Practical Aspects of the X-ray Characterisation of Silicate and Alumino-silicate Industrial Minerals

Kevin Young
Principal Scientist

Presentation Outline

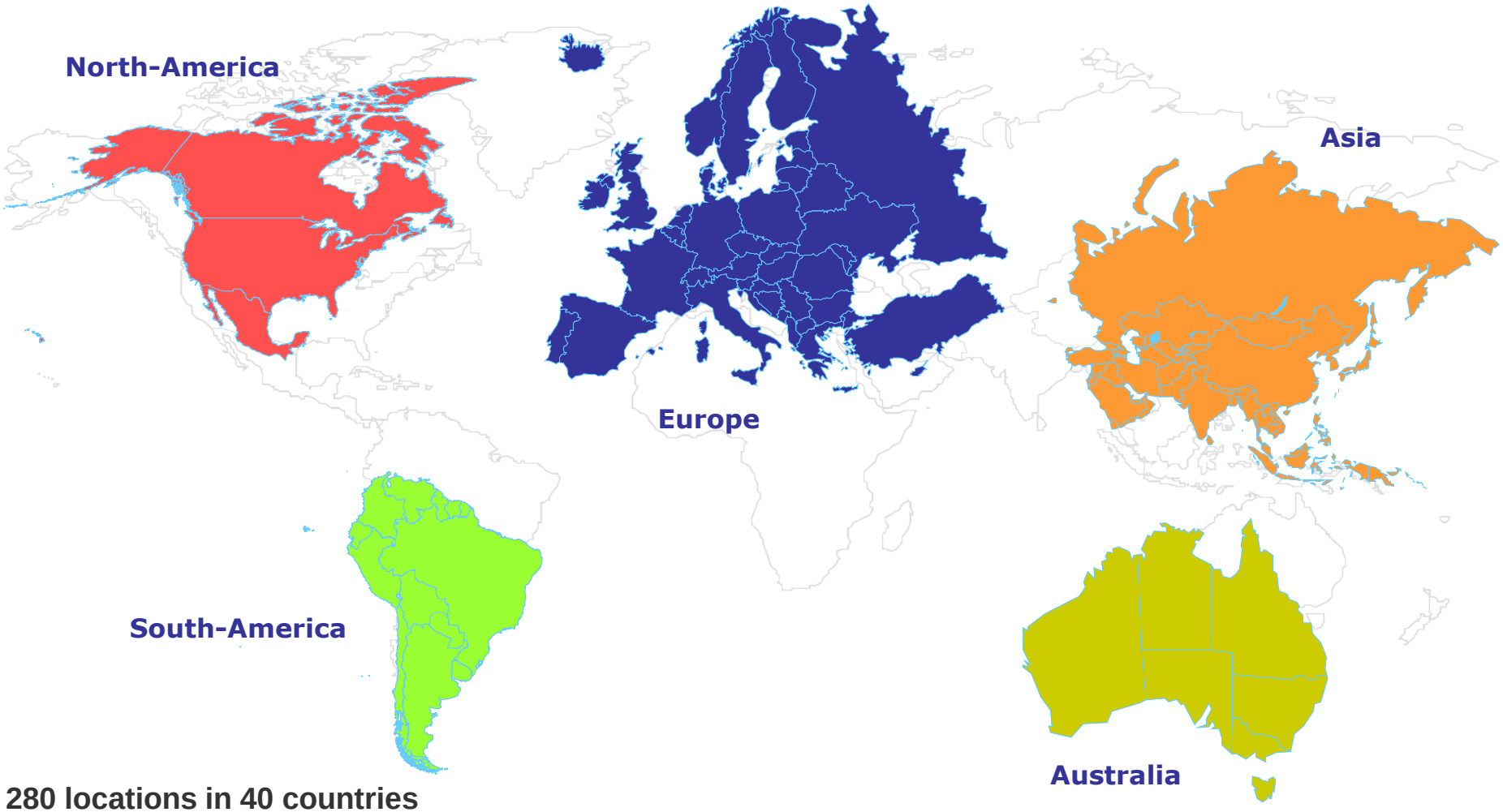
- *Brief Introduction to Sibelco*
- *XRF Instruments and Sample Preparation*
- *Glass Sands and Clays*
- *Mineralogy – XRF and XRD*
- *Quartz Standards and Crystallinity*

Presentation Outline

Brief Introduction to Sibelco

Sibelco

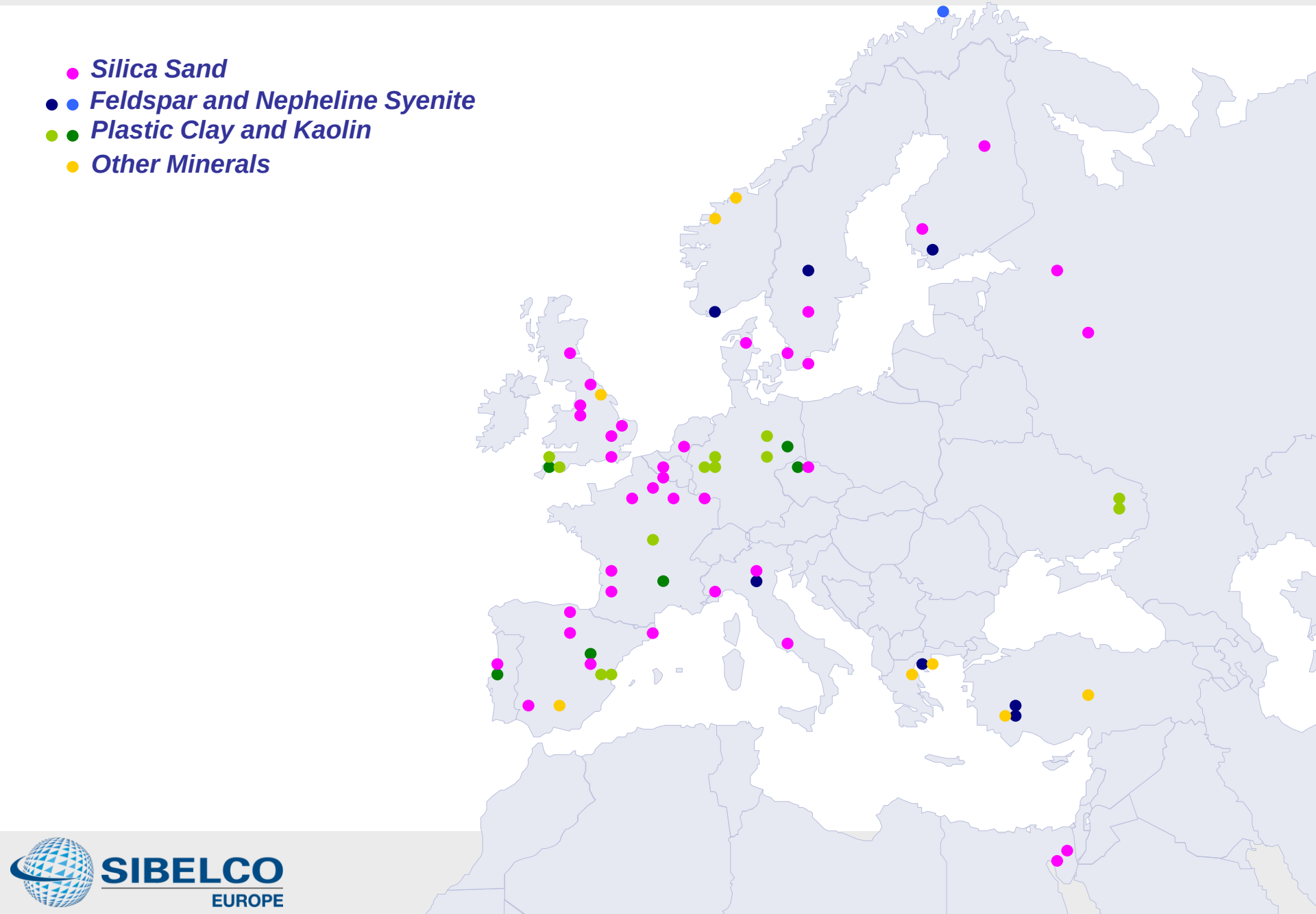
Sibelco



280 locations in 40 countries

Ceramic Related Technical Centres

- *Silica Sand*
- *Feldspar and Nepheline Syenite*
- *Plastic Clay and Kaolin*
- *Other Minerals*



SIBELCO EUROPE

Sibelco Group

Sibelco is one of the top five industrial mining groups in the world, holding leading market shares across a number of key mineral groups

Product	Estimated Worldwide Market Position
Silica Sand	1
High Purity Quartz	1
Ball Clay	1
Feldspathic Minerals	1
Olivine	1

Sibelco and XRF

- For QC:
  - Routine for dispatches of Glass Grade Minerals
    - Energy Dispersive – Fe_2O_3 and K_2O
    - Fixed Channel if Al_2O_3 as well
- For QA, exploration and calibration support:
  - High power sequential spectrometers
- Several Thousand XRFs per week
  - ~10 Sequential spectrometers in Europe
  - >50 ED or Fixed Channel Instruments
- XRD less common – support from 'central' laboratories

Presentation Outline

XRF Instruments and Sample Preparation

XRF Instruments

Wavelength Dispersive XRF

Energy Dispersive Scanning XRF

Powder XRD

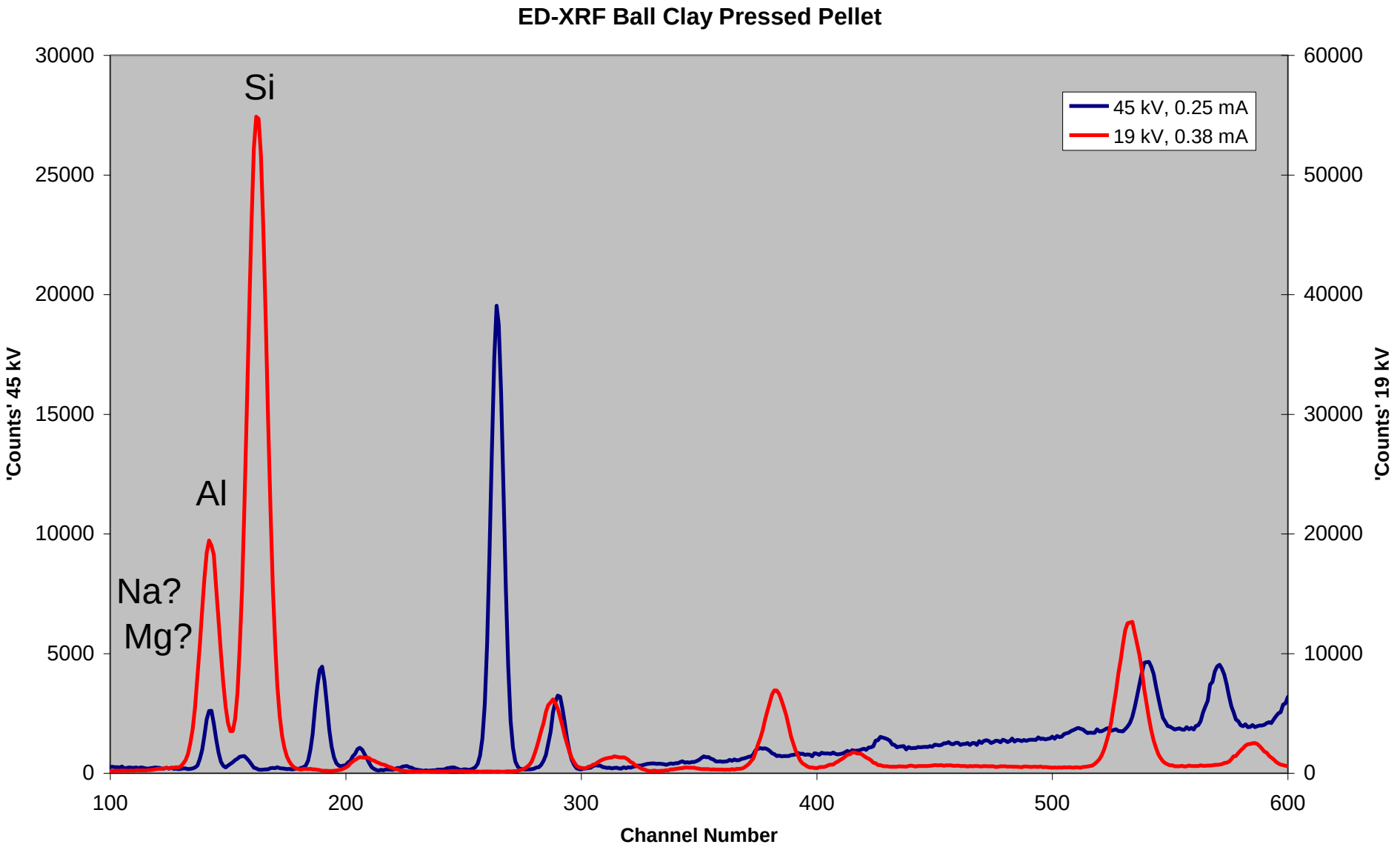
- **Used for routine analyses** -

Powder XRD

- **Used for research analyses** -

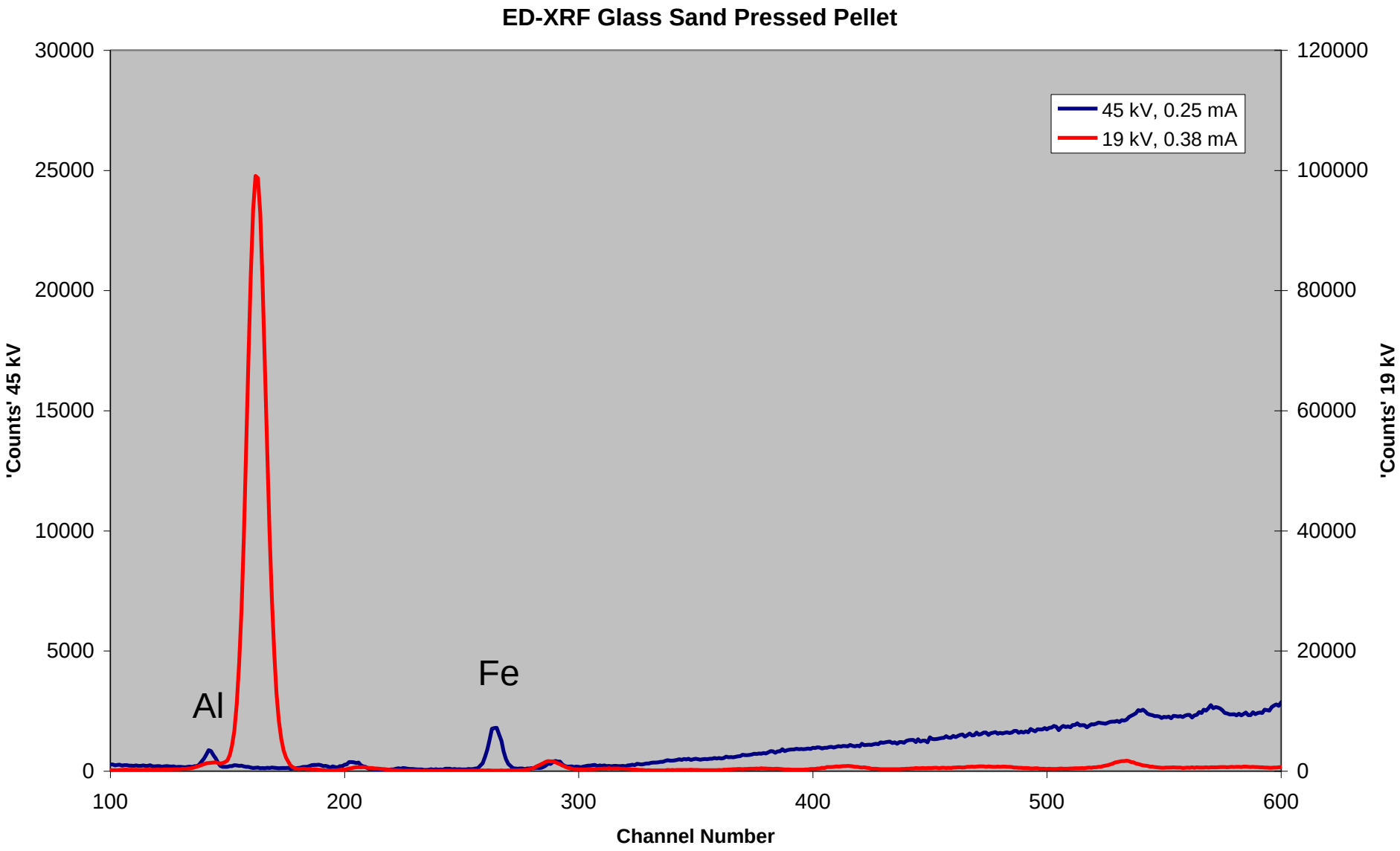
SIBELCO EUROPE

Energy Dispersive XRF



SIBELCO EUROPE

Energy Dispersive XRF



SIBELCO EUROPE

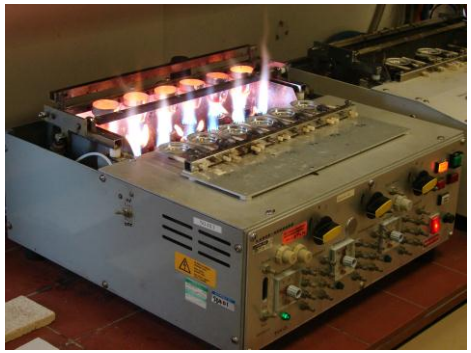
Wavelength Dispersive XRF

3kW Rh Tube

Crystals and Power Settings Optimised for Light Elements

Channel	Type	Line	X-tal	Collimator	Detector	Tube filter	kV	mA
Fe1	Gonio	KA	LiF 200	150 µm	Duplex	None	60	50
Ti1	Gonio	KA	LiF 200	150 µm	Flow	None	40	75
I	Gonio	LA	LiF 200	300 µm	Flow	None	40	75
Ca1	Gonio	KA	LiF 200	300 µm	Flow	None	40	75
K1	Gonio	KA	LiF 200	300 µm	Flow	None	40	75
Si1	Gonio	KA	InSb 111	700 µm	Flow	None	24	125
Al1	Gonio	KA	PE 002	700 µm	Flow	None	24	125
Mg1	Gonio	KA	PX1	700 µm	Flow	None	24	125
Na1	Gonio	KA	PX1	700 µm	Flow	None	24	125

Sample Preparation



Gas Fusion

XRF bead manufacture

Electric Fusion

Produces individual fused glass beads

Pellet Press

Non-glass XRF pellets

Kilns

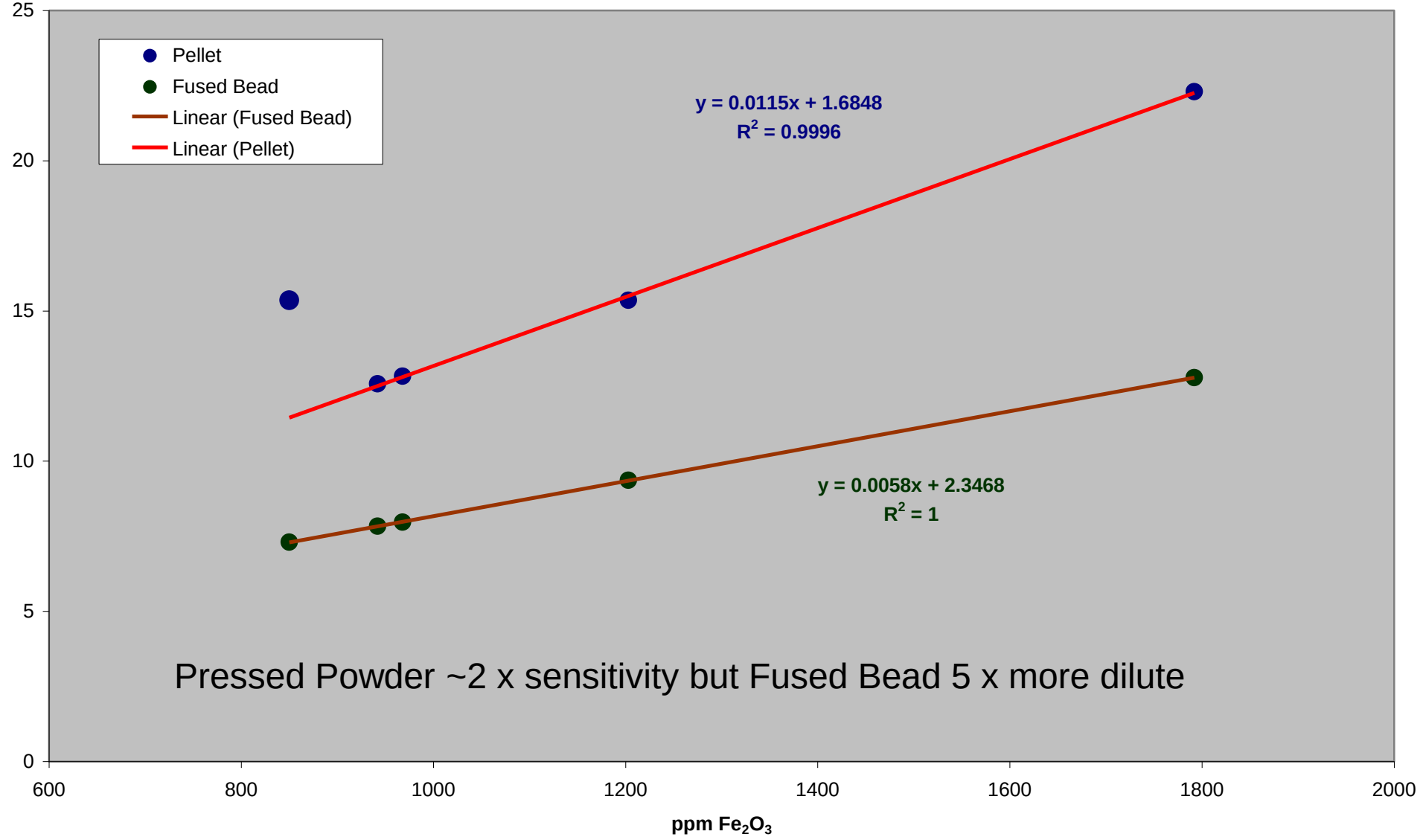
Loss on Ignition

Pressed Powders or Fused Beads?

- Pressed Powders
  - No Complex Equipment
  - Cheap
  - High Count Rates?
  - Sample Matrix still intact

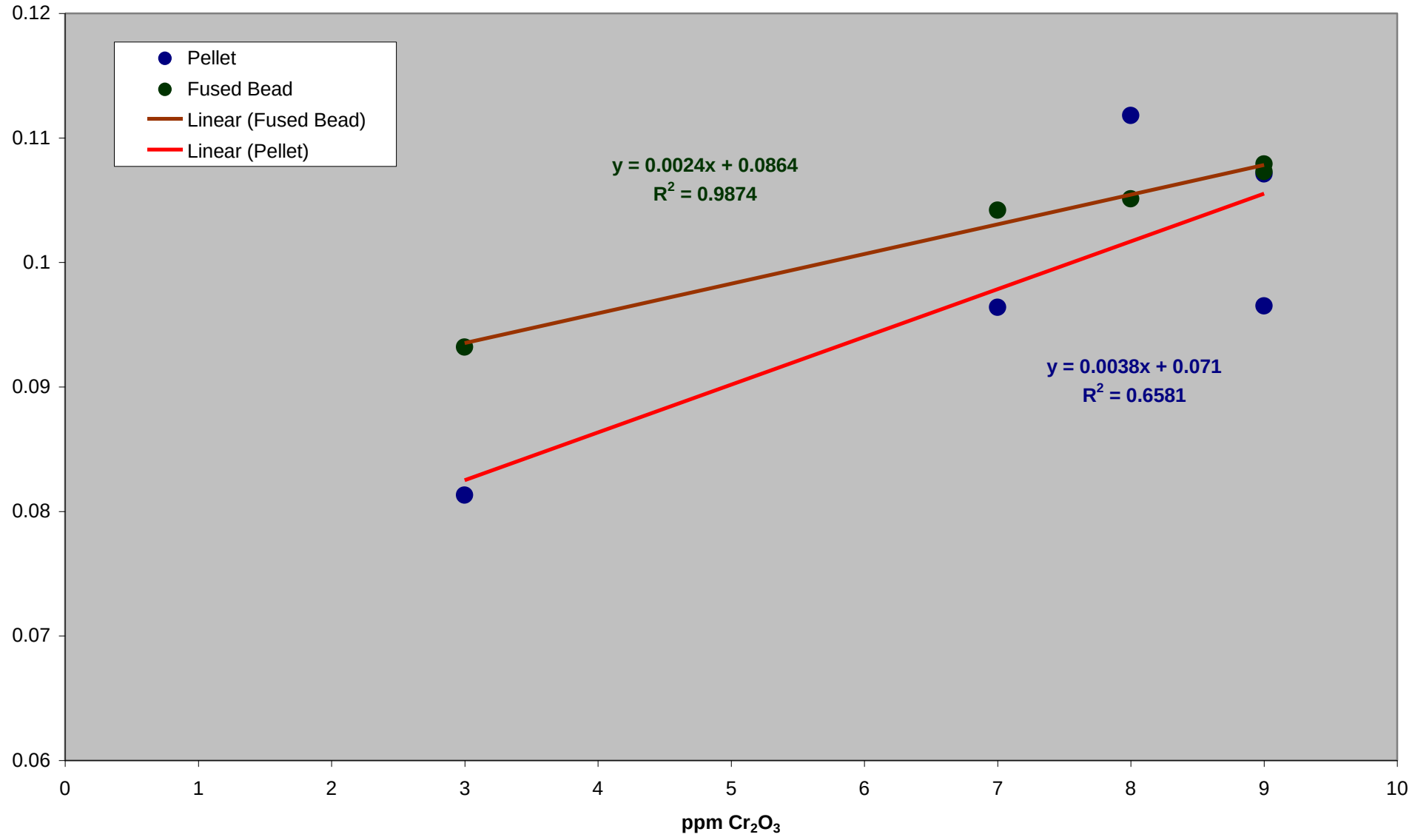
- Fused Beads
  - Complicated equipment (gas/electricity supply, etc)
  - Equipment and Platinum is expensive
  - Complicated to set-up correctly
  - Cost of flux is not insignificant
  - Glass (sample matrix removed)
  - Dilute: inter-element effects reduced

Pressed Pellet vs Fused Bead



SIBELCO EUROPE

Pressed Pellet vs Fused Bead



SIBELCO EUROPE

Calibration: CRMs or Primary Standards

- BCS CRM 348 – Ball Clay

ANALYSES

Mean values — mass content in % All results relate to the dried (105°C) sample

Analyst No.	SiO_2	Al_2O_3	TiO_2	Fe_2O_3	CaO	MgO	Na_2O	K_2O	P_2O_5	Cr_2O_3	LOI	BaO	ZrO_2	C (Total)	S
1	50.92	31.41	1.066	1.006	.....	0.307	0.320	.....	0.071	.....	11.64	.....	.....	.....	.....
2	51.09	31.69	1.090	1.020	0.170	0.305	0.362	2.255	0.072	0.020	11.64	*0.05*	*0.04*	*1.63*	.....
3	51.39	31.61	1.077	1.042	0.175	0.298	0.334	2.210	0.072	0.014	11.68	*0.03*	*0.03*	.....	.....
4	51.03	31.57	1.065	1.038	0.165	0.310	0.358	2.195	0.086	0.015	11.82	*0.05*	*0.03*	.....	.....
5	51.34	31.65	1.062	1.041	0.177	0.314	0.312	2.213	0.075	0.018	11.78	*0.05*	*0.02*	.....	.....
6	51.00	31.51	1.076	1.042	0.188	0.280	0.340	2.234	0.058	.....	11.82	.....	*0.04*	*1.65*	*0.1*
7	51.14	31.71	1.100	1.068	0.180	0.315	0.353	2.220	0.060	0.015	11.86	.....	*0.02*	.....	.....
8	51.35	31.37	1.093	1.027	0.172	0.308	.....	2.264	.....	.....	11.95	.....	.....	.....	.....
9	50.92	31.80	1.127	1.082	0.158	0.305	0.370	2.250	.....	.....	11.60	.....	.....	.....	.....
M_M	**51.1**	**31.6**	**1.08**	**1.04**	**0.17**	**0.30**	**0.34**	**2.23**	**0.071**	**0.016**	**11.8**	.....	.....	.....	.....
s_M	0.2	0.2	0.02	0.03	0.01	0.01	0.02	0.03	0.009	0.002	0.1	.....	.....	.....	.....

M_M: Mean of the intralaboratory means. s_M: Standard deviation of the intralaboratory means.

Calibration: CRMs or Primary Standards

- BCS CRM 348 – Ball Clay

SILICA

Analysts Nos. 1, 3, and 4 determined the bulk of the silica gravimetrically after double dehydration, and determined the residual silica photometrically as molybdenum blue. The remaining analysts determined silica by XRF, using a fused bead technique and synthetic calibration with pure materials.

ALUMINA

Analysts Nos. 1, 3, 4 and 9 separated iron and titanium by solvent extraction with cupferron and chloroform. No. 1 determined alumina gravimetrically as the oxinate. Nos. 3, 4 and 9 determined alumina titrimetrically. Nos. 3 and 9 added an excess of EDTA, and back titrated with standard zinc solution. No. 4 used an excess of DCTA. The remaining analysts used XRF.

Analyst No. 9 also determined alumina by XRF and obtained a mean value of 31.92%.

TITANIA

Analysts Nos. 1, 3, 4 and 9 determined titania photometrically, No. 1 with tiron, No. 3 with diantipyrylmethane and Nos. 4 and 9 with hydrogen peroxide. The remaining analysts used XRF.

Analyst No. 9 also determined titania by XRF and obtained a mean value of 1.16%.

FERRIC OXIDE

Analysts Nos. 1 and 3 determined iron photometrically with 1,10-phenanthroline. No. 4 determined iron titrimetrically with titanous chloride solution. The remaining analysts used XRF.

Calibration: CRMs or Primary Standards

- Primary Standards

Element	Report Cpd	Calib Cpd	Drying / C	min Mass / g	Factor
Si	SiO_2		1200	236.1600	1
Al	Al_2O_3		1200	23.1250	1
Fe	Fe_2O_3		700	1.5075	1
K	K_2O	K_2CO_3	220	2.5929	1.4672
Ti	TiO_2		1000	1.2825	1
Zr	ZrO2		1000	1.0800	1
Ba	BaO	$BaCO_3$	220	1.3900	1.2870
Ca	CaO	$CaCO_3$	220	2.1713	1.7848
Mn	Mn_3O_4	MnO_2	1000	1.2310	1.1398
Cr	Cr_2O_3		1000	1.0800	1
Na	Na_2O	Na_2CO_3	220	2.9844	1.7101
S	S	Li_2SO_4	220	3.7030	3.4287
S		Flux Correction factor			0.2718
Mg	MgO		1200	1.2825	1
W	WO3		110	0.9375	1

Calibration: CRMs or Primary Standards

Silica Calibration from Primary Oxides - Jan 2003

Flux 7.5000 g to 4 Sig. Figs Dried Sample 1.5000 g

%	mass / g	No.	mass / g	%
SiO_2		:	Al_2O_3	
0	0.0000	1	1.5000	100
0	0.0000	2	1.5000	100
5	0.0750	3	1.4250	95
10	0.1500	4	1.3500	90
20	0.3000	5	1.2000	80
30	0.4500	6	1.0500	70
40	0.6000	7	0.9000	60
50	0.7500	8	0.7500	50
50	0.7500	9	0.7500	50
60	0.9000	10	0.6000	40
70	1.0500	11	0.4500	30
80	1.2000	12	0.3000	20
90	1.3500	13	0.1500	10
92	1.3800	14	0.1200	8
94	1.4100	15	0.0900	6
96	1.4400	16	0.0600	4
98	1.4700	17	0.0300	2
100	1.5000	18	0.0000	0
100	1.5000	19	0.0000	0
SiO_2		:	CaO	
99.67	1.4951	20	0.0088	0.33
99.33	1.4900	21	0.0179	0.67
99.00	1.4850	22	0.0268	1.00

%	mass / g	No.	mass / g	%
SiO_2		:	Na_2O	
99.67	1.4951	49	0.0085	0.33
99.33	1.4900	50	0.0172	0.67
99.00	1.4850	51	0.0257	1.00
96.50	1.4475	52	0.0898	3.50
95.00	1.4250	53	0.1283	5.00
90.00	1.3500	54	0.2565	10.00
85.00	1.2750	55	0.3848	15.00
85.00	1.2750	56	0.3848	15.00
SiO_2		:	BaO	
99.67	1.4951	57	0.0064	0.33
99.33	1.4900	58	0.0129	0.67
99.00	1.4850	59	0.0193	1.00
95.00	1.4250	60	0.0965	5.00
95.00	1.4250	61	0.0965	5.00
SiO_2		:	Fe_2O_3	
99.75	1.4963	62	0.0038	0.25
99.50	1.4925	63	0.0075	0.50
99.25	1.4888	64	0.0113	0.75
99.00	1.4850	65	0.0150	1.00
97.00	1.4550	66	0.0450	3.00
95.00	1.4250	67	0.0750	5.00
90.00	1.3500	68	0.1500	10.00
90.00	1.3500	69	0.1500	10.00

Calibration: CRMs or Primary Standards

96.50	1.4475	**23**	0.0937	3.50
95.00	1.4250	**24**	0.1339	5.00
95.00	1.4250	**25**	0.1339	5.00
SiO_2		**:**	**TiO_2**	
99.67	1.4951	**26**	0.0050	0.33
99.33	1.4900	**27**	0.0101	0.67
99.00	1.4850	**28**	0.0150	1.00
96.50	1.4475	**29**	0.0525	3.50
95.00	1.4250	**30**	0.0750	5.00
95.00	1.4250	**31**	0.0750	5.00
SiO_2		**:**	**K_2O**	
99.67	1.4951	**32**	0.0073	0.33
99.33	1.4900	**33**	0.0147	0.67
99.00	1.4850	**34**	0.0220	1.00
98.50	1.4775	**35**	0.0330	1.50
97.50	1.4625	**36**	0.0550	2.50
95.00	1.4250	**37**	0.1100	5.00
90.00	1.3500	**38**	0.2201	10.00
85.00	1.2750	**39**	0.3301	15.00
85.00	1.2750	**40**	0.3301	15.00
SiO_2		**:**	**ZrO_2**	
99.67	1.4951	**41**	0.0050	0.33
99.33	1.4900	**42**	0.0101	0.67
99.00	1.4850	**43**	0.0150	1.00
95.00	1.4250	**44**	0.0750	5.00
95.00	1.4250	**45**	0.0750	5.00
SiO_2		**:**	**WO_3**	
99.50	1.4925	**46**	0.0075	0.50
99.00	1.4850	**47**	0.0150	1.00
99.00	1.4850	**48**	0.0150	1.00

SiO_2		**:**	**MgO**	
99.67	1.4951	**70**	0.0050	0.33
99.33	1.4900	**71**	0.0101	0.67
99.00	1.4850	**72**	0.0150	1.00
96.50	1.4475	**73**	0.0525	3.50
95.00	1.4250	**74**	0.0750	5.00
95.00	1.4250	**75**	0.0750	5.00
SiO_2		**:**	**Cr_2O_3**	
99.67	1.4951	**76**	0.0050	0.33
99.33	1.4900	**77**	0.0101	0.67
99.00	1.4850	**78**	0.0150	1.00
95.00	1.4250	**79**	0.0750	5.00
95.00	1.4250	**80**	0.0750	5.00
SiO_2		**:**	**Mn_3O_4**	
99.67	1.4951	**81**	0.0056	0.33
99.33	1.4900	**82**	0.0115	0.67
99.00	1.4850	**83**	0.0171	1.00
95.00	1.4250	**84**	0.0855	5.00
95.00	1.4250	**85**	0.0855	5.00
SiO_2		**:**	**S**	
99.67	1.4951	**86**	0.0170	0.33
			7.4954	Flux
99.33	1.4900	**87**	0.0345	0.67
			7.4906	Flux
99.00	1.4850	**88**	0.0514	1.00
			7.4860	Flux
95.00	1.4250	**89**	0.2572	5.00
			7.4301	Flux
95.00	1.4250	**90**	0.2572	5.00
			7.4301	Flux

Calibration: CRMs or Primary Standards

α – Correction Beads

Alumina Beads

% Oxide	5.00	Mass Bead / g	1.5000	[5 % by Mass of Oxide + 95 % Al_2O_3]

Al_2O_3	1.4250	**91**	0.0750	Fe_2O_3	
Al_2O_3	1.4250	**92**	0.0750	Fe_2O_3	
Al_2O_3	1.4250	**93**	0.1100	K_2O	
Al_2O_3	1.4250	**94**	0.1100	K_2O	
Al_2O_3	1.4250	**95**	0.0750	TiO_2	
Al_2O_3	1.4250	**96**	0.0750	TiO_2	
Al_2O_3	1.4250	**97**	0.0750	MgO	
Al_2O_3	1.4250	**98**	0.0750	MgO	
Al_2O_3	1.3500	**99**	0.2565	Na_2O	10 % Na_2O, therefore 90 % alumina
Al_2O_3	1.3500	**100**	0.2565	Na_2O	10 % Na_2O, therefore 90 % alumina
Al_2O_3	1.4250	**101**	0.1339	CaO	
Al_2O_3	1.4250	**102**	0.1339	CaO	

Silica Beads

% Oxide	5.00	Mass Silica / g	1.3500	[5 % by Mass of each Oxide + 90 % SiO_2]

Fe_2O_3	0.0750	**103**	0.1100	K_2O		
Fe_2O_3	0.0750	**104**	0.1100	K_2O		
Fe_2O_3	0.0750	**105**	0.0750	TiO_2		
Fe_2O_3	0.0750	**106**	0.0750	TiO_2		
Fe_2O_3	0.0750	**107**	0.0750	MgO		
Fe_2O_3	0.0750	**108**	0.0750	MgO		
Fe_2O_3	0.0750	**109**	0.2565	Na_2O	Silica 1.275 g	10 % Na_2O, therefore 85 % silica
Fe_2O_3	0.0750	**110**	0.2565	Na_2O	Silica 1.275 g	10 % Na_2O, therefore 85 % silica
Fe_2O_3	0.0750	**111**	0.1339	CaO		
Fe_2O_3	0.0750	**112**	0.1339	CaO		

Calibration: CRMs or Primary Standards

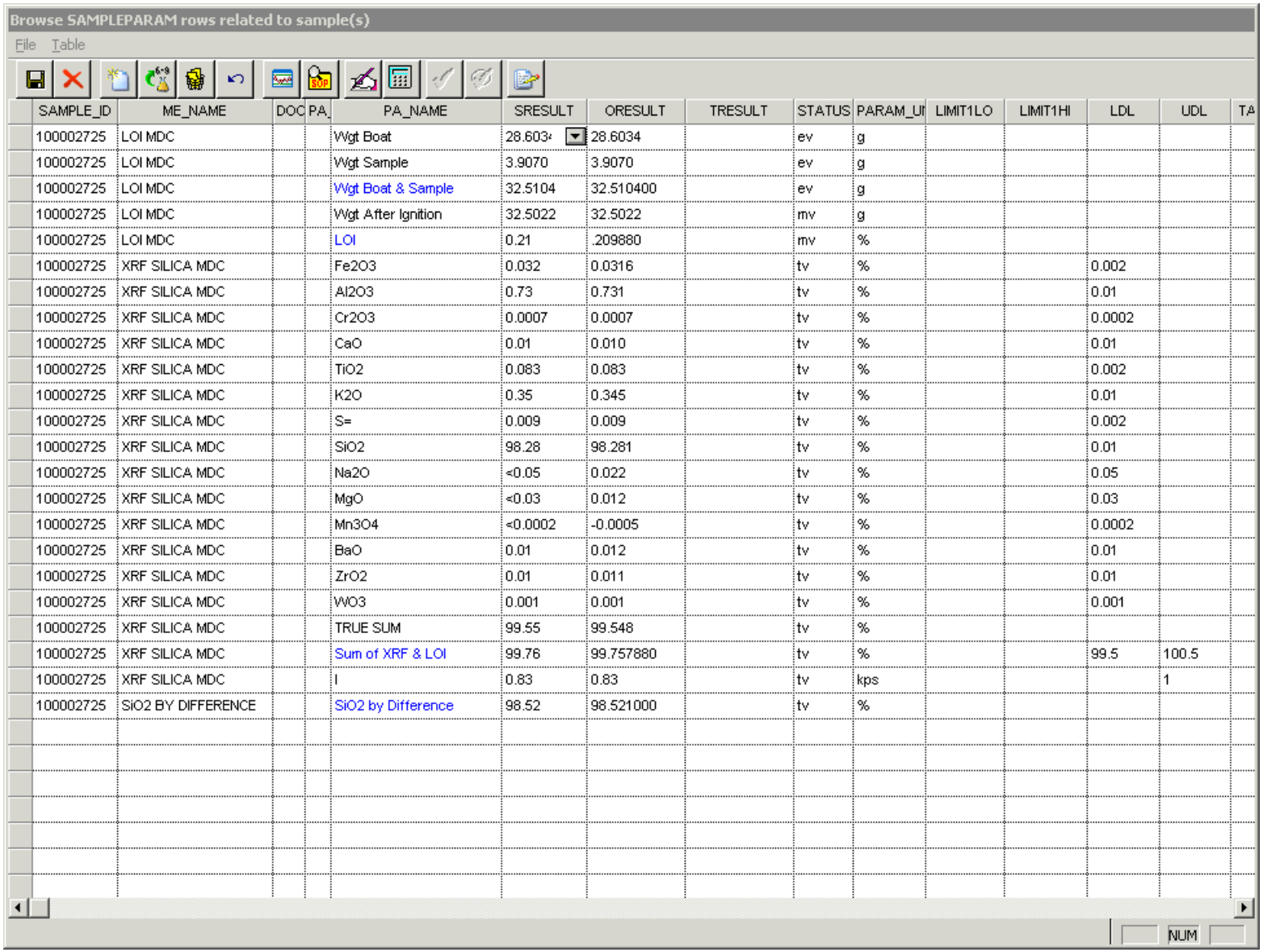
- CRMS
  - Limited range of elements covered
  - Vital Calibration Check Materials

- Primary Oxides
  - ~ 200 Combinations for Main Calibrations:
  - Quartz Glass Sands
  - Quartz Sand Exploration and Mineral Processing
  - Clays – Kaolins and Ball Clays
  - Feldspars – Alkali and plagioclase
- Beads at least in duplicate!!!
- Used to Analyse Appropriate Local Minerals
  - In-house Secondary Standards

Presentation Outline

Glass Sands and Clays

Challenges – Glass Sands



Browse SAMPLEPARAM rows related to sample(s)

File Table

SAMPLE_ID	ME_NAME	DOC	PA_	PA_NAME	SRESULT	ORESULT	TRESULT	STATUS	PARAM_UI	LIMIT1LO	LIMIT1HI	LDL	UDL	TA
100002725	LOI MDC			Wgt Boat	28.603	28.6034		ev	g					
100002725	LOI MDC			Wgt Sample	3.9070	3.9070		ev	g					
100002725	LOI MDC			Wgt Boat & Sample	32.5104	32.510400		ev	g					
100002725	LOI MDC			Wgt After Ignition	32.5022	32.5022		mv	g					
100002725	LOI MDC			LOI	0.21	.209880		mv	%					
100002725	XRF SILICA MDC			Fe2O3	0.032	0.0316		tv	%			0.002		
100002725	XRF SILICA MDC			Al2O3	0.73	0.731		tv	%			0.01		
100002725	XRF SILICA MDC			Cr2O3	0.0007	0.0007		tv	%			0.0002		
100002725	XRF SILICA MDC			CaO	0.01	0.010		tv	%			0.01		
100002725	XRF SILICA MDC			TiO2	0.083	0.083		tv	%			0.002		
100002725	XRF SILICA MDC			K2O	0.35	0.345		tv	%			0.01		
100002725	XRF SILICA MDC			S=	0.009	0.009		tv	%			0.002		
100002725	XRF SILICA MDC			SiO2	98.28	98.281		tv	%			0.01		
100002725	XRF SILICA MDC			Na2O	<0.05	0.022		tv	%			0.05		
100002725	XRF SILICA MDC			MgO	<0.03	0.012		tv	%			0.03		
100002725	XRF SILICA MDC			Mn3O4	<0.0002	-0.0005		tv	%			0.0002		
100002725	XRF SILICA MDC			BaO	0.01	0.012		tv	%			0.01		
100002725	XRF SILICA MDC			ZrO2	0.01	0.011		tv	%			0.01		
100002725	XRF SILICA MDC			WO3	0.001	0.001		tv	%			0.001		
100002725	XRF SILICA MDC			TRUE SUM	99.55	99.548		tv	%					
100002725	XRF SILICA MDC			Sum of XRF & LOI	99.76	99.757880		tv	%			99.5	100.5	
100002725	XRF SILICA MDC			I	0.83	0.83		tv	kps				1	
100002725	SiO2 BY DIFFERENCE			SiO2 by Difference	98.52	98.521000		tv	%					

NUM

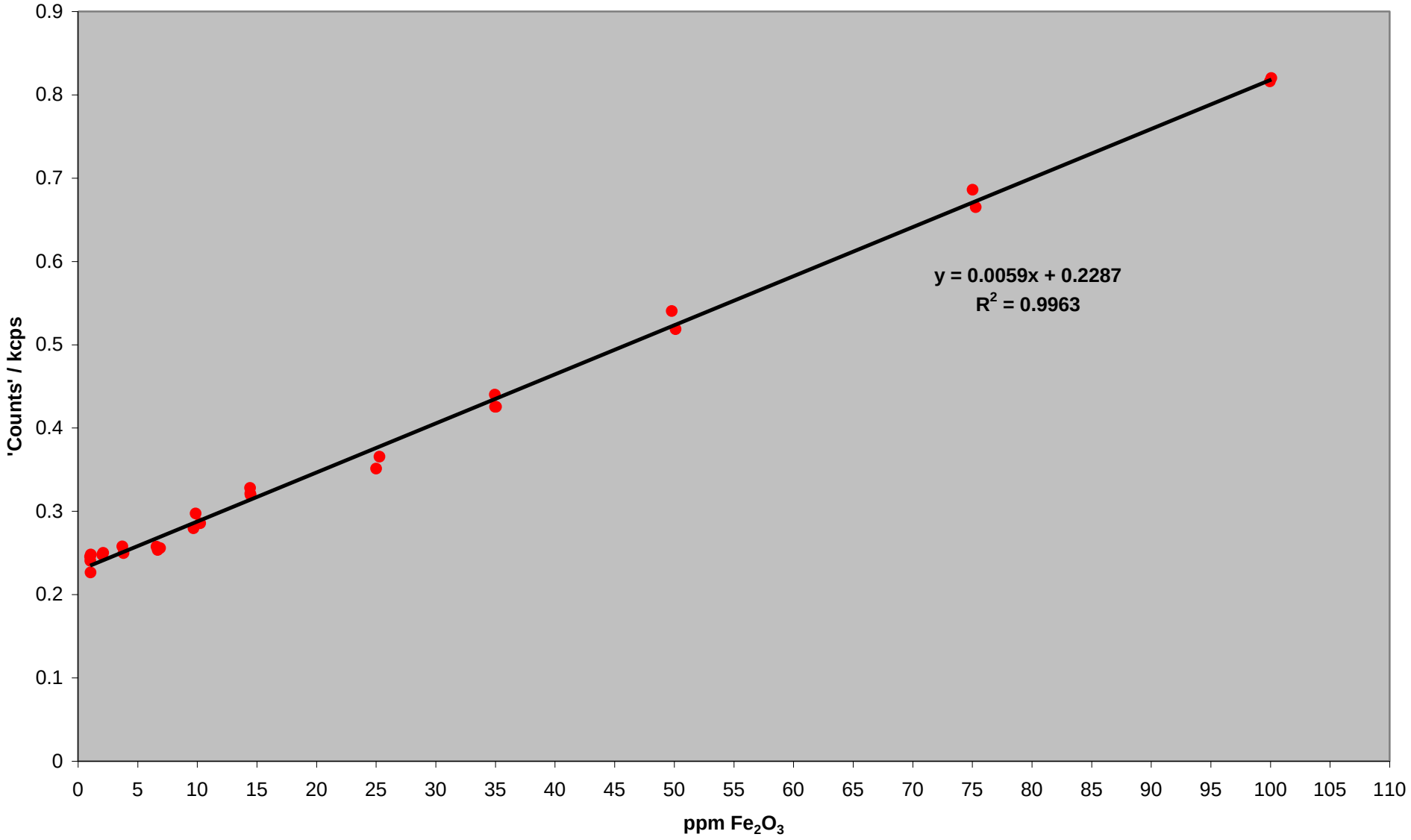
SIBELCO EUROPE

Glass Sands

- Require very low levels of:
  - Refractory Oxides – Cr_2O_3
    - Usually ICP as ~5 ppm
  - Colouring oxides – Fe_2O_3
    - 50 – 350 ppm
- Becoming more challenging:
- Solar Glass
- Coated Glass

- No alpha corrections required for dilute beads

Glass Sand – Low Fe2O3 Calibration



SIBELCO EUROPE

Challenges – Clays and Feldspars

Browse SAMPLEPARAM rows related to sample(s)

File Table

SAMPLE_ID	ME_NAME	DOC	PA	PA_NAME	SRESULT	ORESULT	TRESULT	STATUS	PARAM_UI	LIMIT1LO	LIMIT1HI	LDL	UDL
100003277	CL PREP RAW MATERIA			Raw Material Prep Complet	Yes	Yes		ev					
100003277	CL WET SIEVE +125um			Initial Dry Wgt	1000.00	1000		ev	g				
100003277	CL WET SIEVE +125um			Residue Wgt 125um	0.31	.31		ev	g				
100003277	CL WET SIEVE +125um			Res >125um	0.03	.031000		ev	%				
100003277	CL WET SIEVE +125um			Res <125um	99.97	99.969000		ev					
100003277	LOI MDC			Wgt Boat	28.6185	28.6185		ev	g				
100003277	LOI MDC			Wgt Sample	7.5243	7.5243		ev	g				
100003277	LOI MDC			Wgt Boat & Sample	36.1428	36.142800		ev	g				
100003277	LOI MDC			Wgt After Ignition	35.3728	35.3728		ev	g				
100003277	LOI MDC			LOI	10.23	10.233510		ev	%				
100003277	XRF CLAY			XRF Fe2O3	1.1618	1.161823948		tv					
100003277	XRF CLAY			XRF Al2O3	29.6286	29.62860194		tv					
100003277	XRF CLAY			XRF CaO	0.1622	0.162200376		tv					
100003277	XRF CLAY			XRF TiO2	1.5333	1.533252607		tv					
100003277	XRF CLAY			XRF K2O	2.1810	2.181033981		tv					
100003277	XRF CLAY			XRF SiO2	64.6108	64.61083641		tv					
100003277	XRF CLAY			XRF Na2O	0.3285	0.328481264		tv					
100003277	XRF CLAY			XRF MgO	0.3938	0.393769465		tv					
100003277	XRF CLAY			XRF I	0.5000	0.5		tv					1
100003277	XRF CLAY			TRUE SUM	100.00	100		tv				98	100.5
100003277	XRF CLAY			SiO2	58.0	57.998880		tv	%			0.01	
100003277	XRF CLAY			Al2O3	26.6	26.596556		tv	%			0.01	
100003277	XRF CLAY			Fe2O3	1.04	1.042929		tv	%			0.002	
100003277	XRF CLAY			TiO2	1.38	1.376347		tv	%			0.002	
100003277	XRF CLAY			CaO	0.15	.145602		tv	%			0.01	
100003277	XRF CLAY			K2O	1.96	1.957838		tv	%			0.01	
100003277	XRF CLAY			Na2O	0.29	.294866		tv	%			0.01	
100003277	XRF CLAY			MgO	0.35	.353473		tv	%			0.01	
100003277	LECO CARBON SULPHU			Carbon	1.735	1.735		ev	%				

Clays and Feldspars

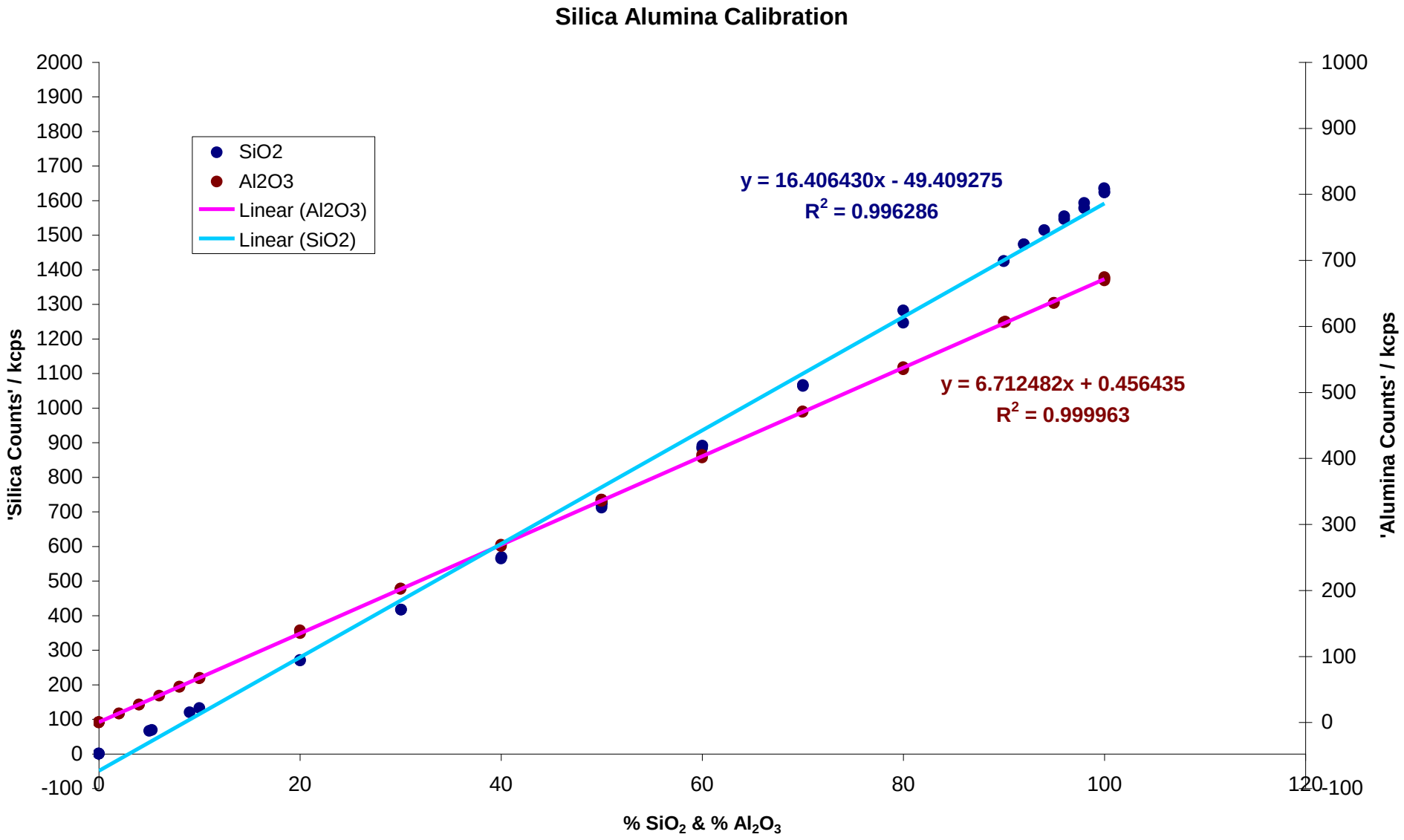
- For dilute beads and primary oxides:
  - Linear calibration lines
  - Simple calculation of alpha corrections

- Lachance-Traill:
  - $C=c + m*I*(1+\Sigma\alpha_i C_i)$

- Primary Oxides therefore reduces to single term

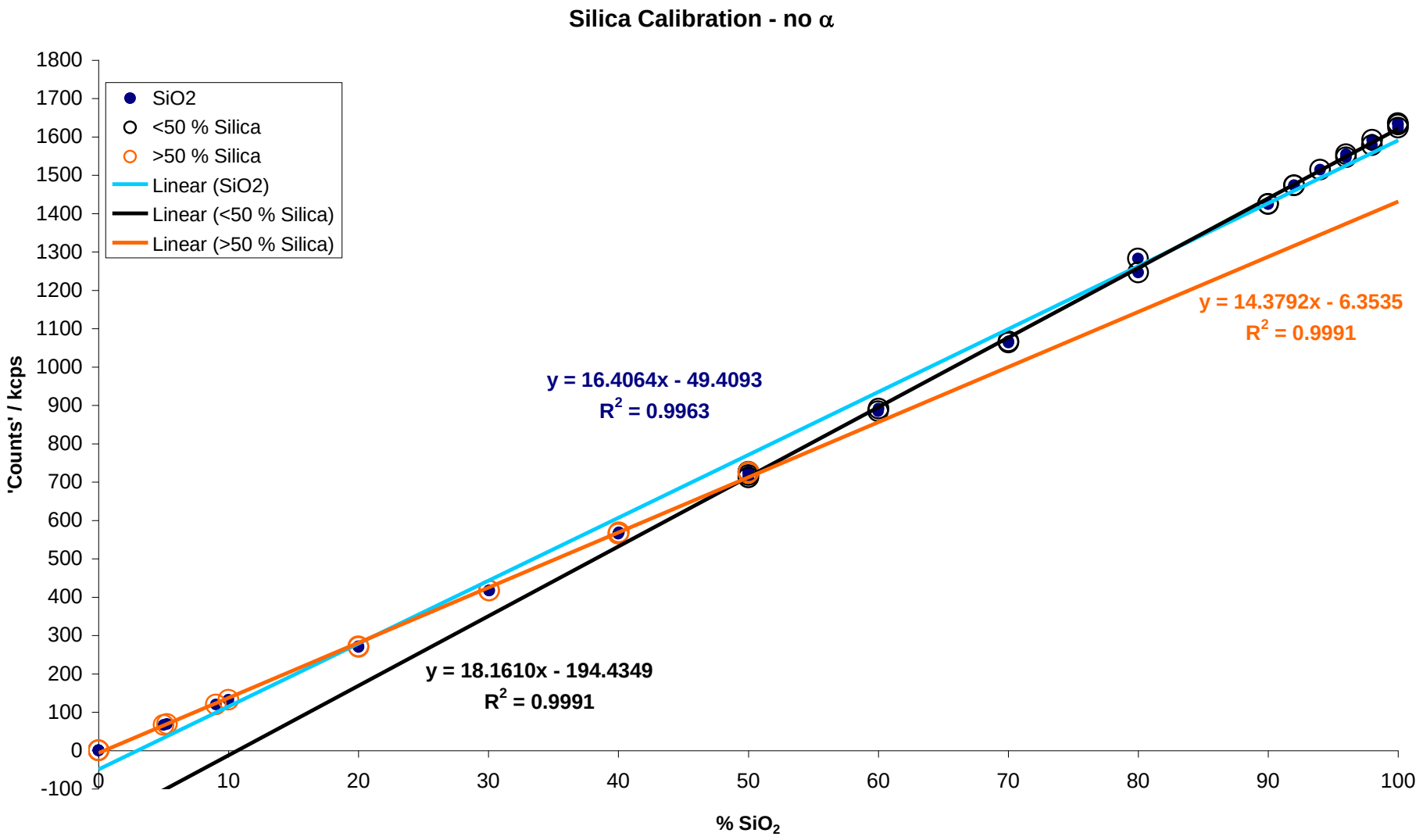
- clay and feldspar.xls – Now as Slides

α-Correction

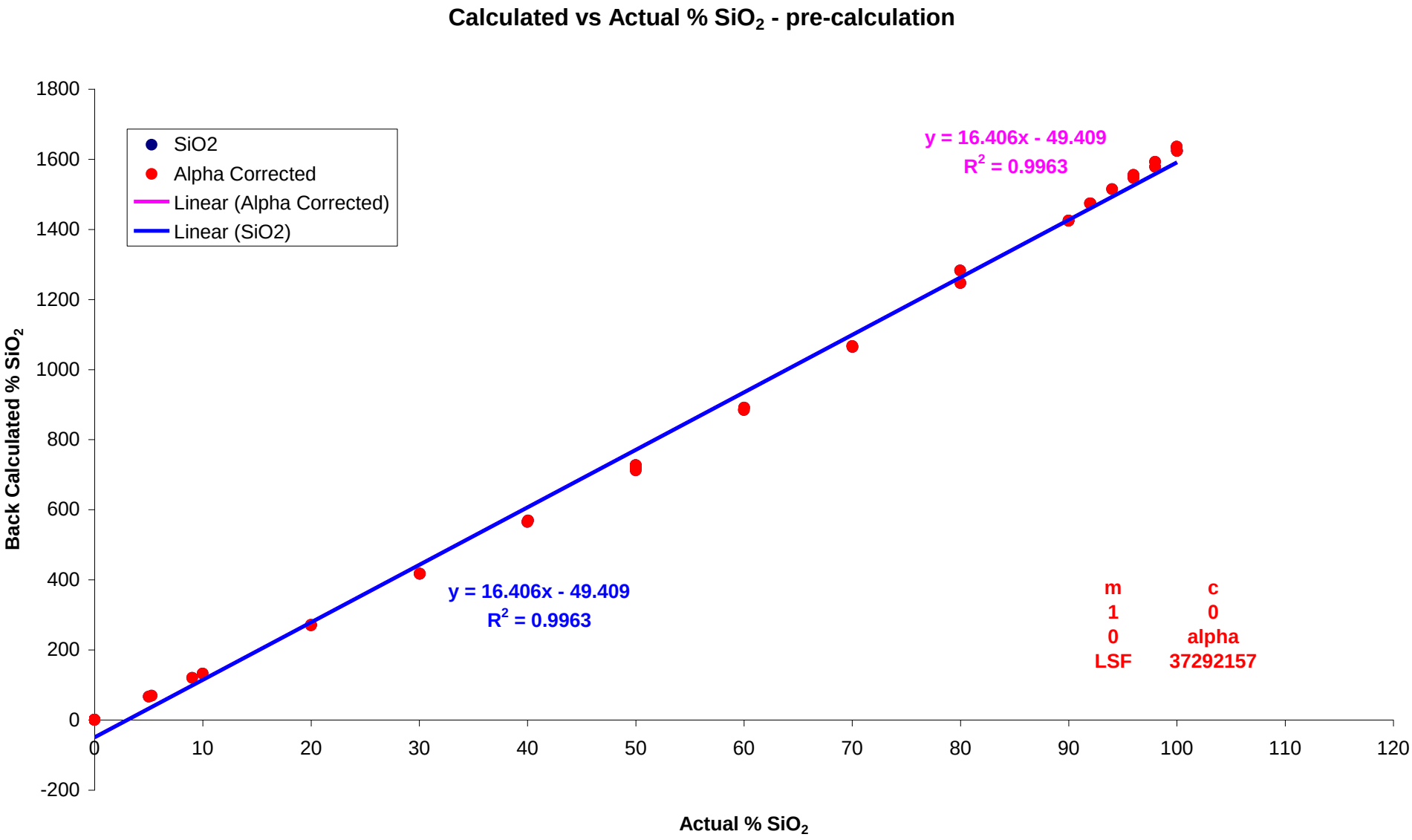


SIBELCO EUROPE

α-Correction



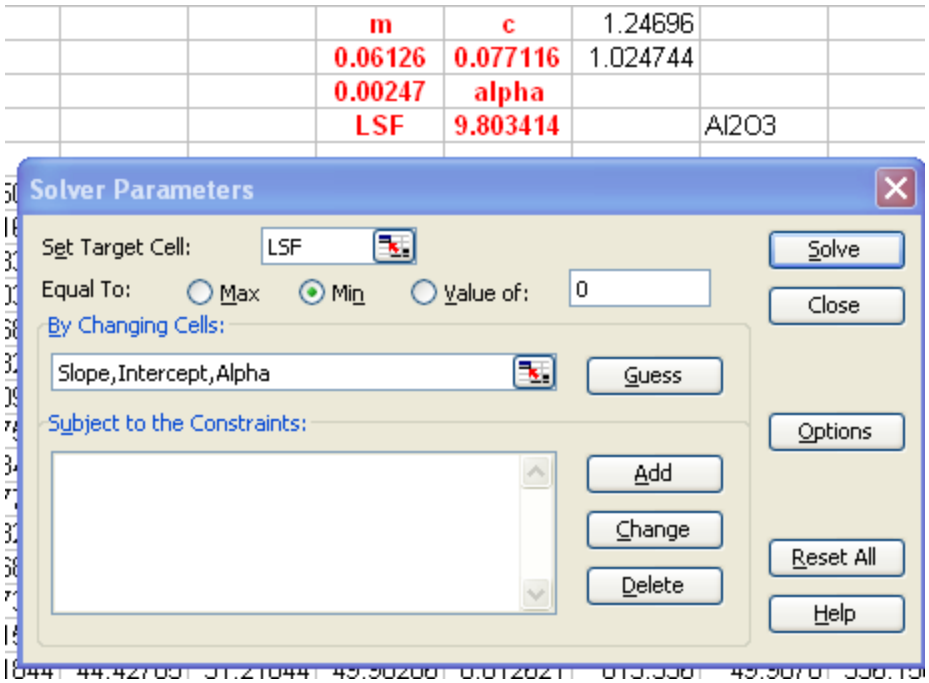
α-Correction



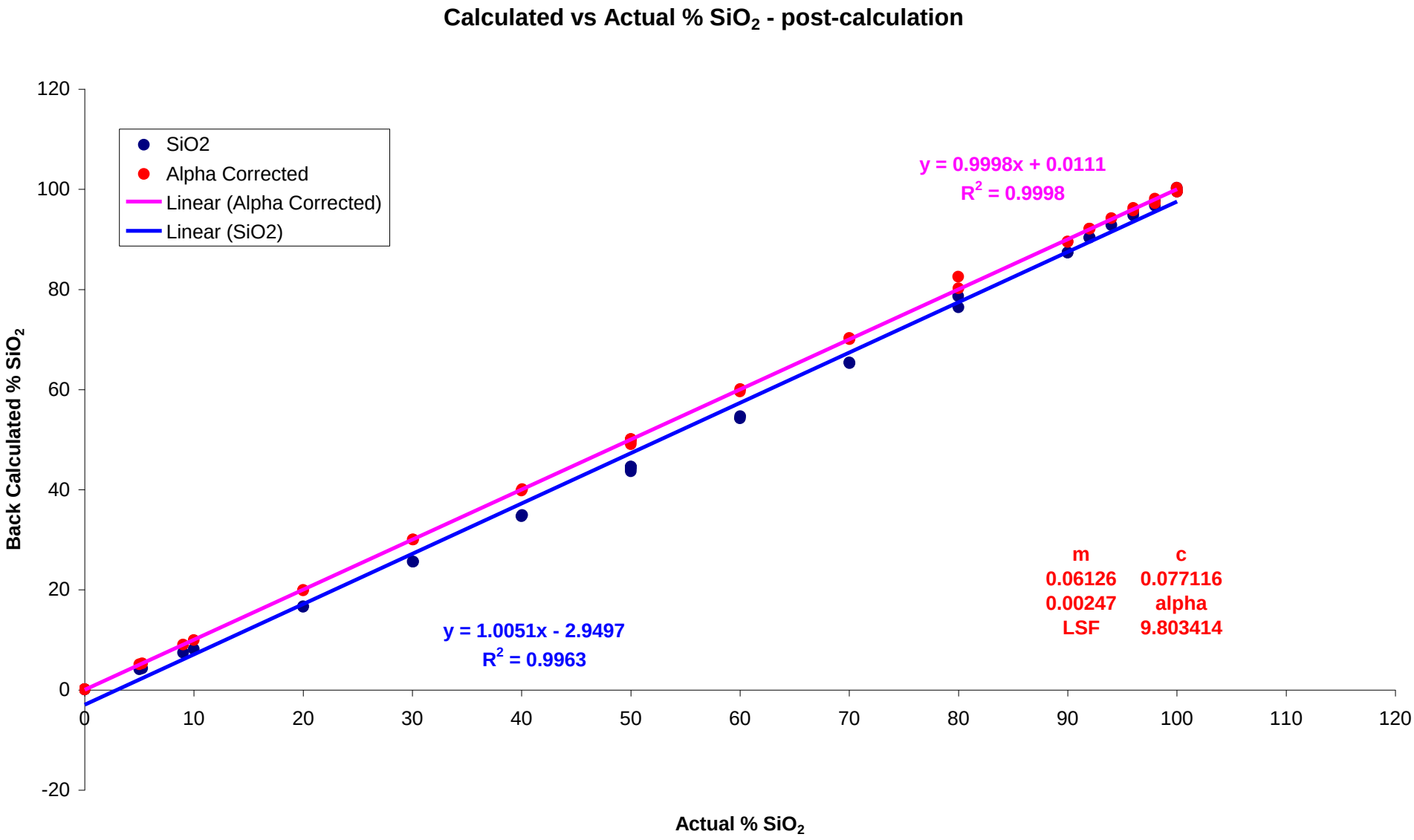
SIBELCO EUROPE

α-Correction

m	c
1	0
0	alpha
LSF	37292157

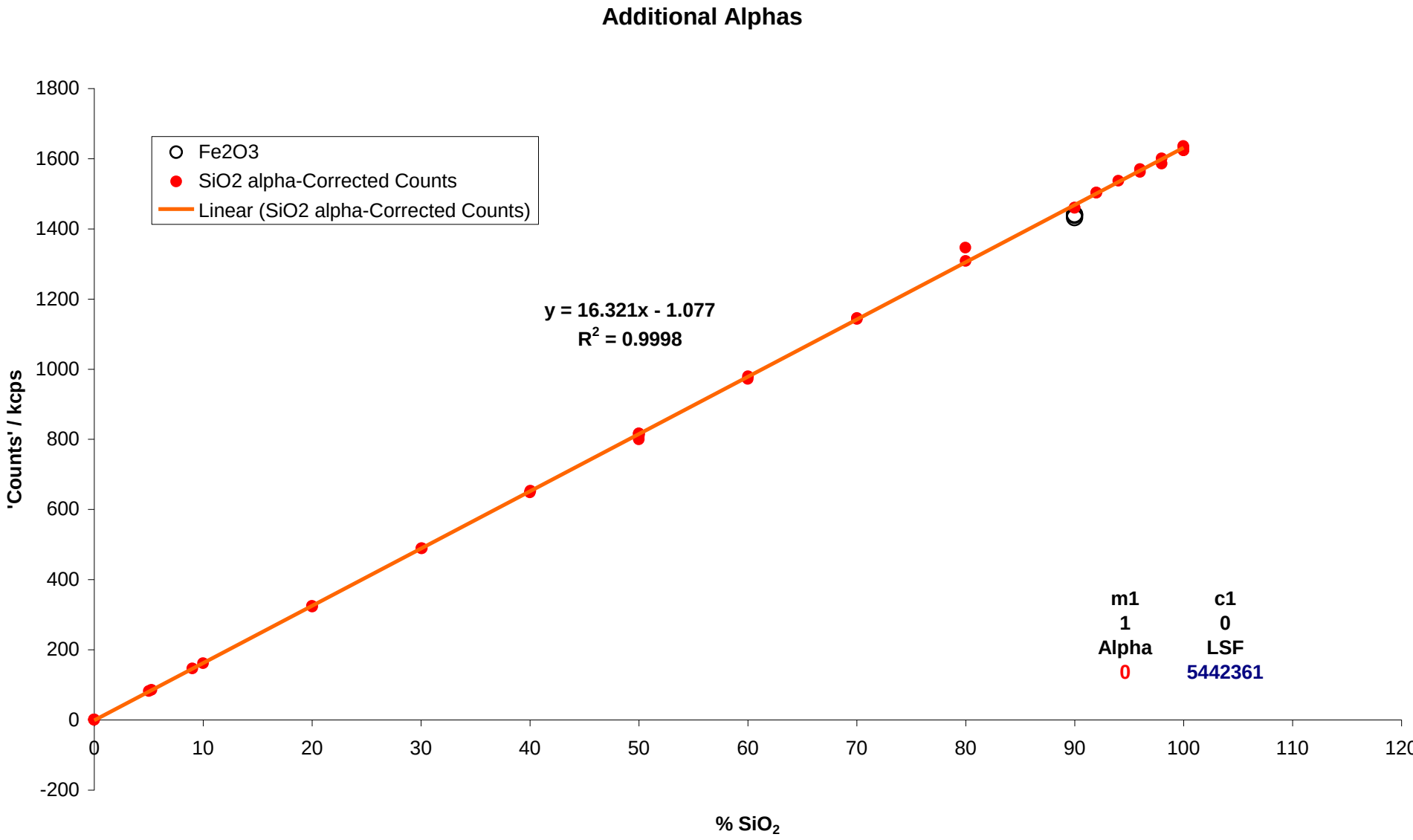


α-Correction



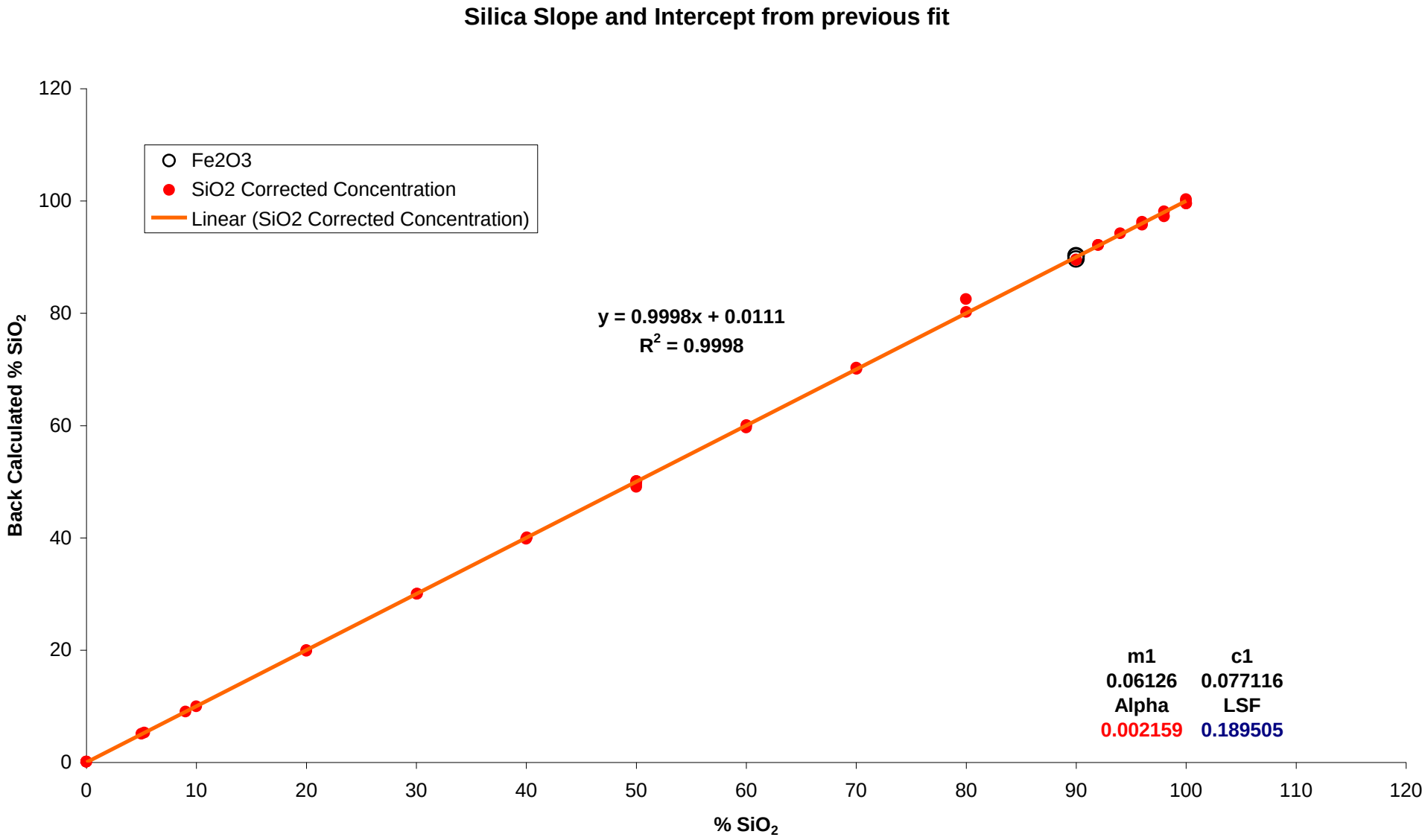
SIBELCO EUROPE

Fe_2O_3 α-Correction



SIBELCO EUROPE

Fe_2O_3 α-Correction



SIBELCO EUROPE

Alpha Corrections Alumino Silicates

Compound	Calibrated	Channel	D	E	F	RMS	RE
SiO2	Yes	Si1	! -0.04301	! 0.06129	! 0.00000	0.46253	
Al2O3	Yes	Al1	! -0.00875	! 0.14878	! 0.00000	0.22432	
Fe2O3	Yes	Fe1	! -0.00406	! 0.01858	! 0.00000	0.03644	
TiO2	Yes	Ti1	! 0.00095	! 0.11808	! 0.00000	0.01502	
CaO	Yes	Ca1	! 0.00020	! 0.05757	! 0.00000	0.01256	
K2O	Yes	K1	! 0.00072	! 0.06249	! 0.00000	0.03646	
Na2O	Yes	Na1	! -0.05418	! 0.34628	! 0.00000	0.02676	
MgO	Yes	Mg1	! -0.07444	! 0.14409	! 0.00000	0.01794	
I	Yes	I	! 0.00000	! 1.00000	! 0.00000	1.96346	

Correction coefficients:

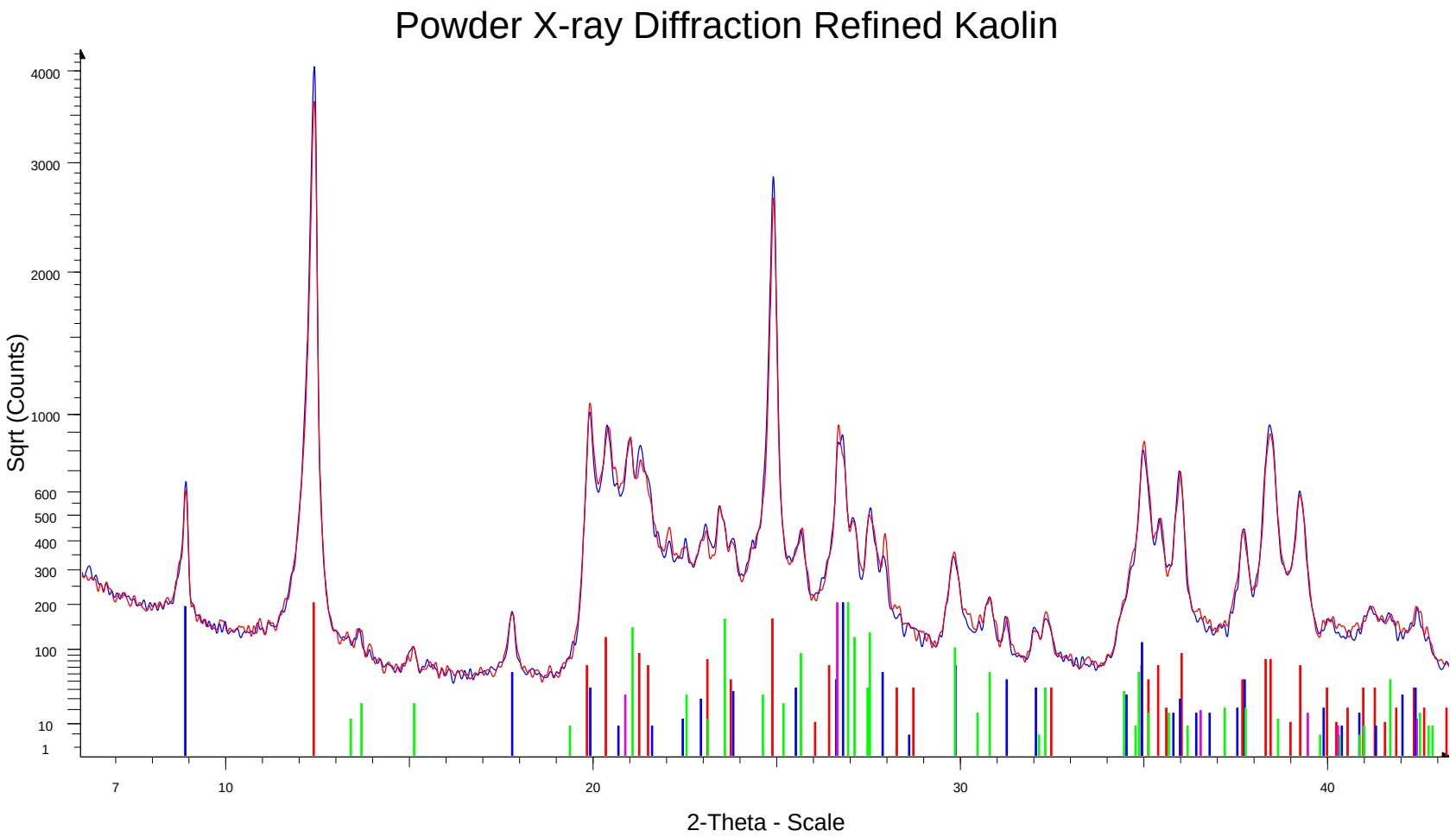
Compound	Alpha Al2O3	Alpha Fe2O3	Alpha TiO2	Alpha CaO	Alpha K2O	Alpha Na2O	Alpha MgO
SiO2	! 0.2555	! 0.1812	! 0.0084	! 0.0004	! -0.0855	! 0.1377	! 0.2283
Al2O3		! 0.1691	! 0.1674	! 0.1067	! 0.0497	! 0.2281	! 0.3615
Fe2O3	! -0.0687		! 0.8289	! 0.8150	! 0.6999	! -0.2795	! -0.3570
TiO2	! -0.0484	! -0.3257		! 1.0152	! 0.8114	! -0.2159	! -0.2378
CaO	! -0.0586	! -0.2728	! -0.4232		! 0.7852	! -0.1340	! -0.1472
K2O	! -0.0446	! -0.1648	! -0.1856	! 0.4367		! 0.6431	! 0.0199
Na2O	! -0.0202	! 0.3091	! 0.2423	! 0.2059	! 0.2370		! 0.0487
MgO	! -0.0616	! 0.0585	! 0.0440	! 0.6165	! 0.0425	! 0.3219	
I							

Should be <1 for dilute beads

Presentation Outline

Mineralogy – XRF and XRD

Mineralogy Refined Kaolin



Presentation Outline

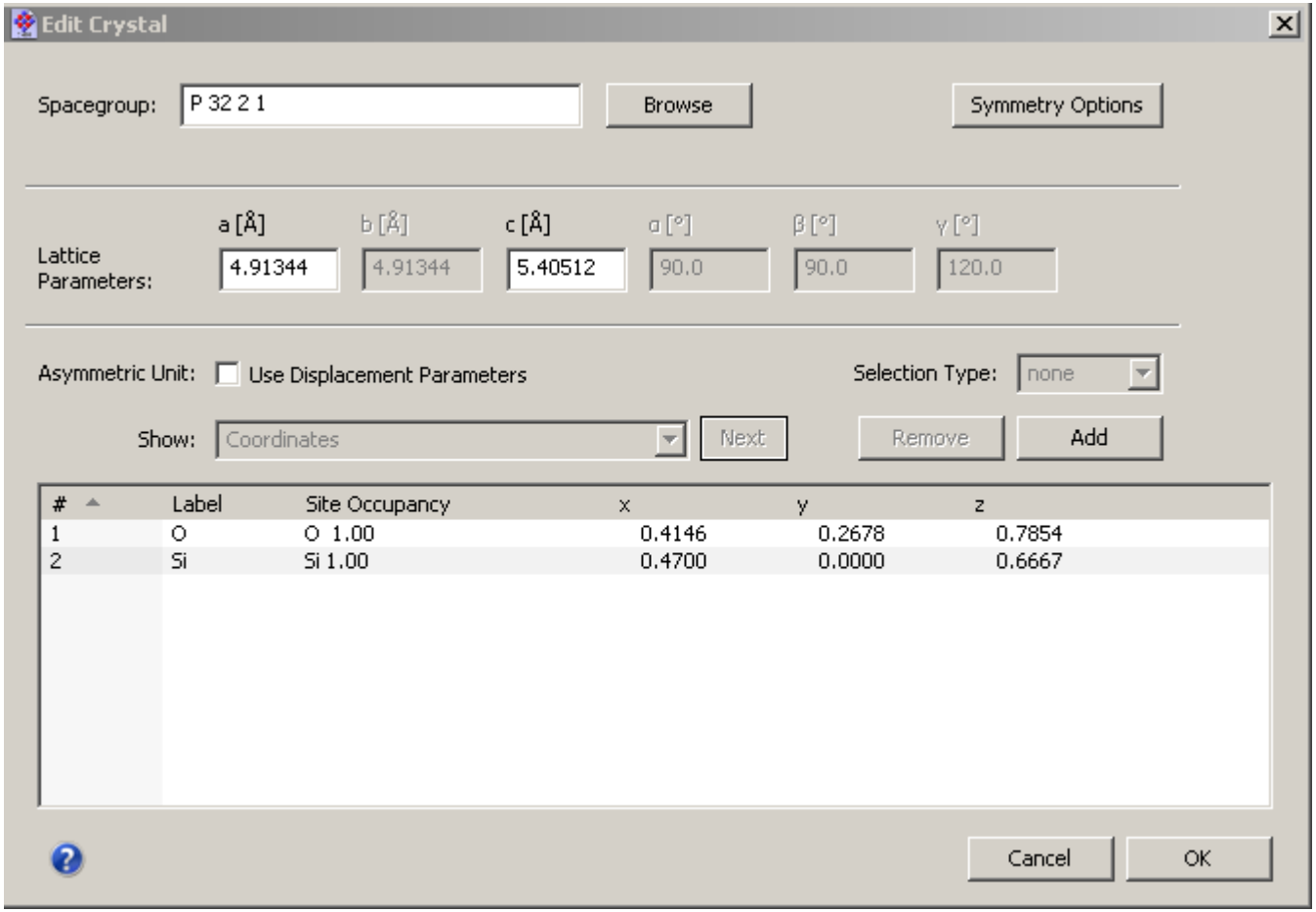
Quartz Standards and Crystallinity

Quartz Standards and Crystallinity

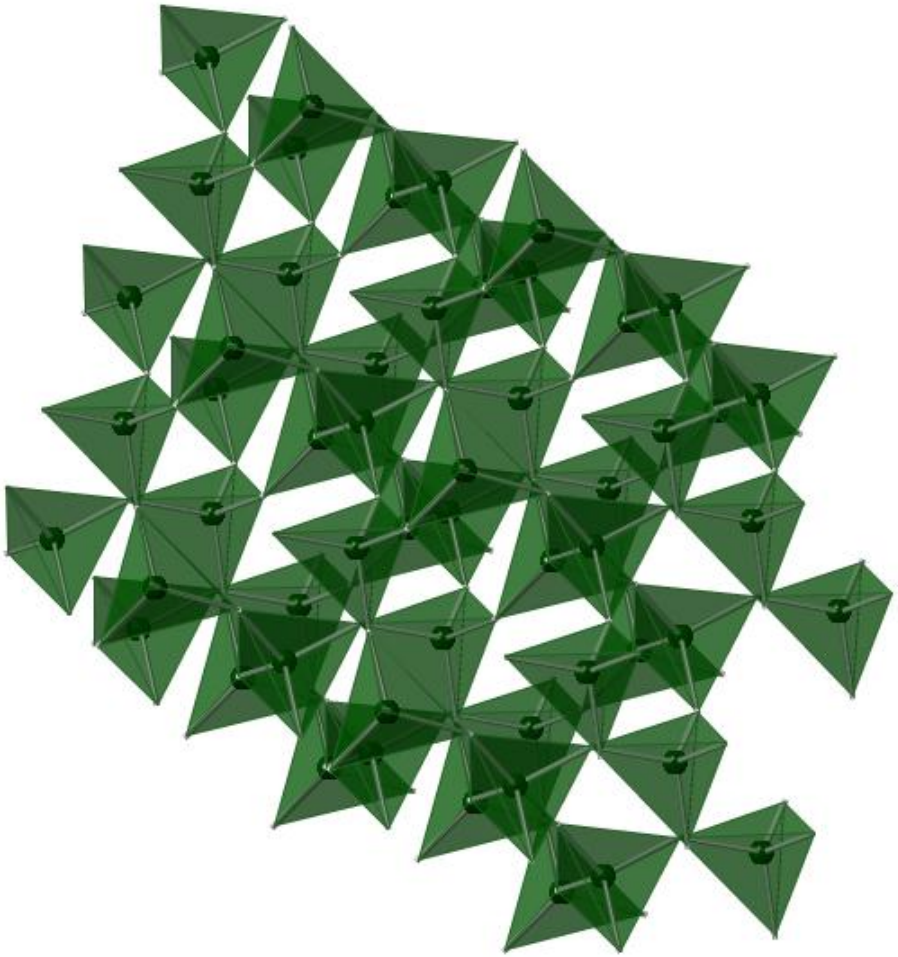
- Issue is Amorphous Content –
  - Is it really there?

- Important for:
  - Respirable Silica Analysis
  - New STOT Labelling Regulations

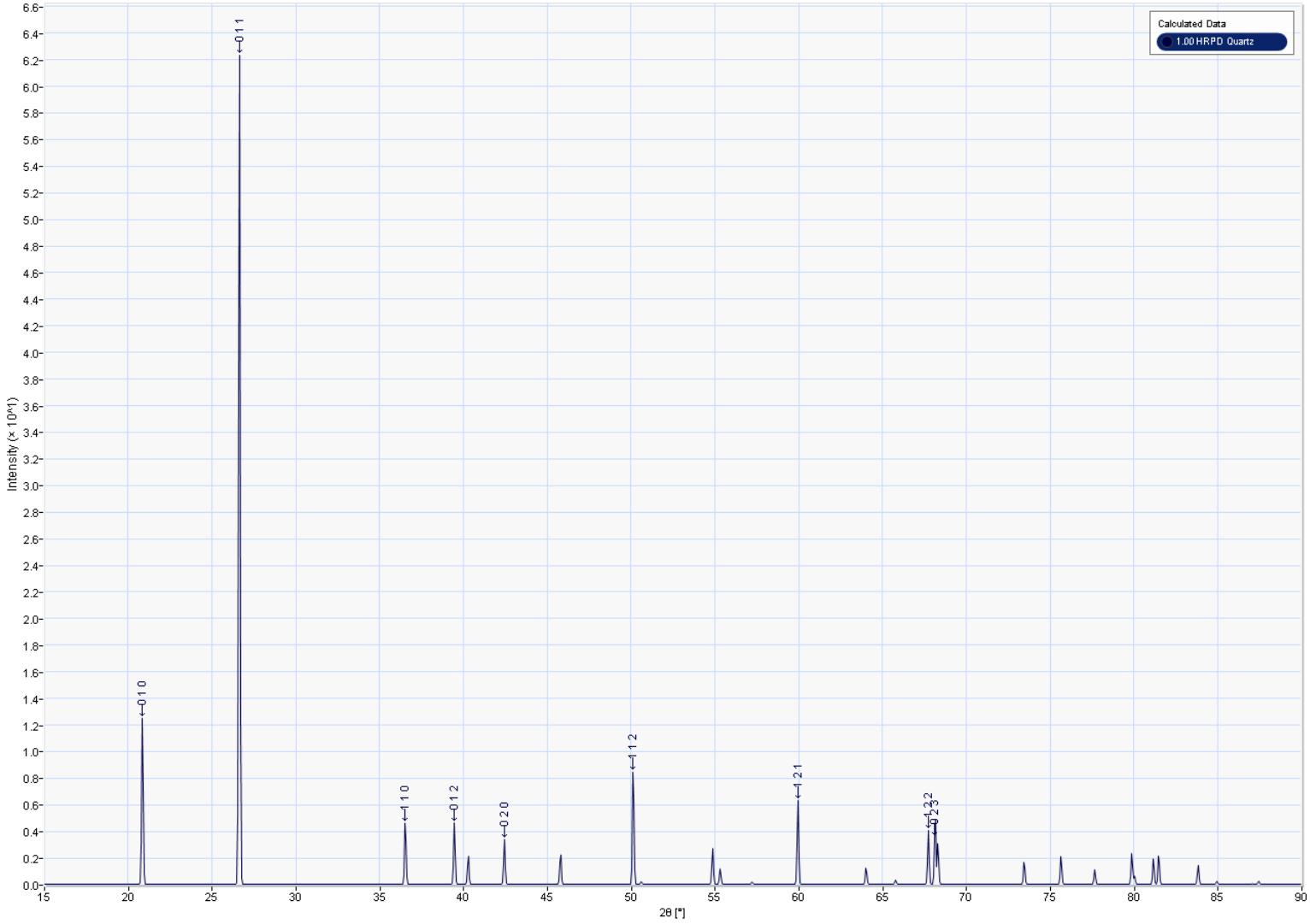
Quartz Standards and Crystallinity



Quartz Standards and Crystallinity

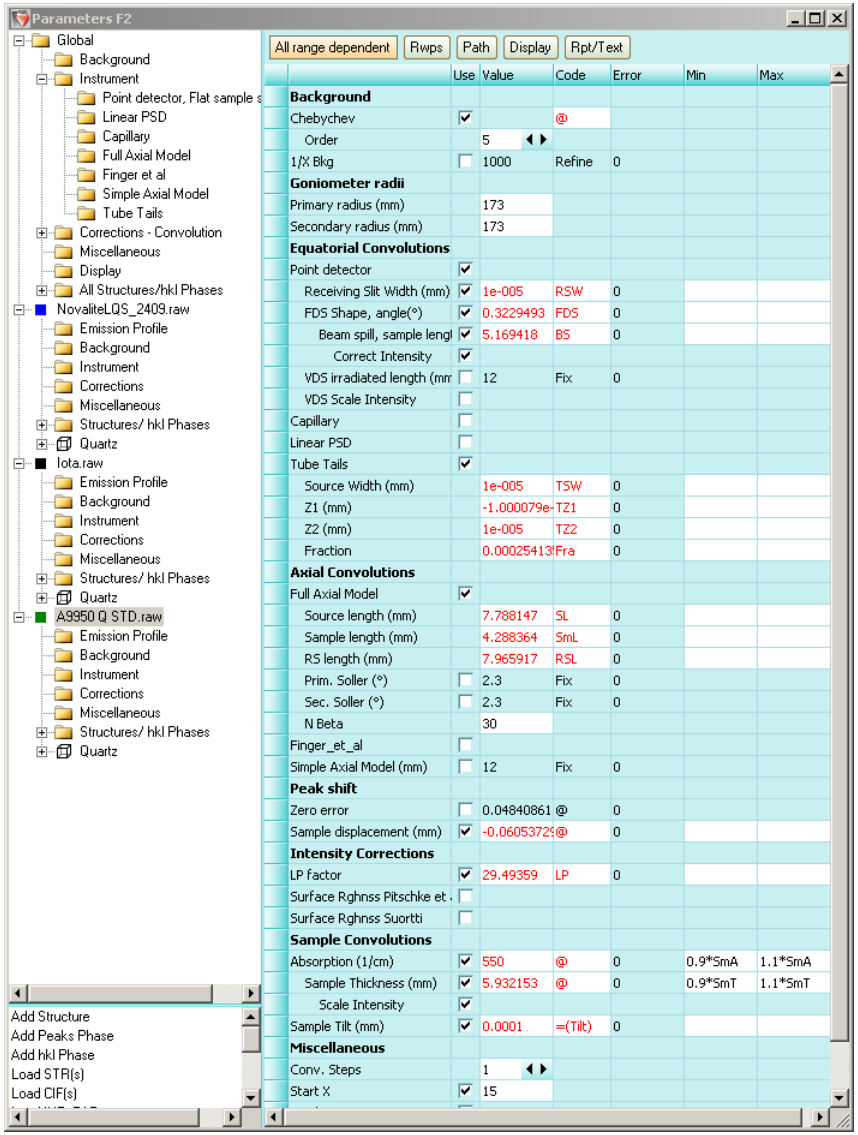


Quartz Standards and Crystallinity



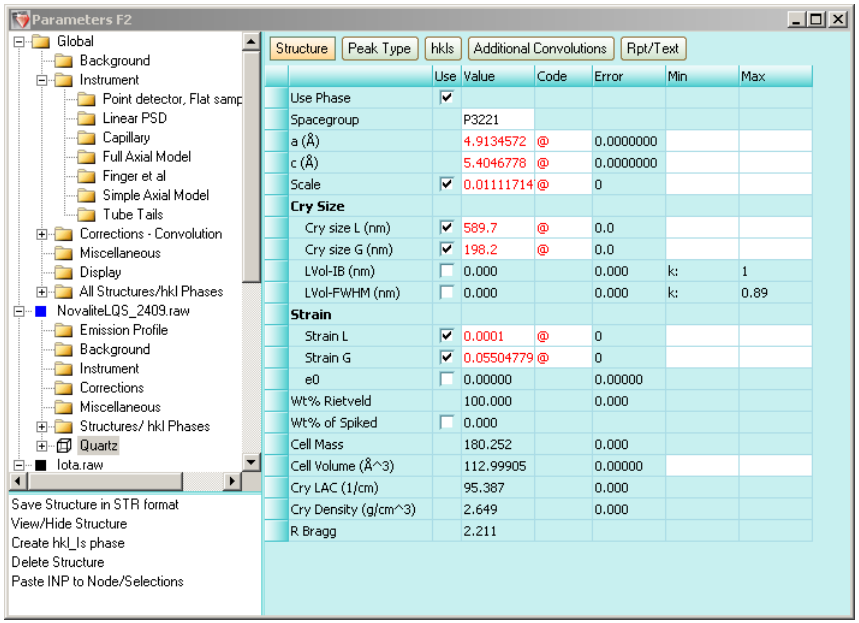
SIBELCO EUROPE

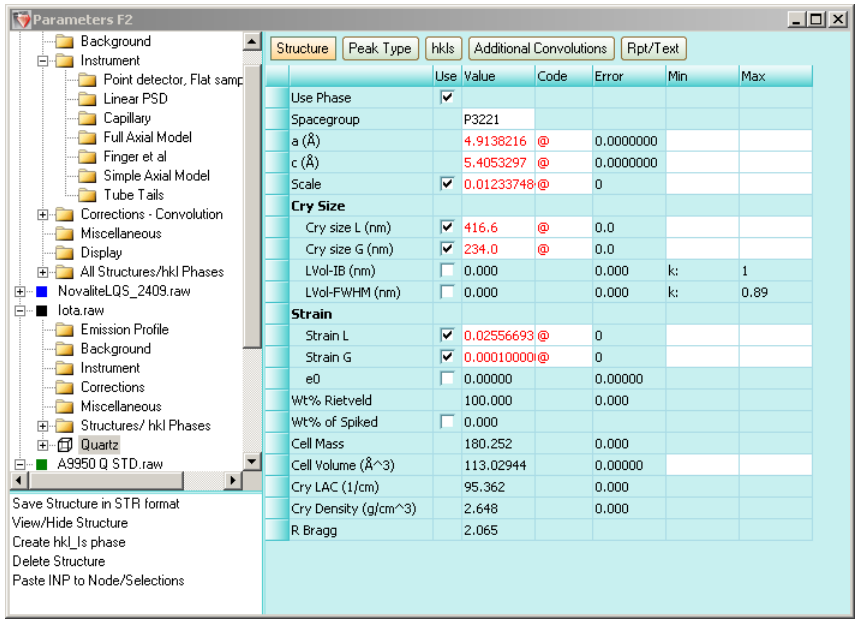
Quartz Standards and Crystallinity

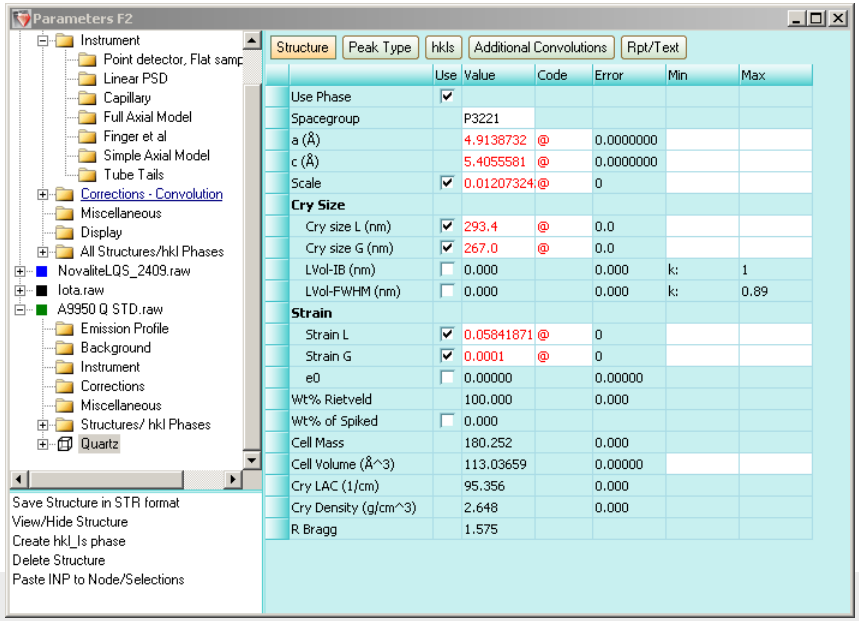


SIBELCO EUROPE

Quartz Standards and Crystallinity

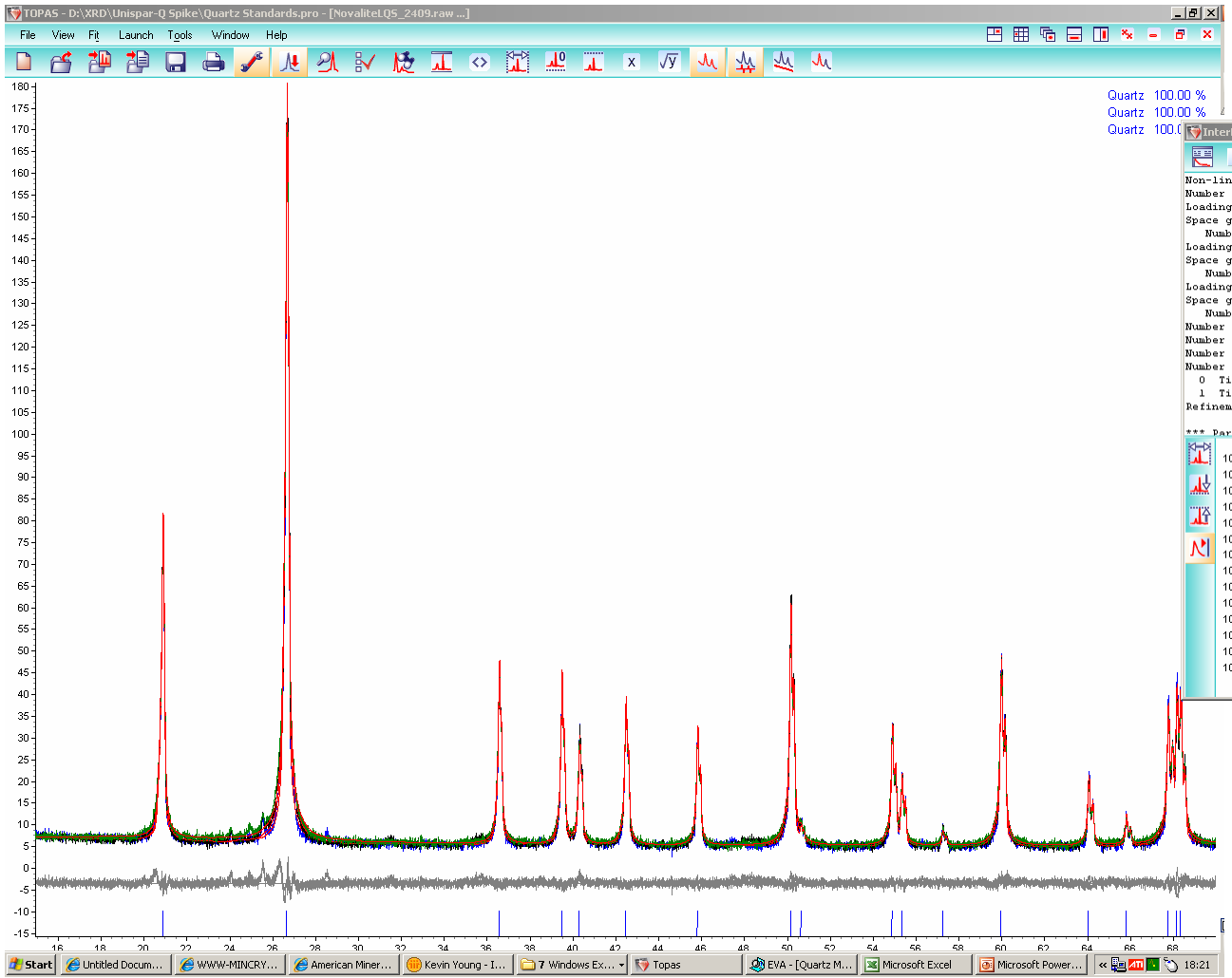


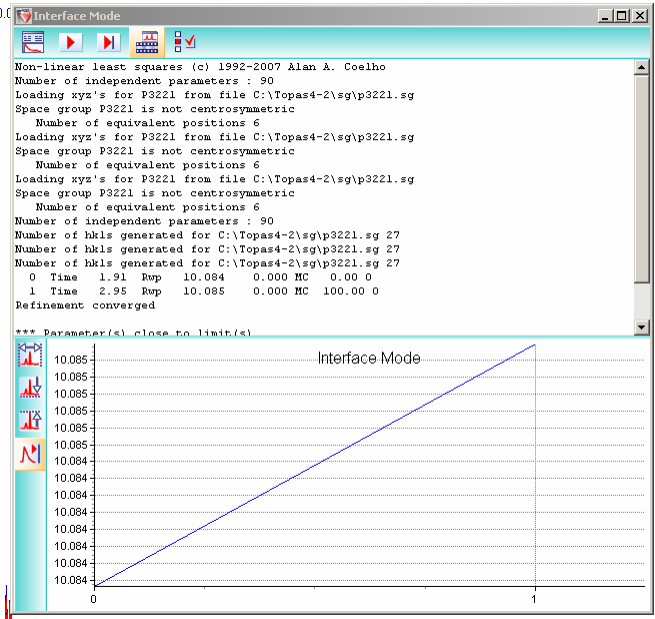




SIBELCO EUROPE

Quartz Standards and Crystallinity





SIBELCO EUROPE

The End

- Sorry for being late

- Thank You for Listening