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# How to Leverage Portable XRF for Exploration & Grade Control - 2019

**Chris Calam – European Sales Manager**
**Stand A13**

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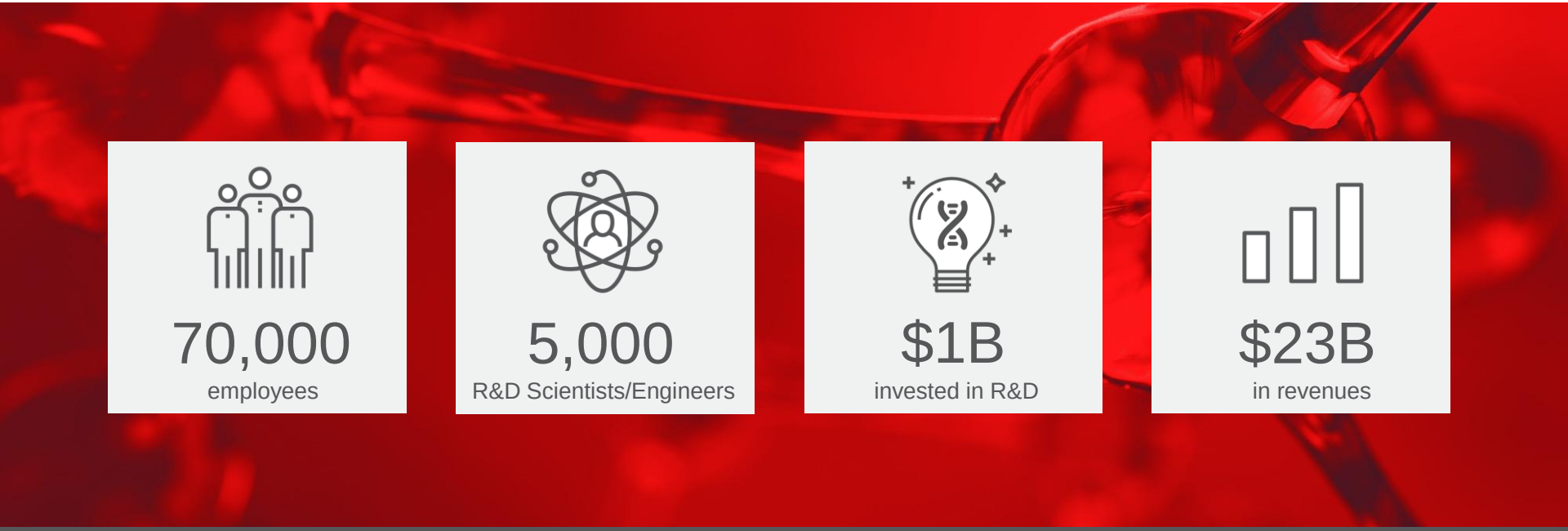


**70,000**
employees

**5,000**
R&D Scientists/Engineers

**$1B**
invested in R&D

**$23B**
in revenues

The world leader in serving science

# Handheld XRF – Used in Multiple Mining Applications

- Soils
- Outcrop

**Exploration: Early Stage**

- Drilling cores
- Mud logging

**Exploration: Late Stage**

- Grade control
- Process control

**Mining Operations**

- Base metals
- Precious metals
- Li, Uranium, rare earth

**Hard Rocks**

- Coal
- Oil
- Gas

**Mineral Fuels**

- Limestone
- Phosphates
- Potash

**Industrial minerals**

# Mining Applications



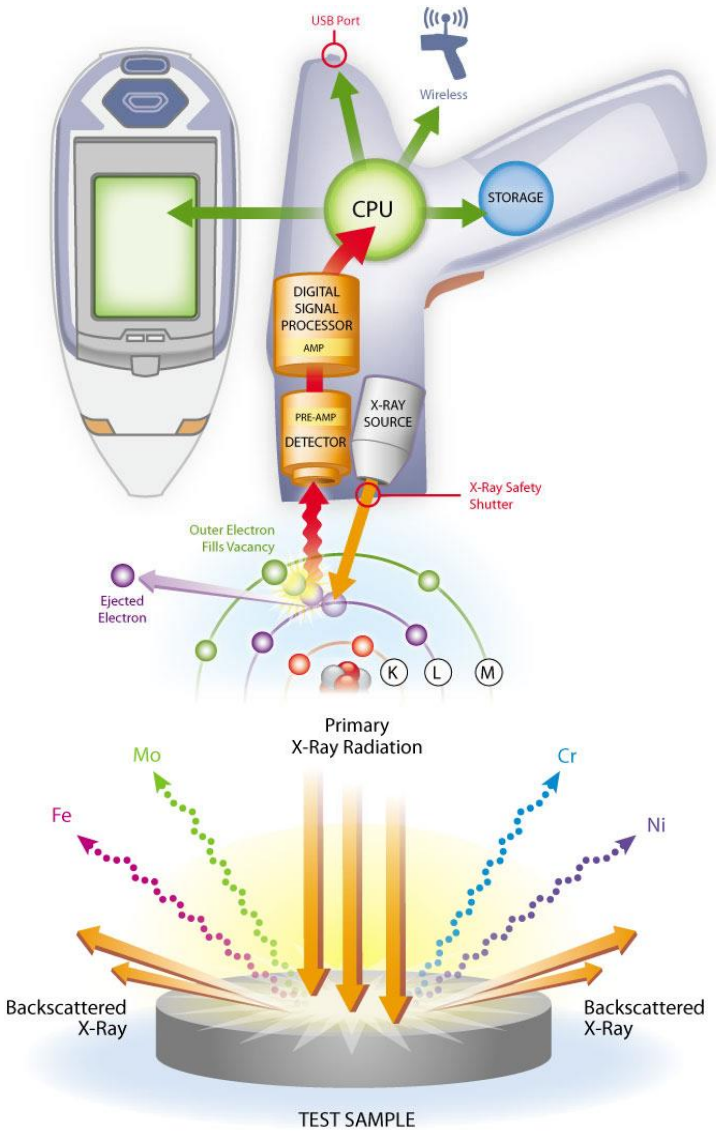



| | Niton XL5 | Niton XL3t Ultra | Niton XL3t GOLDD+ | Niton XL3t | Niton XL2 Plus | Niton XL2 |
|---|---|---|---|---|---|---|
| Base & precious metal exploration | ✸ | ✸ | ✸ | ✸ | | |
| Ore trading | ✸ | ✸ | ✸ | ✸ | ✸ | ✸ |
| Base metals– grade control | ✸ | ✸ | ✸ | ✸ | ✸ | ✸ |
| Uranium ore | ✸ | ✸ | ✸ | ✸ | | |
| Oil and Gas exploration | ✸ | ✸ | | | | |
| Penalty elements | ✸ | ✸ | ✸ | | ✸ | |
| Industrial minerals | ✸ | ✸ | ✸ | | | |
| Soils - traces | ✸ | ✸ | ✸ | ✸ | | |

# Set-up and working principle of Niton handheld x-ray fluorescence spectrometry

**Simplified description**

- X-ray radiation from the analyzer strikes the surface of the sample.
- The energy of the x-ray is transferred to the sample (Photoelectric absorption)
- The atom contained in the sample emit a characteristic x-ray fluorescence.
- The emitted x-ray photons produce an electric signal in the detector which is transmitted to the pre-amplifier (pre-amp)
- The electric signal is amplified in the pre-amp and transmitted to the digital signal processor (DSP)
- The DSP digitizes and sums the signals. The resulting spectrum is processed in the central processor unit (CPU) and treated to obtain the elemental analysis.
- The results of analysis are displayed in the screen and stored in the internal memory



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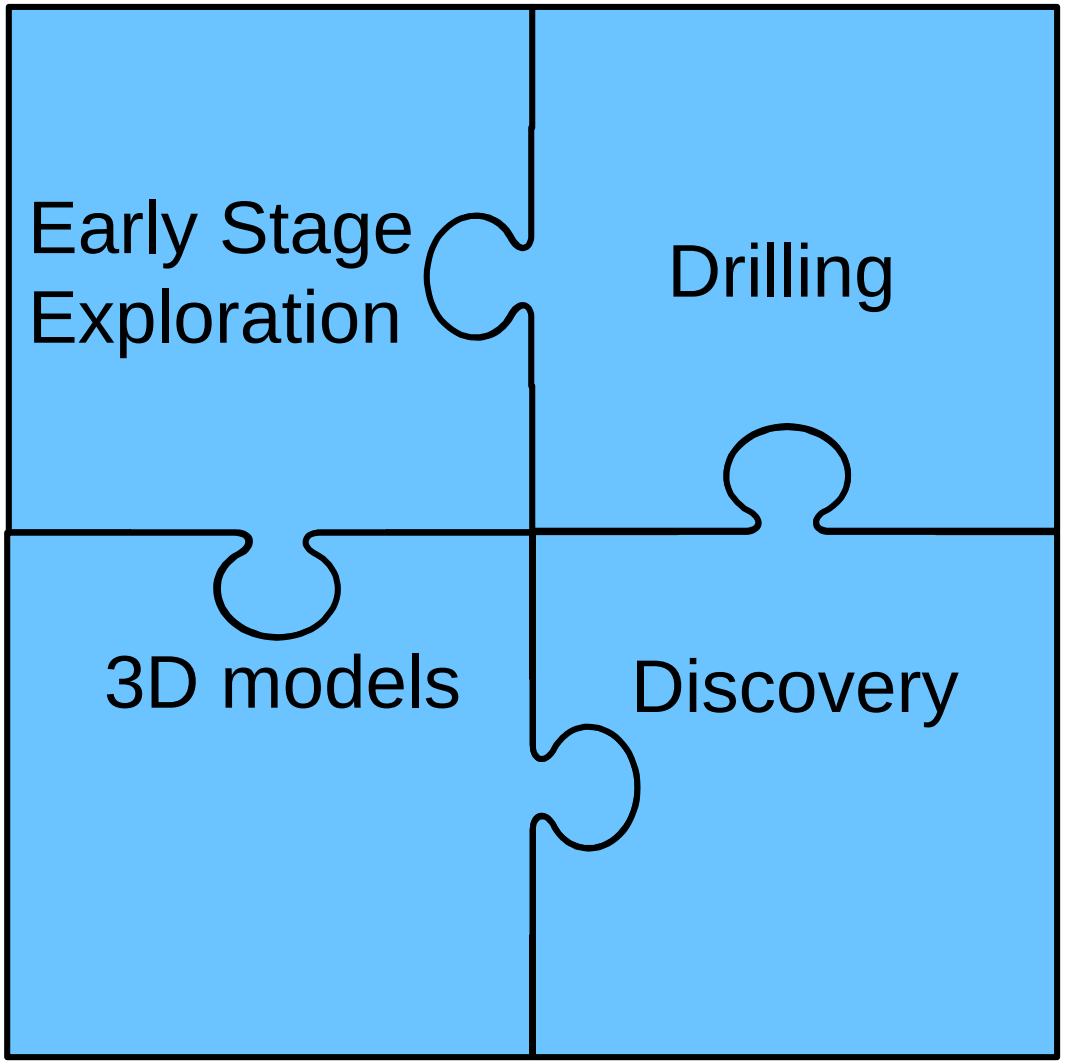
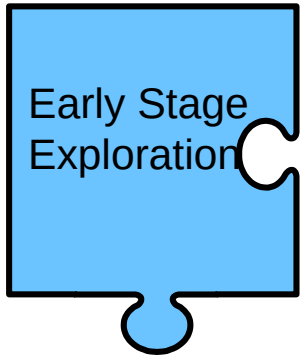
# Mineral Exploration – Where do we look and how do we find it?

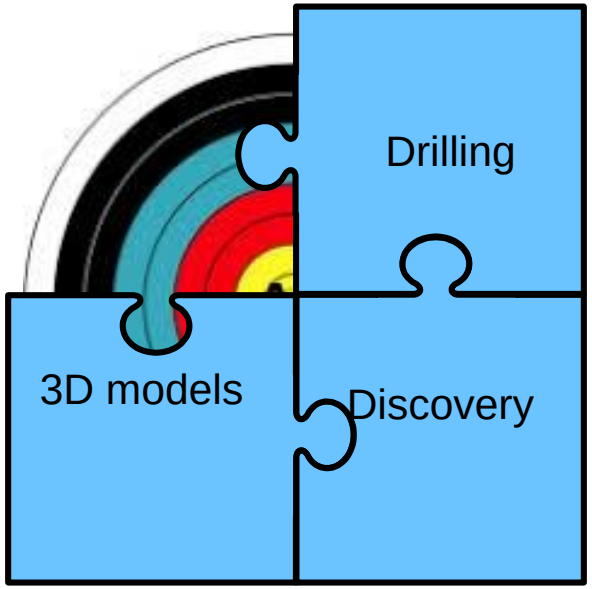
- Geologists look for clues
- Costs millions of dollars to evaluate a property
- Data converted to information helps form a clearer picture of a deposits true economic value



# What does Portable XRF have to offer in Exploration

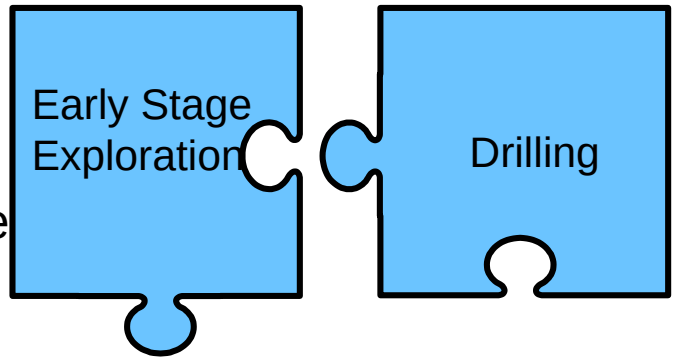
- Soil survey and outcrop evaluation to map anomalies
- Target additional sampling in anomalous areas to identify drill targets
- Provide a geochemical data stream to the geologist
  - Improves confidence in daily decision making
- Speed up exploration efficiency, saving time and money
  - Compliments lab analysis
    - Pre-screen sample selection for lab analysis
    - Maximising analytical budgets
    - Reduce external assay & freight costs
    - Eliminate delays associated with analytical turnaround time

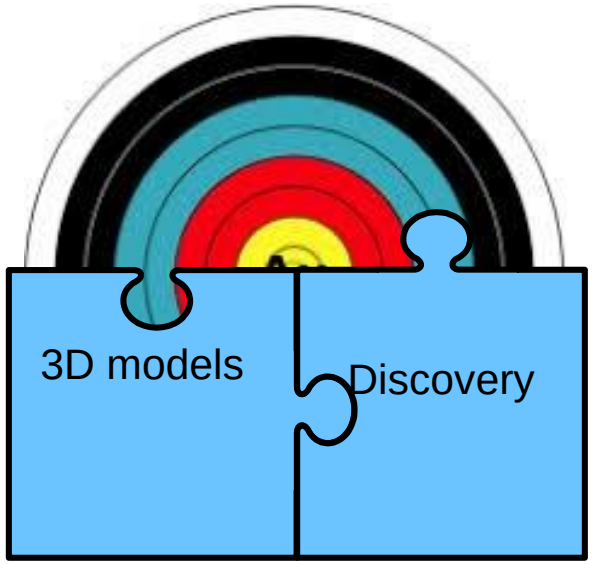


# Exploration – Drilling

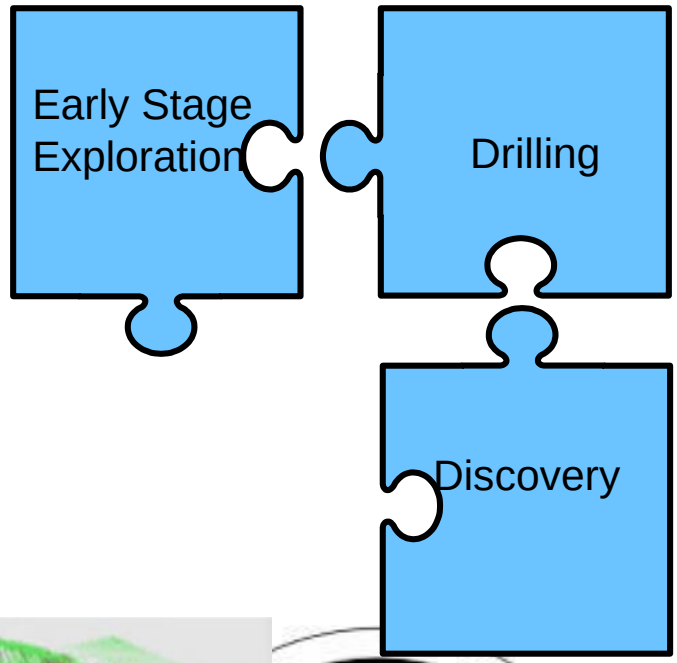
- Scan along or spot test large and well disseminated core for instant results
  - RAB/RC samples
- For poorly disseminated core (e.g. vein-like or spotty core) use the average function to generate composite values
- pXRF data ensures drilling is not halted above the base of the anomaly
  - Relocate to next drill hole if mineralization is tailing off
- Pre-screen core to prevent sending barren core to the lab
- Identify and measure valuable elements not expected to be on the property.

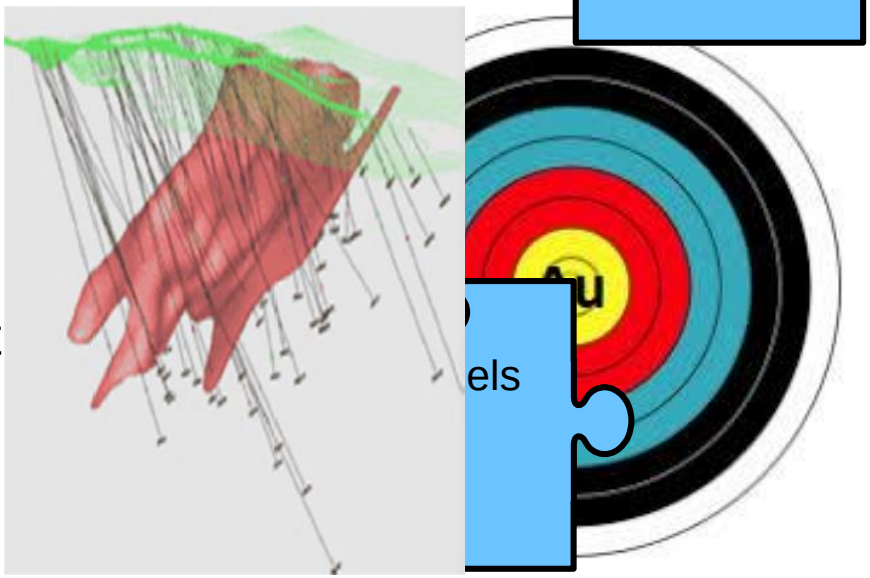



# Discovery

- You've found something
- Commence step-out drilling
  - How far and deep does your mineralisation extend
- Infill drilling
  - Confirm the presence of mineralisation between step-out drill holes
- Cores split vertically
  - Half stored and analysed by pXRF
  - Half sent to the lab for assay
    - Assays to confirm pXRF data and grades
    - Economic extraction?
- Generate 3D models of the ore deposit
- Environmental assessments



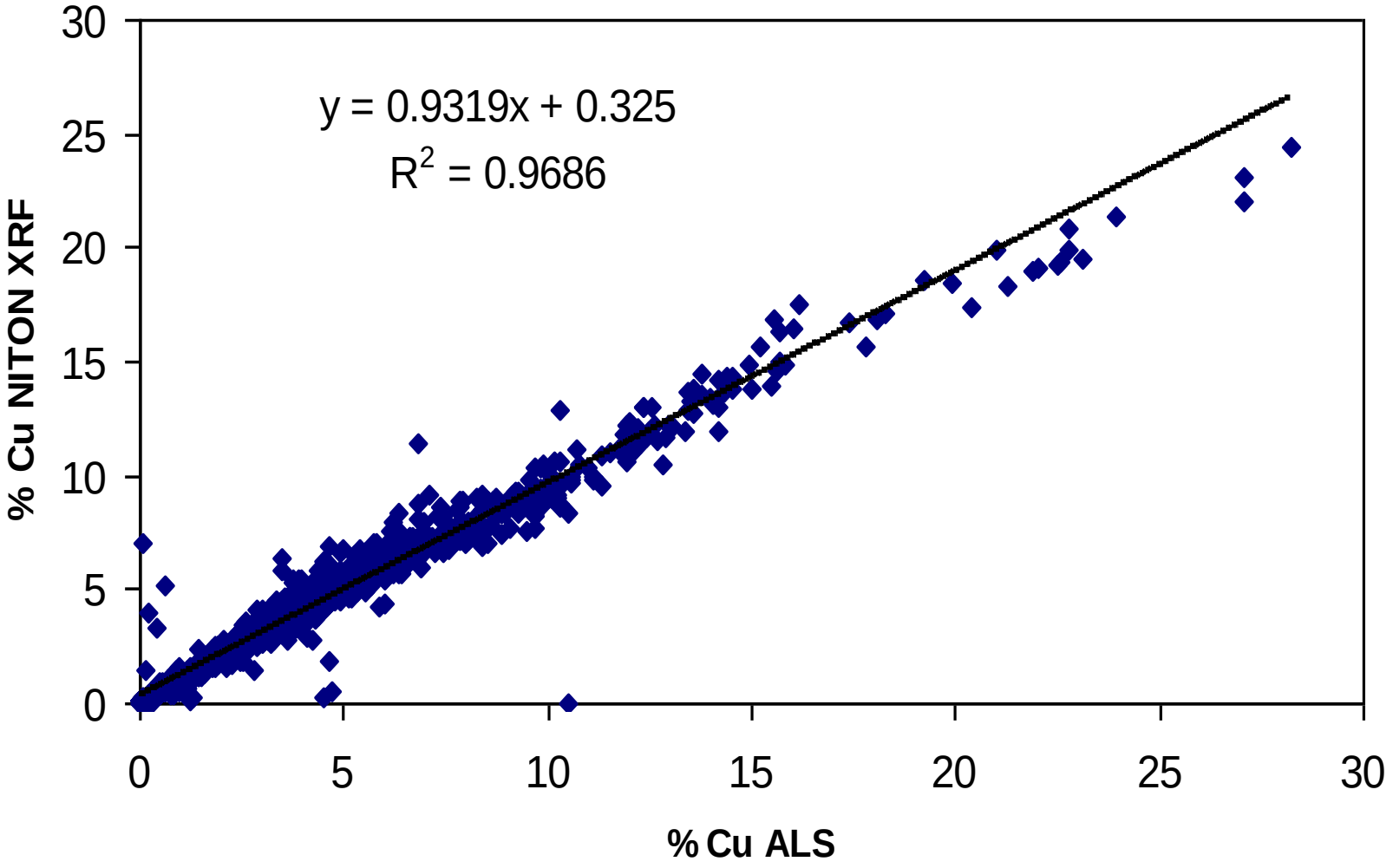



# What does Portable XRF have to offer in Grade Control?

- Improved mine efficiency through optimised extraction and processing
  - Better ore boundary definition
    - Instantly flag grade, sub-grade and waste
    - Prevent grade dilution
    - Improved stockpile management
  - Analyse blast hole cuttings
    - Follow the mineralised veins
  - Drive efficient excavation decisions
  - Matrix specific calibrations
  - Confirm presence of penalty and credit elements
  - Optimise feed to the mill

- Environmental Management
  - Waste effluent monitoring
  - Mine decommissioning
    - Tailings, mineral waste
    - Soil remediation

# Cu Performance on Blast Holes



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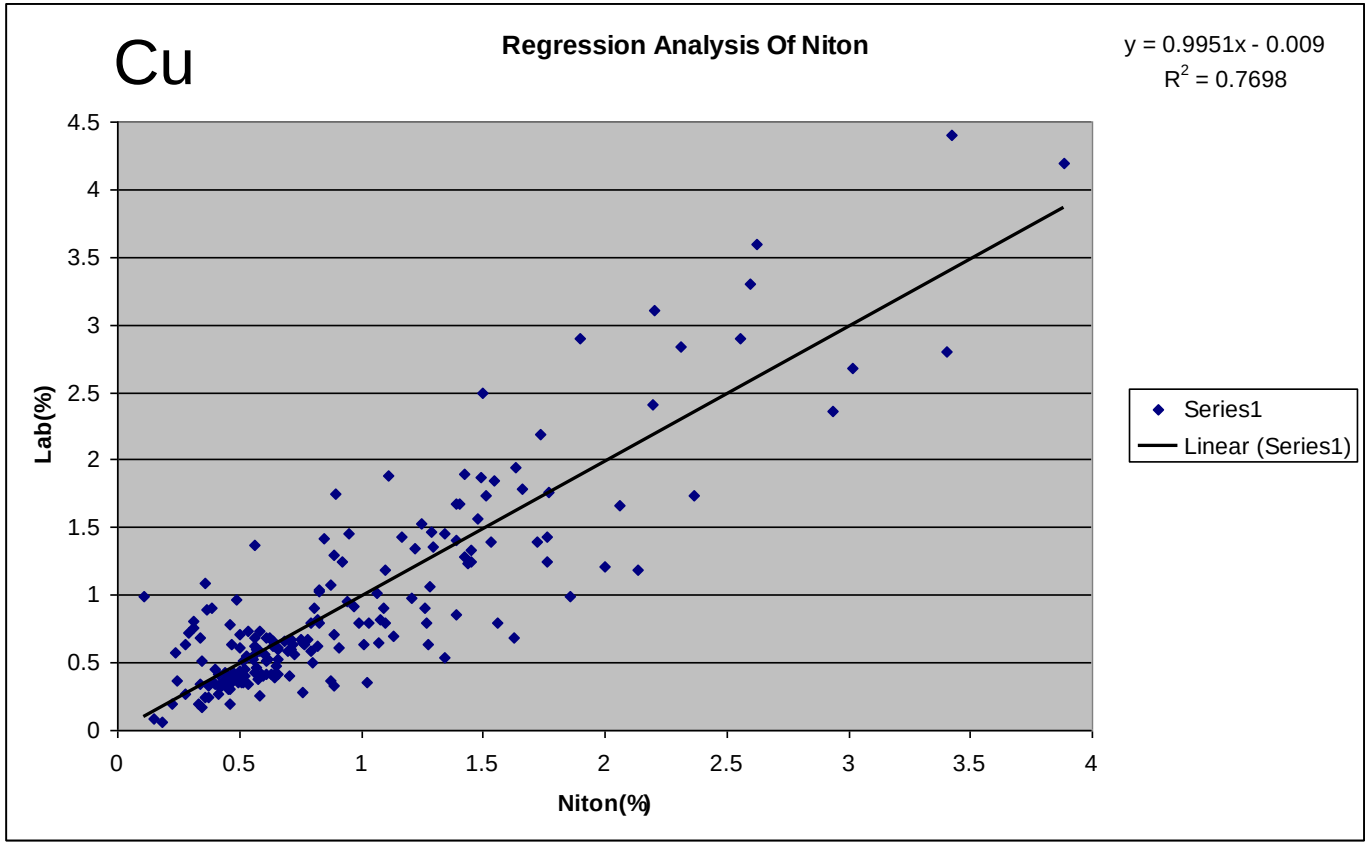
# Grade Control - Underground

"The Niton will not replace laboratory results, it merely takes the pressure off an over-worked on-site lab and enables geology staff to interact with other departments armed with up to date information"



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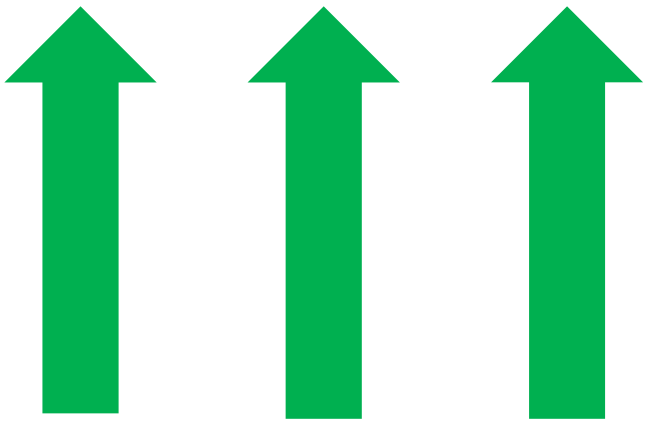
# What's Important in an Analyser?



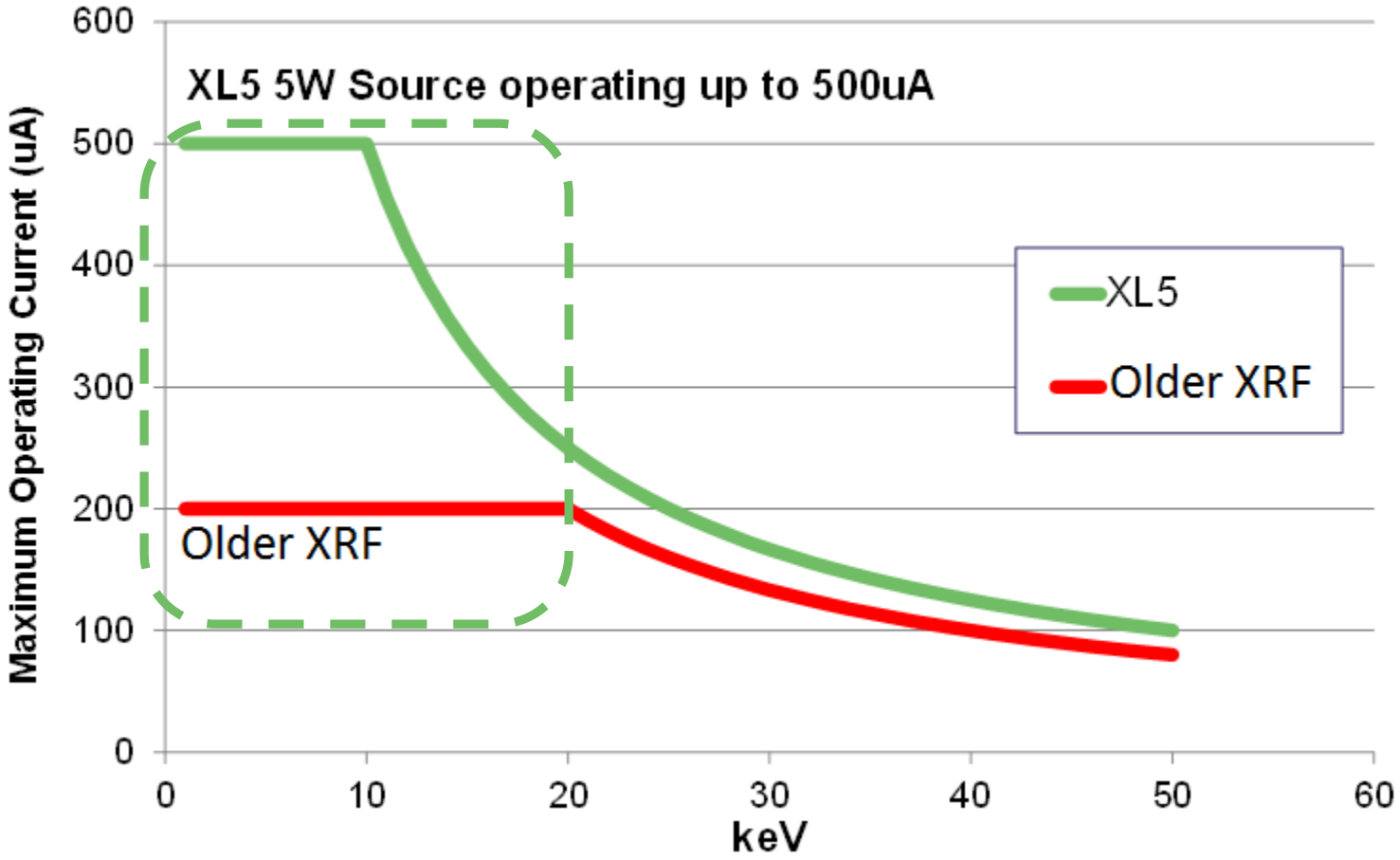
Precision Sensitivity Speed

Cost

# What's Important in an Analyser?

- Performance - Precision & Sensitivity
  - Accuracy & precision of results
  - Can we detect penalty elements
- Productivity – Speed
  - How many test can be done in a day
  - How quickly can penalty elements be quantified
- Reliability – how rugged is the analyzer
  - Does it operate at extremes of temperature
  - Moisture resistant
- Ease of Use – how easy / ergonomic
  - Simple download & conversion of data for GIS programs
- Changes the way we work
    - State of the art, modern design
    - Supports evolving needs of users
- Generate strong ROI

# XL5 Power – 5W tube, Automatic Current Adjustment




***More Actual Power Where it Matters!***

***Improvements of light element LODs***



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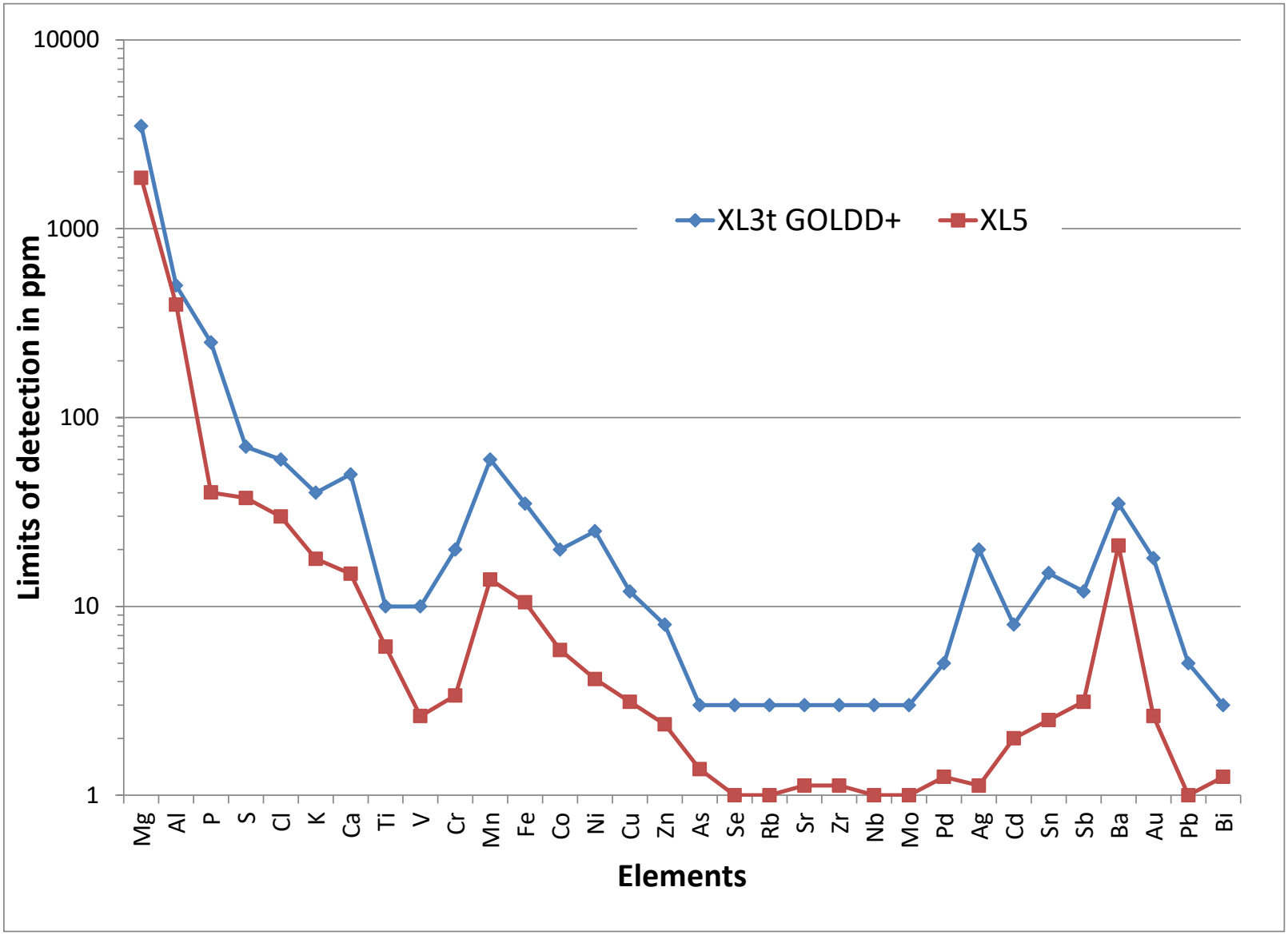
# LODs in ppm - pure silica



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# Setting Up Your Analyser

- What do you want to achieve?
  - Define your objectives
    - Exploration - map anomalies, may be no sample preparation
    - Mining company – sample preparation, optimise calibration
    - Underground face mapping – differentiate waste, low grade and high grade
    - Refiner – optimised calibration to achieve lab quality data
  - What samples will you analyse
    - Direct on soil or outcrops
    - Diamond core or rock chips
  - Degree of sample preparation depends upon desired outcome
    - Grinding
    - Moisture control – dilutes sample
    - Light elements important – define sample preparation
  - Sample presentation
    - XRF sample cups, bags, pressed pellet, or direct on the sample
- All have implications for time, cost & accuracy

# Setting Up Your Analyser

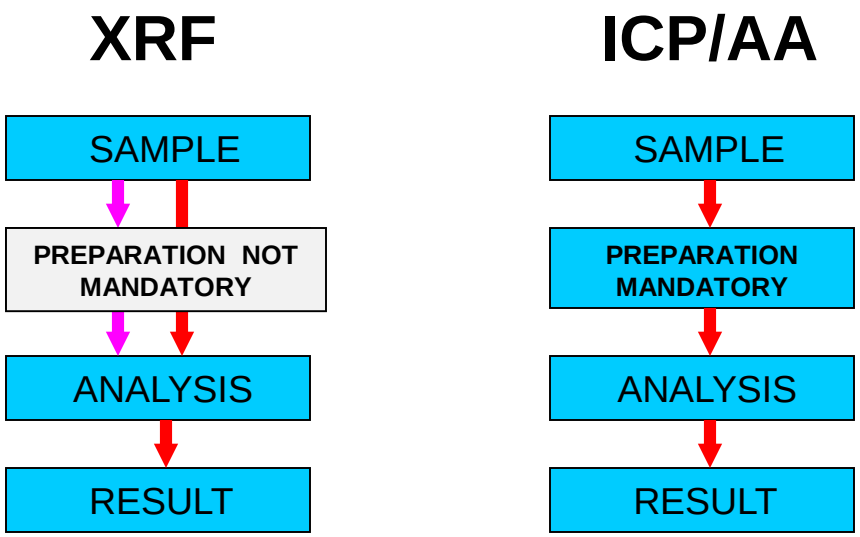
- Create internal SOP
  - Ensure it is implemented
  - Fine tune factory calibration using local reference standards
  - Optimise analysis times
    - Understand their impact on precision
  - Sample preparation – what, if any?
  - Field, lab or both
  - QA/QC running blanks and CRM’s to ensure good data quality
  - Decision criteria for sending samples for assay
  - Understand lab digestion method
    - Aqua regia, 4 acid digestion or fusion
    - Full extraction or partial extraction
  - Compare pXRF data with lab data,
    - Adjust SOP if required

# Setting Up Your Analyser

- Ensure data generated is of the highest possible quality
  - Fit for purpose
  - Confidence in your data
  - Plan for success before you start

# Sources of  Difference between XRF and ICP/AA

- Heterogeneity of sample
- Sample preparation
- Incomplete digestion prior to ICP/AA
- Leading to incorrect interpretation of results



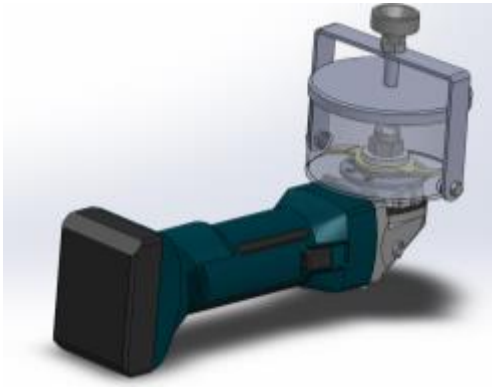
# XRF and acid extraction according to EPA3050 B

Certificate NIST SRM 2710A: total concentration vs. extraction in ppm. Recovery

| Element | Certified Total | # Lab for extraction | Range extraction | Average extraction | Recovery vs. total |
|---|---|---|---|---|---|
| **Al** | 59500 ± 500 | 6 | 8200-12000 | 10000 | 17% |
| **Sb** | 52 ± 1.6 | 6 | 5-12 | 9.6 | 18% |
| **As** | 1540 ± 100 | 6 | 1300-1600 | 1400 | 92% |
| **Ba** | 792 ± 36 | 6 | 490-540 | 510 | 65% |
| **Cd** | 12.3 ± 0.3 | 5 | 9.6-12 | 11 | 86% |
| **Ca** | 9640 ± 450 | 6 | 1700-2000 | 1800 | 19% |
| **Cu** | 3420 ± 50 | 6 | 3100-3500 | 3300 | 95% |
| **Co** | 5.99 ± 0.14 | 6 | 2.8-5.2 | 3.8 | 64% |
| **Fe** | 43200 ± 800 | 6 | 30000-36000 | 34000 | 79% |
| **Pb** | 5520 ± 30 | 6 | 4700-5800 | 5100 | 93% |
| **Hg** | 9.88 ± 0.21 | 6 | 9.3-11.7 | 10 | 104% |
| **Mn** | 2140 ± 60 | 6 | 1500-1800 | 1700 | 77% |
| **K** | 21700 ±1300 | 6 | 3800-4700 | 411 | 19% |
| **Zn** | 4180 ± 150 | 6 | 3300-4400 | 3800 | 90% |

# Field Sample Preparation Tools

## Blade Grinder



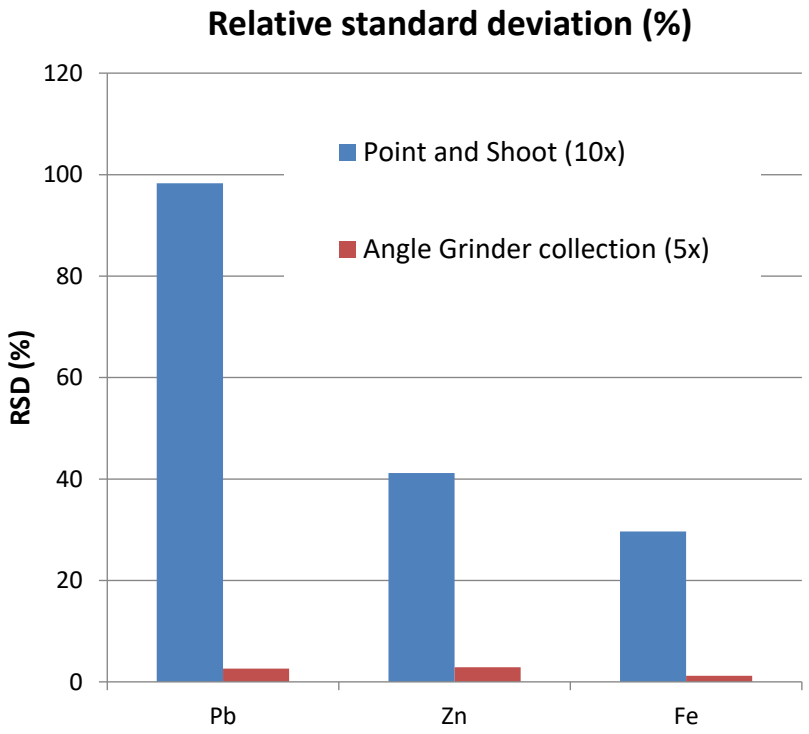
## Rotary Sampler

## Pelletizer

## Consumables

# Benefits of Sample Preparation Zn/Pb/Ag

- Less deviation due to inhomogeneity



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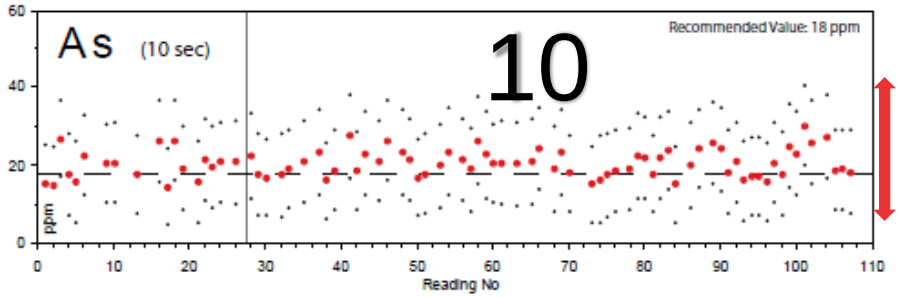
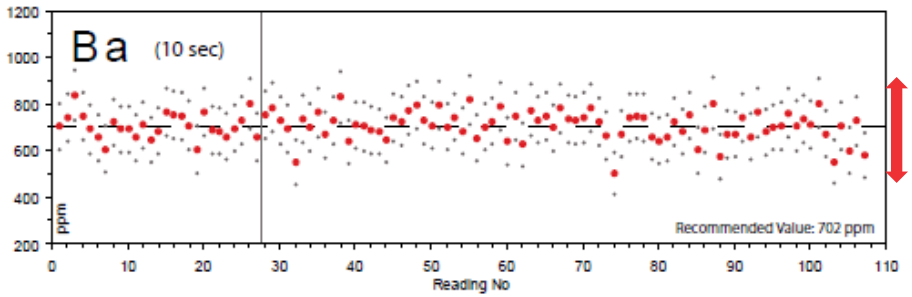
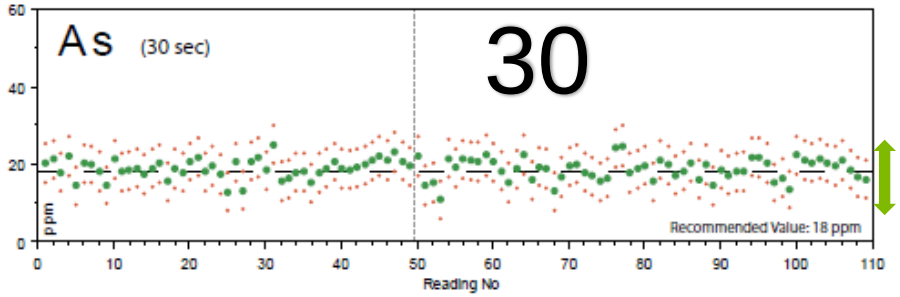
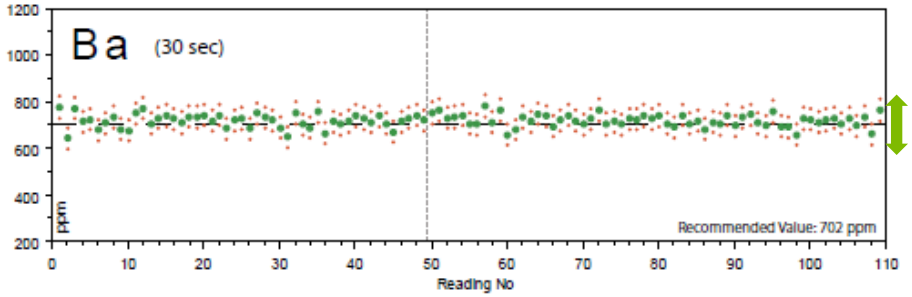
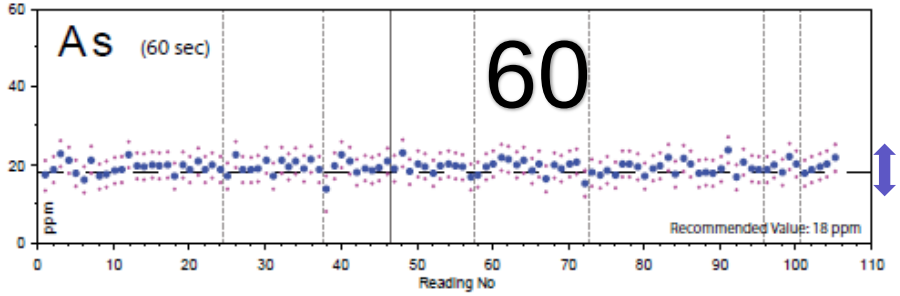
# Analysis Time – soil pulp, 10, 30, 60 second / filter

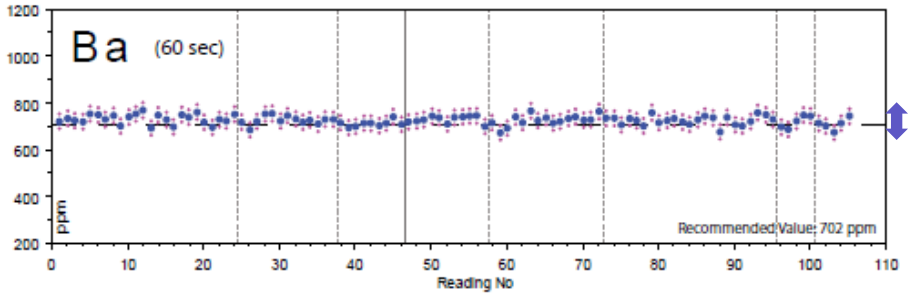


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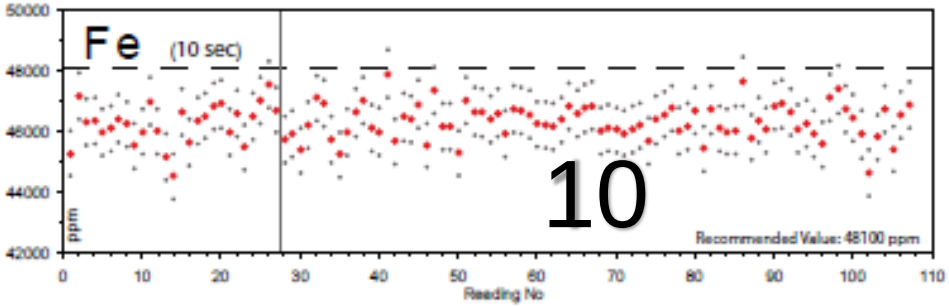
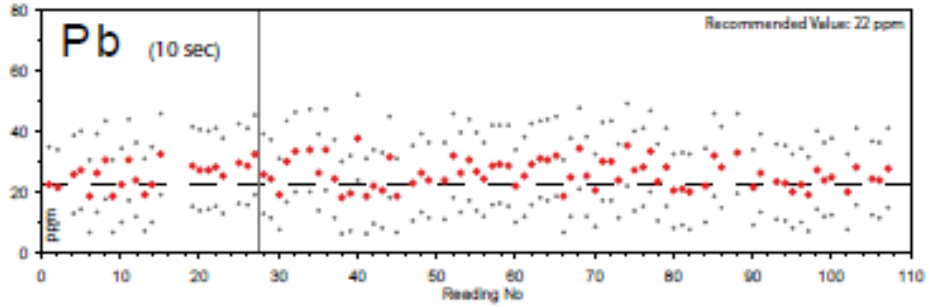
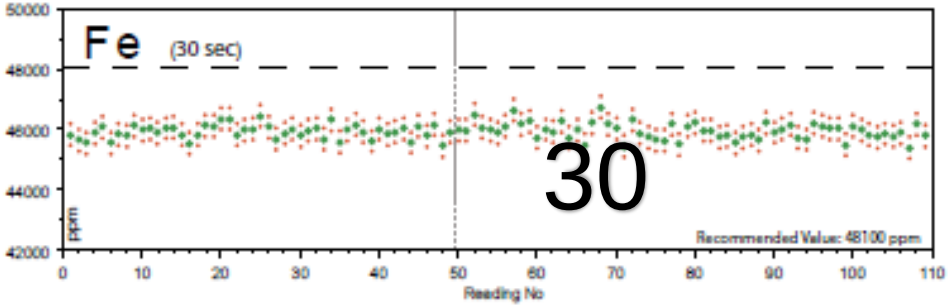
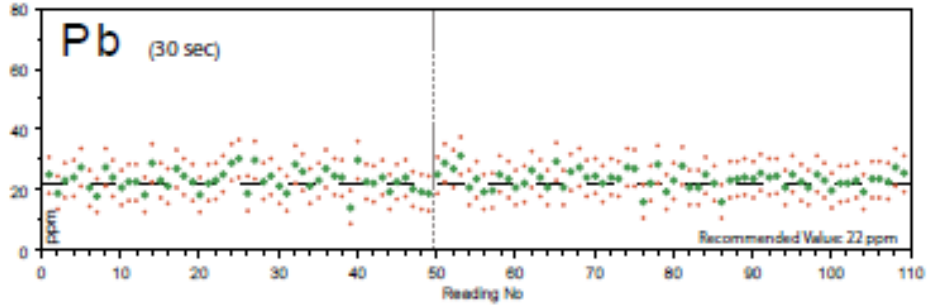
# Analysis Time – soil pulp, 10, 30, 60 second / filter

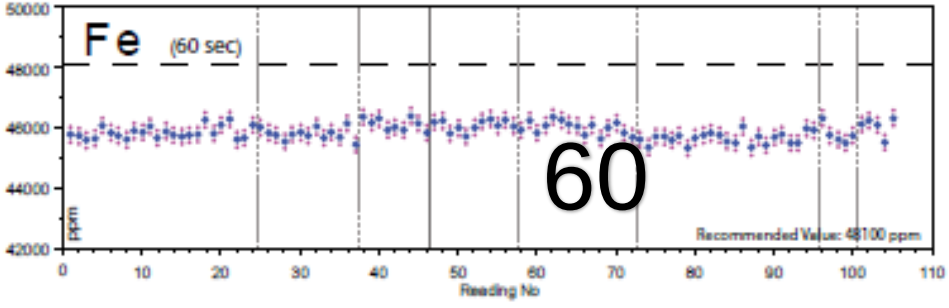
- Fe requires slope correction

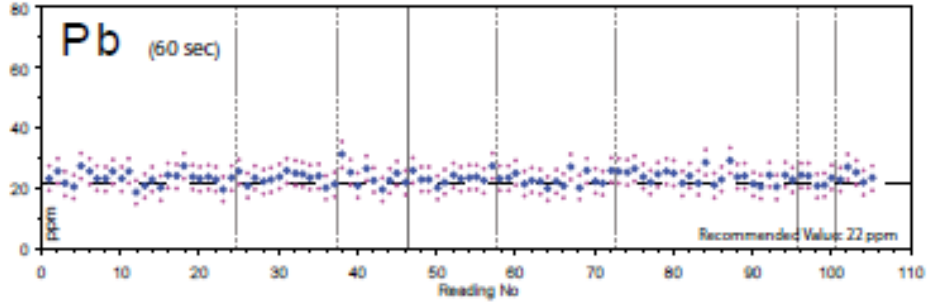


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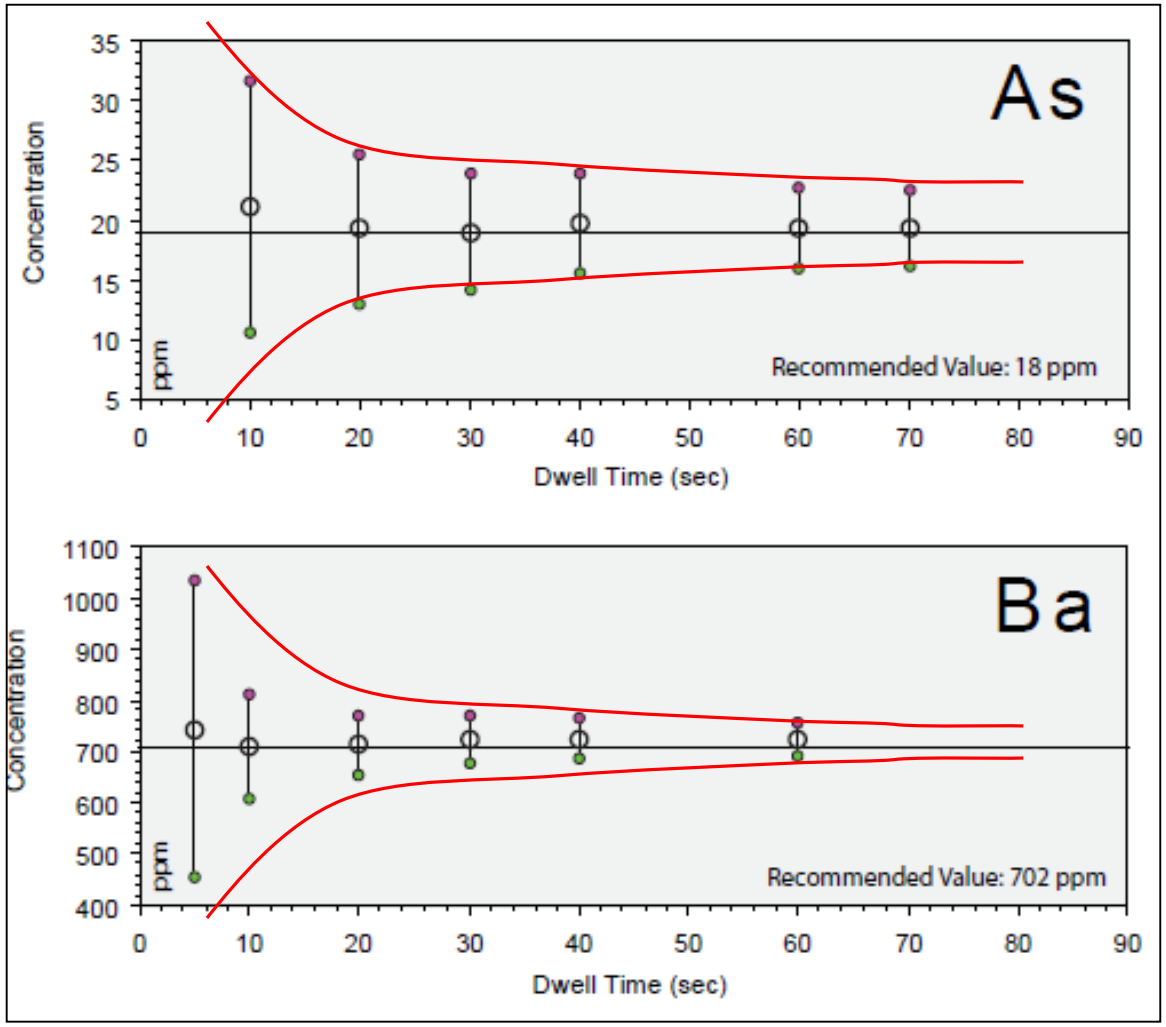
# Analysis Time and Precision




Mean measured value + 2σ
Mean measured value
Mean measured value - 2σ



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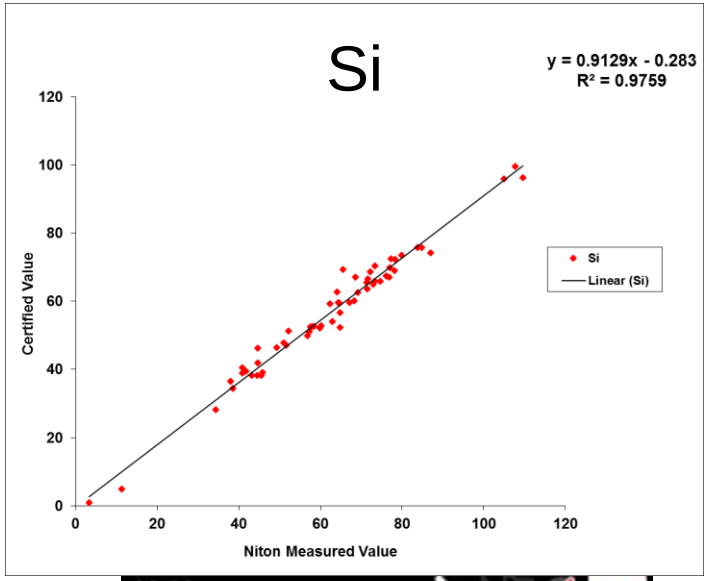
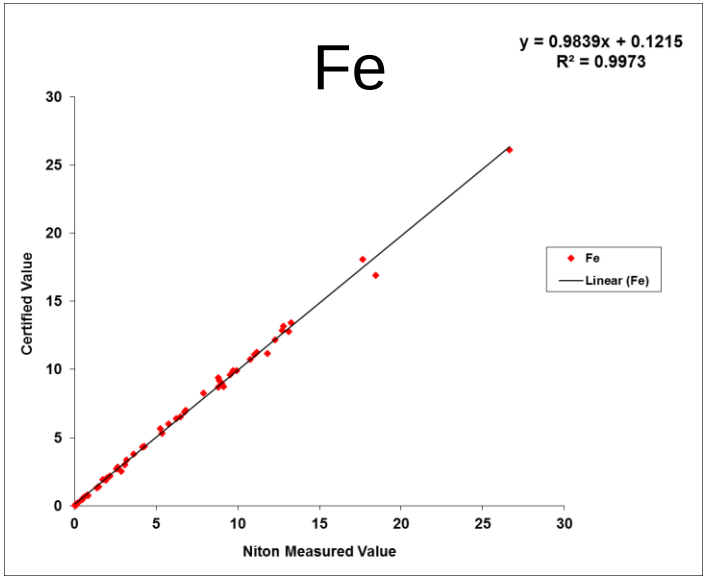
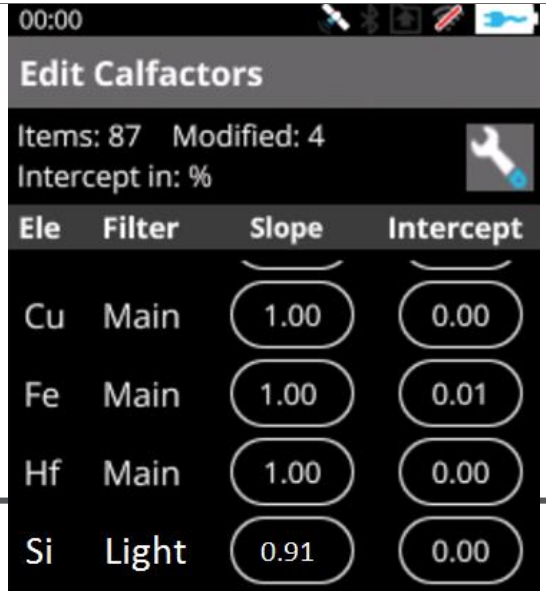
# Factory Calibration Fine Tuning

- Plot measured vs reference values




Fine tuning not required
For Fe



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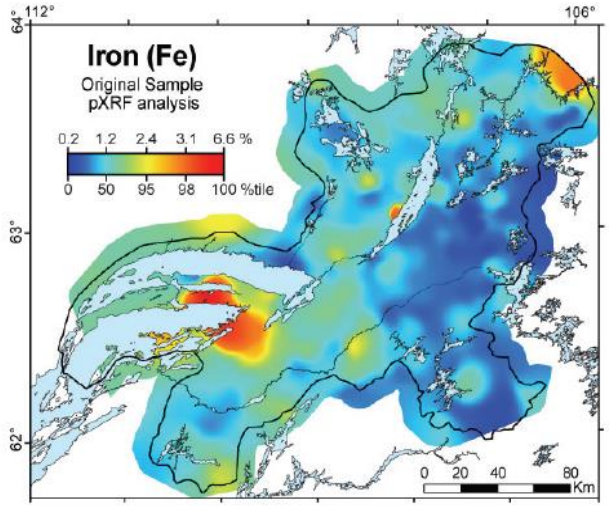
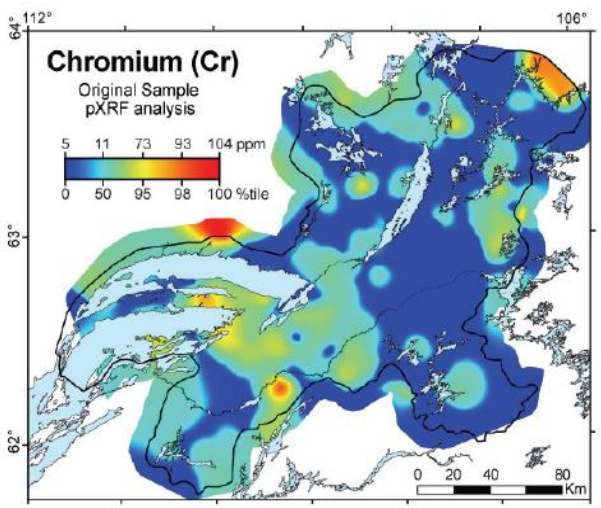
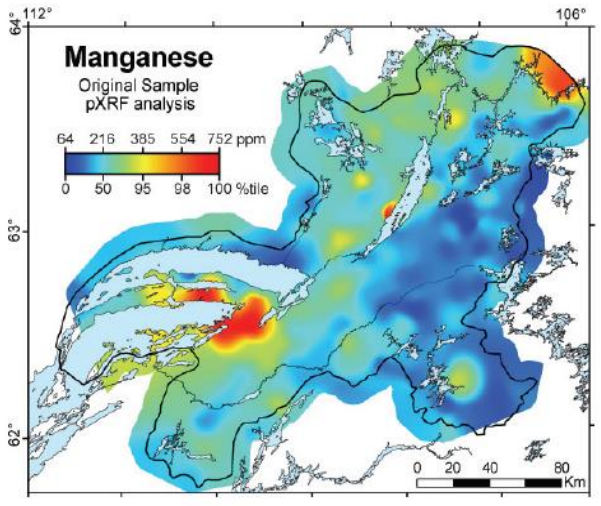
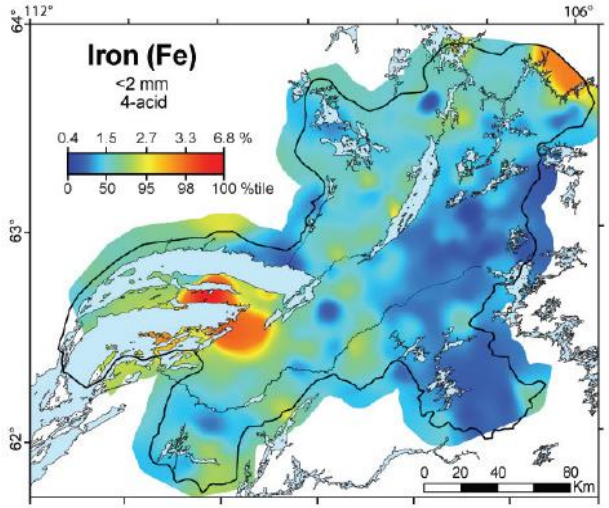
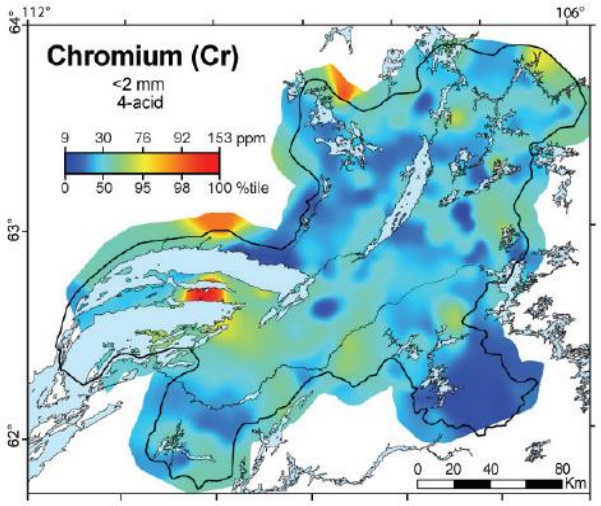
# When Setup Correctly - GIS Maps

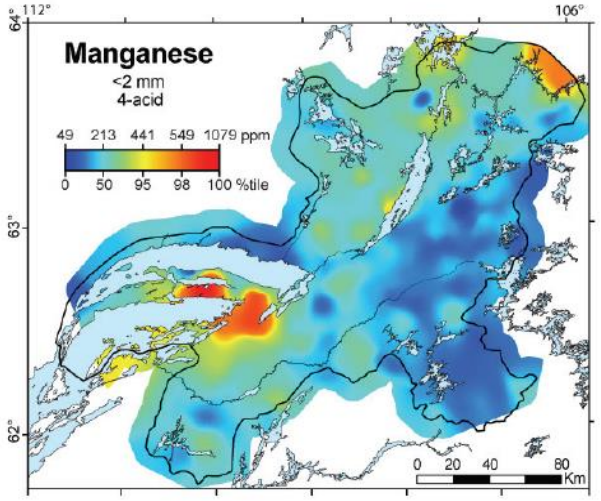


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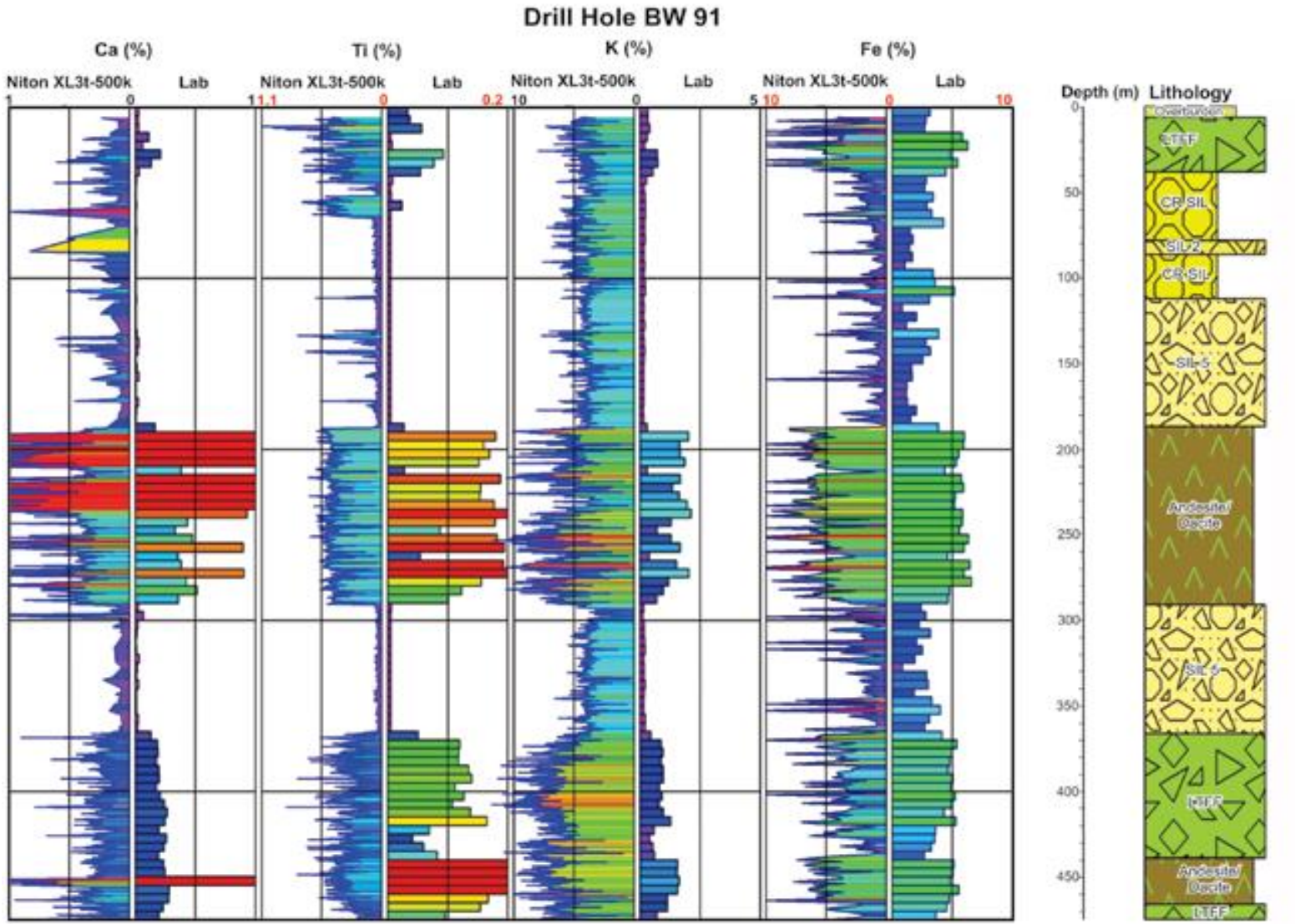
# Strip Logs – drill Core Niton vs Lab



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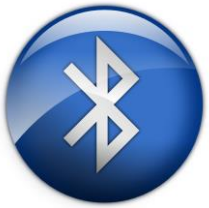
# Niton XL5: Enabled for Smart & Connected







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# Summary

- Niton XL5
- Delivering accuracy and speed
- Changing the way we work
- Suitable for hard rock, mineral fuels and industrial minerals
- Extending the capability of exploration