



# **Applications of Elemental Analysis in the Mining and Mineral Resource Industry**

## **Part 1**





# Welcome to our Minerals, Mining & Geology Webinar Series



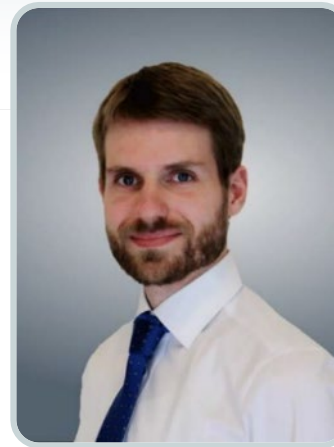
## Applications of Elemental Analysis in the Mining and Mineral Resource Industry

**Part 1:** *XRF as a flexible tool for elemental analysis of geological samples*

**Dec. 1<sup>st</sup> 2020:** 9:00 AM, 4:00 PM (CET)

**Part 2:** *Process Monitoring and Grade Control in the Mining and Mineral Resource Industry by XRF*

**Dec. 15<sup>th</sup> 2020:** 9:00 AM, 4:00 PM (CET)



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# Today's Topics



## Outline Part 1

- Introduction: What is XRF?
- Bruker's Solutions for Minerals, Mining & Geology
- Sample preparation: Fused beads
- Out-of-box solutions
  - GEO-QUANT Basic (EDXRF)
  - GEO-QUANT Advanced (WDXRF)
  - GEO-QUANT Traces (WDXRF)
- Summary & Outlook
- Q&A Session

## Join us again on Dec. 15<sup>th</sup> for Part 2

- Topics: Pressed pellets, online-XRF, (base) metal mining and more



# X-ray Fluorescence Analysis (XRF) Capabilities

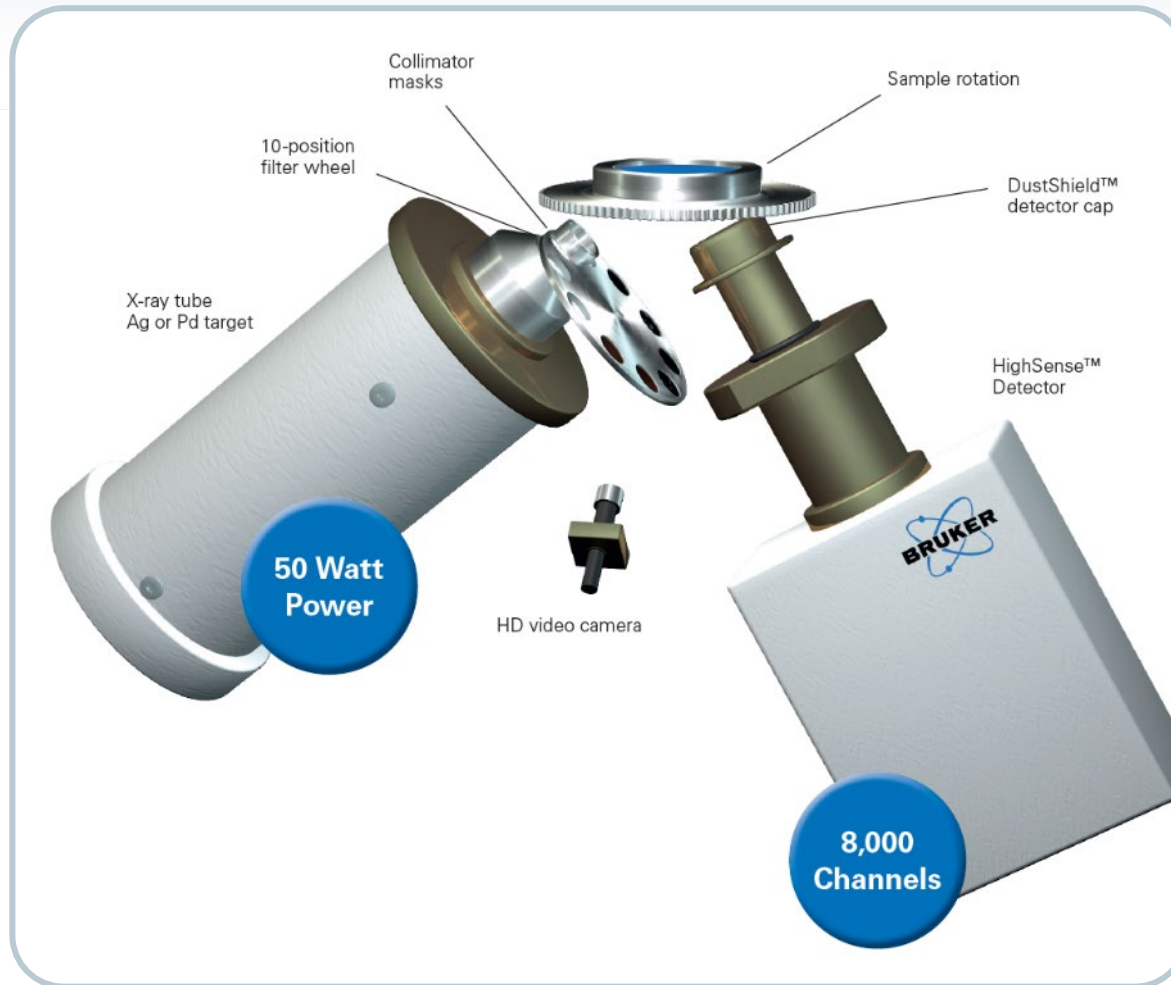


- Qualitative Analysis
  - Identification of elements
  - "What's inside?"
- Quantitative Analysis
  - Determination of concentrations
  - "How much is inside?"
- Semi-Quantitative Analysis
  - Estimation of concentration
  - "About how much?"





# Energy-dispersive X-Ray Fluorescence (EDXRF)



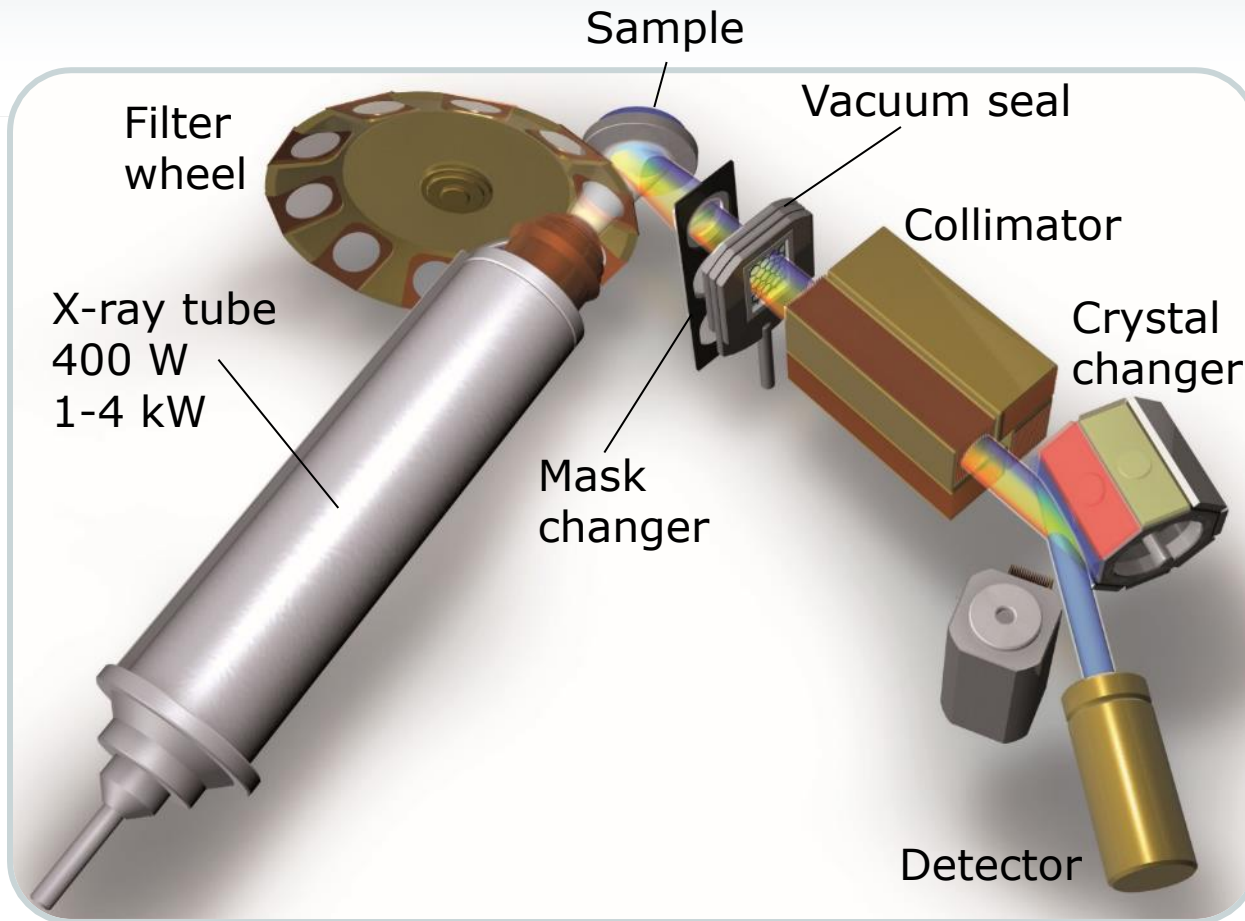
- Simple
- Robust
- Reliable
- Compact

Detects:

- Energy
- Intensity



# Wavelength-dispersive X-Ray Fluorescence (WDXRF)



- Sophisticated setup
- Best resolution and sensitivity

Detects:

- Intensity at a given wavelength



# X-ray fluorescence analysis (XRF)

## WDXRF vs. EDXRF



### WDXRF

- High precision mechanics
- Higher capital
- Precision: <0.05%
- Higher resolution
- Sensitivities: down to the ppm level, but roughly 1-2 orders more sensitive
- Very fast analysis
- Highest sample throughput

### EDXRF

- Mechanical simplicity
- Cheaper
- Sensitivities: down to the ppm level
- Easy handling
- Smaller, "can be brought to the sample"
- Faster sample identification (semi-quantitative analysis)

Versatile and Robust



# X-ray Fluorescence (XRF) spectrometry

## Element range



X-ray Fluorescence (XRF) analysis is qualitative and quantitative method for the determination of element concentrations via excitation of atoms in the sample and detection of the characteristic X-rays.

- High-power WDXRF (4–1 kW):  
Be (B) – Am
- Medium WDXRF (400 W):  
O (F) – Am
- Modern EDXRF:  
C (F) – Am
- Low-power EDXRF:  
Na (Mg) – Am

A periodic table of elements where each element's symbol is inside a grey box. Yellow horizontal bars are placed below the symbols of elements that are within the range of X-ray Fluorescence (XRF) analysis. The elements with yellow bars are: Be, B, C, N, O, F, Ne, Na, Mg, Al, Si, P, S, Cl, Ar, K, Ca, Sc, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Ga, Ge, As, Se, Br, Kr, Rb, Sr, Y, Zr, Nb, Mo, Tc, Ru, Rh, Pd, Ag, Cd, In, Sn, Sb, Te, I, Xe, Cs, Ba, La, Hf, Ta, W, Re, Os, Ir, Pt, Au, Hg, Tl, Pb, Bi, Po, At, Rn, Fr, Ra, Ac, Ce, Pr, Nd, Pm, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu, Th, Pa, U, Np, Pu, and Am.

- Element range XRF:  
(Be) B to Am
- Concentration range:  
Sub-ppm to 100 %



# Why “elements” matter XRF Applications



Wide range of XRF applications for

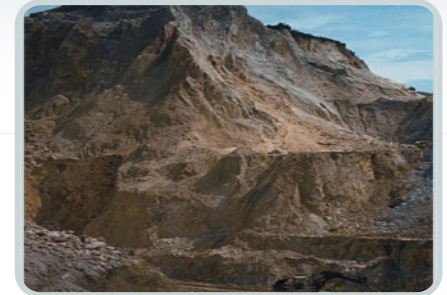
- Geological surveys
- Mining: Exploration and exploitation
- Industrial minerals
- Raw Materials for
  - Cement
  - Ceramics, Refractories, Glass
  - Catalysts, Chemicals, ...
  - Metals

Analysis of major and minor elements as oxides

- for grade control and product quality (purity) based on fused beads

Analysis of traces

- for purity control, geological and environmental mapping based on pressed pellets





# X-ray Fluorescence (XRF) analysis in Minerals, Mining & Geology



## **Bruker provides a full XRF portfolio**

- S1 TITAN: Portable / Hand-held EDXRF (HHXRF)
- M4 TORNADO: Micro XRF mapping ( $\mu$ XRF)
- S2 KODIAK: Online XRF
- S2 PUMA Series 2: High-performance EDXRF
- S6 JAGUAR: Benchtop sequential WDXRF
- S8 TIGER Series 2: High-power sequential WDXRF
- S8 LION: Multi-channel WDXRF





# Advantages of XRF

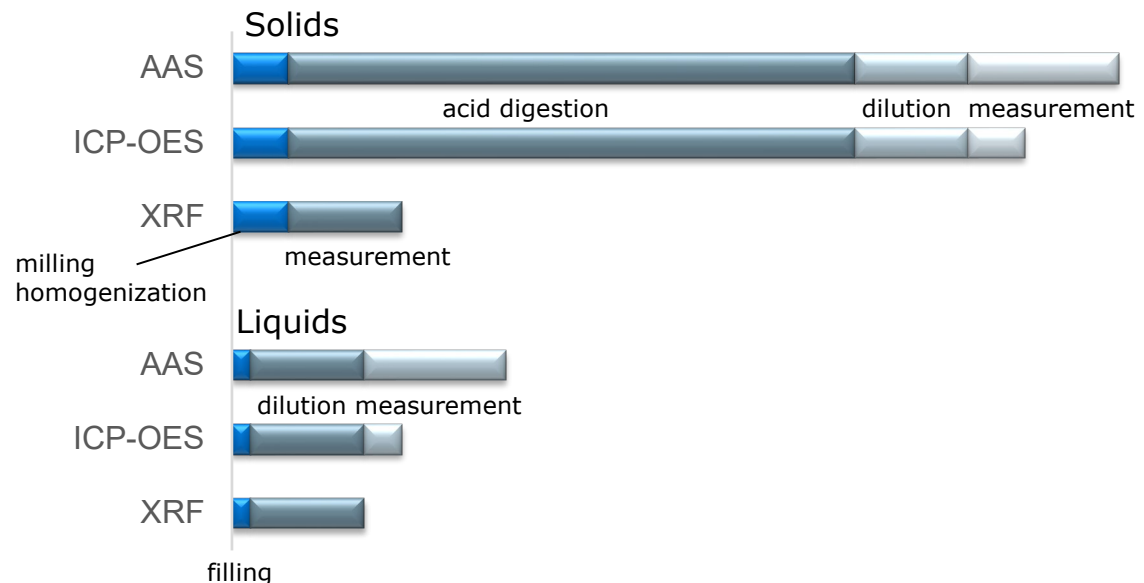
## Time-to-Result: XRF vs. AAS and ICP



Effective quality and process control requires the **shortest time-to-result** possible. This is the time needed from sampling to the final quantitative result. Any advantage results in:

- Higher sample throughput
- Stable industrial processes due to immediate feedback
- Constantly high product quality

### Time-to-result





# Poll: Which technique are you currently using / are you interested in?



## 1. Which technique are you currently using / are you interested in?

- ☐ Portable / Hand-held EDXRF (HHXRF)
- ☐ Micro XRF mapping ( $\mu$ XRF)
- ☐ Online XRF
- ☐ Online PGNA (neutron activation)
- ☐ EDXRF
- ☐ WDXRF
- ☐ AAS/ICP-OES
- ☐ Automated sample preparation
- ☐ Other





# What Do We Need to Do?



- Sample preparation needs to be fit for purpose
- We need to provide the requested information:
  - As Fast
  - As Precisely
  - As Economically (Cost)
  - As Easily
  - As Repeatedly
  - As Accurately



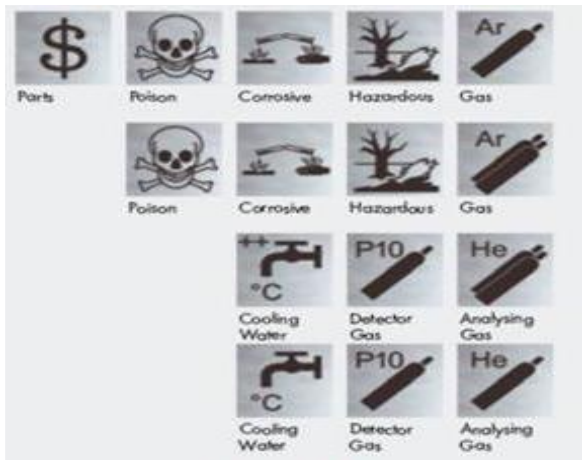
# Advantages of XRF: Its all about money!

## Cost of Ownership: XRF vs. AAS and ICP



The investment for the analytical instrument is only one part of the total cost of ownership. Expenses for laboratory equipment and consumables add to that cost.

- **Use of expensive accessories (AAS: graphite tubes)**
- **Consumption of noble gases (ICP: Argon)**
- **Need for hazardous chemicals (compliance with high-level safety regulations)**
- **Complicated sample preparation equipment (training and time)**



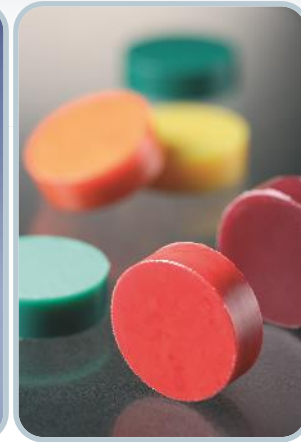


# X-ray fluorescence analysis (XRF) Capabilities



## Samples measured as

- Liquids
  - directly
- Powders
  - directly
  - as pressed pellets
  - as fused beads
- Bulks
  - Directly, after fitting into sample cups





# Atmosphere Modes

## Enhancing Performance, Reducing Cost



### Optimal Atmosphere

- Vacuum, Helium, Air, Nitrogen
- Vacuum: Best light element detection and lowest cost of operation

### For All Sample Types and Applications

- Solids, Liquids, Powders, Pressed Pellets, Fused Beads, Bulk

### S2 PUMA Series 2

- High pump rate: Vacuum reached in seconds
- Lowest (0.08L/min) gas consumption liquids





# Preparing a Representative Sample for XRF Analysis - Requirements



Pressed Pellet



Fused Bead

- Representative material
- Homogeneous
- Consist of particles small enough so that several layers will be measured
- Smooth flat surfaces without irregularities
- Fit the sample holder/ring being used
- Thick enough to be infinitely thick for X-rays to be measured



# Sample preparation

## Pressed pellets vs. Fused beads



### **Pressed Pellets**

#### **Pro's**

- Fast & simple sample preparation method
- No loss of volatile elements
- Easily automatable

#### **Con's**

- Grain size and matrix effects
- Sample contamination via the grinding vessel



### **Fused Beads**

#### **Pro's**

- No Matrix and grain size
- High reproducibility for best accuracy and precision
- Larger calibration range

#### **Con's**

- More expensive equipment and consumables
- Higher dilution factor → not suitable for traces



# So What is Fusion?



- Fusion is dissolution of oxide sample into borate flux at high temperature;
- Dissolution takes place **if and only if** the sample is completely oxidized;
- ALL OXIDES are soluble in lithium borate salts;
- NON OXIDES and/or reduce materials can be fused by doing an oxidation before fusion





# Sample preparation

## Fused beads



- Sample amount e.g.: 1g
- Melting in electrical, induction or gas devices can be (semi-) automated
- Platinum vessels required
- Oxidizing agents: for ferro alloys, sulfides
- Efficiency of melting and pouring; Lowering the melting temperature

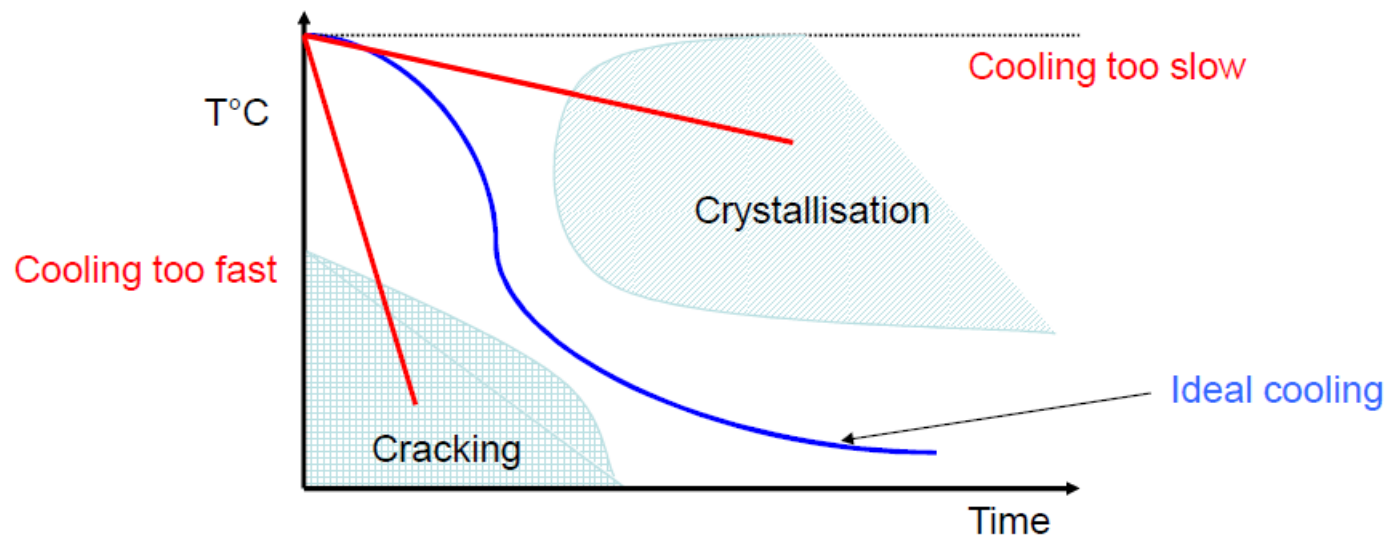
Flux	w/w (%)	Melting point (°C)	Attribute	Application
Lithium Tetraborate	100	920	Acidic	Basic oxides, carbonates, alumino silicates, concrete mixes, soils, magnesites, bauxites and cement
Lithium Metaborate	100	845	Basic	Acidic oxides, silicas, sands, clays & spinel glasses.
Lithium Tetraborate Lithium Metaborate	80:20	840		aluminosilicate range; aluminas, borax frits, cement
Lithium Tetraborate Lithium Metaborate	35.3:64.7	825		Gypsum, universal flux
Lithium Tetraborate Lithium Carbonate	55.5:45.5	740	Basic	Samples with traces of reduced species. sulfates, phosphates, metals, alloys, acidic minerals
Sodium Tetraborate	100	740		Iron, iron ores



# Fused beads

## What can go wrong?

- Not only the melting process is critical, but also the cooling phase



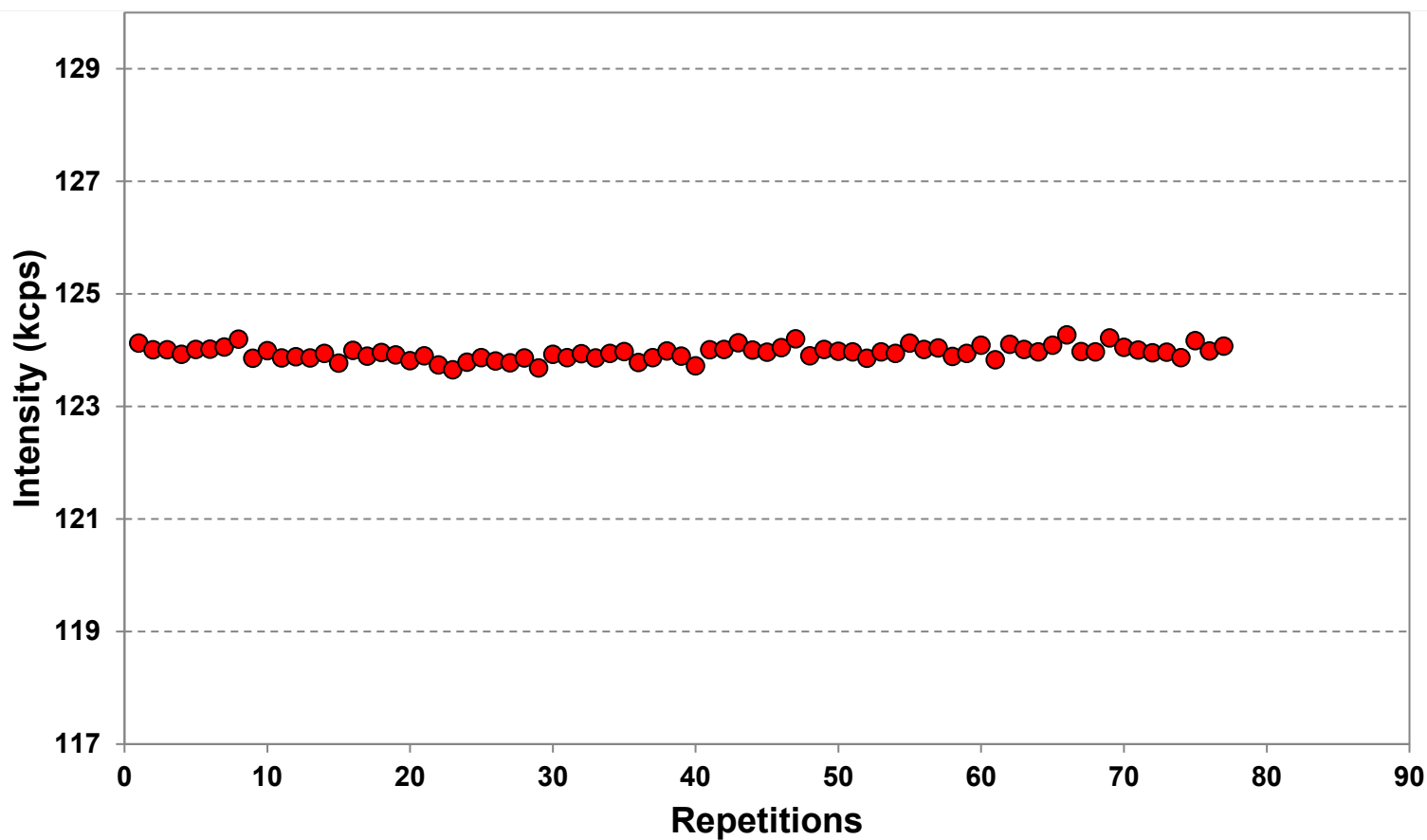
Source: XRF Scientific



# Fused beads What can go wrong?



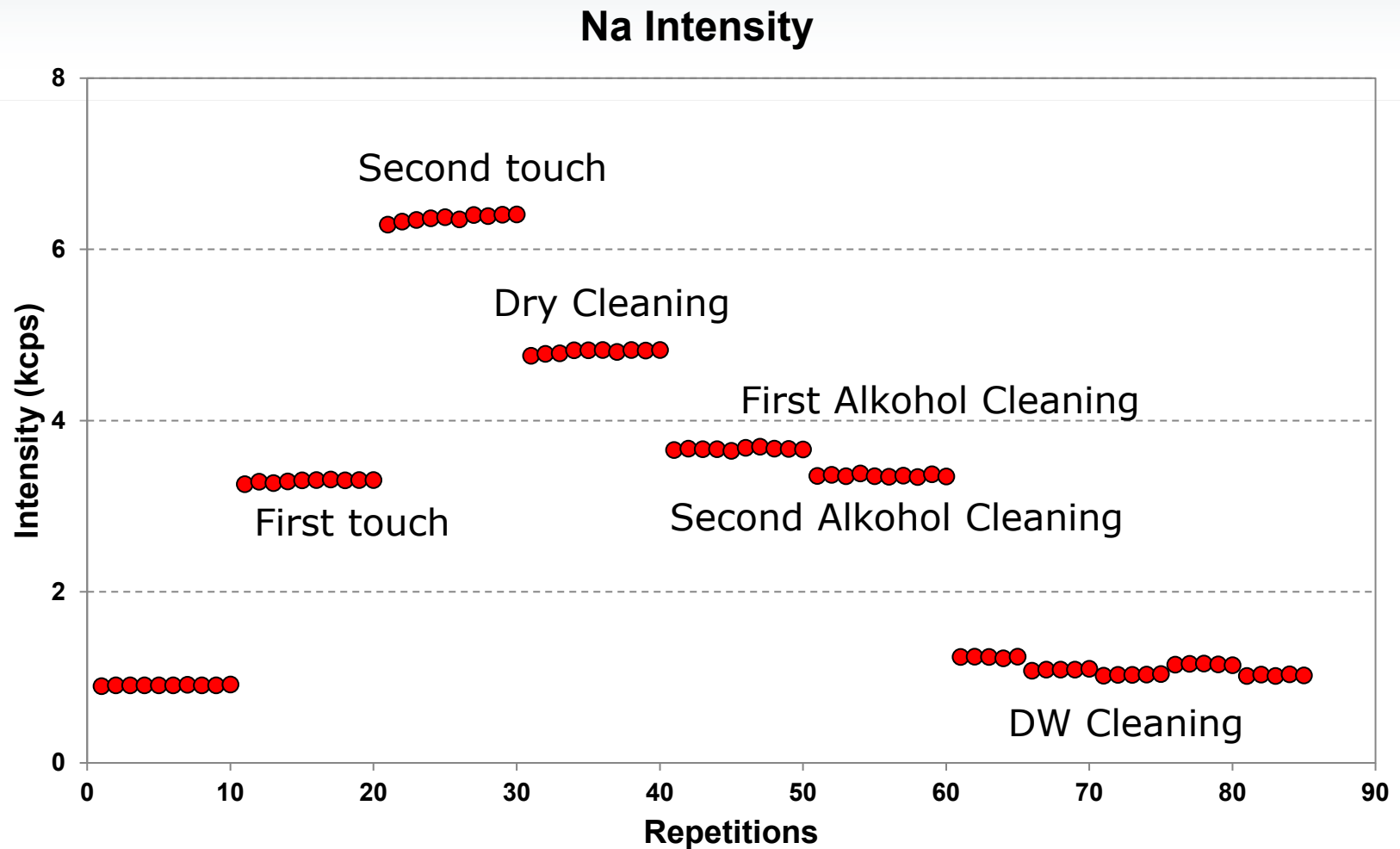
## Ca intensity





# Fused beads

## What can go wrong?



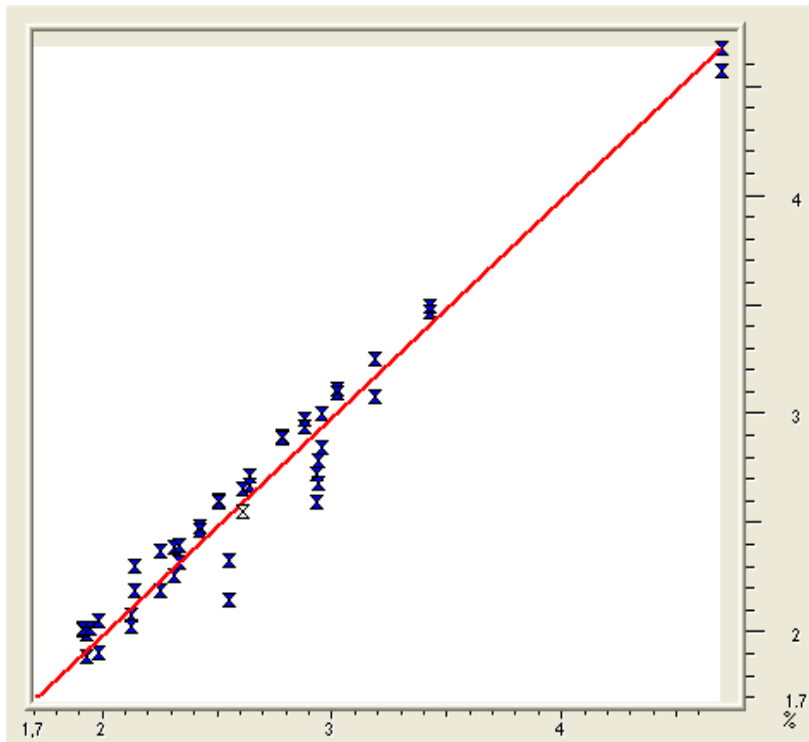


# Fused beads

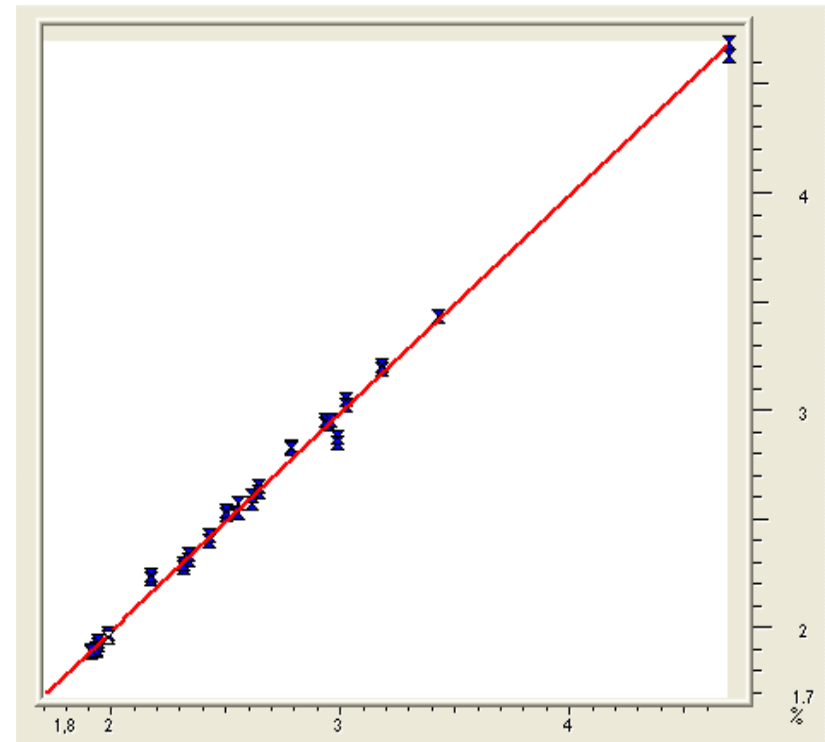
## What can go wrong?

**Preparation:**  
 Same standards  
 Same fusion device  
 Same recipe and flux

SD: 1.3%



SD: 0.036%





# Poll Results



## 1. Which technique are you currently using / are you interested in?

- ☐ Portable / Hand-held EDXRF (HHXRF)
- ☐ Micro XRF mapping ( $\mu$ XRF)
- ☐ Online XRF
- ☐ Online PGNA (neutron activation)
- ☐ EDXRF
- ☐ WDXRF
- ☐ AAS/ICP-OES
- ☐ Automated sample preparation
- ☐ Other





# S2 PUMA & S6 JAGUAR

## Modern EDXRF & WDXRF



Compact X-ray fluorescence devices are now very powerful due to new detector technologies

- Improved spectral resolution
- High analytical precision thanks to higher counting rates
- Simple operation and therefore quick integration into quality control



Decision about the technology (ED or WD) by:

- Element range, number of elements
- Required precision
- Detection limits
- Required sample flexibility





# S2 PUMA Series 2 XY Autochanger



- 20-position EasyLoad™ XY sample tray (plus 2 fixed positions)
- Different sample types can be mixed in one sequence (liquids, powders, solids)
- New samples can be loaded at any time into the sample tray
- SampleCare™ guarantees highest instrument uptime
- Soft shut-down feature – important for liquid samples!



# XRF - X-ray Fluorescence Analysis

## Precision and Counting Statistics

Precision limited by counting statistical error

$$\Delta c / c = \text{SQRT}(N) / N = 1 / \text{SQRT}(N)$$

N = 100	SQRT(N) = 10	3*SQRT(N) / N = 30 %
N = 1000	SQRT(N) = 30	3*SQRT(N) / N = 10 %
N = 10 000	SQRT(N) = 100	3*SQRT(N) / N = 3 %
N = 100 000	SQRT(N) = 300	3*SQRT(N) / N = 1 %
N = 1 000 000	SQRT(N) = 1000	3*SQRT(N) / N = 0.3 %
N = 10 000 000	SQRT(N) = 3000	3*SQRT(N) / N = 0.1 %

The S6 JAGUAR delivers more precise results:

- 400 W power, closely coupled optics
- Optimal excitation
- Enhanced sensitivity with optimal analyzer crystals
- HighSense detectors and counting electronics with up to 2 Mcps



# S6 JAGUAR

## High Performance Benchtop WDXRF



Maintain WDXRF resolution:

- Compact goniometer with high precision gears and closely coupled X-ray beam path
- Optimized analyzer crystals for the entire element range and special applications

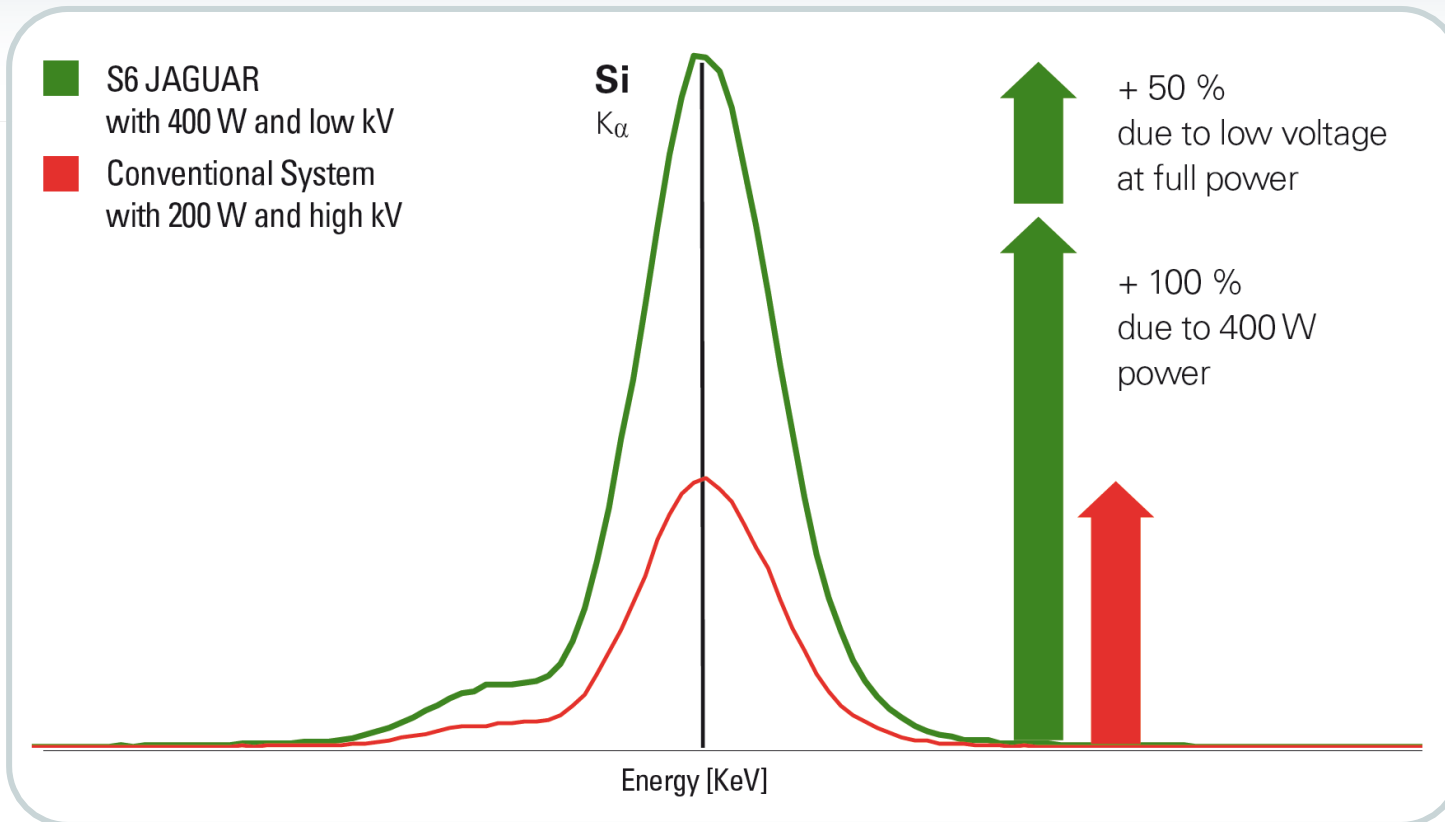
Maintain analytical precision and sensitivity:

- Higher power X-ray tube compared to EDXRF (there is no saturation due to single element detection)
- HighSense detection with 2 Mcps count rate
- HighSense XE detector for medium and heavy elements



# S6 JAGUAR

## HighSense™: Light Elements



Not only the overall performance is important! Also the excitation parameters:  
The S6 JAGUAR analyzes light elements with optimal low voltage and full 400 W power settings!



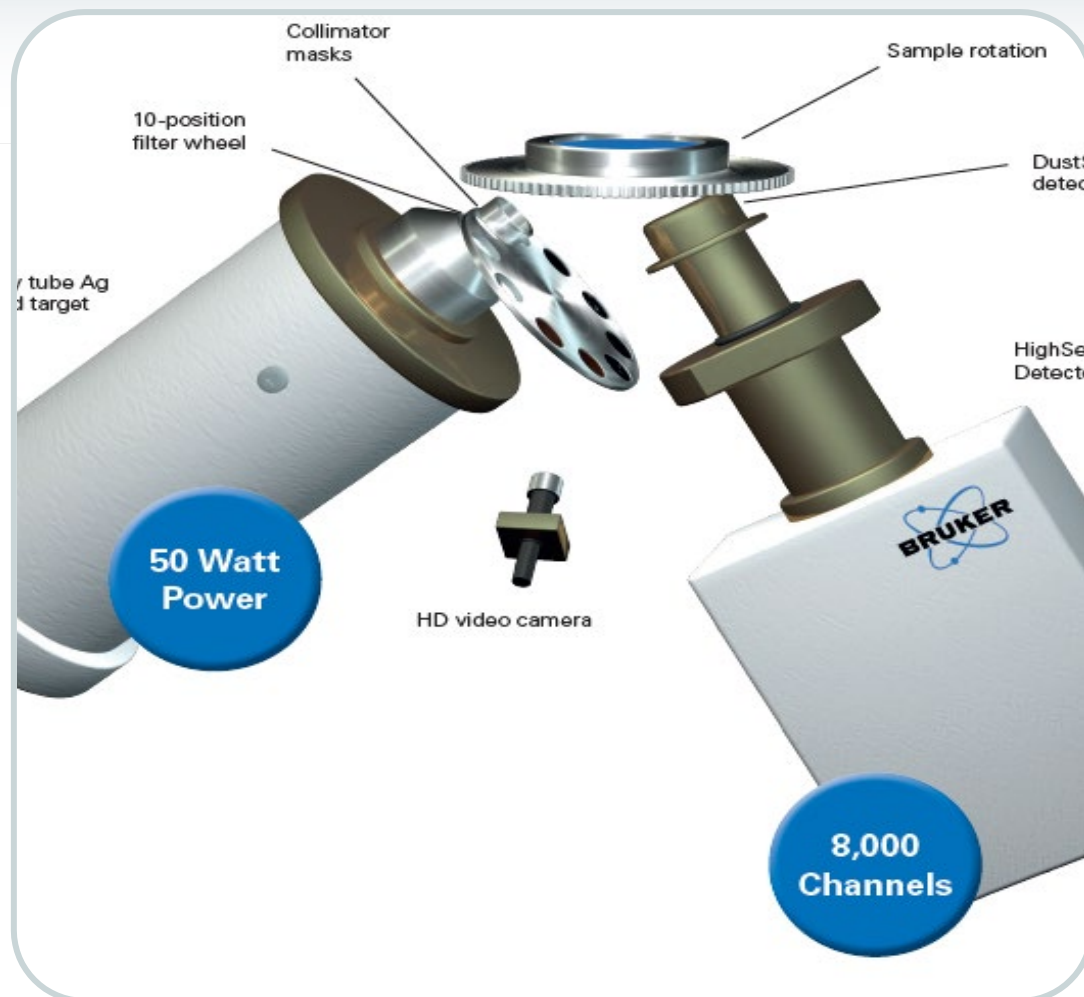
# S2 PUMA Series 2 With HighSense™ Technology



## Optimal excitation of the sample is ensured by:

- High power 50 Watt X-ray tube
- Up to 2 mA and 50 kV
- Optional 30 kV version
- Closely coupled optics
- 10-position primary beam filter
- The Next generation silicon drift detectors (SDD) with super high count rate and excellent energy resolution

**HighSense™ is the key to the unrivaled analytical performance of the S2 PUMA Series 2**





# How to get started?

## Out-of-the-box solutions



GEO-QUANT packages: Versatile solutions based on certified reference materials for the quantitative elemental analysis of:

- Mining operations (exploration, exploitation, grade control),
- Industrial minerals,
- Raw materials for cement and building materials,
- Refractories,
- Ceramics and glass,
- Academic geochemical research,
- Archaeology,
- Environmental studies and profiling,
- and more,...





# How to get started?

## Out-of-the-box solutions



### **GEO-QUANT Basic**

- Analysis of major and minor elements as oxides
- Grade control and product quality based on fused beads
- Spectrometer: S2 PUMA, S6 JAGUAR, S8 TIGER



### **GEO-QUANT Advanced**

- Analysis of major and minor elements as oxides
- Grade control and product quality based on fused beads
- Spectrometer: S8 TIGER



### **GEO-QUANT Traces**

- Analysis of trace elements
- Purity control and geological and environmental mapping based on pressed pellets
- Spectrometer: S8 TIGER





# GEO-QUANT Basic S2 PUMA



- Fused bead solution
- Geological applications and minerals & mining
- 20 CRMs deliver wide concentration range solution for 14 elements:  
Na, Mg, Al, Si, P, S, K, Ca, Ti, Cr, Mn, Fe, Zn, Sr
- Requires LE configuration for light element analysis





# GEO-QUANT Basic S2 PUMA



Compound	Number of Standards	Max. concentration [wt%]
Na <sub>2</sub> O	16	11
MgO	18	40
Al <sub>2</sub> O <sub>3</sub>	19	85
SiO <sub>2</sub>	19	100
P <sub>2</sub> O <sub>5</sub>	16	7.5
SO <sub>3</sub>	13	58
K <sub>2</sub> O	18	12
CaO	18	100
TiO <sub>2</sub>	19	4
Cr <sub>2</sub> O <sub>3</sub>	14	0.1
MnO	16	0.9
Fe <sub>2</sub> O <sub>3</sub>	20	100
ZnO	11	0.1
SrO	13	0.1

Major improvements and customer benefits:

- 14 instead of 11 elements (+ Cr, Zn, Sr)
- Wider concentration range
- Faster measuring time: 4 min instead of 11 min
- Standards re-buy possible



# GEO-QUANT Basic S2 PUMA



	Cement (CRM 101)			Gypsum (GYP-C)			Iron Ore (ECRM 683-1)		
[wt%]	Mean	Cert.	SD	Mean	Cert.	SD	Mean	Cert.	SD
Na <sub>2</sub> O	0.55	0.68	0.04	0.04	0.03	0.04	0.06	0.04	
MgO	1.65	1.7	0.05	6.83	7.22	0.09	1.62	1.7	0.05
Al <sub>2</sub> O <sub>3</sub>	8.7	8.81	0.04	0.88	1.07	0.07	2.03	2.44	0.04
SiO <sub>2</sub>	30.22	30.31	0.05	4.42	4.72	0.07	7.5	7.16	0.05
P <sub>2</sub> O <sub>5</sub>	0.18	0.19	0.01	0.24	0.02	0.04	0.34	0.01	
SO <sub>3</sub>	3.17	3.16	0.01	44.75	44.53	0.06	0.04	0.01	
K <sub>2</sub> O	1.91	2.1	0.06	0.41	0.49	0.04	0.21	0.18	0.04
CaO	48.19	48.24	0.16	41.07	41.02	0.17	7.91	7.89	0.04
TiO <sub>2</sub>	0.43	0.47	0.02	0.06	0.05	0.02	0.16	0.02	
Cr <sub>2</sub> O <sub>3</sub>	0.01	0.01	0	0.01	0	0.01	0.01		
Mn <sub>2</sub> O <sub>3</sub>	0.11	0.12	0	0.02	0.01	0.01	0.65	0.66	0.01
Fe <sub>2</sub> O <sub>3</sub>	3.47	3.52	0.01	0.57	0.54	0	78.86	79.4	0.07
ZnO	0.05	0.04	0.01	0	0	0	0.01	0	
SrO	0.24	0.25	0	0.48	0.47	0	0.01	0	0

- Improved accuracy



# GEO-QUANT Advanced S8 TIGER



**Covering 20 element**

Oxide	Min. Conc. [%]	Max. Conc. [%]
Na <sub>2</sub> O	0.01	20.06
MgO	0.02	95.5
Al <sub>2</sub> O <sub>3</sub>	0.05	100
SiO <sub>2</sub>	0.41	99.8
P <sub>2</sub> O <sub>5</sub>	0.01	40.6
SO <sub>3</sub>	0.03	57.7
K <sub>2</sub> O	0.01	9.0
CaO	0.03	98.2
TiO <sub>2</sub>	0.01	41.1
V <sub>2</sub> O <sub>5</sub>	0.07	10.0
Cr <sub>2</sub> O <sub>3</sub>	0.01	18.5
Mn <sub>2</sub> O <sub>3</sub>	0.01	77.3
Fe <sub>2</sub> O <sub>3</sub>	0.01	100
NiO	0.01	6.0
CuO	0.01	20.0
ZnO	0.01	10.0
SrO	0.01	20.0
ZrO <sub>2</sub>	0.01	65.0
BaO	0.01	40.0
HfO <sub>2</sub>	0.03	5.0
PbO	2.00	8.0



# GEO-QUANT Traces S8 TIGER



## GEO-QUANT Traces

- Trace element solution for various geological applications
  - Limestone
  - Soils
  - Sediments
  - Industrial Minerals
  - Ceramics
  - ...
- Important in
  - Research
  - Monitoring purposes
  - Exploration





# GEO-QUANT Traces S8 TIGER



- **GEO-QUANT Traces** comes as pre-calibrated package that allows easy analysis of trace elements in geological materials
- Trace analysis to be carried out within hours of the instruments installation
- Master calibration based on hundreds international **CRMs**
  - 27 elements included
  - Optimized pressed pellet preparation
- Needs LiF220 crystal
- Measurements
  - Typically 38 min.
  - Optimized background handling with shared positions



H																	He						
Li	Be															B	C	N	O	F	Ne		
Na	Mg															Al	Si	P	S	Cl	Ar		
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr						
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe						
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn						
Fr	Ra	Ac																					
		Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu								
		Th	Pa	U	Np	Pu	Am	Sum	Matrix	Compton	Rayleigh												

Evaluated as

- Oxide
- Element



# GEO-QUANT Traces S8 TIGER



Element/ Compound	LLD (100s, 3 $\sigma$ ) [ppm]	Max. Concentration [ppm]	Analysis time [s]
Sc	1.6	60	40
TiO <sub>2</sub>	0.001 %	2.60 %	6
V	1.4	340	60
Cr	3.3	2.40 %	40
MnO	0.001 %	1.30 %	6
Fe <sub>2</sub> O <sub>3</sub>	0.001 %	25.70 %	20
Co	2.2	700	60
Ni	1.5	2640	30
Cu	4.7	5400	30
Zn	3.8	1310	30
As	2.9	330	100
Ga	0.7	400	60
Rb	0.9	1300	20
Sr	0.9	1650	20
Y	6.5	800	20
Zr	4.9	550	20
Nb	0.6	700	20
Mo	1.0	700	20
Sn	3.1	1300	60
Sb	1.7	122	60

- Matrix elements
  - TiO<sub>2</sub>, Fe<sub>2</sub>O<sub>3</sub> and MnO calibrated up to the % range to be used for the correction of interferences
  - Automatic matrix correction based on Rh Compton method
- 6 – 100 s counting time

Element/ Compound	LLD (100s, 3 $\sigma$ ) [ppm]	Max. Concentration [ppm]	Analysis time [s]
Cs	4.7	260	60
Ba	5.0	4000	60
La	5.2	1340	60
Ce	4.0	2230	60
Pb	1.5	5500	100
Th	12.6	1003	100
U	1.5	650	100



# S6 JAGUAR & S2 PUMA

## Manual: Quick Sample Change



- Easy access to large sample chamber
- For all kinds of samples:
  - Solids
  - Pressed powders
  - Fused beads
  - Liquids with helium mode
  - Loose powders in cups with helium
- Economical option for lower sample throughput





# TouchControl™: Easy and fail-safe routine operation



Intuitive interface: Three steps to accurate results

- 1) Select sample position and application
  - 2) Enter sample ID
  - 3) Press "Measure"
- No operator training required
  - Standalone operation (no PC): IslandMode
  - Remote access via TCP/IP:
    - Routine with TouchControl: Calibration, evaluation, and reporting remotely
  - Languages: English, German, French, Spanish, Italian, Portuguese, Russian, Chinese, Japanese, Bahasa



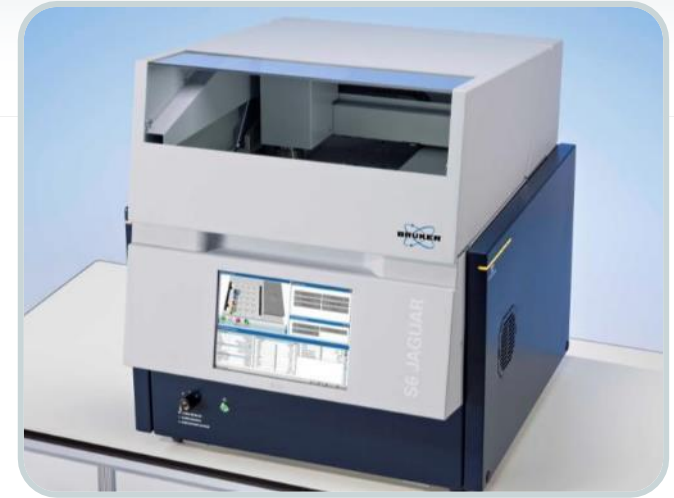


# S6 JAGUAR & S2 PUMA

## EasyLoad™: High Productivity

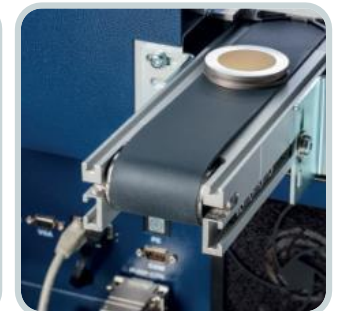


- Automatic measurement of sample batches for high throughput
- Load and prioritize new samples at any time
- Loading of entire batches by swapping trays
- Automatic liquid cup detection
- Soft shut-down in case of power outage



### **Ready for automation:**

- Professional integration in fully automated environments
- The samples are fed directly from the automatic sample preparation system
- AXSCOM communication interface for connection to the control software





# There are some soft criteria! Intuitive Operation and Robust Design



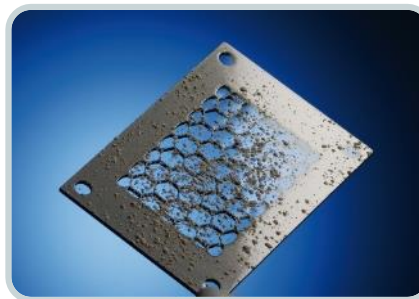
## Ease-of-use



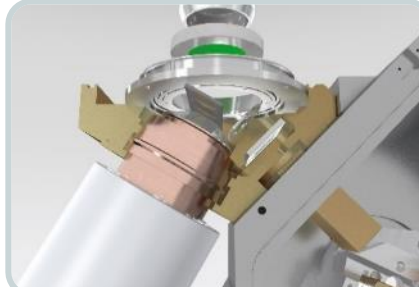
TouchControl™ and  
EasyLoad™



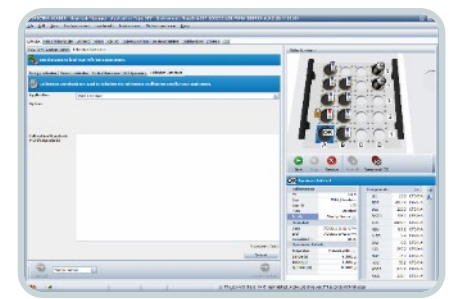
## Low maintenance and high uptime



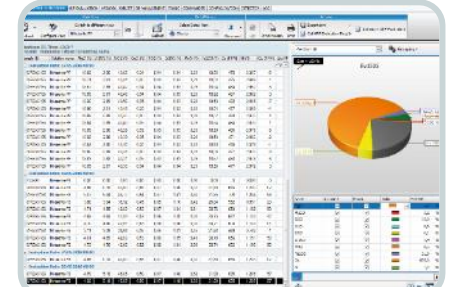
SampleCare™



## Powerful Software



SPECTRA.ELEMENTS





# Need to explore the details? S8 TIGER Series 2 with XRF<sup>2</sup>



XRF<sup>2</sup> on S8 TIGER Series 2 with  
HighSense beam path:

- 60 position loader incl. 5 mapping positions
  - HD camera station
  - Bruker SW with mapping and reporting client
  - Smallest mask size: **300 µm**
  - Step size: **100 µm**
- 
- Highest sensitivity with HighSense beam path and beam guide technology
    1. Shortest measurement times in WDXRF
    2. Best LLD's
    3. Best precision
    4. Smallest spot size
    5. Quick and easy application setup



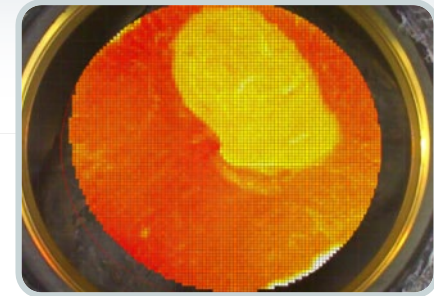


# Need to explore the details? XRF<sup>2</sup> – Meteorite „Canyon Diablo“



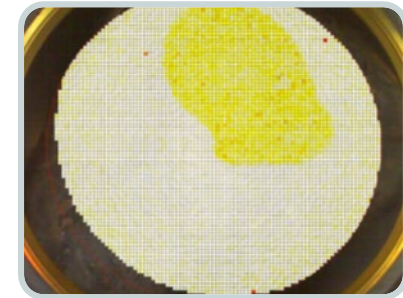
- Mapping of points, lines, several areas and complete sample
- Mapping client for easy setup
- Standardless evaluation and user calibration

$\text{Fe}_2\text{O}_3$

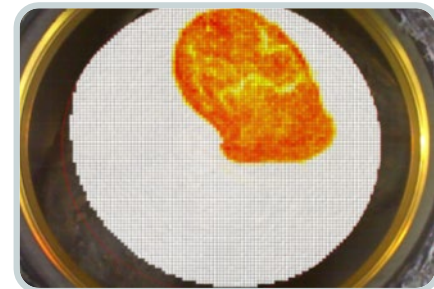


100

$\text{Cr}_2\text{O}_3$



$\text{SO}_3$



0

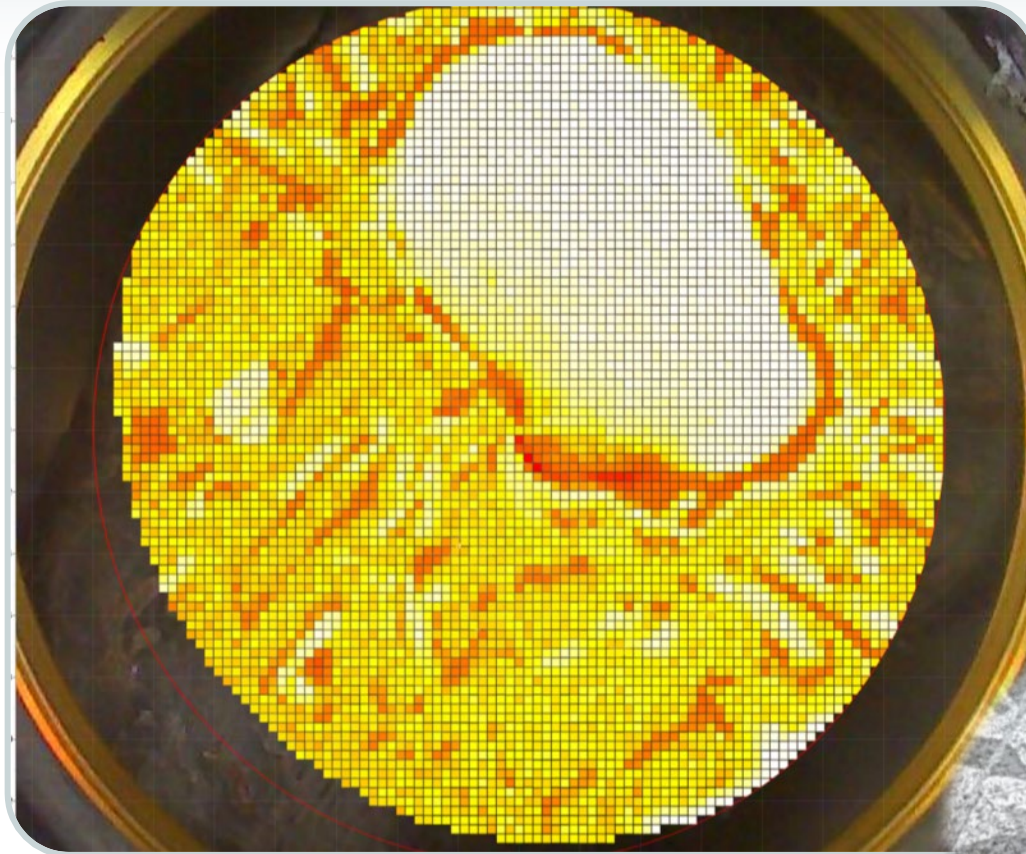


Meteorite sample  
Canyon Diablo, Arizona



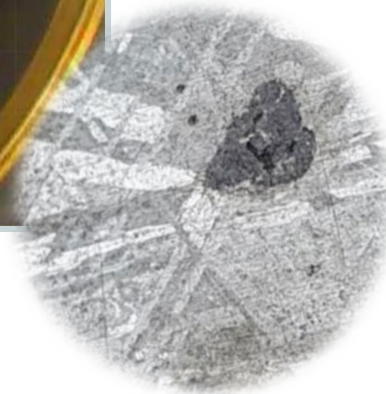


# Need to explore the details? XRF<sup>2</sup> – Meteorite „Canyon Diablo“



Nickel distribution in Meteorite Canyon Diablo  
(Arizona, US)

- High spatial resolution
- High sensitivity to resolve different Fe-Ni phases (kamacite, taenite)
- Structures only seen by leaching experiments (destructive) or
- S8 TIGER Series 2 (non-destructive)



Example for  
Widmanstätten pattern  
/ Thomson structure



# Outlook and Poll



## Outlook

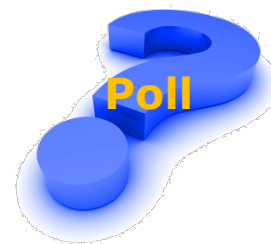
**Part 2:** *Process Monitoring and Grade Control in the Mining and Mineral Resource Industry by XRF*

**Dec. 15<sup>th</sup> 2020:** 9:00 AM, 4 PM (CET)

- Topics: Pressed pellets, online-XRF, application examples for (base) metal mining, and more

**What would you like to learn next?**

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# XRF – The right tool for all tasks

## **S8 TIGER**

- Powerful WDXRF, e.g., for high demanding central labs

## **S6 JAGUAR**

- Benchtop WDXRF: lower throughput but similar performance compared to full-size WDXRF

## **S2 PUMA**

- Versatile tool for minor and major elements

## **S2 KODIAK**

- On-belt analysis

## **QUANT Solutions**

- Basic: 14 minor and major elements
- Advanced: 20 minor and major elements
- Traces: 27 trace elements





# Q&A



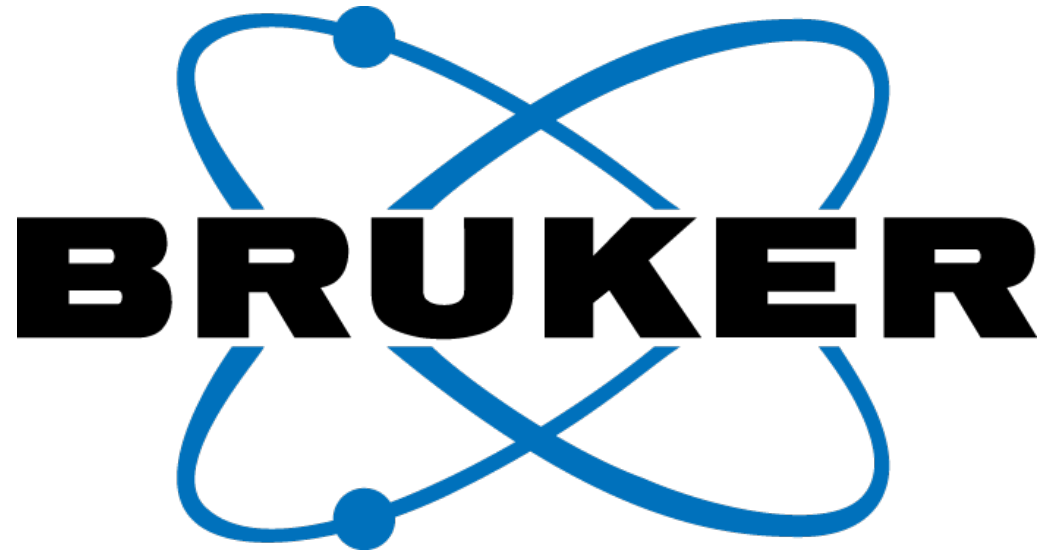
**Any questions?**



**Thanks for your time and interest!**







Innovation with Integrity