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Idaho National Laboratory Cultural
Resource Management Office

INL CRMO XRF Calibration Methods for the Analysis of Ceramics and Brick

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ABSTRACT

This report details the analytical methods used by the Idaho National Laboratory Cultural Resource Management Office to characterize ceramic and brick artifacts using X-ray fluorescence spectrometry. More specifically, this report provides details on instrumentation, analysis times, and matrix-specific calibration protocols for ceramic materials. Calibration curves were developed to adjust raw instrumental output for 13 elements using a suite of reference standards made from historic brick borrowed from the Yale Peabody Museum. Calibration curves were validated by plotting predicted values against published reference values for the calibration set as well as a certified soil reference standard (SRM 2711a).

ACRONYMS

BRICC	Bricks and Rocks for Instruments' Ceramic Calibration
CRMO	Cultural Resource Management Office
ED-XRF	Energy Dispersive X-ray Fluorescence
FP	Fundamental Parameters
ICP-MS	Inductively Coupled Plasma Mass Spectrometry
INL	Idaho National Laboratory
NIST	National Institute of Standards and Technology
NAA	Neutron Activation Analysis
PPM	Parts Per Million
SDD	Silicon Drift Detector
SRM	Standard Reference Material
WD-XRF	Wavelength-Dispersive X-Ray Fluorescence

Elements

Al	aluminum
K	potassium
Ca	calcium
Ti	titanium
Mn	manganese
Fe	iron
Zn	zinc
Rb	rubidium
Rh	rhodium
Sr	strontium
Y	yttrium
Zr	zirconium
Nb	niobium
Ba	barium

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OVERVIEW

This report details the analytical methods employed by the Idaho National Laboratory (INL) Cultural Resource Management Office (CRMO) when using energy-dispersive X-ray fluorescence (ED-XRF) spectrometry to analyze archaeological ceramic and brick artifacts. More specifically, this report provides details on instrumentation, analysis times, and matrix-specific calibration protocols.

Although modern XRF instruments employing a fundamental parameters (FP) calibration generate fairly accurate results for elements of interest in archaeological research, archaeological scientists routinely adjust instrument output using matrix-specific calibration curves for common archaeological materials (Frahm et al. 2022). Application of empirical calibration curves to raw instrumental results enhances the accuracy of the final data, increases scientific transparency, promotes data reproducibility, and reduces siloed production of knowledge within established laboratories. This report describes calibration curves for 13 elements derived through analysis of a suite of reference materials made primarily from historic bricks on loan from the Yale Peabody Museum. Calibration curves were validated by plotting predicted values against published reference values, including a standard that was not part of the calibration curves. This standard is SRM 2711a (Montana soil) from the National Institute of Standards and Technology (NIST).

Calibration curves described in this report are appropriate for post-processing XRF data for archaeological pottery, historic-era bricks, and other ceramic materials. This calibration protocol compliments matrix-specific calibrations developed by the INL CRMO for the analysis of archaeological and geological obsidian and fine-grained volcanics (Freund et al. 2026a, 2026b).

ANALYTICAL METHODS

All ceramic samples are analyzed using an Olympus Vanta M-series portable XRF spectrometer equipped with a 4 W X-ray tube, a Rh anode, and 40 mm^2 silicon drift detector (SDD). The instrument operates using a factory “Geochem” mode that relies on a FP calibration, with standards, and a combination of three beam settings to optimize measurements of separate element groups in silica-rich materials. Each sample is analyzed for a total of 180 seconds (60 seconds per beam setting). Thirteen elements are regularly quantified by the CRMO for ceramic and brick artifacts. Beam 1 measures manganese (Mn), iron (Fe), zinc (Zn), rubidium (Rb), strontium (Sr), yttrium (Y), zirconium (Zr), and niobium (Nb). Beam 2 measures aluminum (Al), potassium (K), calcium (Ca), and titanium (Ti). Beam 3 measures barium (Ba). Table 1 provides a summary of energy, current, and filter parameters used for each beam setting.

Table 1. Energy, current, and filter parameters used for each beam setting for Olympus Vanta instruments employing a three-beam factory "Geochem" calibration.

Beam	Energy (kV)	Current (μA)	Filter Material	Filter Thickness (μm)	Filter Diameter (μm)	Elements Quantified
1	40	58	Aluminum (Al)	2,000	2,718	Mn, Fe, Zn, Rb, Sr, Y, Zr, Nb
2	10	65	None	-	2,718	Al, K, Ca, Ti
3	50	56	Copper (Cu)	350	2,718	Ba

To further improve the accuracy of results, elemental estimates exported from the instrument are adjusted using calibration curves derived from the analysis of 20 ceramic standards available from the Yale Peabody Museum (Frahm et al. 2022; see Appendix A). The Yale Bricks and Rocks for Instruments' Ceramic Calibration (BRICC) standards are provided to researchers in the form of solid brick samples. The range of geochemical variability among the BRICC set adequately encompasses that of ceramic and brick artifacts analyzed to date by the INL CRMO XRF Laboratory (Table 2). The composition of each standard has been independently determined through techniques such as neutron activation analysis (NAA), wavelength-dispersive XRF (WD-XRF), or inductively coupled plasma mass spectrometry (ICP-MS). Recommended reference values for the 13 elements of interest for each standard are compiled in Appendix A.

Table 2. Elemental ranges for ceramic samples analyzed to date by the INL CRMO XRF Laboratory (n=632). All measurements are in ppm.

Element	Min	Max	Median	Mean	1s
Al	32,855	130,018	72,771	73,126	12,441
K	11,337	35,289	21,544	21,814	3,394
Ca	5,696	156,087	31,371	42,444	30,577
Ti	2,143	7,399	3,498	3,625	679
Mn	181	1,513	509	529	161
Fe	21,883	81,751	35,442	35,693	6,221
Zn	0	524	208	210	69
Rb	42	195	119	117	23
Sr	93	500	233	239	59
Y	12	54	27	28	6
Zr	120	453	188	193	40
Nb	6	30	13	14	4
Ba	254	4,409	965	1,030	485

A check standard is regularly analyzed under equivalent conditions at the start and end of each analytical run to monitor instrument performance. The standard employed during analysis of brick and ceramic artifacts is SRM 2711a, Montana Soil, a standard reference material intended primarily for use in the analysis of soils, sediments, or other materials of a similar matrix (Byers et al. 2016; Gonzalez and Choquette 2022).

CALIBRATION CURVES

The following section provides an overview of the calibration curves and associated standards used to calibrate each of the 13 elements that are part of the INL CRMO ceramic calibration routine. Each BRICC reference sample was analyzed twice (once on each planar surface) and results were averaged for calibration against reference values recommended by Frahm et al. (2022). Table 3 summarizes the slopes, Y-intercepts, and R^2 values for each of the calibration curves. Curves were forced through zero when the p-values for the Y-intercepts were not significant at an alpha threshold of 0.05. Individual standards were excluded if plots of residuals showed that they exerted undo leverage. Excluded samples are noted for each calibration curve, if applicable.

Table 3. Slopes, Y-intercepts, and R^2 values for the calibration curves for each of the 13 elements of interest.

Element	Slope	Y-Intercept	R^2
Al	0.8983165	8,184.2684	0.973522
K	1.0082774	1,902.5486	0.977507
Ca	0.806662	0	NA
Ti	0.9001912	511.67322	0.978453
Mn	1.1186061	0	NA
Fe	0.9925596	0	NA
Zn	0.7868471	8.1712713	0.984761
Rb	0.9405096	5.0313576	0.997644
Sr	0.9884577	0	NA
Y	0.9110372	2.9642543	0.978399
Zr	1.0495452	0	NA
Nb	1.0198109	5.0342655	0.933073
Ba	0.754429	69.979492	0.953905

Aluminum (Al)

Figure 2 shows the calibration curve for Al, encompassing all 20 BRICC standards, excluding HVK-1 (Appendix A; see Frahm et al. 2022).

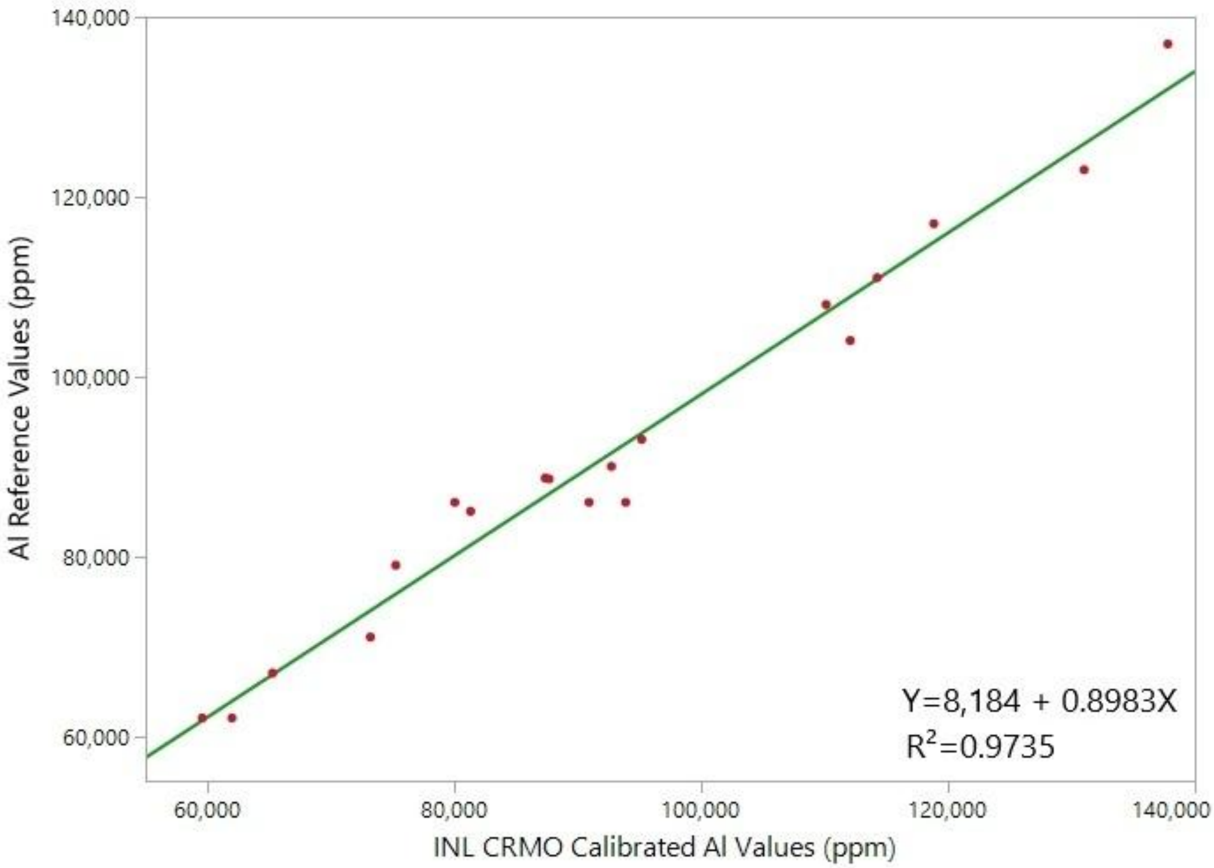

Figure 1. FP calibrated Al values (in ppm) vs. published reference values. The calibration curve for Al is shown in green.

Potassium (K)

Figure 2 shows the calibration curve for K, encompassing all 20 BRICC standards (Appendix A; see Frahm et al. 2022).

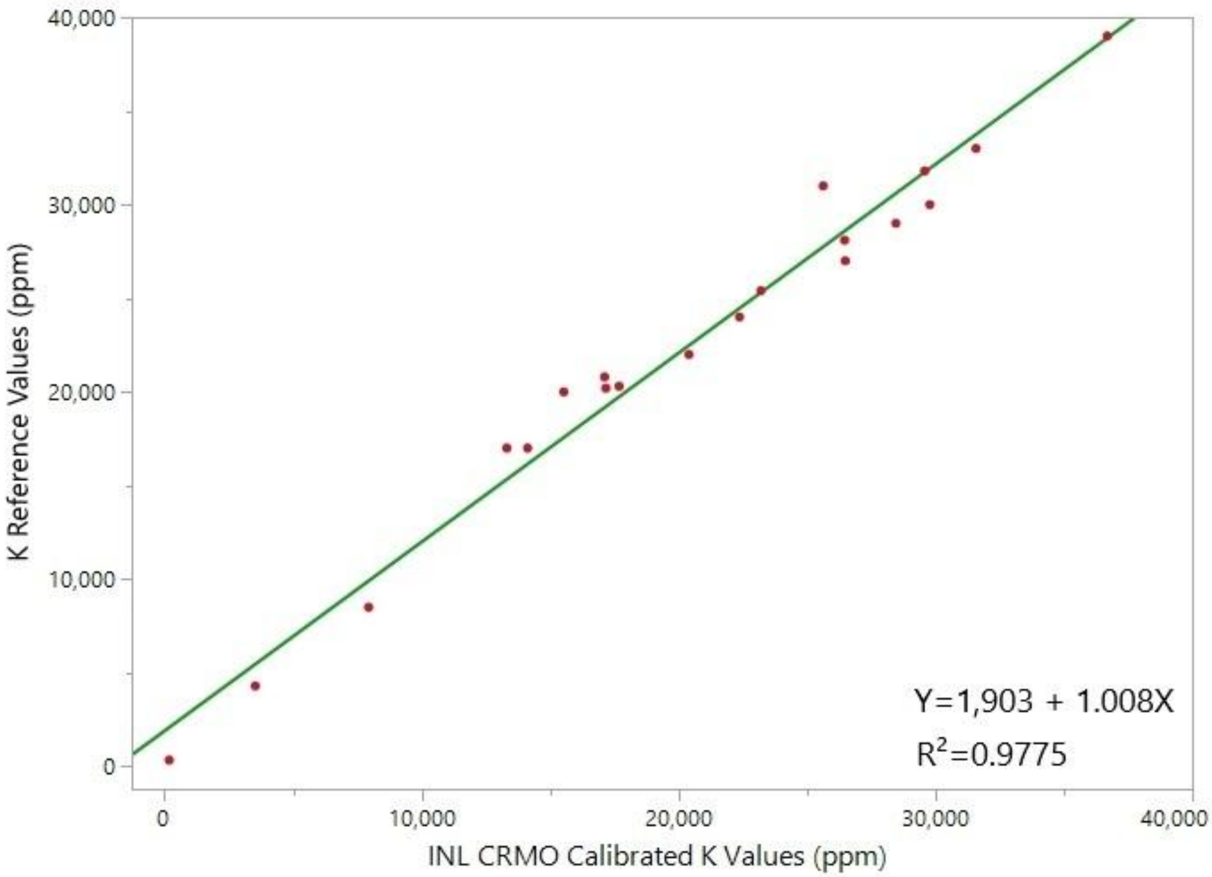

Figure 2. FP calibrated K values (in ppm) vs. published reference values. The calibration curve for K is shown in green.

Calcium (Ca)

Figure 3 shows the calibration curve for Ca, encompassing all 20 BRICC standards, excluding WSS-1 and STD-1 (Appendix A; see Frahm et al. 2022). Before fitting the curve through zero as shown in Figure 3, the Y-intercept was 77.43 with a slope of 0.8056 and an R^2 of 0.9867. The p-value for the Y-intercept was 0.9429, which was not statistically significant at an alpha of 0.05, indicating that the intercept value was not significantly different from 0

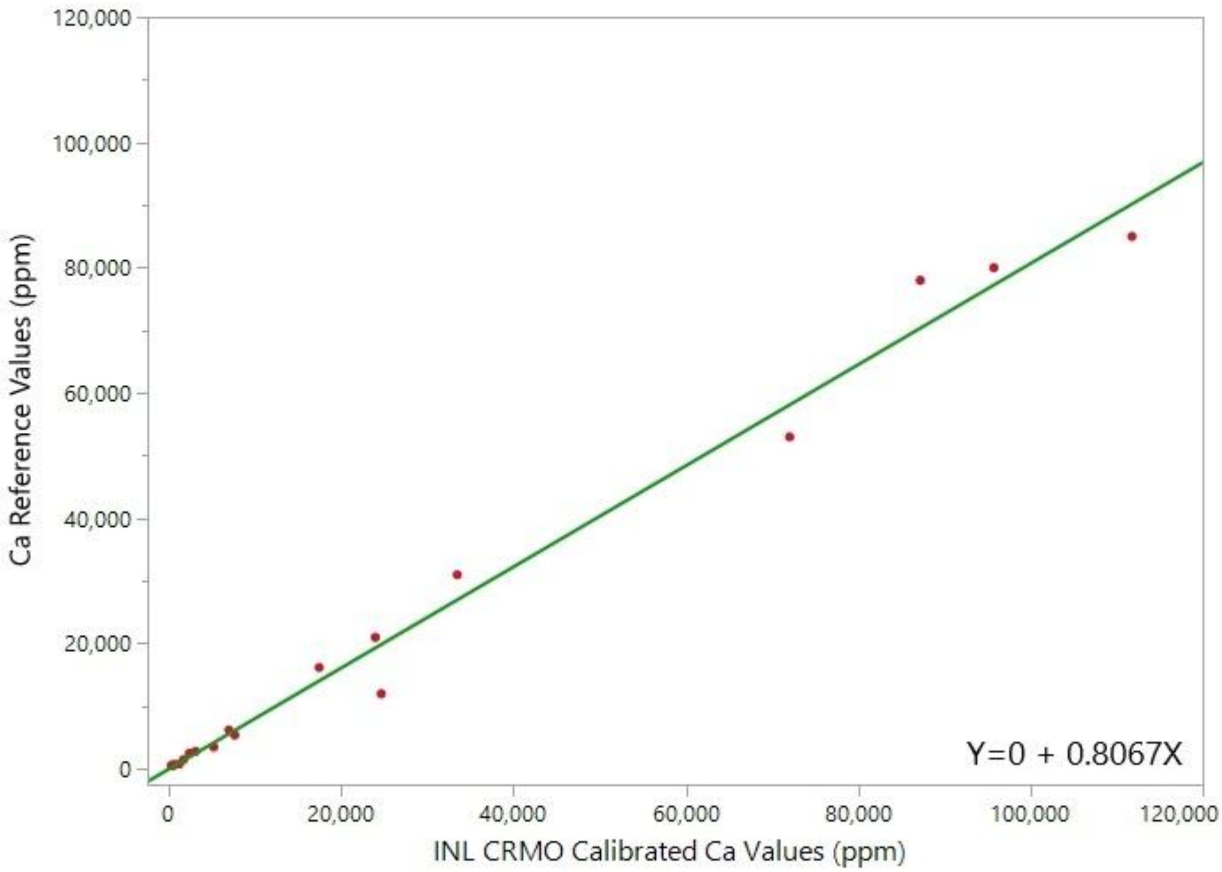

Figure 3. FP calibrated Ca values (in ppm) vs. published reference values. The calibration curve for Ca is shown in green.

Titanium (Ti)

Figure 4 shows the calibration curve for Ti, encompassing all 20 BRICC standards, excluding ACM-1, HVK-1, and WSS-1 (Appendix A; see Frahm et al. 2022).

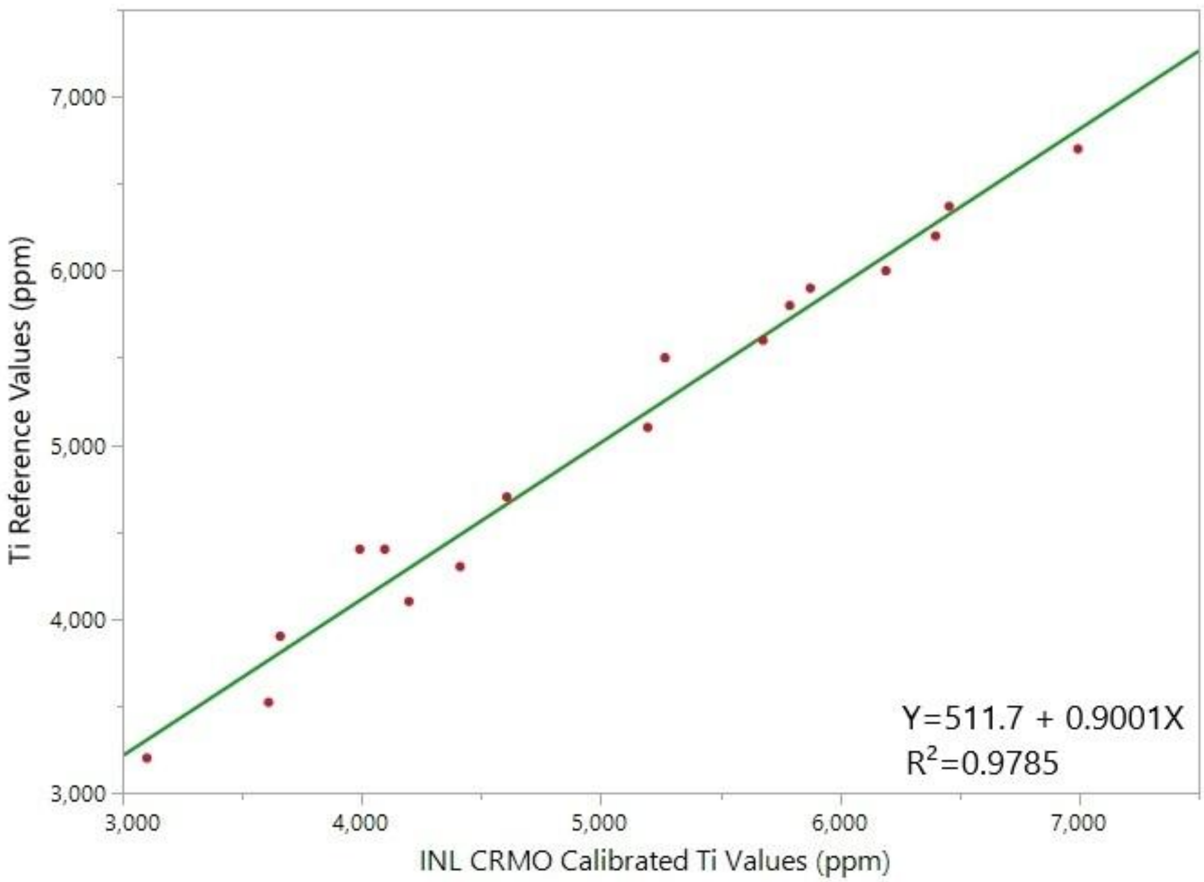

Figure 4. FP calibrated Ti values (in ppm) vs. published reference values. The calibration curve for Ti is shown in green.

Manganese (Mn)

Figure 5 shows the calibration curve for Mn, encompassing all 20 BRICC standards, excluding NSS-1 and WSS-1 (Appendix A; see Frahm et al. 2022). Before fitting the curve through zero as shown in Figure 5, the Y-intercept was 21.13 with a slope of 1.087 and an R^2 of 0.9825. The p-value for the Y-intercept was 0.3232, which was not statistically significant at an alpha of 0.05, indicating that the intercept value was not significantly different from 0

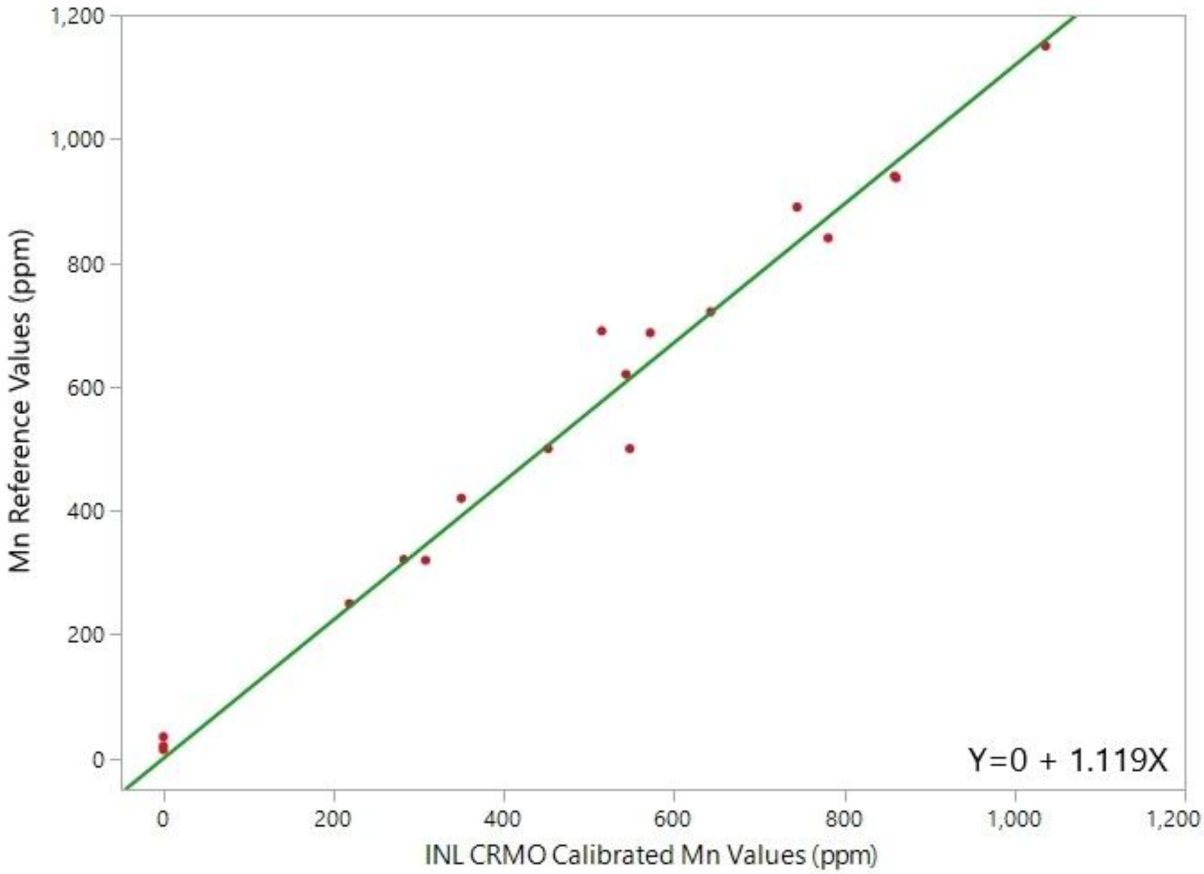

Figure 5. FP calibrated Mn values (in ppm) vs. published reference values. The calibration curve for Mn is shown in green.

Iron (Fe)

Figure 6 shows the calibration curve for Fe, encompassing all 20 BRICC standards, excluding PBS-1 (Appendix A; see Frahm et al. 2022). Before fitting the curve through zero as shown in Figure 6, the Y-intercept was 67.22 with a slope of 0.9911 and an R^2 of 0.9922. The p-value for the Y-intercept was 0.9410, which was not statistically significant at an alpha of 0.05, indicating that the intercept value was not significantly different from 0

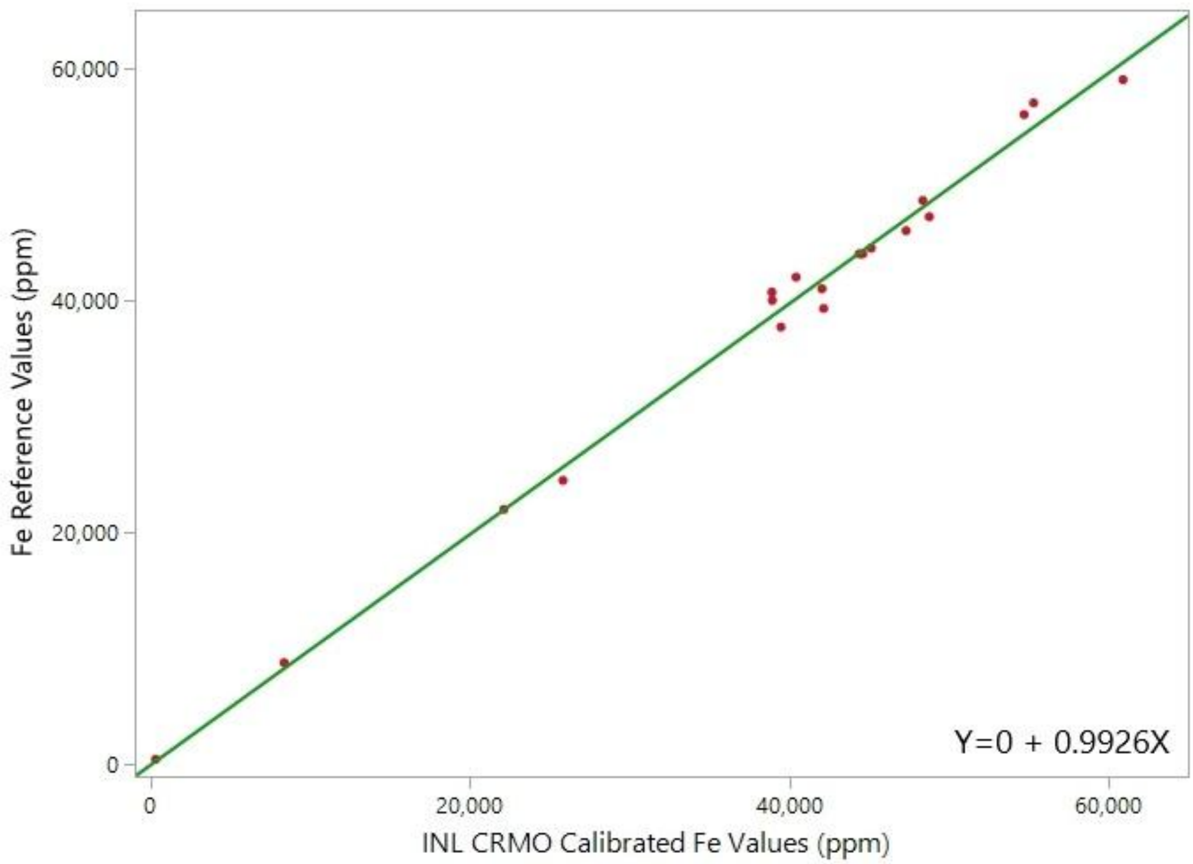

Figure 6. FP calibrated Fe values (in ppm) vs. published reference values. The calibration curve for Fe is shown in green.

Zinc (Zn)

Figure 7 shows the calibration curve for Zn, encompassing all 20 BRICC standards (Appendix A; see Frahm et al. 2022).

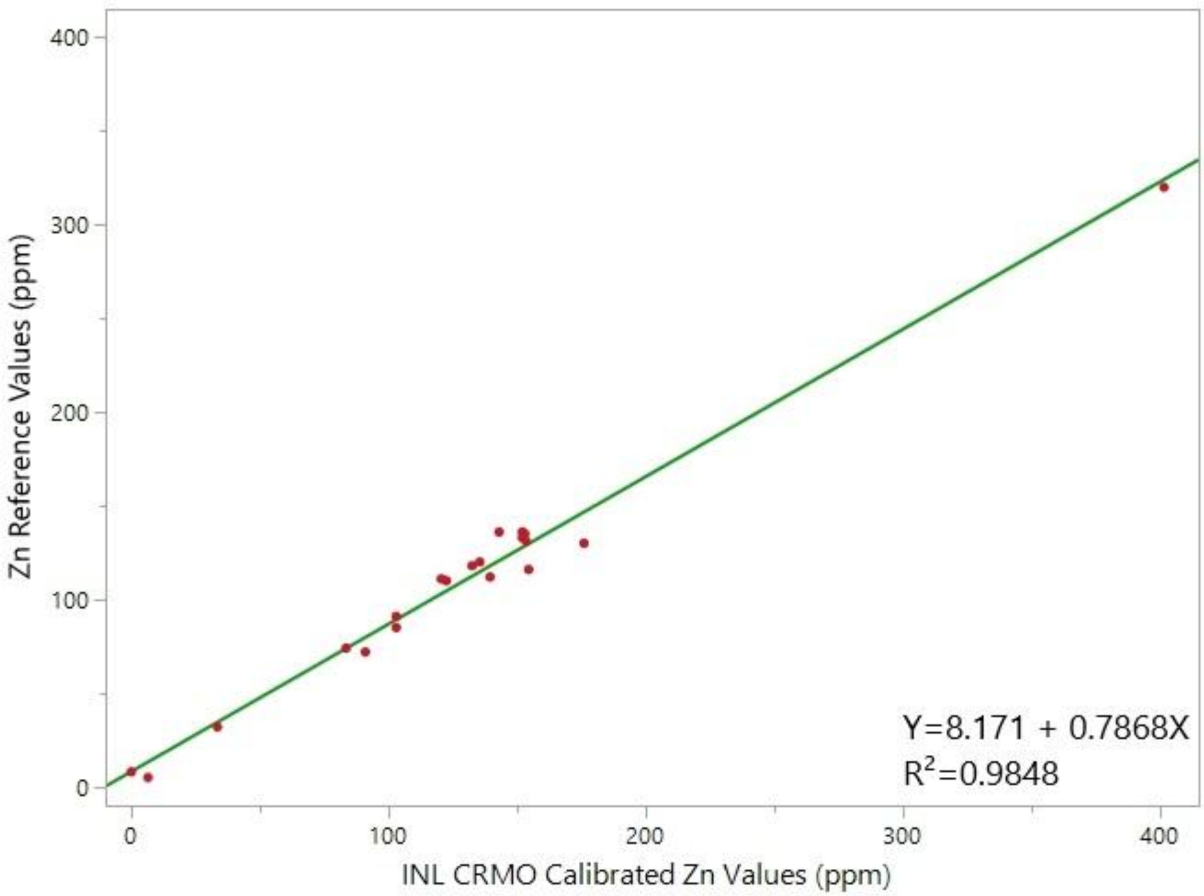

Figure 7. FP calibrated Zn values (in ppm) vs. published reference values. The calibration curve for Zn is shown in green.

Rubidium (Rb)

Figure 8 shows the calibration curve for Rb, encompassing all 20 BRICC standards, excluding NSS-1 and SMS-1 (Appendix A; see Frahm et al. 2022).

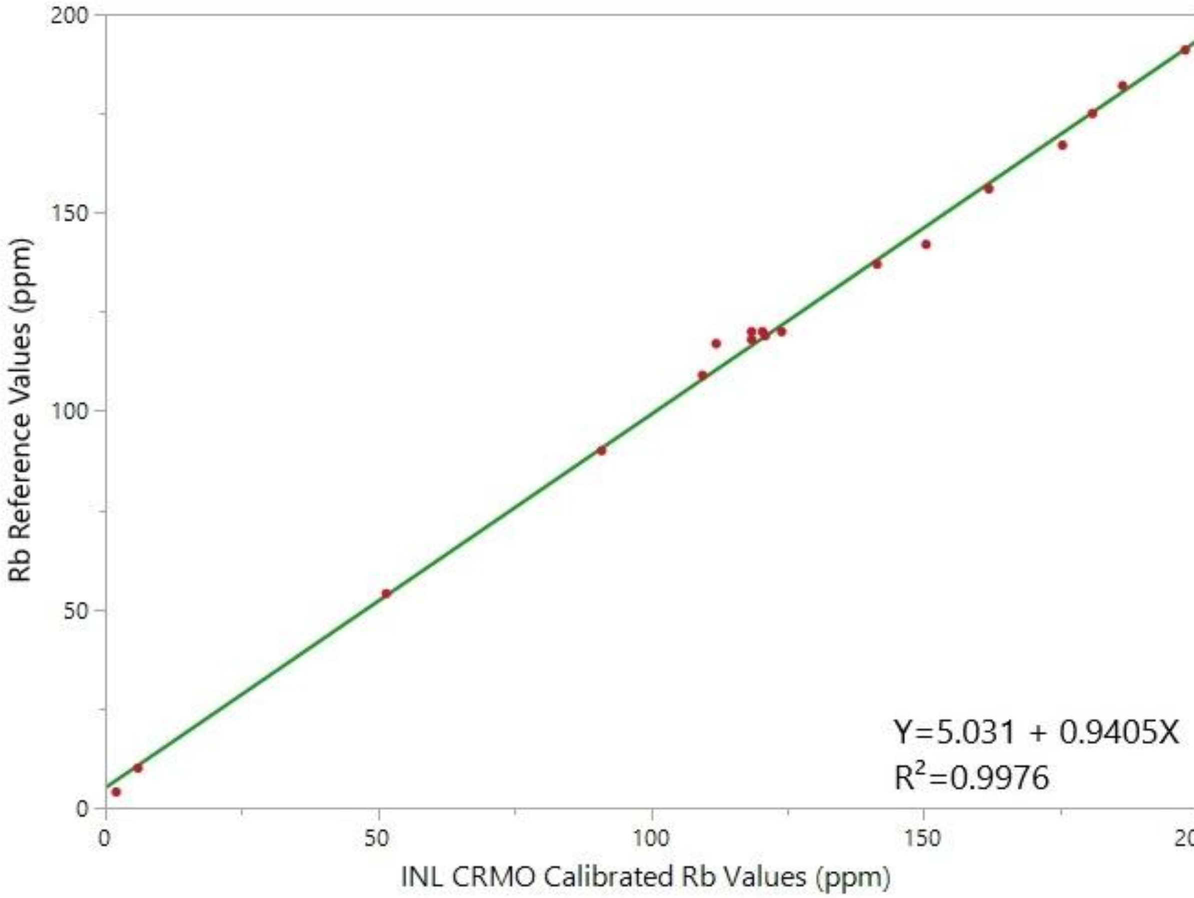

Figure 8. FP calibrated Rb values (in ppm) vs. published reference values. The calibration curve for Rb is shown in green.

Strontium (Sr)

Figure 9 shows the calibration curve for Sr, encompassing all 20 BRICC standards, excluding STD-1 (Appendix A; see Frahm et al. 2022). Before fitting the curve through zero as shown in Figure 9, the Y-intercept was 6.09 with a slope of 0.9764 and an R^2 of 0.9925. The p-value for the Y-intercept was 0.4027, which was not statistically significant at an alpha of 0.05, indicating that the intercept value was not significantly different from 0

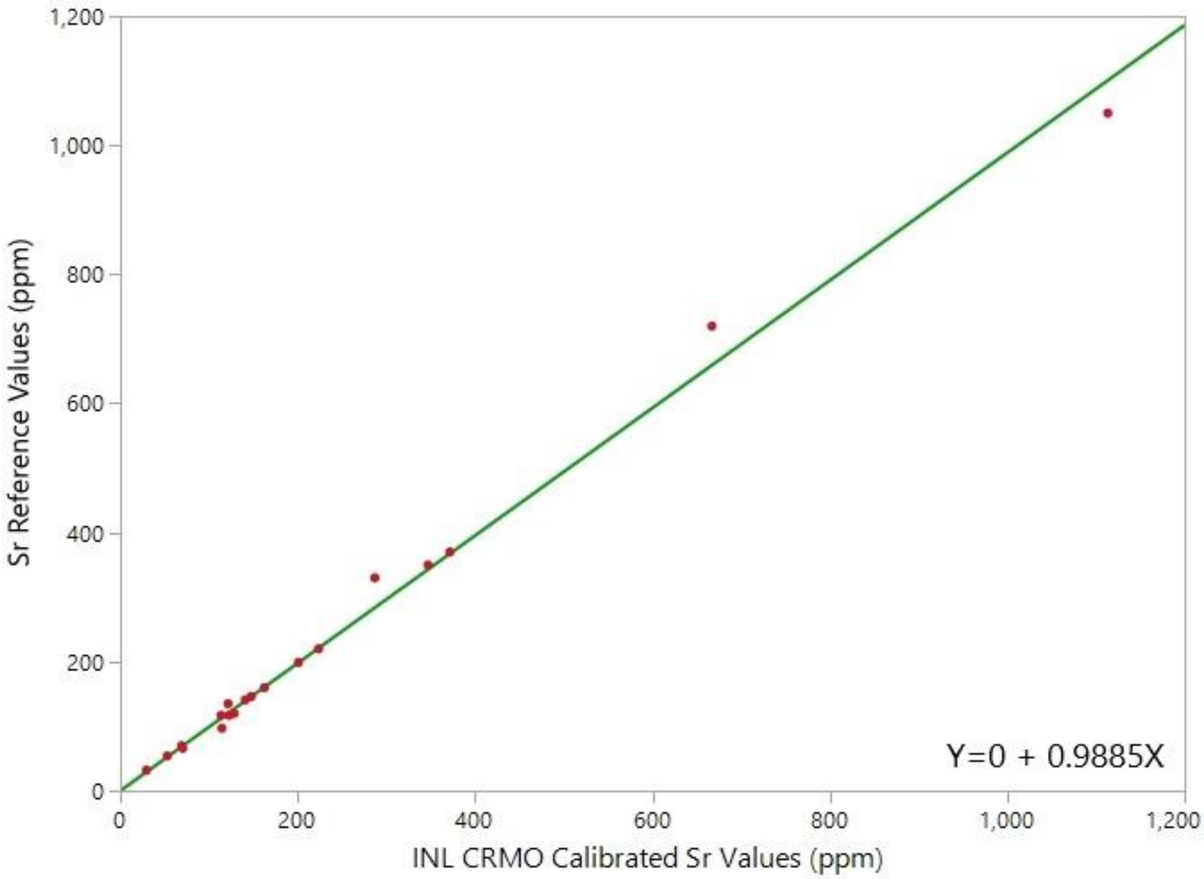

Figure 9. FP calibrated Sr values (in ppm) vs. published reference values. The calibration curve for Sr is shown in green.

Yttrium (Y)

Figure 10 shows the calibration curve for Y, encompassing all 20 BRICC standards, excluding MNC-1 (Appendix A; see Frahm et al. 2022).

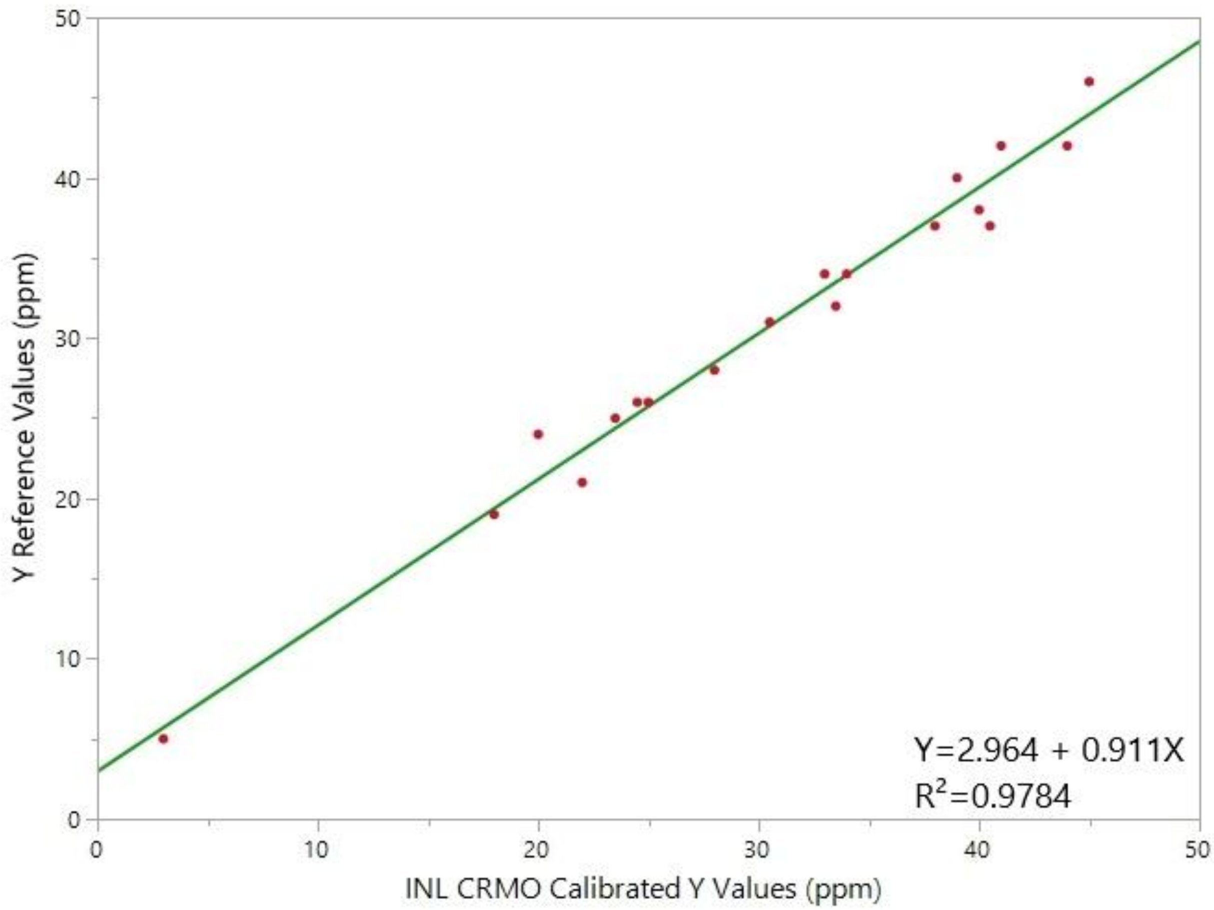

Figure 10. FP calibrated Y values (in ppm) vs. published reference values. The calibration curve for Y is shown in green.

Zirconium (Zr)

Figure 11 shows the calibration curve for Zr, encompassing all 20 BRICC standards, excluding MNC-1 (Appendix A; see Frahm et al. 2022). Before fitting the curve through zero as shown in Figure 11, the Y-intercept was -2.572 with a slope of 1.061 and an R^2 of 0.9868. The p-value for the Y-intercept was 0.6832, which was not statistically significant at an alpha of 0.05, indicating that the intercept value was not significantly different from 0.

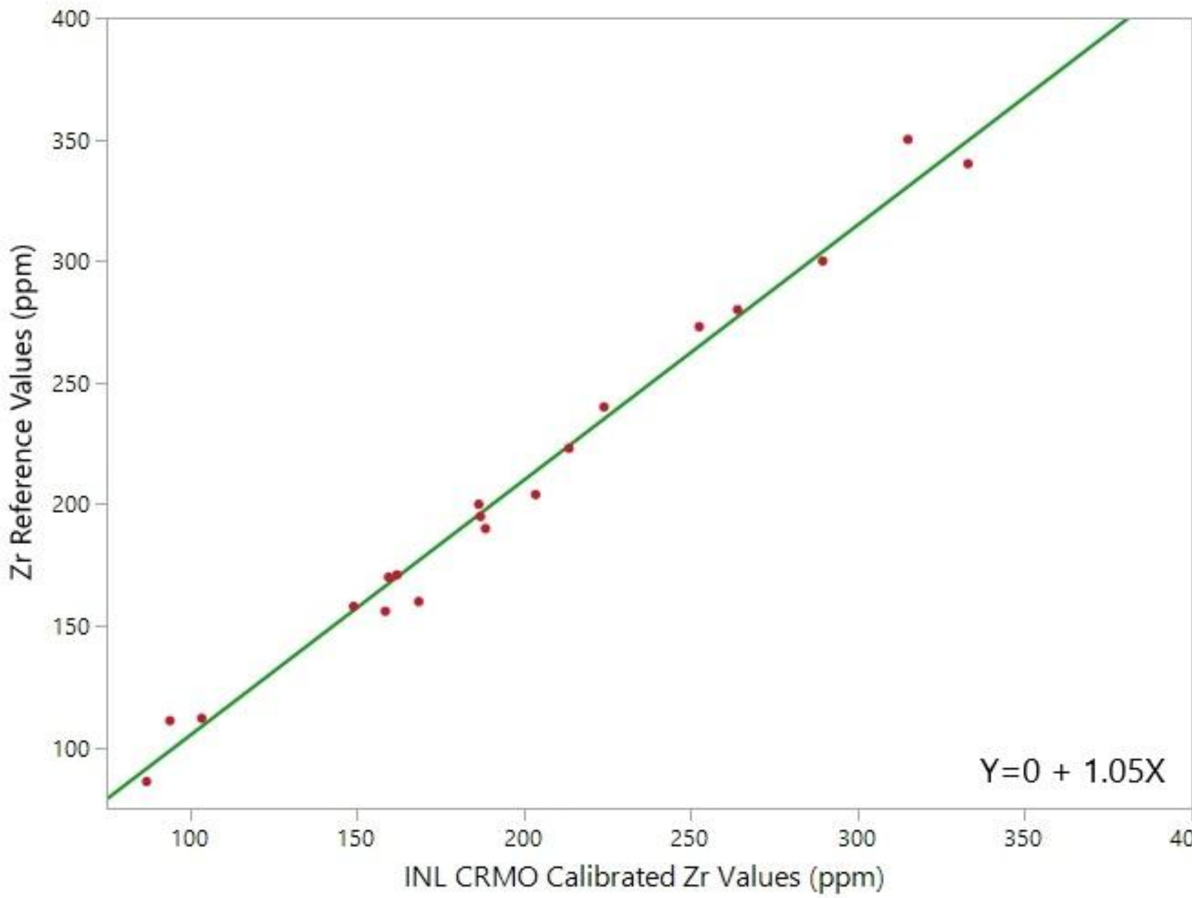

Figure 11. FP calibrated Zr values (in ppm) vs. published reference values. The calibration curve for Zr is shown in green.

Niobium (Nb)

Figure 12 shows the calibration curve for Nb, encompassing all 20 BRICC standards, excluding HVK-1 (Appendix A; see Frahm et al. 2022).

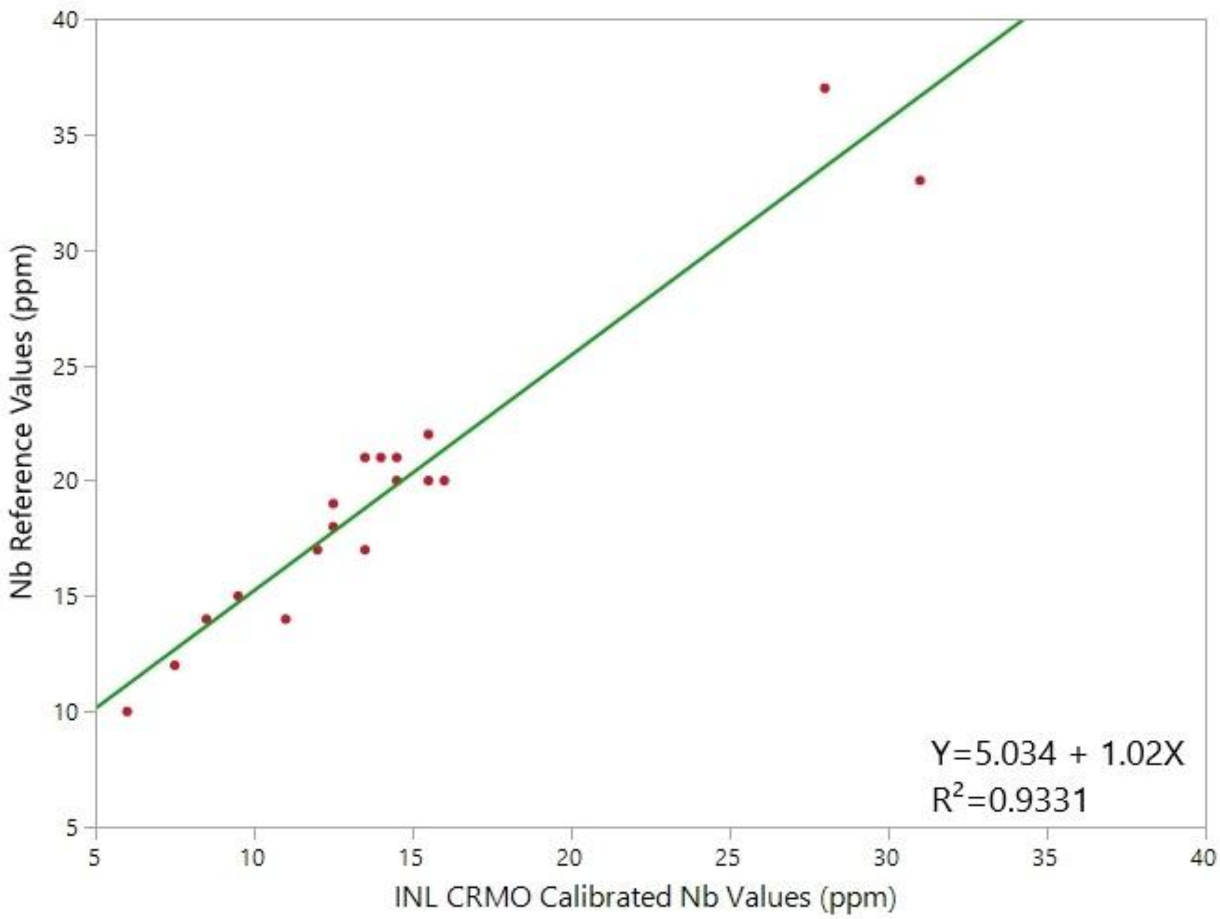

Figure 12. FP calibrated Nb values (in ppm) vs. published reference values. The calibration curve for Nb is shown in green.

Barium (Ba)

Figure 13 shows the calibration curve for Ba, encompassing all 20 BRICC standards, excluding HVK-1 and COL-1 (Appendix A; see Frahm et al. 2022).

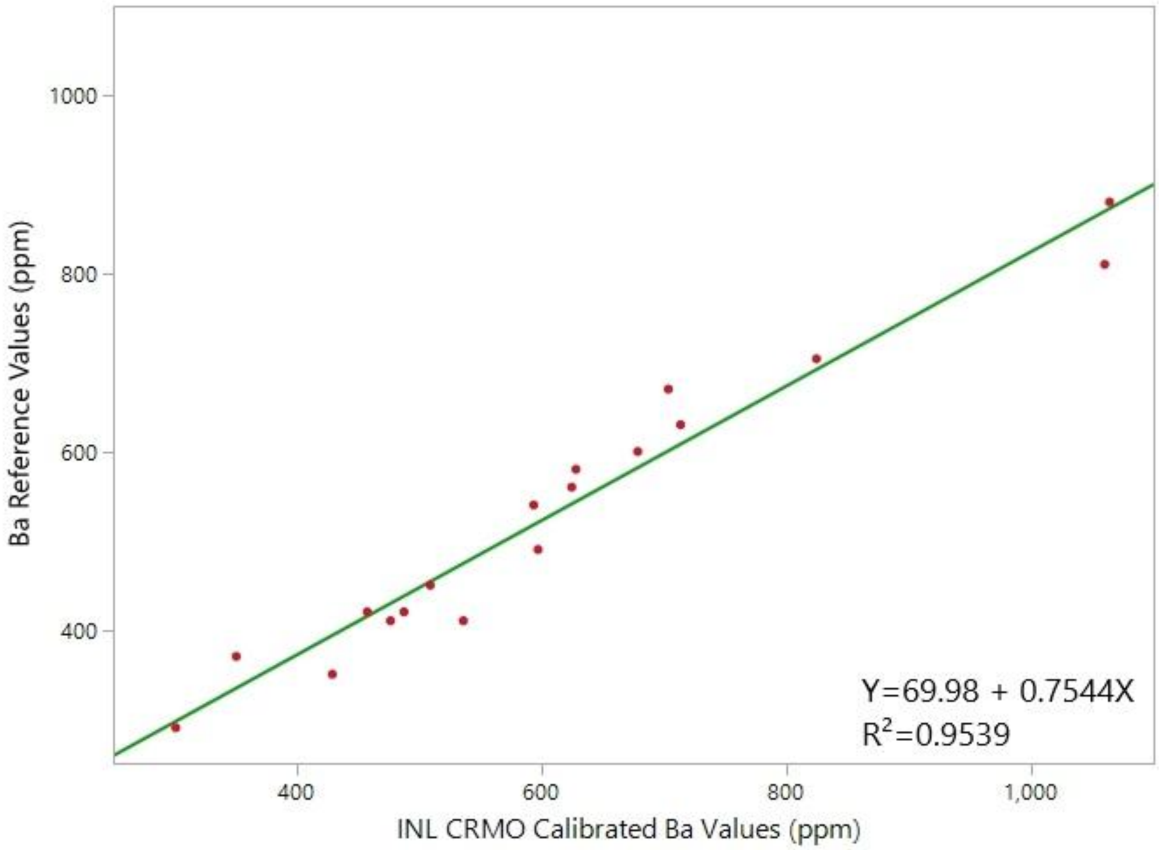

Figure 13. FP calibrated Ba values (in ppm) vs. published reference values. The calibration curve for Ba is shown in green.

VALIDATION

To validate calibration curves for each element, predicted values for the reference standards were plotted against the published reference values (Figure). In this context, one would expect a line of best fit with a slope as close to 1 as possible with a Y-intercept of 0. In general, these lines displayed good accord, with slopes ranging from 0.9719 (Mn) to 1.011 (Zr). The R^2 values for all elements were 0.9331 or higher.

Calibrated values for SRM 2711a were also plotted on Figure, although they were not included in the regression lines. Table 4 provides a comparison of the calibrated results to published values and standard deviations by element for SRM 2711a. Ten of the thirteen calibrated element values fall within two standard deviations of the reference values, and 11 fall within three. Two elements are above three standard deviations from the reference value: Ca and Ba. Ca is a major element with a relatively small reference value standard deviation. The only value greater than three standard deviations from the reference value that is also more than 15% different is Ba. The calibrated value of Ba for SRM 2711a is low, which could be related to infinite thickness assumptions and/or differences in sample density, as SRM 2711a is comprised of loose soil while the BRICC set is made up of solid brick. This may be an issue for Ba specifically because its Kα line is measured at a far greater depth than other elements (Drake and MacDonald 2022). Otherwise, there is strong agreement between calibrated values and published reference values, particularly for elements that are critical for ceramic and brick characterization such as Fe, Rb, Sr, Y, Zr, and Nb, providing justification for the implementation of this calibration for analyses of ceramic and brick artifacts in Idaho.

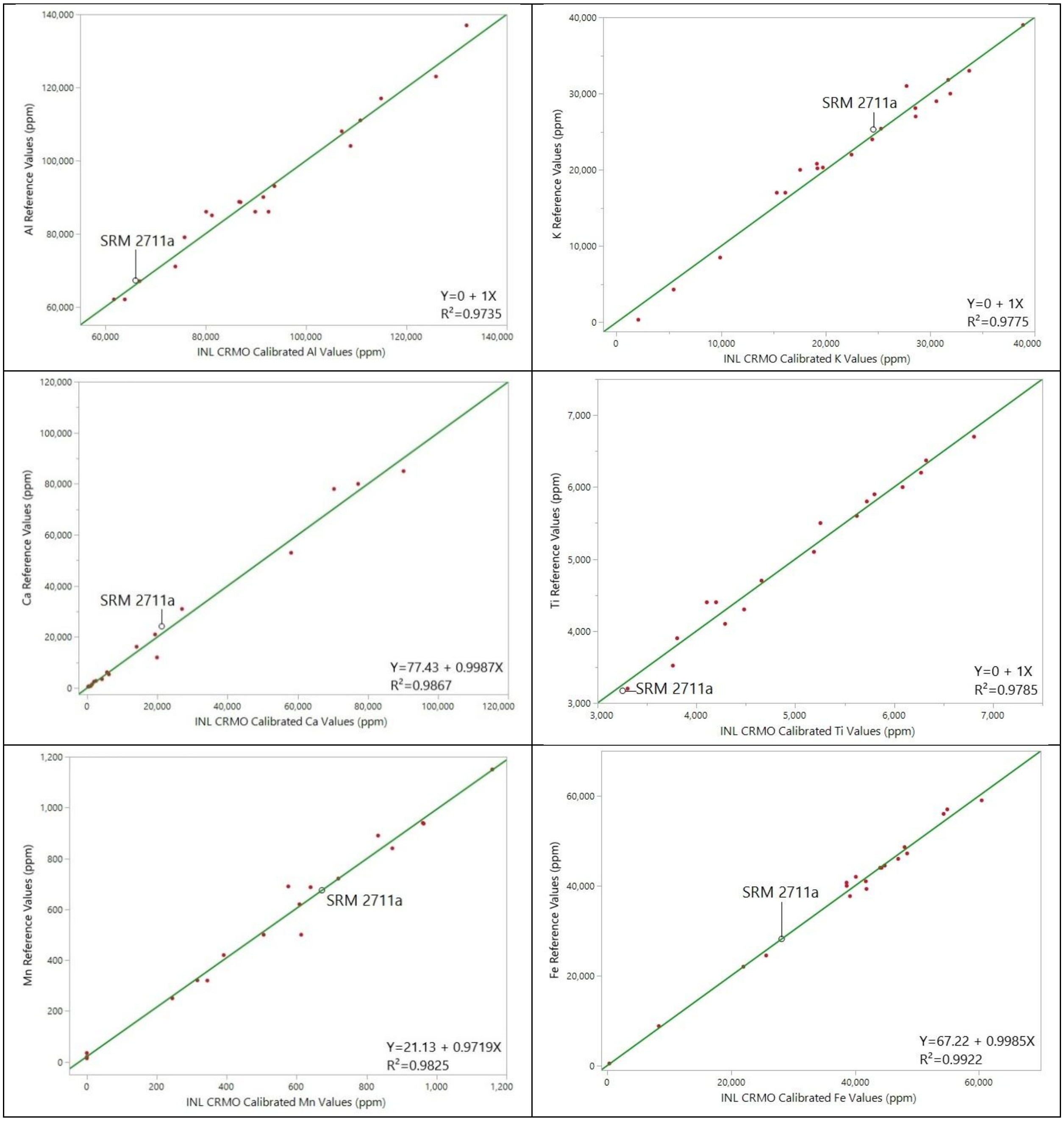

Figure 14. Calibration validation showing calibrated elemental values (in ppm) vs. published reference values with associated regression lines. The reference standard used to validate the accuracy of the calibration (SRM 2711a) is labeled.

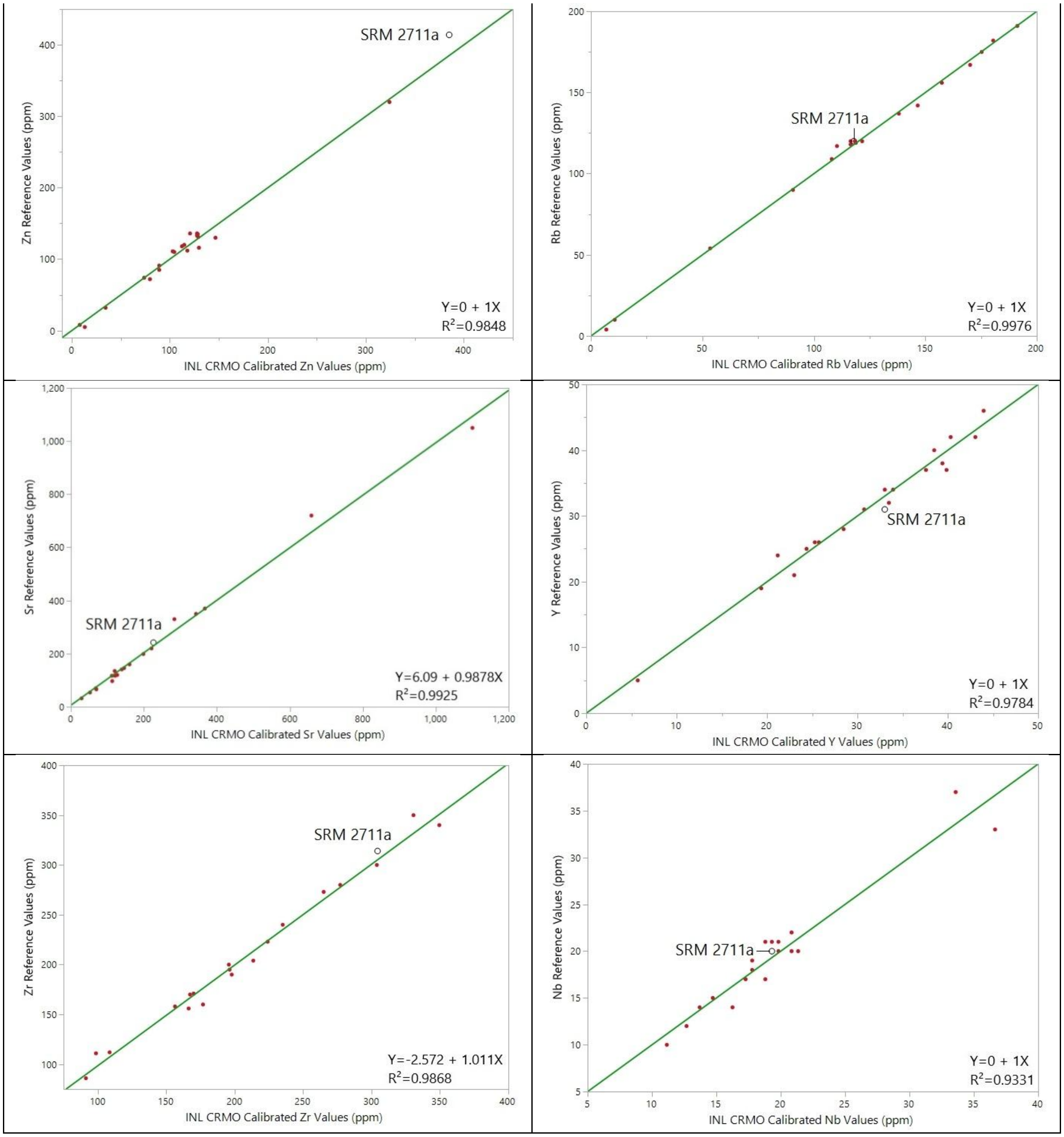

Figure 14 (cont.). Calibration validation showing calibrated elemental values (in ppm) vs. published reference values with associated regression lines. The reference standard used to validate the accuracy of the calibration (SRM 2711a) is labeled.

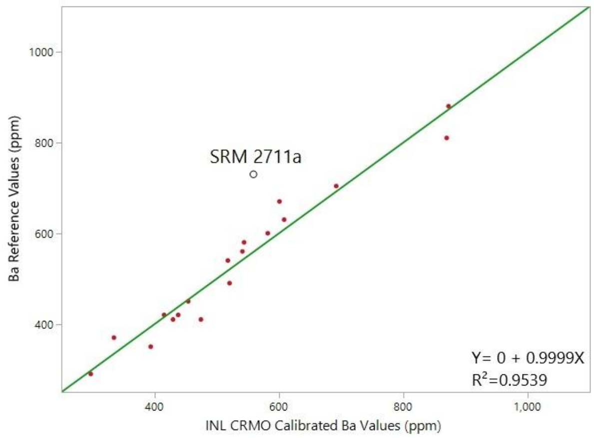

Figure 14 (cont.). Calibration validation showing calibrated elemental values (in ppm) vs. published reference values with associated regression lines. The reference standard used to validate the accuracy of the calibration (SRM 2711a) is labeled.

Table 4. Reference standard used for validation of the calibration curves, including calibrated values (predicted), published reference values (expected), and standard deviations by element (Byers et al. 2016; Gonzalez and Choquette 2022). Calibrated values that are more than two standard deviations from expected values are highlighted in red.

Standard	Element	Predicted (ppm)	Expected (ppm)		Difference	Z-Score	% from Mean
			x̄	1s			
SRM 2711a NIST	Al	66,004	67,200	600	-1,196	-1.99	-1.78
	K	24,564	25,300	1,000	-736	-0.74	-2.91
	Ca	21,227	24,200	600	-2,973	-4.96	-12.29
	Ti	3,254	3,170	80	84	1.05	2.65
	Mn	672	675	18	-3	-0.17	-0.44
	Fe	28,148	28,200	400	-52	-0.13	-0.18
	Zn	385	414	11	-29	-2.64	-7
	Rb	118	120	3	-2	-0.67	-1.67
	Sr	226	242	10	-16	-1.6	-6.61
	Y	33	31	2	2	1	6.45
	Zr	304	314	6	-10	-1.67	-3.18
	Nb	19	20	2	-1	-0.5	-5
	Ba	559	730	15	-171	-11.4	-23.42

REFERENCES CITED

Byers, H.L., L.J. McHenry, and T.J. Grundl
2016 Forty-nine major and trace element concentrations measured in Soil Reference Materials NIST SRM 2586, 2587, 2709a, 2710a and 2711a using ICP-MS and wavelength dispersive-XRF. *Geostandards and Geoanalytical Research* 40(3): 433–445.

Drake, B.L., and B.L. MacDonald (eds.)
2022 *Advances in Portable X-ray Fluorescence Spectrometry: Instrumentation, Application and Interpretation*. Royal Society of Chemistry, London.

Frahm, E., C.M. Carolus, A. Cameron, J. Berner, H. Brown, J. Cheng, J. Kalodner, J.L. Leggett, Jr., A. Natale, S. Seibert, D. Sparks-Stokes, and E. Wuellner
2022 Introducing the BRICC (Bricks and rocks for Instruments' ceramic calibration) sets: Open-source calibration materials for quantitative X-ray fluorescence analysis. *Journal of Archaeological Science: Reports* 43: 103443.

Freund, K.P., J. Pink, and J. Clements
2026a *INL CRMO XRF Calibration Methods for the Analysis of Obsidian Artifacts*. INL CRMO XRF Special Report No. 1. Report prepared by the Idaho National Laboratory, Idaho Falls, ID.

Freund, K.P., J. Pink, and J. Clements
2026b *INL CRMO XRF Calibration Methods for the Analysis of Non-Obsidian Fine-Grained Volcanic Artifacts*. INL CRMO XRF Special Report No. 2. Report prepared by the Idaho National Laboratory, Idaho Falls, ID.

Gonzalez, C.A., and S.J. Choquette
2022 *Certificate of Analysis, Standard Reference Material 2711a*. National Institute of Standards and Technology, Gaithersburg, MD.

APPENDIX A

Published Elemental Values for Reference Standards

Appendix A. Published elemental values for reference standards (in ppm). USGS: U.S. Geological Survey; NIST: National Institute of Standards and Technology.

Sample ID	Description	Al	K	Ca	Ti	Mn	Fe	Zn	Rb	Sr	Y	Zr	Nb	Ba	Reference
ACM-1	BRICC Set	123,000	8,500	800	8,700	35	8,800	32	54	120	37	340	33	290	Frahm et al. 2022
AZT-1	BRICC Set	62,000	20,000	85,000	3,520	500	24,500	72	90	370	26	240	15	580	Frahm et al. 2022
CDR-1	BRICC Set	86,000	17,000	31,000	5,500	420	42,000	320	117	117	40	273	22	420	Frahm et al. 2022
CDS-1	BRICC Set	85,000	20,800	80,000	4,400	687	40,700	91	119	160	31	200	17	670	Frahm et al. 2022
COL-1	BRICC Set	88,700	20,200	78,000	4,300	321	41,000	135	120	720	26	160	20	630	Frahm et al. 2022
FTS-1	BRICC Set	90,000	24,000	6,210	6,370	721	48,600	136	120	141	38	300	21	540	Frahm et al. 2022
HVK-1	BRICC Set	71,000	340	550	830	14	480	8	4	135	5	158	8	160	Frahm et al. 2022
MMS-1	BRICC Set	108,000	39,000	2,500	5,900	690	57,000	111	191	70	34	170	19	704	Frahm et al. 2022
MNC-1	BRICC Set	137,000	4,300	500	4,700	20	22,000	5	10	1,050	129	620	37	410	Frahm et al. 2022
NEB-1	BRICC Set	93,000	31,800	16,200	5,600	840	47,200	131	167	199	32	223	20	880	Frahm et al. 2022
NSS-1	BRICC Set	79,000	31,000	12,000	4,400	1,100	44,500	85	140	97	28	171	14	420	Frahm et al. 2022
NYR-1	BRICC Set	67,000	33,000	1,500	3,200	890	44,000	74	175	32	19	112	10	630	Frahm et al. 2022
PBS-1	BRICC Set	117,000	29,000	700	6,700	620	69,000	120	156	54	46	204	21	810	Frahm et al. 2022
PST-1	BRICC Set	71,000	25,400	5,400	6,000	320	39,300	116	109	66	42	350	20	450	Frahm et al. 2022
SAG-1	BRICC Set	104,000	27,000	2,800	6,200	1,150	56,000	133	142	117	42	280	20	490	Frahm et al. 2022
SMS-1	BRICC Set	62,000	17,000	53,000	3,900	500	40,000	136	102	350	24	111	12	410	Frahm et al. 2022
STD-1	BRICC Set	86,000	20,300	79,000	4,100	250	37,700	112	118	1,100	25	156	17	370	Frahm et al. 2022
STL-1	BRICC Set	88,600	28,100	21,000	5,100	937	46,000	130	137	146	34	190	18	560	Frahm et al. 2022
WSS-1	BRICC Set	86,000	22,000	87,000	3,500	270	44,000	110	120	330	21	86	14	350	Frahm et al. 2022
YOK-1	BRICC Set	111,000	30,000	3,500	5,800	940	59,000	118	182	220	37	195	21	600	Frahm et al. 2022
SRM 2711a	NIST Soil Standard	67,200	25,300	24,200	3,170	675	28,200	414	120	242	31	314	20	730	Byers et al. 2016; Gonzalez and Choquette 2022

APPENDIX B

INL CRMO Elemental Values for Reference Standards

Appendix B. INL CRMO elemental values for reference standards (in ppm). Raw values refer to FP ppm values. Cal: Calibrated.

Sample ID	Al Raw	Al Cal	K Raw	K Cal	Ca Raw	Ca Cal	Ti Raw	Ti Cal	Mn Raw	Mn Cal	Fe Raw	Fe Cal	Zn Raw	Zn Cal	Rb Raw	Rb Cal
ACM-1	131,023	125,884	7,944	9,912	1,182	953	9,329	8,910	0	0	8,359	8,296	34	35	52	53
AZT-1	61,994	63,874	15,535	17,566	111,783	90,171	3,611	3,762	452	506	25,828	25,635	91	80	91	91
CDR-1	80,044	80,089	13,320	15,332	33,463	26,993	5,269	5,254	350	392	40,436	40,135	402	324	112	110
CDS-1	81,324	81,239	17,126	19,170	95,745	77,234	4,097	4,199	572	640	38,919	38,629	103	89	121	119
COL-1	87,369	86,669	17,174	19,219	87,215	70,353	4,412	4,483	283	316	42,054	41,741	153	129	119	116
FTS-1	92,734	91,489	22,376	24,464	6,952	5,608	6,457	6,324	643	719	48,374	48,014	152	128	121	118
HVK-1	49,208	52,389	181	2,085	265	214	1,019	1,429	0	0	305	303	0	8	2	7
MMS-1	110,125	107,111	36,688	38,894	2,364	1,907	5,876	5,801	515	576	55,320	54,908	121	103	198	191
MNC-1	137,809	131,980	3,531	5,462	429	346	4,607	4,659	0	0	22,126	21,961	7	13	6	11
NEB-1	95,185	93,691	29,585	31,732	17,424	14,055	5,678	5,623	781	874	48,779	48,416	154	129	176	170
NSS-1	75,262	75,793	25,635	27,749	24,638	19,875	3,992	4,105	1,271	1,422	45,140	44,804	103	89	132	129
NYR-1	65,285	66,830	31,580	33,743	1,687	1,361	3,102	3,304	745	833	44,385	44,054	84	74	181	175
PBS-1	118,855	114,953	28,464	30,602	546	440	6,995	6,809	544	608	75,456	74,895	136	115	162	157
PST-1	73,212	73,952	23,209	25,303	7,628	6,153	6,192	6,086	308	345	42,162	41,848	155	130	110	108
SAG-1	112,082	108,869	26,494	28,616	3,081	2,485	6,400	6,272	1,037	1,159	54,723	54,315	152	128	151	147
SMS-1	59,588	61,713	14,129	16,148	72,051	58,120	3,659	3,805	548	613	38,944	38,654	143	121	91	90
STD-1	90,926	89,865	17,691	19,739	84,952	68,527	4,198	4,290	219	244	39,483	39,189	140	118	119	116
STL-1	87,683	86,951	26,468	28,590	23,957	19,325	5,196	5,189	861	963	47,326	46,973	176	147	142	138
WSS-1	93,888	92,525	20,410	22,481	82,458	66,515	3,320	3,500	192	214	44,611	44,279	123	105	124	122
YOK-1	114,258	110,824	29,783	31,932	5,188	4,185	5,790	5,724	859	961	60,918	60,465	133	112	187	180
SRM 2711a	64,365	66,004	22,475	24,564	26,314	21,227	3,046	3,254	601	672	28,359	28,148	479	385	120	118

Sample ID	Sr Raw	Sr Cal	Y Raw	Y Cal	Zr Raw	Zr Cal	Nb Raw	Nb Cal	Ba Raw	Ba Cal
ACM-1	129	127	38	38	333	349	31	37	301	297
AZT-1	372	367	25	26	224	235	10	15	628	544
CDR-1	114	112	39	38	253	265	16	21	458	415
CDS-1	163	161	31	31	187	196	14	19	704	601
COL-1	667	659	25	25	169	177	15	20	329	318
FTS-1	141	139	40	39	290	304	14	19	594	518
HVK-1	122	120	3	6	149	156	7	12	149	182
MMS-1	69	68	33	33	160	167	13	18	825	692
MNC-1	1,114	1,101	143	133	678	711	28	34	536	474

Sample ID	Sr Raw	Sr Cal	Y Raw	Y Cal	Zr Raw	Zr Cal	Nb Raw	Nb Cal	Ba Raw	Ba Cal
NEB-1	201	199	34	33	214	224	16	21	1,064	873
NSS-1	115	113	28	28	162	170	9	14	488	438
NYR-1	30	29	18	19	104	109	6	11	714	608
PBS-1	53	52	45	44	204	214	15	20	1,060	870
PST-1	71	70	41	40	315	331	15	20	509	454
SAG-1	123	121	44	43	264	277	16	21	597	520
SMS-1	347	343	20	21	94	99	8	13	477	429
STD-1	661	653	24	24	159	166	12	17	351	334
STL-1	148	146	34	34	189	198	13	18	625	541
WSS-1	287	284	22	23	87	91	11	16	429	394
YOK-1	224	221	41	40	187	196	14	19	679	582
SRM 2711a	229	226	33	33	290	304	14	19	648	559