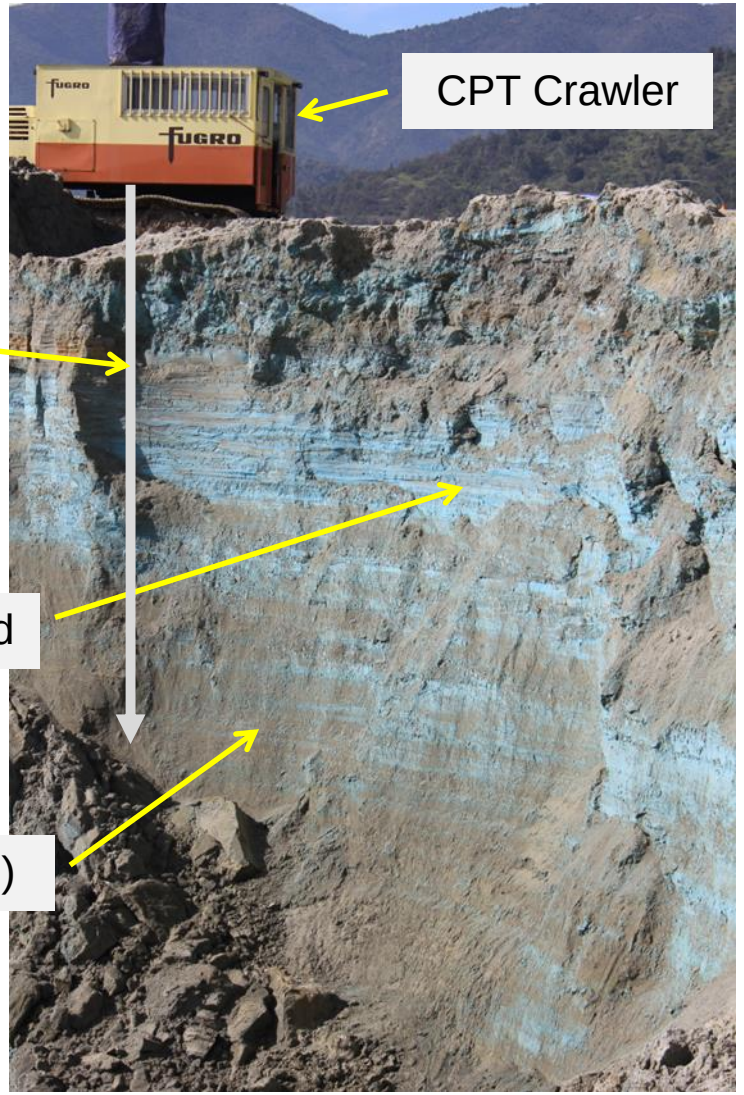
Static Push

SILT

Copper contend

FINE SAND

Soil type (fine / coarse)



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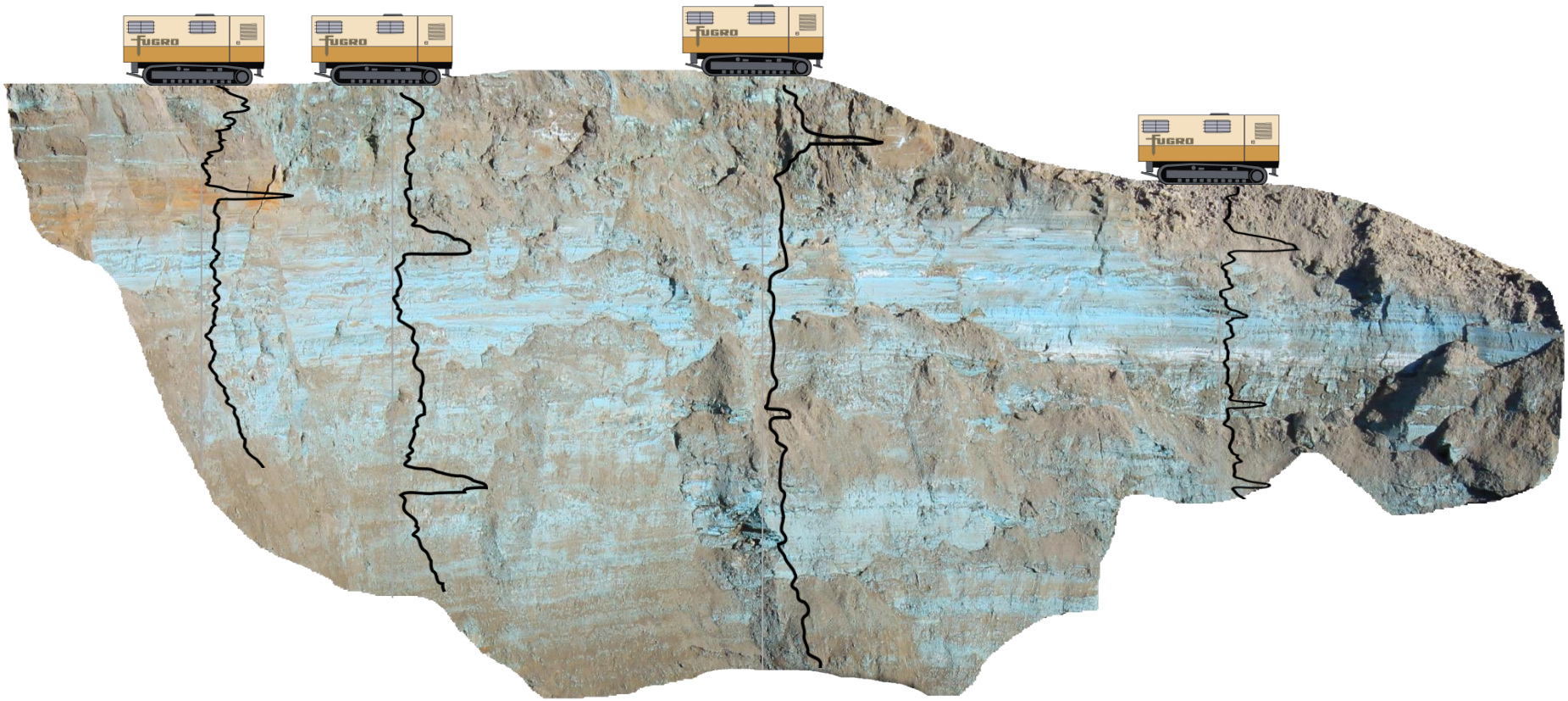
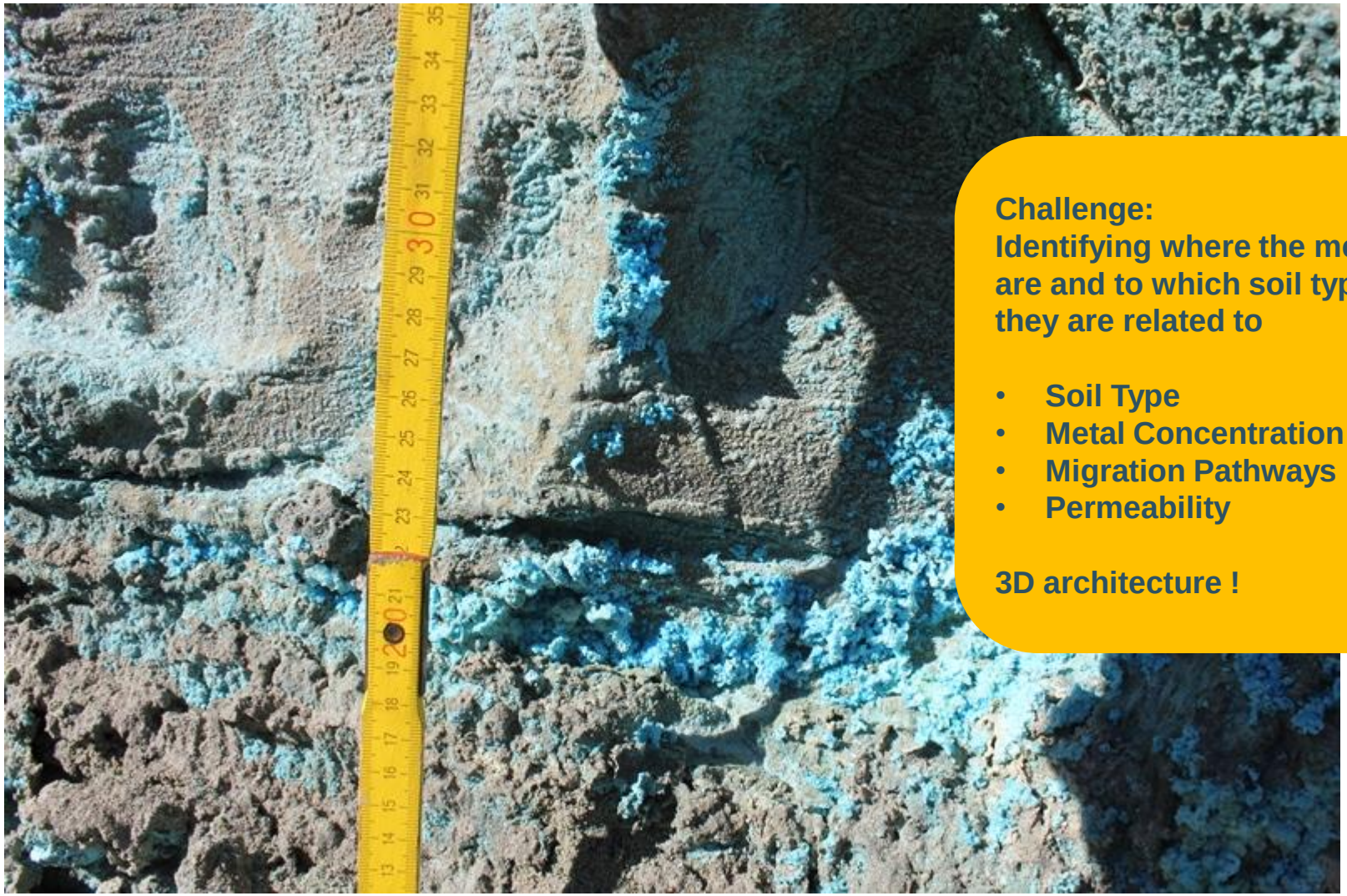


XRF-CPT Tailings Investigation



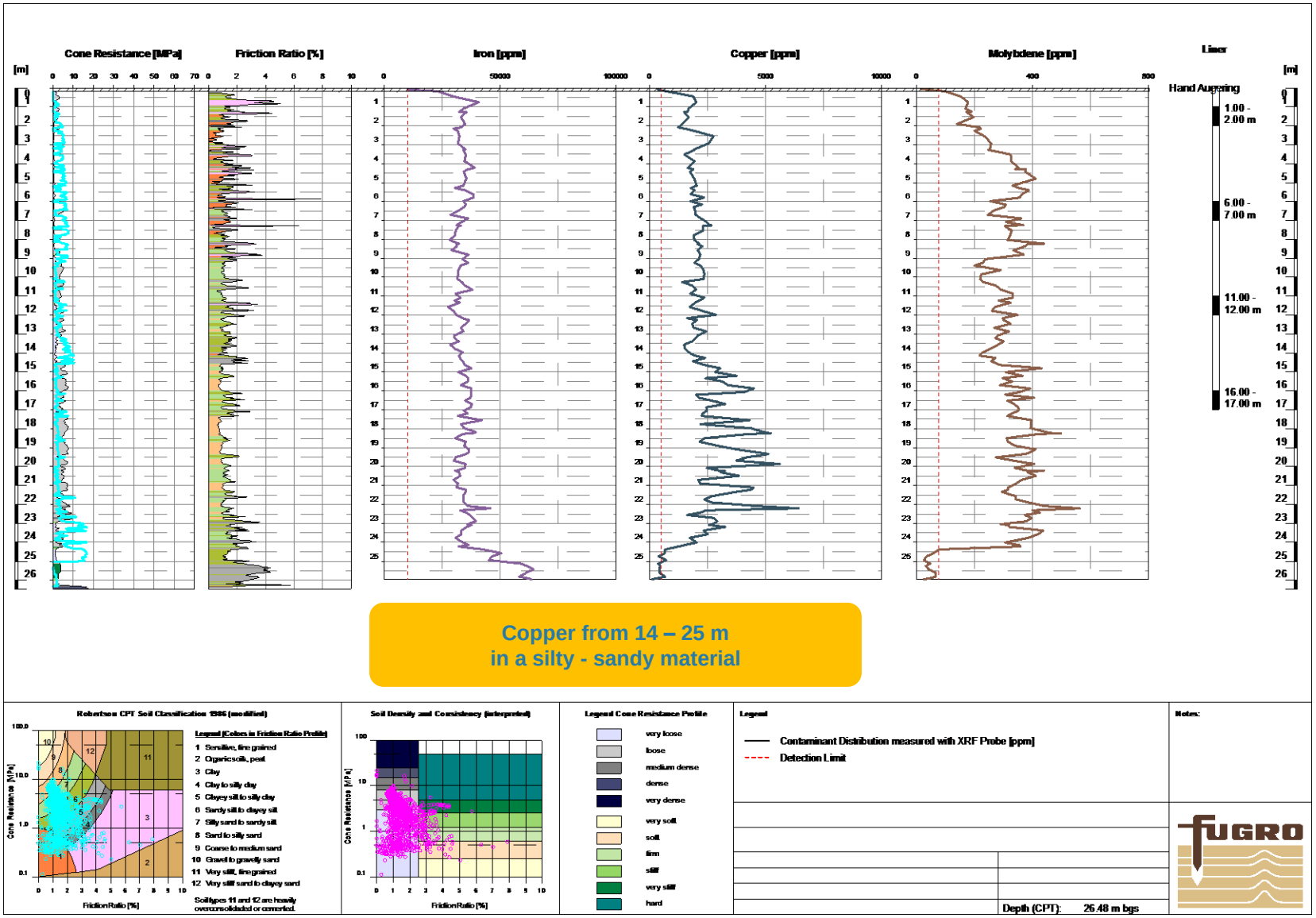
Challenge:
Identifying where the metals are and to which soil type they are related to

- **Soil Type**
- **Metal Concentration**
- **Migration Pathways**
- **Permeability**

3D architecture !

XRF-CPT Investigation – El Teniente's Colihues tailing, Chile

XRF-CPT data Tailings Investigation Colihues Tailing

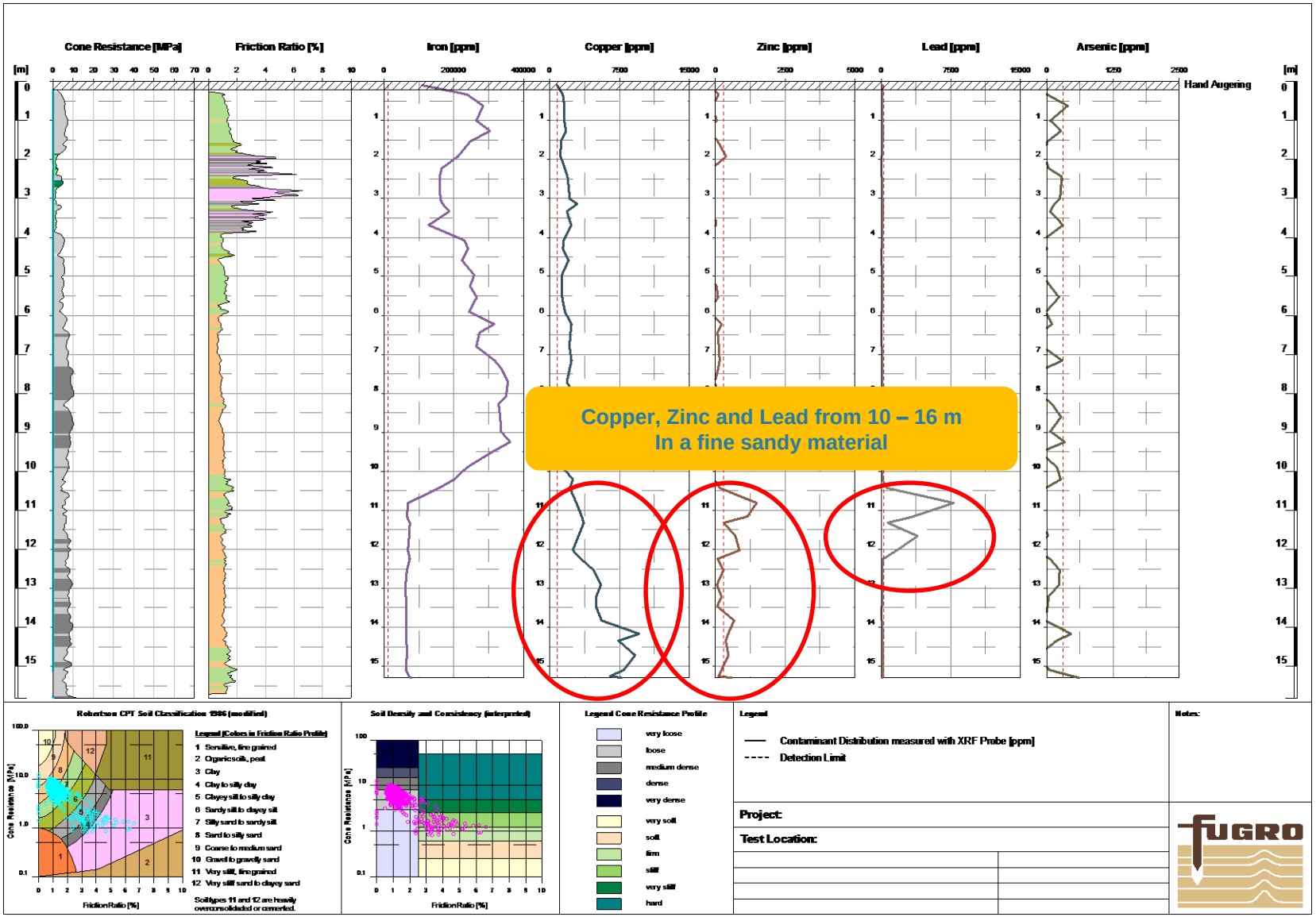


Copper from 14 – 25 m
in a silty - sandy material

XRF-CPT Investigation – Cu - tailing Copiapo, Chile

- CPT provides geotechnical data
- XRF provides metal concentrations
- High Resolution / Fast / Real Time
- Enables 3D modeling of resources for remining
- Sampling of soil and groundwater in one campaign

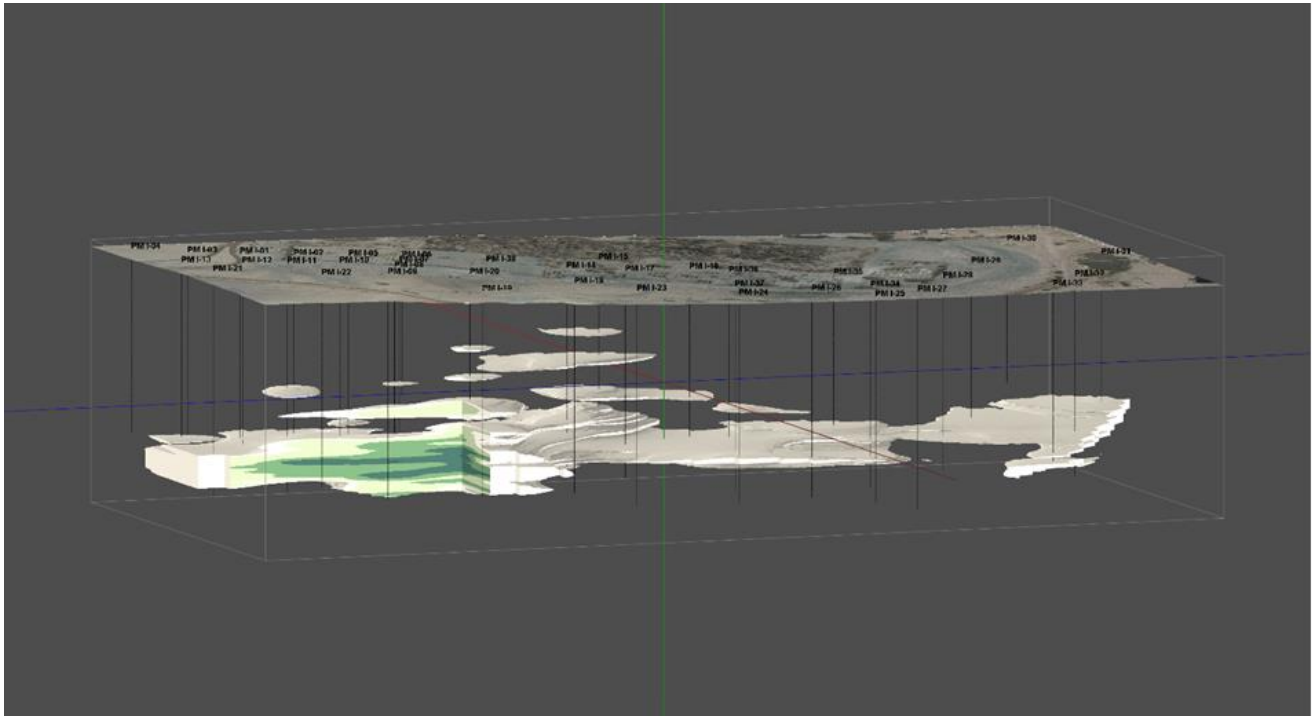
XRF-CPT data Tailings Investigation Copiapo



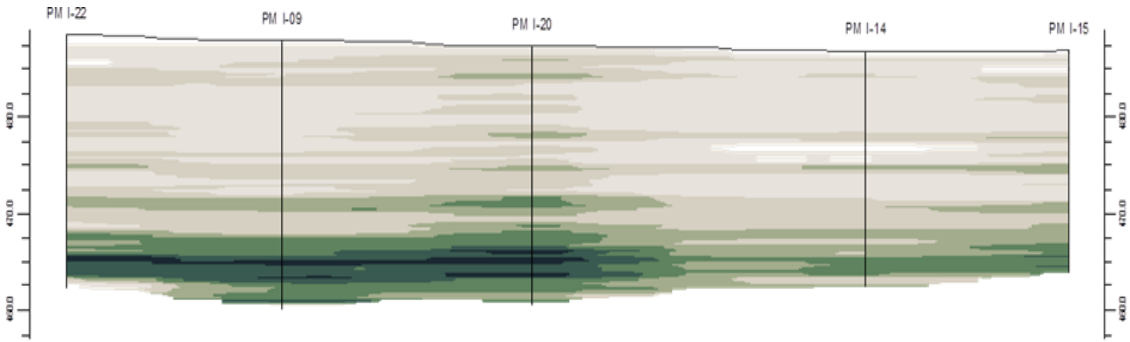
XRF-CPT Investigation – Cu - tailing Copiapo, Chile

- Grid of 40 points / 100m spacing
- 2 weeks site investigation
- Liner sampling for calibration (lab tests)
- Depth 25 - 30 m
- Map of copper distribution (total depth)

Tailings Investigation Copiapo - Results

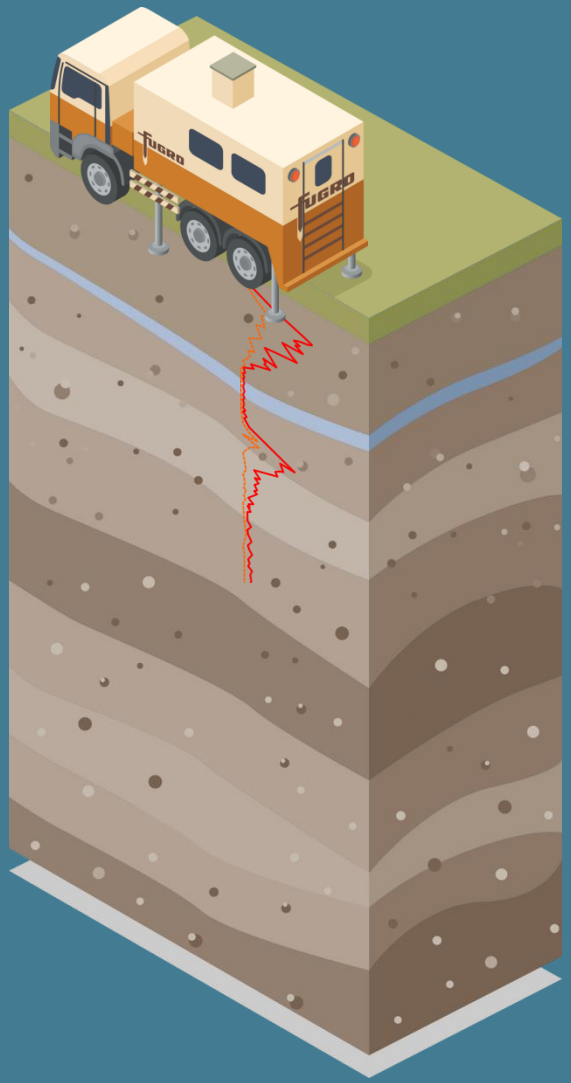


- 2D / 3D distribution of copper
- Volume estimation / concentration
- Resource estimation
- How much do we have and where
- Baseline data for remining design



Conclusions:

- System for real-time high resolution tailings characterization
- Geotechnical and metal data
- Fast and reliable
- Daily productivity 75-100 m
- Continuous measurement (point measurements possible)
- Cost effective compared to traditional approaches (drilling & sampling)
- Delivers digital data for 3D models



Thank you for your attention

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you need relevant, reliable, insightful information.

Fugro's Data Acquisition, Analysis & Advice provides a strong foundation for your projects.

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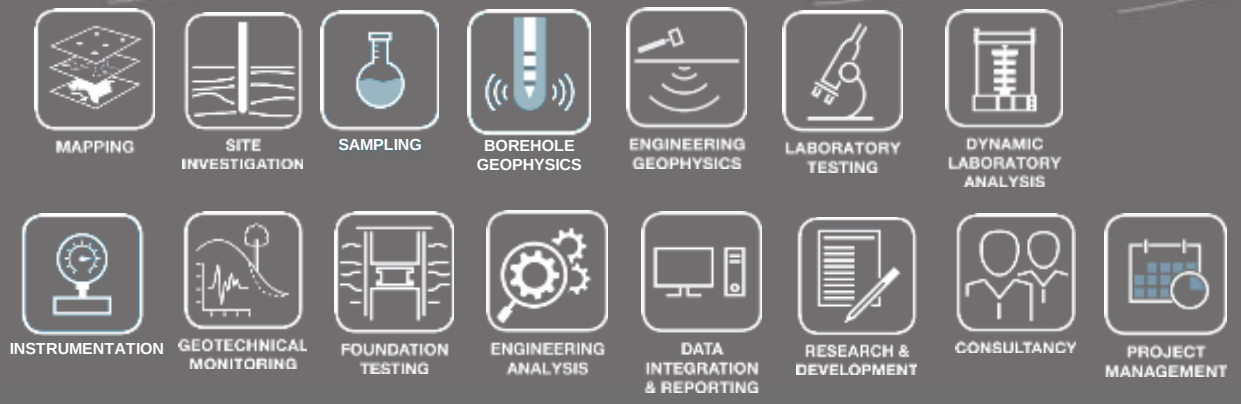


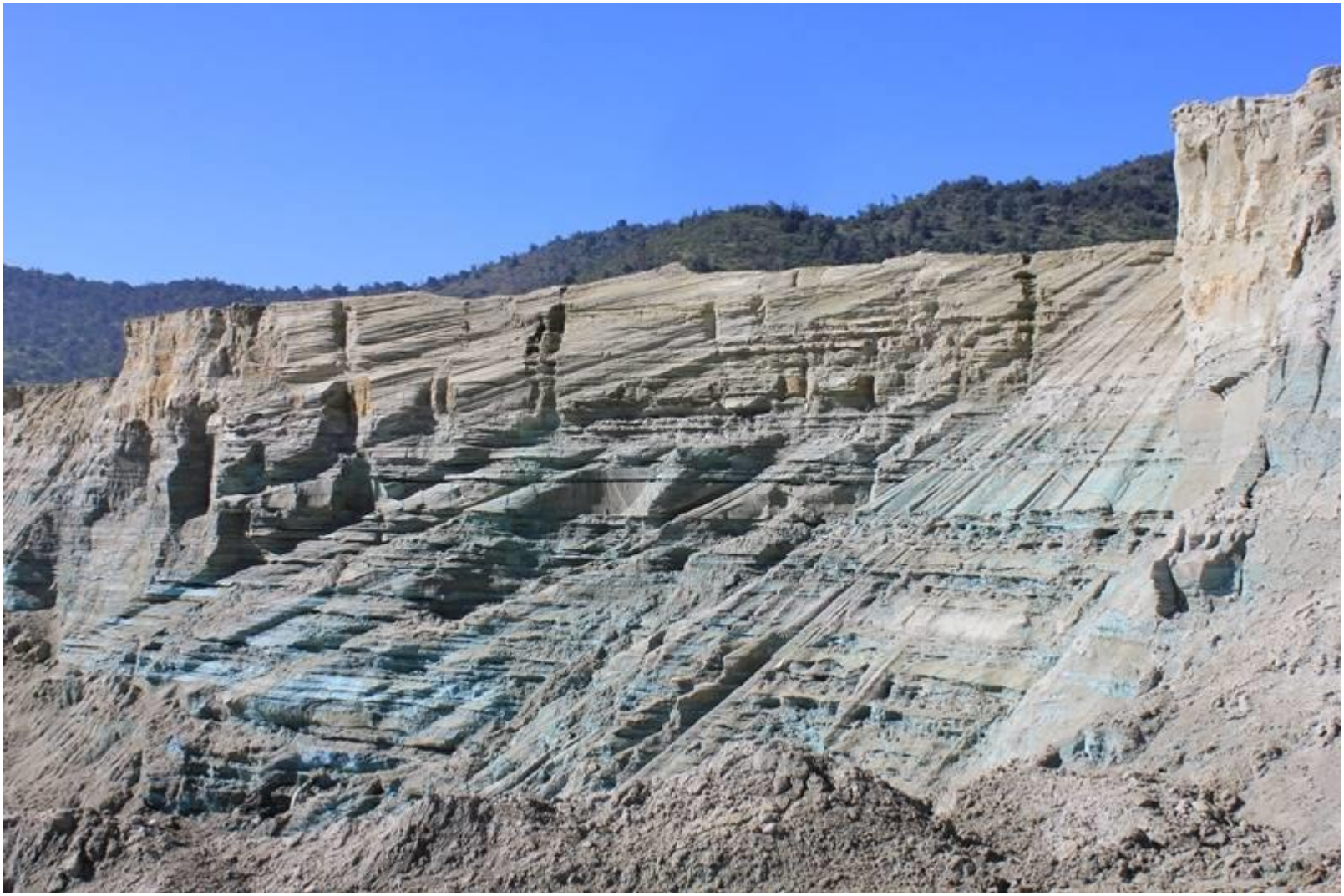
Remining of Tailings

Remining must be profitable – Most cost effective Solution required

	Dry Mining	Wet Mining	In-Situ Mining
Mining	Excavater, Multi Bucket Excavator	Hydro Guns Dredger	Fracking Leaching
Transport	Trucks, Wheel Loader Conveyor Belts	Trenches Pipelines	(Horizontal) Wells Drains, Pipelines
Material for Plant	Dry, sticky	Slurry	Liquid
Energy Demand	High	Medium	Low
Operational Costs	High	Medium – High	Low

The most cost effective solution depends on the architecture of the metal distribution

Wet Mining (Hydroguns – Trenches – Pipelines)



Wet Mining (Hydroguns – Trenches – Pipelines)

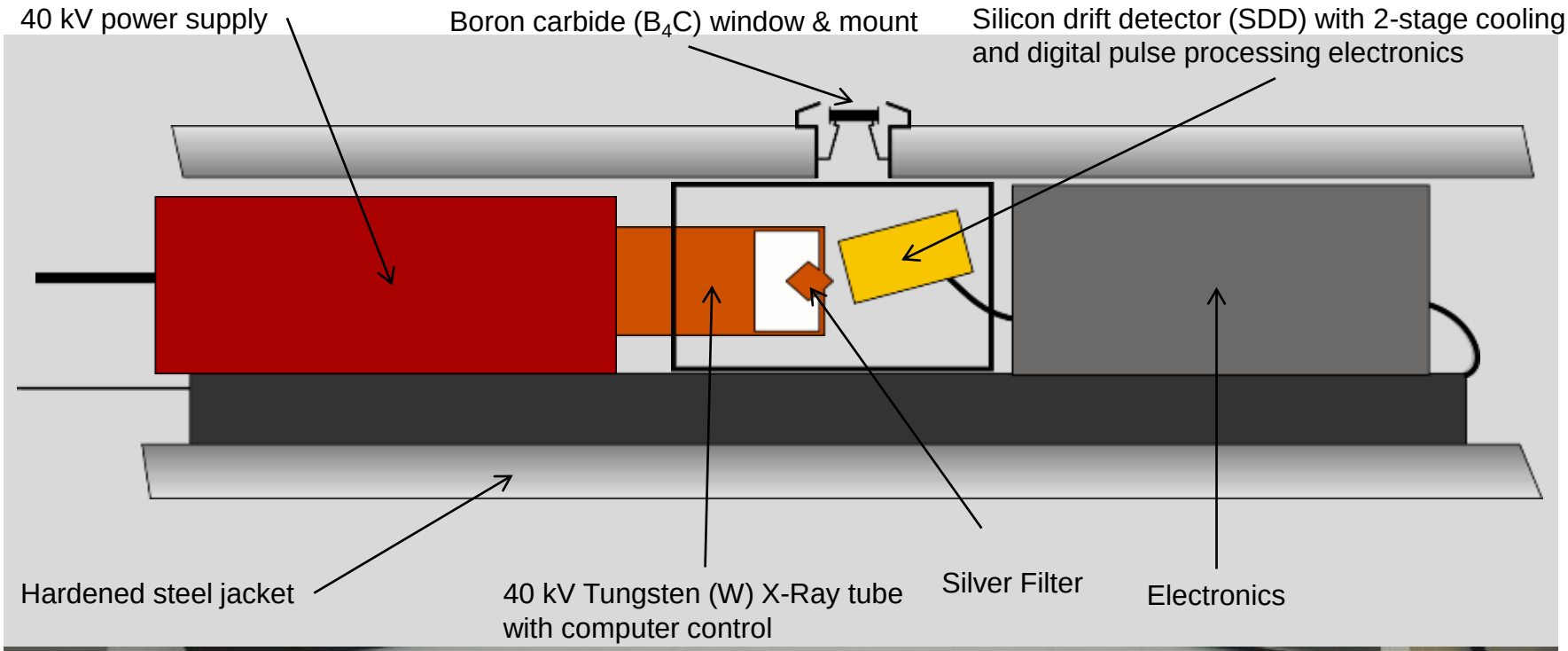
Wet Mining (Hydroguns – Trenches – Pipelines)

The CPT – XRF System

Fugro has developed an X-Ray Fluorescence (XRF) probe that is able to measure metal concentrations in the subsurface in real-time.

The sensor is connected to a CPT cone and can be deployed with top push CPT equipment.

The CPT – XRF System

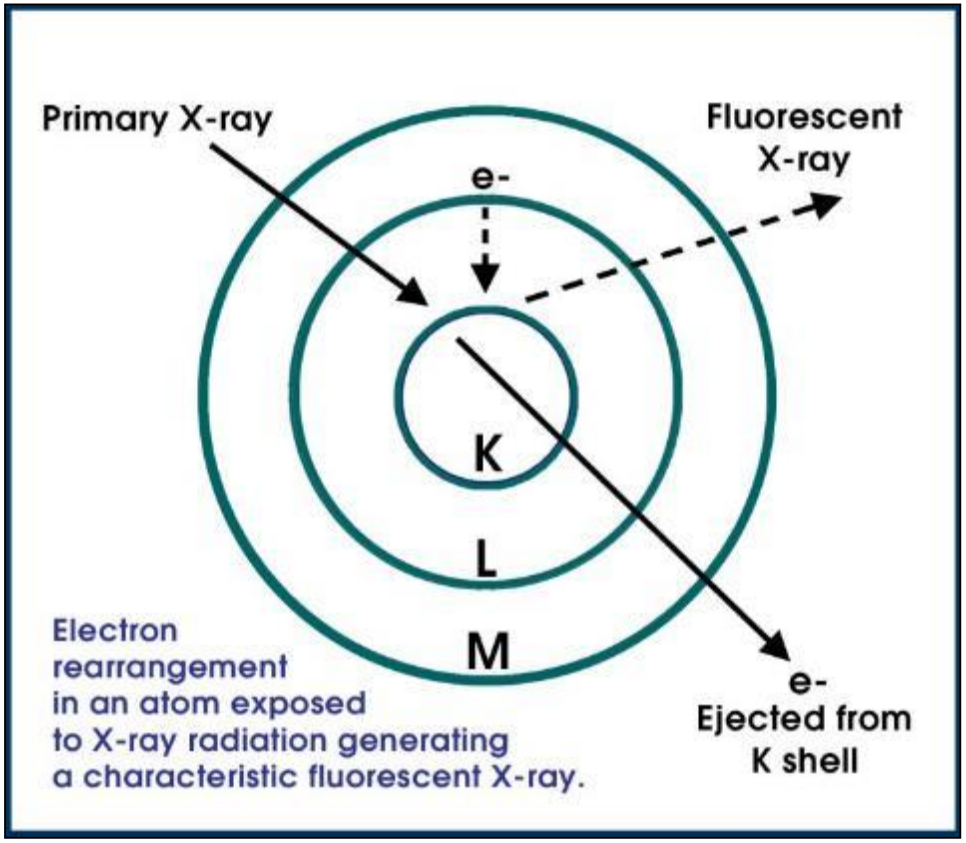


All electronics are built in the downhole tool

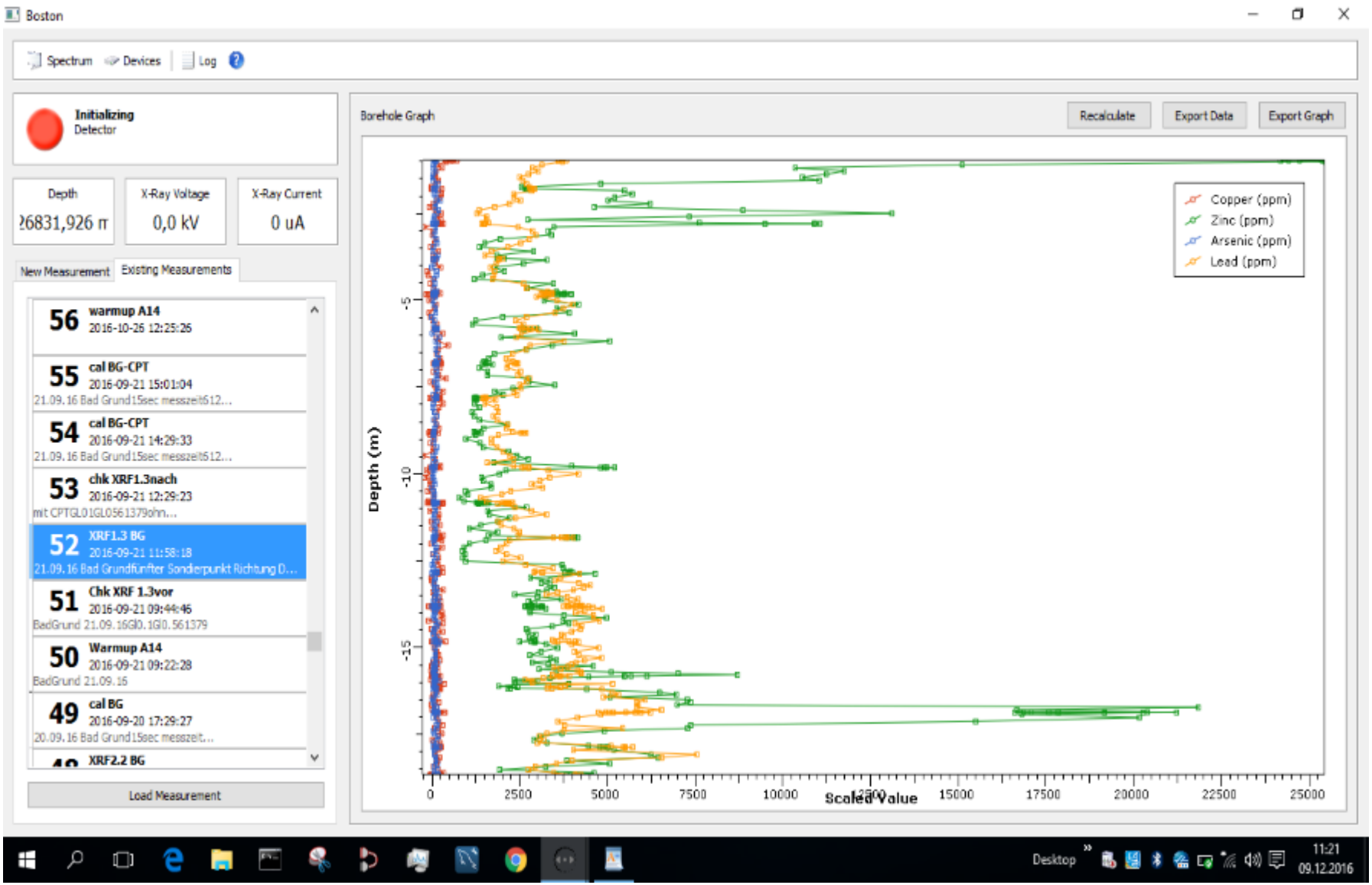
ED-XRF (*energy dispersive X-Ray fluorescence*) Basics

X-ray fluorescence (XRF) is the emission of characteristic "secondary“ (or fluorescent) X-rays from a material that has been excited by high-energy X-rays

- X-rays are energetic enough to expel tightly held electrons from the inner orbital's of an atom.
- The removal of an electron makes the structure of the atom unstable, and electrons in higher orbitals "fall" into the lower orbital to fill the hole left behind.
- In falling, energy is released in the form of a photon
- Thus, the material emits radiation, which has energy characteristic of the atoms present.
- The term *fluorescence* is applied to phenomena in which the absorption of radiation of a specific energy results in the re-emission of radiation of a different energy (generally lower)



Real Time Data



What you get on screen