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HIGH LEVEL WASTE (HLW) SLUDGE BATCH 4 (SB4) WITH FRIT 418: RESULTS OF A PHASE II VARIABILITY STUDY

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Aiken, SC 29808

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EXECUTIVE SUMMARY

In early October 2006, the Liquid Waste Organization (LWO) began to consider decanting Tank 40 at the end of Sludge Batch 3 (SB3) processing and transferring the aqueous phase from the decant to Tank 51. This transfer would be done to remove water added to Tank 40 by a slurry pump bearing water leak. Tank 40 decant water would be used to decrease Tank 51 yield stress and facilitate a transfer of Tank 51 to Tank 40. The projected composition of Sludge Batch 4 (SB4) was adjusted by LWO to reflect the impact of the Tank 40 decant leading to new projected compositions for SB4, designated as the 10-04-06 and the 10-10-06 compositions. A comparison between these SB4 compositions and those provided in June 2006 indicated that the new compositions are slightly higher in Al_2O_3, Fe_2O_3, and U_3O_8 and slightly lower in SiO_2. The most dramatic change, however, is the new projection's Na_2O concentration, which is more than 4.5 wt% lower than the June 2006 projection.[a] This is a significant change due to the frit development team's approach of aligning the Na_2O concentration in a candidate frit to the Na_2O content of the sludge.[b]

Questions surfaced regarding the applicability of Frit 503 to these revised compositions since the Savannah River National Laboratory (SRNL) recommended Frit 503 for use with SB4 based on the June 2006 compositional projection without the Tank 40 decant. Based on paper study assessments, the change in SB4's expected Na_2O content had a significant, negative impact on the projected operating window for the Frit 503/SB4 glass system. Frit 418 had a slightly larger operating window for the 10-04-06 projection (as compared to a lower Na_2O frit, Frit 503) and the Frit 418/10-04-06 glass system was no longer nepheline limited. Thus, strictly from the perspective of this paper study, Frit 418 was more attractive than Frit 503 for the new SB4 projected compositions. This comparison, however, did not reflect other aspects of interest for the glass systems such as their respective melt rates or the development of alternative frits to balance the projected operating windows, melt rate, waste throughput, and robustness to compositional variation.

In discussions with Waste Solidification Engineering (WS-E) regarding the paper study results, their decision was to utilize Frit 418 for initial processing of SB4. This decision was not only based on the paper study assessments, but also on the fact that Frit 418 is currently being used to process SB3 and, perhaps more importantly, frit optimization efforts for SB4 may be premature given the uncertainties in tank transfers, volumes, and any operational issues associated with the decant transfer from Tank 40 to Tank 51 and the sludge transfer from Tank 51 to Tank 40.

Given this decision and recognizing that a SB4/Frit 503 variability study had been initiated as part of the qualification process, questions regarding the need for a supplemental variability study to demonstrate applicability of the process control models for a Frit 418 based system surfaced. In response to the change in the projected composition for SB4 and the selection of Frit 418 by WS-E, SRNL complemented the SB4/Frit 503 variability study with 13 additional glasses using Frit 418. The composition region for the new glasses (or the SB4/Frit 418 variability study) was determined using the October 2006 projections of the SB4 composition. Variation was

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[a] The most recent composition changes are a result of using the Sludge Receipt and Adjustment Tank (SRAT) and/or updated Tank 51 compositional information based on the SB4 qualification sample and proposed Tank 40 decant. The June 2006 composition was based on the early analyses of SB4 and the Waste Acceptance Product Specifications (WAPS) sample analyses of SB3.

[b] This approach enhances the projected operating window and the waste throughput potential for the resulting glass system while eliminating the potential for nepheline crystallization. Nepheline can have a detrimental impact on durability.

introduced into the composition of the sludge to account for the uncertainty present in these projections as well as for process variation that may be experienced at the DWPF during its normal operations (e.g., a range of waste loadings was covered).

The glasses chosen for the variability study were fabricated and characterized by SRNL. The objectives of the variability study are to show that the vitrified waste product has a durability that is both acceptable as compared to the Environmental Assessment (EA) glass and predictable using the current DWPF process control models. The durability of each of the SB4/Frit 418 glasses studied, as measured by the Product Consistency Test (PCT), was very acceptable compared to the durability of the EA glass. The highest normalized boron release, NL[B], was 0.84 g/L for the centerline canister-cooled (ccc) version of SB4VS-43 based on the measured compositional view. The highest NL[B] for a quenched glass was 0.82 g/L for SB4VS-36, based on the target and measured compositional views. These are more than an order of magnitude better than the EA glass.

The durability of each of the study glasses was also predictable using the current DWPF models. The measured PCT response of all of the glasses studied fell within the 95% confidence bounds of the DWPF durability model regardless of heat treatment or compositional view. No nepheline was detected in the canister centerline cooled glasses via X-ray diffraction. The Product Composition Control System (PCCS) Measurement Acceptability Region (MAR) criteria were met for all of the glasses regardless of compositional view.

Based on these results, glasses formulated with Frit 418 and SB4 (the October 2006 composition) should be both acceptable as compared to the durability of the EA glass and predictable using the DWPF PCCS models.

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LIST OF ABBREVIATIONS

AD	Analytical Development
ANOVA	ANalysis Of VAriance
ARM	Approved Reference Material
ARP	Actinide Removal Process
ASTM	American Society for Testing and Materials
bc	bias-corrected
ccc	centerline canister-cooled
DWPF	Defense Waste Processing Facility
EA	Environmental Assessment glass
EVs	Extreme Vertices
HLW	High Level Waste
ICP-AES	Inductively Coupled Plasma – Atomic Emission Spectroscopy
LM	Lithium Metaborate
LWO	Liquid Waste Organization
MAR	Measurement Acceptability Region
MCU	Modular Caustic side solvent extraction Unit
NL	Normalized Leachate
PAR	Property Acceptability Region
PCCS	Product Composition Control System
PCT	Product Consistency Test
PF	Peroxide Fusion
ppm	parts per million
PSAL	Process Science Analytical Laboratory
SB3	Sludge Batch 3
SB4	Sludge Batch 4
SRAT	Sludge Receipt and Adjustment Tank
SRNL	Savannah River National Laboratory
WAPS	Waste Acceptance Product Specifications
WL	Waste Loading (weight percent)
WS-E	Waste Solidification - Engineering
XRD	X-Ray Diffraction

1.0 Introduction

In early October 2006, the Liquid Waste Organization (LWO) began to consider decanting Tank 40 at the end of Sludge Batch 3 (SB3) processing and transferring the aqueous phase from the decant to Tank 51. This transfer would be done to remove water added to Tank 40 by a slurry pump bearing water leak. Tank 40 decant water would be used to decrease Tank 51 yield stress and facilitate a transfer of Tank 51 to Tank 40. The projected composition of Sludge Batch 4 (SB4) was adjusted by LWO to reflect the impact of the Tank 40 decant leading to new projected compositions for SB4, designated as the 10-04-06[a] and the 10-10-06[1] compositions. A comparison between these SB4 compositions and those provided in June 2006[2] indicated that the new compositions are slightly higher in Al_2O_3, Fe_2O_3, and U_3O_8 and slightly lower in SiO_2.[3] The most dramatic change, however, is the new projection's Na_2O concentration, which is more than 4.5 wt% lower than the June 2006 projection.[b] This is a significant change due to the frit development team's approach of aligning the Na_2O concentration in a candidate frit to the Na_2O content of the sludge.[c]

Questions surfaced regarding the applicability of Frit 503 to these revised compositions since the Savannah River National Laboratory (SRNL) recommended Frit 503 for use with SB4 based on the June 2006 compositional projection without the Tank 40 decant.[4] Based on paper study assessments, the change in SB4's expected Na_2O content had a significant, negative impact on the projected operating window for the Frit 503/SB4 glass system.[3] Frit 418 had a slightly larger operating window for the 10-04-06 projection (as compared to a lower Na_2O frit, Frit 503) and the Frit 418/10-04-06 glass system was no longer nepheline limited. Thus, strictly from the perspective of this paper study, Frit 418 was more attractive than Frit 503 for the new SB4 projected compositions.[3] This comparison, however, does not reflect other aspects of interest for the glass systems such as their respective melt rates or the development of alternative frits to balance the projected operating windows, melt rate, waste throughput, and robustness to compositional variation.

In discussions with Waste Solidification Engineering (WS-E) regarding the paper study results, their decision was to utilize Frit 418 for initial processing of SB4. This decision was not only based on the paper study assessments, but also on the fact that Frit 418 is currently being used to process SB3 and, perhaps more importantly, frit optimization efforts for SB4 may be premature given the uncertainties in tank transfers, volumes, and any operational issues associated with the decant transfer from Tank 40 to Tank 51 and the sludge transfer from Tank 51 to Tank 40.

A critical step in the SB4 qualification process is to demonstrate the applicability of the durability models,[5] which are used as part of the DWPF's process control strategy, to the frit/sludge system of interest via a variability study. A variability study is an experimentally-driven assessment of the predictability and acceptability of the quality of the vitrified waste product that is anticipated from the processing of a sludge batch. The quality of the waste form is a measure of its durability as determined by the Product Consistency Test (PCT).[6] At the DWPF, the durability of the

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[a] Composition provided by H.B. Shah via email. See WSRC-NB-2006-00017 for details.

[b] The most recent composition changes are a result of using the Sludge Receipt and Adjustment Tank (SRAT) and/or updated Tank 51 compositional information based on the SB4 qualification sample and proposed Tank 40 decant. The June 2006 composition was based on the early analyses of SB4 and the Waste Acceptance Product Specifications (WAPS) sample analyses of SB3.

[c] This approach enhances the projected operating window and the waste throughput potential for the resulting glass system while eliminating the potential for nepheline crystallization. Nepheline can have a detrimental impact on durability.

vitrified waste product is not directly measured by this test during normal operation. Instead, the durability is predicted using models that relate the PCT response of a glass to the chemical composition of that glass. The objectives of a variability study are to demonstrate (1) the applicability of the durability models, which are used as part of the DWPF's process control strategy, to the frit/sludge system of interest and (2) the acceptability of the glasses within the compositional region of interest in comparison to the Environmental Assessment (EA) glass benchmark. The success of this demonstration allows the DWPF to confidently rely on the predictions of the durability/composition models as they are used in the control of the DWPF process.

Recognizing that a SB4/Frit 503 variability study had been initiated as part of the qualification process,[7, 8] questions regarding the need for a supplemental variability study to demonstrate applicability of the process control models for a Frit 418 based system surfaced. In response to the change in projected composition for SB4 and the selection of Frit 418 by WS-E, SRNL complemented the SB4/Frit 503 variability study with 13 additional glasses using Frit 418.[3] The composition region for the new glasses (or the SB4/Frit 418 variability study) was determined using the October 2006 projections of the SB4 composition. Variation was introduced into the composition of the sludge to account for the uncertainty present in these projections as well as for process variation that may be experienced at the DWPF during its normal operations (i.e., a range of waste loadings was covered).

The glasses chosen for the variability study were fabricated by SRNL. Both quenched and canister centerline-cooled (ccc) heat treatments were performed, and chemical compositions were verified. The PCT was used to gauge the durability of each glass based on both quenched and ccc heat treatments. X-ray diffraction (XRD) was used to assess the possible formation of crystalline phases in the ccc glasses.

The results of this variability study will confirm the applicability of the DWPF durability models to the SB4/Frit 418 systems based on the October 2006 compositional projections. This work was initiated by a DWPF Technical Task Request[9] and is performed under a SRNL Task Technical and Quality Assurance Plan.[10]

2.0 Experimental Procedure

2.1 Glass Selection Strategy

The strategy used in selecting glasses for the SB4/Frit 418 variability study was described in a previous report,[3] however, a brief overview of the process will be provided here. WS-E decided to utilize Frit 418 for initial processing of SB4 based on the Measurement Acceptability Region (MAR) assessments of the October 2006 compositions.[3] Therefore, the variability study focused solely on the use of this frit. The decision to use Frit 418 was not only based on paper study assessments,[3] but also on the fact that Frit 418 is currently being used to process SB3 and, perhaps more importantly, frit optimization efforts for SB4 may be premature given the uncertainties in tank transfer and heel volumes associated with the SB4 flowsheet. The nominal composition of Frit 418 is given in Table 2-1.

Table 2-1. Composition (in wt%) of Frit 418.

Frit ID	B_2O_3	Li_2O	Na_2O	SiO_2
418	8	8	8	76

The new projected sludge compositions that were considered in this study are provided in Table 2-2. Elemental concentrations for these options were provided to the frit development team by LWO,[1] and these were converted to oxide concentrations by multiplying the values for each element by the gravimetric factor for the corresponding oxide. The compositions submitted to the frit development team did not include estimates of the SO_4^{2-} concentrations. However, LWO personnel did provide information, as part of the washing scenarios and preparation plans, which was used to derive an estimate for the SO_4^{2-} concentration. The concentration was added to the oxide list and the resulting oxide concentrations were then normalized to 100%. It should be noted that the projected sludge compositions presented in Table 2-2 are sludge-only flowsheets and do not account for any potential secondary streams from the Actinide Removal Process (ARP) or the Modular Caustic Side Solvent Extraction Unit (MCU). These auxiliary streams are not considered in this report.

Table 2-2. Nominal SB4 Projected Compositions (wt% calcine basis).

Oxide	10-04-06 SB4 Projection	10-10-06 SB4 Projection
	Blend 1 Processing	Blend 1 Processing
Al_2O_3	25.65	25.490
BaO	0.07	0.070
CaO	2.79	2.765
Ce_2O_3	0.22	0.214
Cr_2O_3	0.20	0.198
CuO	0.05	0.051
Fe_2O_3	29.20	28.989
K_2O	0.07	0.068
La_2O_3	0.03	0.031
MgO	2.79	2.774
MnO	5.83	5.783
Na_2O	18.22	18.708
NiO	1.67	1.660
PbO	0.39	0.383
SO_4^{2-}	0.79	0.866
SiO_2	2.73	2.711
ThO_2	0.03	0.031
TiO_2	0.04	0.035
U_3O_8	9.10	9.031
ZnO	0.05	0.000
ZrO_2	0.09	0.050
SUM	100.00	100.00

A statistical analysis approach was used to optimally select Frit 418-based glasses that cover this SB4 composition region at a series of waste loadings (WLs) likely to be processed at DWPF.[3] The goal was to maximize the compositional range studied to adequately address the effect of the potential variation on the applicability of the durability models while limiting the number of glasses to be fabricated in the laboratory. The selection process led to the identification of 11 sludge compositions (extreme vertices, (EVs)) plus a centroid composition (the average of all the EVs) to support the study objectives.[3] These sludge compositions were then combined with Frit 418 at WLs likely to be processed at the DWPF to arrive at glass compositions for the study. The glass compositions selected met all of the DWPF Product Composition Control System (PCCS) MAR criteria based on their targeted compositions.[3]

2.2 Target Compositions of Selected Glasses

The target compositions of the glasses selected for the SB4/Frit 418 variability study are listed in Table 2-3. The compositions of the glasses derived from the EVs of the sludge region are identified as SB4VS-36 through SB4VS-46. These glasses cover WLs from 28 to 42% with eight falling within the WL interval from 30 to 38% (inclusive). The compositions of the glasses derived from the centroid of the sludge region are identified as SB4VS-47 and SB4VS-48. These glasses targeted WLs of 32 and 36%, respectively, which is the primary WL interval of interest for this glass system.[3] Values of the nepheline discriminator for each glass are also presented. Nepheline discriminator values of greater than 0.62 indicate that nepheline is not likely to precipitate in the glass.[11]

Table 2-3. Target Compositions (in wt%) of the Frit 418 SB4 Variability Study Glasses.

	SB4VS-36	SB4VS-37	SB4VS-38	SB4VS-39	SB4VS-40	SB4VS-41	SB4VS-42	SB4VS-43	SB4VS-44	SB4VS-45	SB4VS-46	SB4VS-47	SB4VS-48
WL	40	34	38	38	36	28	30	42	32	34	30	32	36
Nepheline Discriminator	0.677	0.715	0.686	0.684	0.692	0.747	0.743	0.663	0.739	0.714	0.752	0.729	0.703
Al_2O_3	9.43	9.15	10.41	10.41	9.70	7.39	7.07	9.90	7.55	9.32	7.07	8.13	9.15
B_2O_3	4.80	5.28	4.96	4.96	5.12	5.76	5.60	4.64	5.44	5.28	5.60	5.44	5.12
BaO	0.04	0.04	0.06	0.06	0.05	0.03	0.03	0.06	0.05	0.04	0.04	0.04	0.05
CaO	1.21	0.86	1.15	0.96	1.09	0.70	0.90	1.06	0.80	1.03	0.90	0.89	1.00
Ce_2O_3	0.05	0.04	0.07	0.07	0.06	0.03	0.04	0.07	0.06	0.04	0.05	0.05	0.05
Cr_2O_3	0.07	0.06	0.09	0.09	0.09	0.05	0.05	0.10	0.08	0.06	0.07	0.07	0.08
CuO	0.02	0.02	0.03	0.03	0.03	0.01	0.01	0.03	0.02	0.02	0.02	0.02	0.02
Fe_2O_3	12.20	10.60	10.35	10.19	9.65	7.51	8.54	12.44	9.84	9.39	9.28	9.25	10.40
K_2O	0.11	0.09	0.15	0.15	0.14	0.08	0.08	0.16	0.12	0.09	0.12	0.11	0.12
La_2O_3	0.04	0.03	0.05	0.05	0.04	0.02	0.03	0.05	0.04	0.03	0.04	0.03	0.04
Li_2O	4.80	5.28	4.96	4.96	5.12	5.76	5.60	4.64	5.44	5.28	5.60	5.44	5.12
MgO	1.21	0.86	0.96	1.15	0.91	0.71	0.76	1.06	0.97	1.03	0.76	0.89	1.00
MnO	2.14	1.82	2.36	2.03	1.93	1.50	1.87	2.61	1.99	2.11	1.60	1.85	2.08
Na_2O	12.84	11.16	11.54	11.91	12.36	11.39	11.63	13.09	10.98	11.16	10.79	11.38	11.81
NiO	0.56	0.48	0.54	0.54	0.69	0.53	0.42	0.59	0.61	0.65	0.57	0.53	0.60
PbO	0.03	0.03	0.04	0.04	0.04	0.02	0.02	0.04	0.03	0.03	0.03	0.03	0.03
SO_4^{2-}	0.39	0.26	0.37	0.29	0.28	0.27	0.23	0.41	0.25	0.33	0.29	0.28	0.31
SiO_2	46.58	51.00	48.06	48.25	49.53	55.41	54.09	45.32	52.47	51.17	54.09	52.55	49.62
ThO_2	0.02	0.02	0.03	0.03	0.03	0.01	0.02	0.03	0.02	0.02	0.02	0.02	0.02
TiO_2	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
U_3O_8	3.34	2.84	3.69	3.69	3.01	2.72	2.91	3.51	3.11	2.84	2.91	2.90	3.26
ZnO	0.03	0.03	0.04	0.04	0.04	0.02	0.02	0.05	0.04	0.03	0.03	0.03	0.04
ZrO_2	0.08	0.07	0.10	0.10	0.10	0.05	0.06	0.12	0.09	0.07	0.08	0.08	0.08

2.3 Glass Fabrication

Each variability study glass was prepared from the proper proportions of reagent-grade metal oxides, carbonates, H_3BO_3, and salts in 150 g batches.[12] The raw materials were thoroughly mixed and placed into a 95% platinum / 5% gold, 250 ml crucible. The batch was placed into a high-temperature furnace at the target melt temperature of 1150°C.[13] The crucible was removed from the furnace after an isothermal hold at 1150°C for 1 hour. The glass was poured onto a clean, stainless steel plate and allowed to air cool (quench). The glass pour patty was used as a sampling stock for the various property measurements, including chemical composition and durability testing.

Approximately 25 g of each glass was heat-treated to simulate cooling along the centerline of a DWPF-type canister[14] to gauge the effects of thermal history on the product performance. This cooling schedule is referred to as the ccc curve. Visual observations on both quenched and ccc glasses were documented.[a]

2.4 Property Measurements

This section provides a general discussion of the chemical composition analyses, the PCTs, and the XRD analyses of the SB4 variability study glasses.

2.4.1 *Compositional Analysis*

To confirm that the as-fabricated glasses met the target compositions, a representative sample from each glass was submitted to the SRNL Process Science Analytical Laboratory (PSAL) for chemical analysis under the auspices of an analytical plan. The plan (see Appendix A) identified the cations to be analyzed and the two dissolution techniques, sodium peroxide fusion (PF) and lithium-metaborate (LM), to be used. The samples prepared by LM were used to measure barium (Ba), calcium (Ca), cerium (Ce), chromium (Cr), copper (Cu), potassium (K), lanthanum (La), magnesium (Mg), sodium (Na), lead (Pb), sulfur (S), thorium (Th), titanium (Ti), zinc (Zn), and zirconium (Zr) concentrations. Samples prepared by PF were used to measure aluminum (Al), boron (B), iron (Fe), lithium (Li), manganese (Mn), nickel (Ni), silicon (Si), and uranium (U) concentrations. Each glass was prepared in duplicate for each of the two cation dissolution techniques. All of the prepared samples were analyzed twice for each element of interest by Inductively Coupled Plasma – Atomic Emission Spectroscopy (ICP-AES), with the instrumentation being re-calibrated between the duplicate analyses. The analytical plan was developed in such a way as to provide the opportunity to evaluate potential sources of bias and error. Glass standards were also intermittently measured to assess the performance of the ICP-AES instrument over the course of these analyses.

2.4.2 *Product Consistency Test (PCT)*

The PCT[6] was performed in triplicate on each quenched and ccc glass to assess chemical durability. Also included in the experimental test matrix was the EA glass,[15] the Approved Reference Material (ARM) glass, and blanks from the sample cleaning batch. Samples were ground, washed, and prepared according to the standard procedure.[6] Fifteen milliliters of Type I American Society for Testing and Materials (ASTM) water were added to 1.5 g of glass in stainless steel vessels. The vessels were closed, sealed, and placed in an oven at 90 ± 2°C where the samples were maintained at temperature for 7 days. Once cooled, the resulting solutions were sampled (filtered and acidified), then labeled and analyzed by PSAL under the auspices of an

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[a] WSRC-NB-2004-00135 and WSRC-NB-2006-00168 contain the visual observations of the quenched and ccc glasses, respectively.

analytical plan (see Appendix B). The aim of the plan was to provide an opportunity to assess the consistency (repeatability) of the PCT and analytical procedures in evaluating the chemical durability of the glasses. Normalized release rates were calculated based on target, measured, and bias-corrected (bc) compositions using the average of the common logarithms of the leachate concentrations.

2.4.3 *X-Ray Diffraction Analysis*

Although visual observations for crystallization were performed and documented, representative samples for all ccc glasses were submitted to SRNL Analytical Development (AD) for XRD analysis. Based on both visual observations and PCT responses (as will be discussed), there was no technical driver to submit the quenched samples for XRD analysis. Samples were run under conditions providing a detection limit of approximately 0.5 vol%. That is, if crystals (or undissolved solids) were present at 0.5 vol% or greater, the diffractometer would not only be capable of detecting the crystals but would also allow a qualitative determination of the type of crystal(s) present. Otherwise, a characteristically high background devoid of crystalline spectral peaks indicates that the glass product is amorphous, suggesting either a completely amorphous product or that the degree of crystallization is below the detection limit.

3.0 Results and Discussion

3.1 A Statistical Review of the Chemical Composition Measurements of the SB4/Frit 418 Variability Study Glasses

In this section, the measured versus targeted compositions of the 13 SB4/Frit 418 variability study glasses (SB4VS-36 through SB4VS-48) are presented and compared. The targeted compositions for these glasses are provided in Table C1 of Appendix C. A sum of oxides column is provided in this table as well. Chemical composition measurements for these glasses were conducted by the PSAL following the analytical plan provided in Appendix A. Note that one deviation was made from the analytical plan at the discretion of PSAL personnel: Fe_2O_3 was measured using the LM dissolution. For each study glass, measurements were obtained from samples prepared in duplicate by each of the two dissolution methods. Table C2 in Appendix C provides the elemental concentration measurements derived from the samples prepared using LM, and Table C3 in Appendix C provides the measurements derived from the samples prepared using PF. Measurements for standards (Batch 1 and a uranium standard, U_{std}) that were included in the PSAL analytical plan along with the study glasses are also provided in these two tables.

The elemental concentrations were converted to oxide concentrations by multiplying the values for each element by the gravimetric factor for the corresponding oxide. During this process, an elemental concentration that was determined to be below the detection limit of the analytical procedures used by the PSAL was reduced to half of that detection limit as the oxide concentration was determined.

In the sections that follow, the analytical sequences of the measurements are explored, the measurements of the standards are investigated and used for bias correction, the measurements for each glass are reviewed, the average chemical compositions (measured and bias-corrected) for each glass are determined, and comparisons are made between the measurements and the targeted compositions for the glasses.

3.1.1 *Measurements in Analytical Sequence*

Exhibit C1 in Appendix C provides plots of the measurements generated by the PSAL for samples prepared using the LM method. The plots are in analytical sequence with different symbols and colors being used to represent each of the study and standard glasses. Similar plots for the samples prepared using the PF method are provided in Exhibit C2 in Appendix C. These plots include all of the measurement data from Tables C2 and C3. While there are a couple of (relatively) large Ce_2O_3 values for Batch 1 and one large value for La_2O_3 for a sample of a study glass, review of these plots indicates no significant patterns or trends in the analytical process over the course of these measurements, and there appear to be no significant outliers in these chemical composition measurements.

3.1.2 *Batch 1 and Uranium Standard Results*

In this section, the PSAL measurements of the chemical compositions of the Batch 1 and uranium standard (U_{std}) glasses are reviewed. These measurements are investigated across the ICP analytical blocks, and the results are used to bias correct the measurements for the study glasses.

Exhibit C3 in Appendix C provides statistical analyses of the Batch 1 and U_{std} results generated by the LM prep method by block/sub-block for each oxide of interest. The results include analysis of variance (ANOVA) investigations looking for statistically significant differences between the means of these groups for each of the oxides for each of the standards. The results from the statistical tests for the Batch 1 standard may be summarized as follows: Fe_2O_3, MnO, and Na_2O have measurements that indicate a significant ICP calibration effect on the block averages at the 5% significance level. For the U_{std}, Fe_2O_3, MnO, and TiO_2 have measurements that indicate a significant ICP calibration effect on the block averages at the 5% significance level. The reference values for the oxide concentrations of the standard are given in the header for each set of measurements in the exhibit.

Exhibit C4 in Appendix C provides a similar set of analyses for the measurements derived from samples prepared via the PF method. The results from the statistical tests for the Batch 1 standard may be summarized as follows: Li_2O and NiO have measurements that indicate significant ICP calibration effects on the block averages at the 5% significance level. For the U_{std}, Li_2O and NiO have measurements that indicate significant ICP calibration effects on the block averages at the 5% significance level. The reference values for the oxide concentrations of the standard are given in the headers for each set of measurements in the exhibit.

Thus, some of these results provide incentive for adjusting the measurements by the effects of the ICP calibration. Therefore, the oxide measurements of the study glasses are to be bias corrected for the effect of the ICP calibration on each of the analytical blocks and sub-blocks. The basis for this bias correction is presented as part of Exhibits C3 and C4 – the average measurement for Batch 1 for each ICP block/sub-block for Al_2O_3, B_2O_3, BaO, CaO, Cr_2O_3, CuO, Fe_2O_3, Li_2O, MgO, MnO, Na_2O, NiO, SiO_2, and TiO_2 and the average measurement for U_{std} for each ICP set/block for U_3O_8. The Batch 1 results served as the basis for bias correcting all of the oxides (that were bias corrected) except uranium. The U_{std} results were used to bias correct for uranium. For the other oxides, the Batch 1 results were used to conduct the bias correction as long as the reference value for the oxide concentration in the Batch 1 glass was greater than or equal to 0.1 wt%. Thus, applying this approach and based upon the information in the exhibits, the Batch 1 results were used to bias correct the Al_2O_3, B_2O_3, BaO, CaO, Cr_2O_3, CuO, Fe_2O_3, K_2O, Li_2O, MgO, MnO, Na_2O, NiO, SiO_2, and TiO_2 measurements. No bias correction was conducted for Ce_2O_3, La_2O_3, PbO, SO_4^{2-}, ThO_2, ZnO, or ZrO_2.

The bias correction was conducted as follows. For each oxide, let $\overline{a}_{ij}$ be the average measurement for the i^{th} oxide at analytical block j for Batch 1 (or U_{std} for uranium), and let t_i be the reference value for the i^{th} oxide for Batch 1 (or for U_{std} if uranium). (The averages and reference values are provided in Exhibits C3 and C4.) Let $\overline{c}_{ijk}$ be the average measurement for the i^{th} oxide at analytical block j for the k^{th} glass. The bias adjustment was conducted as follows

$$\overline{c}_{ijk} \bullet \left(1 - \frac{\overline{a}_{ij} - t_i}{\overline{a}_{ij}}\right) = \overline{c}_{ijk} \bullet \frac{t_i}{\overline{a}_{ij}}$$

Bias-corrected measurements are indicated by a "bc" suffix, and such adjustments were performed for all of the oxides of this study except for Ce_2O_3, La_2O_3, PbO, SO_4, ThO_2, ZnO, and ZrO_2. Both measured and measured "bc" values are included in the discussion that follows. In these discussions bias-corrected values for Ce_2O_3, La_2O_3, PbO, SO_4, ThO_2, ZnO, and ZrO_2 are included for completeness (e.g., to allow a sum of oxides to be computed for the bias-corrected results), however these bias-corrected values are the same as the original Ce_2O_3, La_2O_3, PbO, SO_4, ThO_2, ZnO, and ZrO_2 values.

3.1.3 *Composition Measurements by Glass Number*

Exhibits C5 and C6 in Appendix C provide plots of the oxide concentration measurements by Glass ID (including Batch 1, labeled as glass numbered 100, and U_{std}, labeled as glass numbered 200) by ICP calibration block/sub-block for the measured and bias-corrected (bc) values for the LM and PF preparation methods, respectively. Different symbols and colors are used to represent the different glasses. These plots show the individual measurements across the duplicates of each preparation method and the two ICP calibrations. A review of the plots presented in these exhibits reveals the repeatability of the four individual, oxide values for each glass. The two large Ce_2O_3 values for the Batch 1 samples are visible as is one La_2O_3 value for glass SB4VS-43 for block/sub-block 1-2. There appears to be a good bit of scatter in the pair of Na_2O values for SB4VS-42 for block/sub-block 1-1 and for the SiO_2 values for SB4VS-43 for both block/sub-blocks. There is also some scatter in the PbO values for SB4VS-40. None of these issues are seen as having any significant impact on the conclusions of this report.

3.1.4 *Measured versus Targeted Compositions*

The four measurements for each oxide for each glass (over both preparation methods) were averaged to determine a representative chemical composition for each glass. These determinations were conducted both for the measured and for the bias-corrected data. A sum of oxides was also computed for each glass based upon both the measured and bias-corrected values. Exhibit C7 in Appendix C provides plots showing results for each glass for each oxide to help highlight the comparisons among the measured, bias-corrected, and targeted values.

Some observations from the plots of Exhibit C7 are offered: For every glass, the average measured Al_2O_3 and CaO values are above the targeted values, and the same can be said for the Na_2O measurements for both the study glasses and the standards. For the Na_2O, the bias-corrected values move many of these measurements nearer to their respective targeted values. For nearly every study glass, the average measured Ce_2O_3, Fe_2O_3, MgO and NiO values are less than their respective targeted concentrations. In general, bias-correcting helps move the MgO and NiO measurements towards their respective targets but not the Fe_2O_3 measurements.

Table C4 in Appendix C provides a summary of the average compositions as well as the targeted compositions and some associated differences and relative differences. Notice that the targeted sums of oxides for the standard glasses do not sum to 100% due to an incomplete coverage of the oxides in the Batch 1 (Glass # 100) and U_{std} (Glass # 200) glasses. All of the sums of oxides (both measured and bias-corrected) for the study glasses fall within the interval of 95 to 105 wt%. Entries in Table C4 show the relative differences between the measured or bias-corrected values and the targeted values. These differences are shaded when they are greater than or equal to 5%. Overall, these comparisons between the measured and targeted compositions suggest only minor difficulties in hitting the targeted compositions for some of the oxides for some of the glasses, which should have no significant impacts on the outcome of this report.

3.1.5 *Assessment of SO_4^{2-} Values*

The targeted SO_4^{2-} concentrations for the SB4/Frit 418 study glasses are all in the range of 0.22 to 0.41 wt%. The measured SO_4^{2-} concentrations versus the targets are shown in Figure 3-1 (this plot is also part of Exhibit C7).

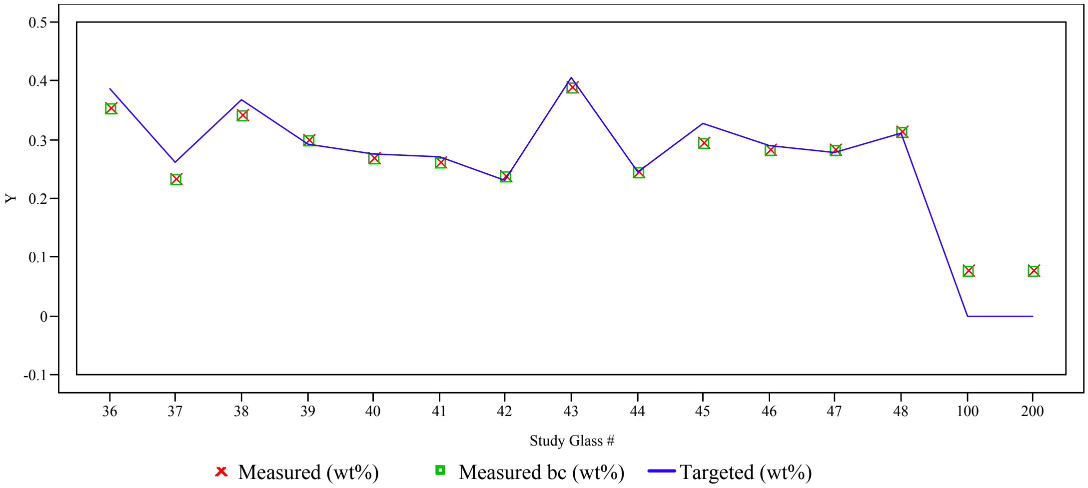


Figure 3-1. Sulfate Values for the Frit 418 Variability Study Glasses by Glass Number
(100 – Batch 1 and 200 – Ustd)

Since Batch 1 and the U_{std} standards contain no SO_4^{2-}, their measurements are below the detection limit for this analyte (see Table C2). For the study glasses the averages of the measured values fall near or slightly below the targeted concentrations. From Table C4, the percent differences range from 11.2% below to 2.3% above their respective targets. These results suggest that there are no issues with sulfur solubility in the glasses over the range of sulfate concentrations included in the study. Note however that these concentrations did not approach the PCCS limit of 0.6 wt% SO_4^{2-} in the glass.

3.1.6 *MAR Assessment of the SB4/Frit 418 Variability Study Glasses*

Another assessment that can be made for these SB4 variability study glasses is how well they satisfy the MAR criteria of DWPF's PCCS. All of the glasses that were selected for this study satisfied these criteria. That is, the targeted composition for each of these glasses fell within the MAR of the PCCS. In this section, the results of the MAR assessment of the measured and measured bias-corrected compositions for these glasses are presented along with the results for the targeted compositions.

Table 3-1 provides this information. The columns in the table give the glass identifier, compositional view, the ΔGp value for boron (B Del Gp Value), the normalized leachate for boron in grams/Liter (NL[B (g/L)]), the liquidus temperature prediction in degrees Celsius (T_L Pred (ºC)), the viscosity prediction in Poise (Visc Pred (P)), the sum of oxides (in wt%), the Al_2O_3 concentration (in wt%), the Na_2SO_4 concentration (in wt%), and the total alkali concentration (R_2O) as a wt%, the nepheline value, and the overall MAR assessment excluding any limitation on Na_2SO_4. Note that the 0.6 wt% SO_4^{2-} limit in PCCS would only be an issue at very high WLs, since the nominal sludge composition projection for SO_4^{2-} is relatively low (see Table 2-2). All of the results for these glasses indicate that they would pass the PCCS MAR and be deemed suitable for processing by and acceptable for the DWPF.

Table 3-1. Results of MAR Assessment of SB4 VS Glasses for Measured, Bias-Corrected, and Targeted Compositional Views

Glass ID	Compositional View	B Del Gp Value	NL[B (g/L)]	T_L Pred (ºC)	Visc Pred (P)	Sum of Oxides	Al_2O_3 wt%	Na_2SO_4 wt%	R_2O wt%	Nepheline Value	MAR Status w/o Na_2SO_4
SB4VS-36	targeted	-9.254	0.60	971.3	46.14	99.614	9.431	0.572	17.75	0.677	All constraints met.
SB4VS-37	targeted	-7.944	0.35	935.2	74.18	99.739	9.152	0.385	16.54	0.715	All constraints met.
SB4VS-38	targeted	-8.053	0.36	966.6	73.35	99.633	10.413	0.543	16.64	0.686	All constraints met.
SB4VS-39	targeted	-8.249	0.39	961.2	70.77	99.709	10.413	0.431	17.02	0.684	All constraints met.
SB4VS-40	targeted	-8.940	0.52	934.1	65.76	99.725	9.7	0.408	17.62	0.692	All constraints met.
SB4VS-41	targeted	-9.042	0.55	823.6	81.60	99.730	7.393	0.400	17.23	0.747	All constraints met.
SB4VS-42	targeted	-9.403	0.63	835.4	70.79	99.770	7.074	0.340	17.32	0.743	All constraints met.
SB4VS-43	targeted	-9.344	0.62	989.3	43.68	99.592	9.903	0.600	17.89	0.663	All constraints met.
SB4VS-44	targeted	-8.595	0.45	919.3	71.49	99.757	7.545	0.363	16.54	0.739	All constraints met.
SB4VS-45	targeted	-8.152	0.38	932.3	81.60	99.671	9.317	0.486	16.54	0.714	All constraints met.
SB4VS-46	targeted	-8.551	0.44	887.6	76.25	99.709	7.074	0.429	16.51	0.752	All constraints met.
SB4VS-47	targeted	-8.714	0.48	894.7	73.91	99.722	8.134	0.410	16.93	0.729	All constraints met.
SB4VS-48	targeted	-8.634	0.46	943.8	65.59	99.688	9.151	0.461	17.05	0.703	All constraints met.
SB4VS-36	measured	-9.462	0.65	944.2	43.77	97.918	9.636	0.520	17.96	0.666	All constraints met.
SB4VS-37	measured	-8.241	0.39	919.3	69.15	98.568	9.528	0.342	16.92	0.702	All constraints met.
SB4VS-38	measured	-8.281	0.40	939.8	75.70	99.284	11.002	0.502	17.08	0.675	All constraints met.
SB4VS-39	measured	-8.808	0.50	918.9	66.92	98.818	10.747	0.440	17.78	0.671	All constraints met.
SB4VS-40	measured	-8.920	0.52	912.3	67.69	99.274	10.095	0.393	17.74	0.686	All constraints met.
SB4VS-41	measured	-9.254	0.60	803.2	82.03	99.187	7.841	0.382	17.65	0.737	All constraints met.
SB4VS-42	measured	-9.923	0.79	814.0	65.41	99.237	7.355	0.348	17.98	0.730	All constraints met.
SB4VS-43	measured	-9.862	0.77	947.5	39.53	97.281	10.08	0.573	18.42	0.648	All constraints met.
SB4VS-44	measured	-8.858	0.51	891.3	66.71	98.000	7.865	0.360	16.82	0.727	All constraints met.
SB4VS-45	measured	-8.414	0.42	892.9	82.82	98.197	9.712	0.432	16.89	0.704	All constraints met.
SB4VS-46	measured	-8.989	0.53	854.5	75.93	100.254	7.459	0.413	17.14	0.743	All constraints met.
SB4VS-47	measured	-8.994	0.53	865.0	71.05	97.713	8.361	0.415	17.24	0.719	All constraints met.
SB4VS-48	measured	-8.879	0.51	919.6	65.20	98.771	9.362	0.461	17.33	0.696	All constraints met.
SB4VS-36	measured bc	-8.847	0.50	967.1	53.52	99.260	9.653	0.520	17.30	0.679	All constraints met.
SB4VS-37	measured bc	-7.674	0.31	939.9	82.01	100.012	9.544	0.342	16.32	0.713	All constraints met.
SB4VS-38	measured bc	-7.597	0.30	968.9	88.59	100.220	11.042	0.502	16.30	0.686	All constraints met.
SB4VS-39	measured bc	-8.055	0.36	949.0	81.86	100.332	10.765	0.440	16.95	0.684	All constraints met.
SB4VS-40	measured bc	-8.203	0.38	942.1	79.48	100.148	10.132	0.393	16.93	0.696	All constraints met.
SB4VS-41	measured bc	-8.554	0.45	829.3	94.81	100.026	7.87	0.382	16.86	0.747	All constraints met.
SB4VS-42	measured bc	-9.205	0.58	840.7	76.28	100.084	7.382	0.348	17.17	0.741	All constraints met.
SB4VS-43	measured bc	-9.065	0.55	979.9	49.83	98.693	10.098	0.573	17.52	0.662	All constraints met.
SB4VS-44	measured bc	-8.312	0.40	914.7	78.79	99.546	7.879	0.360	16.26	0.738	All constraints met.
SB4VS-45	measured bc	-7.852	0.33	915.0	97.70	99.683	9.729	0.432	16.30	0.715	All constraints met.
SB4VS-46	measured bc	-8.465	0.43	875.0	86.06	101.125	7.486	0.413	16.58	0.751	All constraints met.
SB4VS-47	measured bc	-8.280	0.40	894.4	85.52	99.276	8.375	0.415	16.46	0.732	All constraints met.
SB4VS-48	measured bc	-8.329	0.41	941.6	75.05	99.570	9.397	0.461	16.73	0.705	All constraints met.

3.2 A Statistical Review of the SB4/Frit 418 Variability Study PCT Results

The study glasses, after being batched and fabricated, were subjected to the 7-day PCT-A to assess their durability. Both quenched and ccc specimens of each study glass were subjected to the PCT in triplicate. PCTs were also conducted in triplicate for samples of the EA glass and for samples of the ARM glass. Blanks (samples consisting only of ASTM Type I water) were also submitted for the PCT.

An analytical plan, presented in Appendix B, was provided to the PSAL to support the measurement of the compositions of the solutions resulting from the PCTs. Samples of a multi-element, standard solution were also included in the analytical plan as a check on the accuracy of the ICP-AES instrument used for these measurements. In this and the following sections, the measurements generated by the PSAL for these PCTs are presented and reviewed.

Table D1 in Appendix D provides the elemental leachate concentration measurements determined by the PSAL for the solution samples generated by the PCTs. One of the quality control checkpoints for the PCT procedure is solution-weight loss over the course of the 7-day test. None of these PCT results indicated a solution-weight loss problem. Any measurement in Table D1 below the detection limit of the analytical procedure (indicated by a "<") was replaced by one half of the detection limit in subsequent analyses. In addition to adjustments for detection limits, the values were adjusted for the dilution factors: the values for the study glasses, the blanks, and the ARM glass in Table D1 were multiplied by 1.6667 to determine the values in parts per million (ppm) and the values for EA were multiplied by 16.6667. Table D2 in Appendix D provides the resulting measurements.

In the sections that follow, the analytical sequence of the measurements is explored, the measurements of the standards are investigated and used to assess the overall accuracy of the ICP-AES measurement process, the measurements for each glass are reviewed, plots are provided that explore the effects of heat treatment on the PCTs for these glasses, the PCTs are normalized using the compositions (targeted, measured, and bias-corrected) presented in Table C4, and the normalized PCTs are compared to durability predictions for these compositions generated from the current DWPF models.[5]

3.2.1 *Measurements in Analytical Sequence*

Exhibits D1 and D2 in Appendix D provide plots of the leachate (ppm) concentrations in analytical sequence as generated by the PSAL for all of the data and for the data from only the study glasses, respectively. A different color and symbol are used for each study glass or standard. No issues are apparent in these plots.

3.2.2 *Results for the Samples of the Multi-Element Solution Standard*

Exhibit D3 in Appendix D provides analyses of the PSAL measurements of the samples of the multi-element solution standard by ICP analytical (or calibration) block. An ANOVA investigating for statistically significant differences among the block averages for these samples for each element of interest is included in this exhibit. These results indicate a statistically significant (at approximately a 5% level) difference among the Al average measurements, the Fe average measurements, the Li average measurements, and the Si average measurements over these blocks. However, no bias correction of the PCT results for the study glasses was conducted. This approach was taken since the triplicate PCTs for a single study glass were placed in different ICP blocks. Averaging the ppm's for each set of triplicates helps to minimize the impact of the ICP effects.

Table 3-2 summarizes the average measurements and the reference values for the four primary elements of interest. The results indicate consistent and accurate measurements from the PSAL processes used to conduct these analyses.

Table 3-2. Results from Samples of the Multi-Element Solution Standard

Analytical Block	Avg B (ppm)	Avg Li (ppm)	Avg Na (ppm)	Avg Si (ppm)
1	19.0	9.6	81.7	48.3
2	20.1	9.9	83.5	49.2
3	20.4	10.0	81.1	50.2
4	20.1	9.9	83.2	50.4
5	19.9	9.9	82.7	49.5
6	20.3	9.9	82.3	50.0
Grand Average	**20.0**	**9.9**	**82.4**	**49.6**
Reference Value	**20**	**10**	**81**	**50**
% difference	**-0.14%**	**-1.43%**	**1.77%**	**-0.79%**

3.2.3 *Measurements by Glass Number*

Exhibit D4 in Appendix D provides plots of the leachate concentrations for each type of submitted sample: the study glasses by heat treatment and the standards (EA (101), ARM (102), the multi-element solution standard (100), and blanks (103)). Exhibit D5 in Appendix D provides plots of the leachate concentrations for the PCT results of just the study glasses by heat treatment. These plots allow for an assessment of the repeatability of the measurements, which suggests some scatter in the triplicate values for some analytes for some of the glasses. Also, note that some differences between the values for the two heat treatments for some glasses are evident. More will be said regarding comparisons between the heat treatments in the discussions that follow.

3.2.4 *Normalized PCT Results*

PCT leachate concentrations are typically normalized using the cation composition (expressed as a weight percent) in the glass to obtain a grams-per-liter (g/L) leachate concentration. The normalization of the PCTs is usually conducted using the measured compositions of the glasses. This is the preferred normalization process for the PCTs. For completeness, the targeted cation and the bias-corrected cation compositions were also used to conduct this normalization.

As is the usual convention, the common logarithm of the normalized PCT (normalized leachate, NL) for each element of interest was determined and used for comparison. To accomplish this computation, one must

1. Determine the common logarithm of the elemental parts per million (ppm) leachate concentration for each of the triplicates and each of the elements of interest (these values are provided in Table B2 of Appendix B),

2. Average the common logarithms over the triplicates for each element of interest, and then

Normalizing Using Measured Composition (preferred method)

3. Subtract a quantity equal to 1 plus the common logarithm of the average cation measured concentration (expressed as a weight percent of the glass) from the average computed in step 2.

Or Normalizing Using Target Composition

3. Subtract a quantity equal to 1 plus the common logarithm of the target cation concentration (expressed as a weight percent of the glass) from the average computed in step 2.

Or Normalizing Using Measured Bias-Corrected Composition

3. Subtract a quantity equal to 1 plus the common logarithm of the measured bias-corrected cation concentration (expressed as a weight percent of the glass) from the average computed in step 2.

Exhibit D6 in Appendix D provides scatter plots for these results and offers an opportunity to investigate the consistency in the leaching across the elements for the glasses of this study. All combinations of the normalizations of the PCTs (i.e., those generated using the targeted, measured, and bias-corrected compositional views) and both heat treatments are represented in the series of scatter plots. Consistency in the leaching across the elements is typically demonstrated by a high degree of linear correlation among the values for pairs of these elements. The smallest correlation in this plot is that for Na and Si, with a value of ~96%, indicating no issues with consistency in leaching for all of the elements measured.

Table 3-3 summarizes the normalized PCT results for the glasses of this study. The glasses are listed by glass identifier, heat treatment and compositional view. The data show that all of the glasses are very acceptable regardless of compositional view or heat treatment. The highest NL[B] was 0.84 g/L for the ccc version of SB4VS-43 based on the measured compositional view. The highest NL[B] for a quenched glass was 0.82 g/L for SB4VS-36, based on the target and measured compositional views. These are more than an order of magnitude better than the EA glass, which has a reported NL[B] of 16.695 g/L.[15]

Table 3-3. Normalized PCT results by Glass ID and Compositional View

Glass ID	Heat Treatment	Composition	log NL [B(g/L)]	log NL [Li(g/L)]	log NL [Na(g/L)]	log NL [Si(g/L)]	NL B(g/L)	NL Li(g/L)	NL Na(g/L)	NL Si(g/L)
ARM	-	reference	-0.236	-0.175	-0.233	-0.504	0.58	0.67	0.58	0.31
EA	-	reference	1.216	0.951	1.109	0.572	16.46	8.93	12.84	3.74
SB4VS-36	ccc	measured	-0.107	-0.057	-0.090	-0.273	0.78	0.88	0.81	0.53
SB4VS-36	quenched	measured	-0.086	-0.073	-0.042	-0.274	0.82	0.84	0.91	0.53
SB4VS-36	ccc	measured bc	-0.123	-0.054	-0.068	-0.285	0.75	0.88	0.85	0.52
SB4VS-36	quenched	measured bc	-0.102	-0.070	-0.020	-0.286	0.79	0.85	0.96	0.52
SB4VS-36	ccc	targeted	-0.108	-0.063	-0.081	-0.283	0.78	0.86	0.83	0.52
SB4VS-36	quenched	targeted	-0.087	-0.080	-0.033	-0.285	0.82	0.83	0.93	0.52
SB4VS-37	ccc	measured	-0.191	-0.113	-0.218	-0.307	0.64	0.77	0.61	0.49
SB4VS-37	quenched	measured	-0.199	-0.115	-0.213	-0.309	0.63	0.77	0.61	0.49
SB4VS-37	ccc	measured bc	-0.207	-0.110	-0.196	-0.318	0.62	0.78	0.64	0.48
SB4VS-37	quenched	measured bc	-0.215	-0.111	-0.191	-0.320	0.61	0.77	0.64	0.48
SB4VS-37	ccc	targeted	-0.197	-0.119	-0.201	-0.317	0.63	0.76	0.63	0.48
SB4VS-37	quenched	targeted	-0.206	-0.120	-0.196	-0.320	0.62	0.76	0.64	0.48
SB4VS-38	ccc	measured	-0.202	-0.100	-0.204	-0.334	0.63	0.79	0.62	0.46
SB4VS-38	quenched	measured	-0.213	-0.137	-0.220	-0.352	0.61	0.73	0.60	0.44
SB4VS-38	ccc	measured bc	-0.214	-0.098	-0.175	-0.341	0.61	0.80	0.67	0.46
SB4VS-38	quenched	measured bc	-0.225	-0.135	-0.191	-0.359	0.60	0.73	0.64	0.44
SB4VS-38	ccc	targeted	-0.199	-0.105	-0.187	-0.336	0.63	0.79	0.65	0.46
SB4VS-38	quenched	targeted	-0.210	-0.142	-0.202	-0.354	0.62	0.72	0.63	0.44
SB4VS-39	ccc	measured	-0.157	-0.115	-0.214	-0.327	0.70	0.77	0.61	0.47
SB4VS-39	quenched	measured	-0.161	-0.125	-0.197	-0.328	0.69	0.75	0.63	0.47
SB4VS-39	ccc	measured bc	-0.174	-0.112	-0.185	-0.338	0.67	0.77	0.65	0.46
SB4VS-39	quenched	measured bc	-0.177	-0.122	-0.168	-0.339	0.67	0.76	0.68	0.46
SB4VS-39	ccc	targeted	-0.169	-0.119	-0.186	-0.331	0.68	0.76	0.65	0.47
SB4VS-39	quenched	targeted	-0.172	-0.129	-0.169	-0.332	0.67	0.74	0.68	0.47
SB4VS-40	ccc	measured	-0.180	-0.135	-0.163	-0.331	0.66	0.73	0.69	0.47
SB4VS-40	quenched	measured	-0.182	-0.150	-0.170	-0.343	0.66	0.71	0.68	0.45
SB4VS-40	ccc	measured bc	-0.192	-0.133	-0.134	-0.338	0.64	0.74	0.73	0.46
SB4VS-40	quenched	measured bc	-0.194	-0.148	-0.141	-0.350	0.64	0.71	0.72	0.45
SB4VS-40	ccc	targeted	-0.182	-0.137	-0.158	-0.333	0.66	0.73	0.69	0.46
SB4VS-40	quenched	targeted	-0.185	-0.153	-0.165	-0.345	0.65	0.70	0.68	0.45
SB4VS-41	ccc	measured	-0.264	-0.148	-0.238	-0.329	0.54	0.71	0.58	0.47
SB4VS-41	quenched	measured	-0.243	-0.130	-0.208	-0.314	0.57	0.74	0.62	0.49
SB4VS-41	ccc	measured bc	-0.276	-0.146	-0.209	-0.336	0.53	0.72	0.62	0.46
SB4VS-41	quenched	measured bc	-0.255	-0.128	-0.179	-0.321	0.56	0.74	0.66	0.48
SB4VS-41	ccc	targeted	-0.272	-0.151	-0.221	-0.330	0.53	0.71	0.60	0.47
SB4VS-41	quenched	targeted	-0.251	-0.134	-0.191	-0.316	0.56	0.73	0.64	0.48
SB4VS-42	ccc	measured	-0.188	-0.115	-0.197	-0.308	0.65	0.77	0.63	0.49
SB4VS-42	quenched	measured	-0.186	-0.115	-0.185	-0.308	0.65	0.77	0.65	0.49
SB4VS-42	ccc	measured bc	-0.200	-0.113	-0.168	-0.315	0.63	0.77	0.68	0.48
SB4VS-42	quenched	measured bc	-0.198	-0.113	-0.156	-0.315	0.63	0.77	0.70	0.48
SB4VS-42	ccc	targeted	-0.195	-0.119	-0.172	-0.314	0.64	0.76	0.67	0.49
SB4VS-42	quenched	targeted	-0.193	-0.119	-0.160	-0.314	0.64	0.76	0.69	0.49
SB4VS-43	ccc	measured	-0.075	-0.035	-0.093	-0.264	0.84	0.92	0.81	0.54
SB4VS-43	quenched	measured	-0.098	-0.076	-0.089	-0.277	0.80	0.84	0.81	0.53
SB4VS-43	ccc	measured bc	-0.091	-0.032	-0.064	-0.276	0.81	0.93	0.86	0.53
SB4VS-43	quenched	measured bc	-0.114	-0.073	-0.060	-0.289	0.77	0.85	0.87	0.51
SB4VS-43	ccc	targeted	-0.088	-0.050	-0.071	-0.278	0.82	0.89	0.85	0.53
SB4VS-43	quenched	targeted	-0.111	-0.090	-0.068	-0.292	0.77	0.81	0.86	0.51
SB4VS-44	ccc	measured	-0.191	-0.112	-0.208	-0.305	0.64	0.77	0.62	0.50
SB4VS-44	quenched	measured	-0.203	-0.127	-0.207	-0.314	0.63	0.75	0.62	0.49
SB4VS-44	ccc	measured bc	-0.207	-0.109	-0.186	-0.317	0.62	0.78	0.65	0.48
SB4VS-44	quenched	measured bc	-0.219	-0.124	-0.185	-0.326	0.60	0.75	0.65	0.47
SB4VS-44	ccc	targeted	-0.191	-0.115	-0.197	-0.317	0.64	0.77	0.64	0.48
SB4VS-44	quenched	targeted	-0.204	-0.130	-0.196	-0.326	0.63	0.74	0.64	0.47
SB4VS-45	ccc	measured	-0.202	-0.137	-0.218	-0.343	0.63	0.73	0.60	0.45
SB4VS-45	quenched	measured	-0.212	-0.153	-0.227	-0.352	0.61	0.70	0.59	0.44

Table 3-3. Normalized PCT results by Glass ID and Compositional View (continued)

Glass ID	Heat Treatment	Composition	log NL [B(g/L)]	log NL [Li(g/L)]	log NL [Na(g/L)]	log NL [Si(g/L)]	NL B(g/L)	NL Li(g/L)	NL Na(g/L)	NL Si(g/L)
SB4VS-45	ccc	measured bc	-0.218	-0.133	-0.197	-0.355	0.61	0.74	0.64	0.44
SB4VS-45	quenched	measured bc	-0.228	-0.150	-0.206	-0.364	0.59	0.71	0.62	0.43
SB4VS-45	ccc	targeted	-0.214	-0.136	-0.206	-0.348	0.61	0.73	0.62	0.45
SB4VS-45	quenched	targeted	-0.225	-0.152	-0.215	-0.357	0.60	0.70	0.61	0.44
SB4VS-46	ccc	measured	-0.185	-0.104	-0.210	-0.303	0.65	0.79	0.62	0.50
SB4VS-46	quenched	measured	-0.212	-0.131	-0.230	-0.327	0.61	0.74	0.59	0.47
SB4VS-46	ccc	measured bc	-0.197	-0.102	-0.188	-0.310	0.64	0.79	0.65	0.49
SB4VS-46	quenched	measured bc	-0.224	-0.129	-0.208	-0.334	0.60	0.74	0.62	0.46
SB4VS-46	ccc	targeted	-0.186	-0.103	-0.186	-0.301	0.65	0.79	0.65	0.50
SB4VS-46	quenched	targeted	-0.214	-0.130	-0.206	-0.325	0.61	0.74	0.62	0.47
SB4VS-47	ccc	measured	-0.194	-0.123	-0.193	-0.309	0.64	0.75	0.64	0.49
SB4VS-47	quenched	measured	-0.189	-0.110	-0.182	-0.302	0.65	0.78	0.66	0.50
SB4VS-47	ccc	measured bc	-0.210	-0.120	-0.164	-0.321	0.62	0.76	0.69	0.48
SB4VS-47	quenched	measured bc	-0.205	-0.106	-0.153	-0.314	0.62	0.78	0.70	0.49
SB4VS-47	ccc	targeted	-0.206	-0.128	-0.179	-0.319	0.62	0.75	0.66	0.48
SB4VS-47	quenched	targeted	-0.200	-0.114	-0.169	-0.312	0.63	0.77	0.68	0.49
SB4VS-48	ccc	measured	-0.171	-0.108	-0.168	-0.302	0.68	0.78	0.68	0.50
SB4VS-48	quenched	measured	-0.166	-0.099	-0.150	-0.307	0.68	0.80	0.71	0.49
SB4VS-48	ccc	measured bc	-0.183	-0.106	-0.146	-0.309	0.66	0.78	0.71	0.49
SB4VS-48	quenched	measured bc	-0.178	-0.097	-0.128	-0.314	0.66	0.80	0.74	0.48
SB4VS-48	ccc	targeted	-0.169	-0.113	-0.156	-0.306	0.68	0.77	0.70	0.49
SB4VS-48	quenched	targeted	-0.164	-0.104	-0.138	-0.311	0.69	0.79	0.73	0.49

3.2.5 *Effects of Heat Treatment on PCTs*

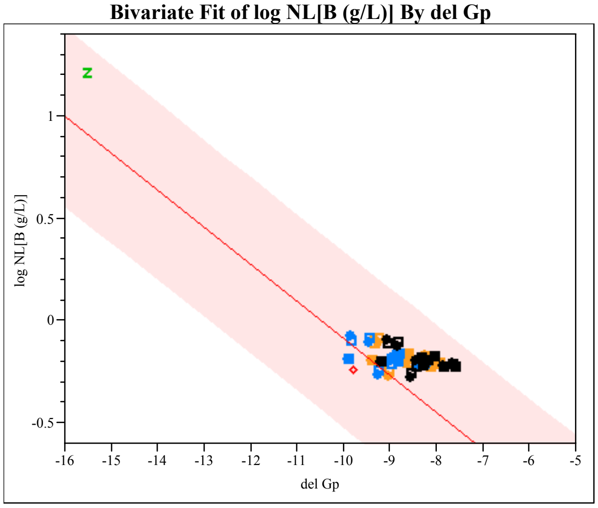
Exhibit D7 in Appendix D provides a series of plots and statistical comparisons that show the effects of heat treatment on the common logarithm ppm-responses of interest of the triplicate PCTs for each element for each study glass. The quenched version of a given glass yielded measurements indicating a significantly (at the 5% significance level) smaller mean log(ppm) response than the ccc version of the glass for a given element if the **Prob<t** value in the exhibit is 0.05 or less. The glasses by number and the element for which this was true (i.e., the ccc version yielded a statistically larger log ppm value as compared to the value from the quenched version) are: #36(Li), #38(Li, Si), #39(Li), #43(Li), #45(Li, Si), and #46(B, Li, Na, Si). Thus, SB4VS-46 is the only study glass showing a statistically significant difference between the ccc and the quenched versions for all 4 elements of interest in the PCTs. However, as shown in Table 3-3, there is no practical impact of these differences (e.g., the NL[B] based on the measured compositions of SB4VS-46 quenched and ccc are 0.65 and 0.61 g/L, respectively). All of the glasses are very acceptable as compared to the EA glass.

Exhibit D8 in Appendix D provides a series of plots that show the effects of heat treatment on the PCT response based on the three different compositional views: measured, measured bias-corrected, and targeted. These plots allow for an assessment of the differences in PCT responses from a practical perspective. Again, SB4VS-46 is the only glass that shows a statistically significant difference in NL[B] between the quenched and ccc versions of this glass, but this difference has no practical impact on the performance of the glass.

3.2.6 *Predicted versus Measured PCTs*

Exhibit D9 in Appendix D provides plots of the DWPF models that relate the logarithm of the normalized PCT (for each element of interest) to a linear function of a free energy of hydration term (ΔG_p, kcal/100g glass) derived from all of the glass compositional views and heat treatments.[5] Prediction limits (at a 95% confidence level) for an individual PCT result are also plotted along with the linear fit. The EA and ARM results are also indicated on these plots.

One of these plots, the normalized release for boron versus the ΔG_p prediction, is reproduced in Figure 3-2. As seen in the plot, all of the SB4/Frit 418 variability study glasses fall within the prediction limits.



Legend

	Sludge	Heat Treatment	Composition
1	ARM		reference
2	EA		reference
3	SB4VS	ccc	measured
4	SB4VS	ccc	measured bc
5	SB4VS	ccc	targeted
6	SB4VS	quenched	measured
7	SB4VS	quenched	measured bc
8	SB4VS	quenched	targeted

Figure 3-2. Free Energy of Hydration (ΔG_p) Predictions Versus Common Logarithm Normalized Leachate for Boron (log NL[B]).

Exhibit D10 in Appendix D provides a version of these plots for the quenched glasses only while Exhibit D11 in Appendix D provides a version for ccc glasses only. All of these glasses show acceptable and predictable PCT responses.

3.3 Homogeneity

Table 3-4 lists the visual and XRD results for the quenched and ccc versions of the variability study glasses. These results will be summarized below. For a more detailed description of the visual observations and XRD results, see WSRC-NB-2004-00135 and WSRC-NB-2006-00168.

Table 3-4. Visual Observations and XRD Results for the Variability Study Glasses.

Glass	Target WL	Heat Treatment	Visual Observations	XRD
SB4VS-36	40	quenched	Crucible: clean with bubbles; Patty: homogeneous	-
		ccc	Surface: black, shiny and clean; Bulk: clean	amorphous
SB4VS-37	34	quenched	Crucible: clean with bubbles; Patty: homogeneous	-
		ccc	Surface: black, shiny and clean; Bulk: clean	amorphous
SB4VS-38	38	quenched	Crucible: clean with bubbles; Patty: homogeneous	-
		ccc	Surface: black, shiny and clean; Bulk: clean	amorphous
SB4VS-39	38	quenched	Crucible: clean with bubbles; Patty: homogeneous	-
		ccc	Surface: black, shiny and clean; Bulk: clean	amorphous
SB4VS-40	36	quenched	Crucible: clean with bubbles; Patty: homogeneous	-
		ccc	Surface: black, shiny and clean; Bulk: clean	amorphous
SB4VS-41	28	quenched	Crucible: clean with bubbles; Patty: homogeneous	-
		ccc	Surface: black, shiny and clean; Bulk: clean	amorphous
SB4VS-42	30	quenched	Crucible: clean with bubbles; Patty: homogeneous	-
		ccc	Surface: black, shiny and clean; Bulk: clean	amorphous
SB4VS-43	42	quenched	Crucible: clean with bubbles; Patty: homogeneous	-
		ccc	Surface: black, shiny and clean; Bulk: clean	amorphous
SB4VS-44	32	quenched	Crucible: clean with bubbles; Patty: homogeneous	-
		ccc	Surface: black, shiny and clean; Bulk: clean	amorphous
SB4VS-45	34	quenched	Crucible: clean with bubbles; Patty: homogeneous	-
		ccc	Surface: black, shiny and clean; Bulk: clean	amorphous
SB4VS-46	30	quenched	Crucible: clean with bubbles; Patty: homogeneous	-
		ccc	Surface: black, shiny and clean; Bulk: clean	amorphous
SB4VS-47	32	quenched	Crucible: clean with bubbles; Patty: homogeneous	-
		ccc	Surface: black, shiny and clean; Bulk: clean	amorphous
SB4VS-48	36	quenched	Crucible: clean with bubbles; Patty: homogeneous	-
		ccc	Surface: black, shiny and clean; Bulk: clean	one unidentified peak

3.3.1 *Visual Observations*

Prior to discussing the visual observations, a few words regarding the terminology used are warranted. The term “surface” refers to the surface of the quenched pour patty or glass sample after the ccc heat treatment. The term “bulk” refers to the cross-section of the quenched pour patty or glass sample after the ccc heat treatment. The use of “homogeneous” or “clean” indicates that the sample was classified as a single-phase system (i.e., no visible evidence of crystallization).

Visual observations of the quenched variability study glasses indicate that all of the glasses were homogeneous. The ccc version of each glass was also found to be homogeneous by visual examination. Though no evidence of crystallization was visually observed in the ccc glasses, XRD analysis was performed as a further check for possible crystallization.

3.3.2 *XRD Results*

The XRD results are included in Table 3-4 and provide qualitative results regarding crystallization in the variability study glasses. Only the ccc versions of the glasses were submitted for XRD analysis given that the visual observations and durability responses suggested no significant crystallization in the quenched glasses. That is, with normalized boron releases ranging from 0.53 to 0.84 g/L, there is no evidence of nepheline formation in the quenched glasses.

All but one of the ccc glasses was found to be amorphous by XRD. XRD results for glass SB4VS-36 ccc are shown in Figure 3-3. The characteristically high background devoid of crystalline spectral lines indicates that this glass is either amorphous or has a crystalline content below the detection limit of 0.5 vol%. This pattern is representative of all of the ccc glasses in the variability study except for SB4VS-48.

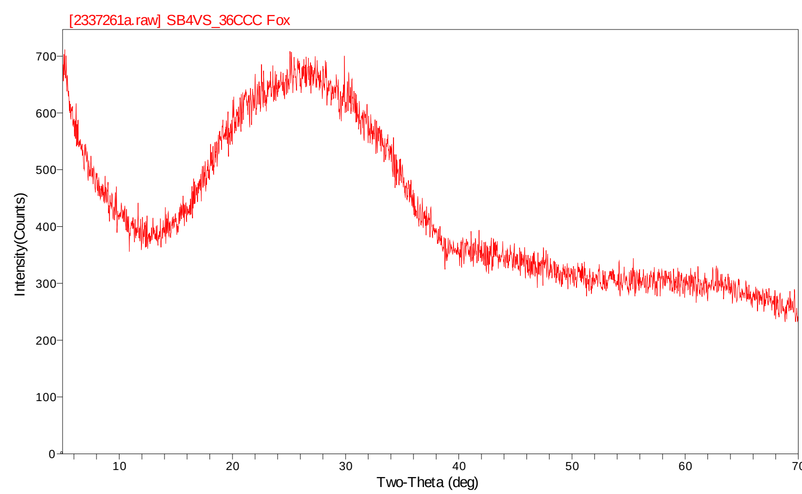


Figure 3-3. XRD Pattern for the ccc Version of Glass SB4VS-36.

A single peak was identified in the XRD spectrum for glass SB4VS-48 ccc, as shown in Figure 3-4. This peak was not found to correspond with nepheline, spinel, or any other crystalline phase. The NL[B] for this glass ranges from 0.66 to 0.69 g/L for both quenched and ccc versions of this glass when considering all compositional views. Based on the visual observations and PCT results, the detection of this peak is of no practical concern to the performance of this glass.

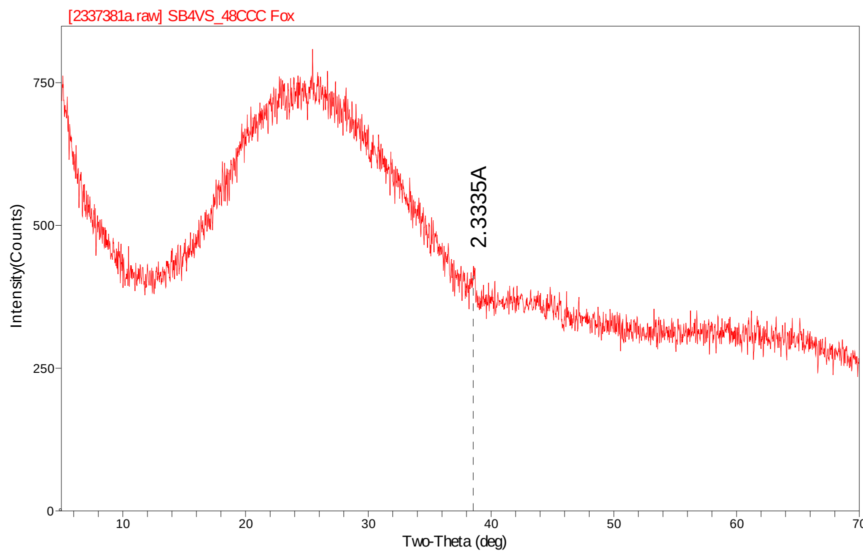


Figure 3-4. XRD pattern for the ccc Version of SB4VS-48.

4.0 Conclusions

Thirteen additional glasses, based on Frit 418, were developed and fabricated to supplement the SB4 variability study in response to a change in the projected composition for SB4. Chemical composition measurements showed no significant differences between the target and measured composition for each glass. All thirteen of the SB4/Frit 418 glasses studied were very acceptable as compared to the EA glass and predictable using the current DWPF models.

The highest NL[B] was 0.84 g/L for the ccc version of SB4VS-43 based on the measured compositional view. The highest NL[B] for a quenched glass was 0.82 g/L for SB4VS-36, based on the target and measured compositional views. These are more than an order of magnitude better than the EA glass, which has a reported NL[B] of 16.695 g/L.[15]

All of the glasses studied fell within the 95% confidence bounds of the DWPF durability model regardless of heat treatment or compositional view. The PCCS MAR criteria were met for all of the glasses regardless of compositional view.

Visual observations of the quenched and ccc versions of each glass showed no evidence of crystallization. All of the study glasses were found to be amorphous by XRD with the exception of SB4VS-48. A single peak was detected in this glass by XRD, but it was not identifiable. Based on the visual observations and PCT response of this glass, the detection of this peak is of no practical significance.

Based on these results, glasses formulated with Frit 418 and SB4 (the October 2006 composition[1]) should be both acceptable as compared to the durability of the EA glass and predictable using the DWPF PCCS models.

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5.0 Recommendations

Based on the results and observations of this study, the following recommendations are made:

- Utilize Frit 418 to process SB4 in DWPF given the projected sludge compositions used to develop glasses for this study.
    - This recommendation is made based solely on WS-E's intent to utilize Frit 418 for initial processing of SB4 and the October 2006 compositional projections. Melt rate assessments, which will have a strong effect on melter throughput, are not considered in this recommendation.

- Should the composition projection for SB4 be further modified before processing begins, additional studies should be undertaken to verify that Frit 418 will produce an acceptable and predictable glass and/or identify alternative frits for SB4 processing.

    - Specifically, Nominal and Variation Stage assessments should be performed using the updated composition projection
    - The results of these paper studies should be used to determine whether additional glasses should be appended to the SB4 variability study

- Melt rate assessments should be considered in order to optimize a frit for SB4 processing at the DWPF.

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6.0 References

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Appendix A

An Analytical Plan for Measuring the Chemical Compositions of Glasses from the SB4/Frit 418 Variability Study (U)

(SRNL-SCS-2006-00040)

SRNL SAVANNAH RIVER NATIONAL LABORATORY

INTER-OFFICE MEMORANDUM

SRNL-SCS-2006-00040

October 30, 2006

To: K. M. Fox, SRNL

cc:
R. A. Baker, 773-42A
D. R. Best, 786-1A (wo)
C. C. Herman, 999-W
D. K. Peeler, 999-W
I. A. Reamer, 999-1W
P. A. Toole, 786-1A (wo)
R. C. Tuckfield, 773-42A
R. J. Workman, 999-1W

From: T. B. Edwards, 999-W (819-8464)
Statistical Consulting Section

wo – without glass identifiers

R. A. Baker, Technical Reviewer — 11/1/2006 Date

R. C. Tuckfield, Manager
Statistical Consulting Section — 11/1/2006 Date

An Analytical Plan for Measuring the Chemical Compositions of Glasses from the SB4/Frit 418 Variability Study (U)

1.0 EXECUTIVE SUMMARY

A glass variability study is underway at the Savannah River National Laboratory (SRNL) to support the processing of Sludge Batch 4 (SB4) with Frit 418 at the Defense Waste Processing Facility (DWPF). Thirteen (13) glasses have been selected to be batched and fabricated as part of this study. The chemical compositions of these glasses are to be analyzed by SRNL's Process Science Analytical Laboratory (PSAL). This memorandum provides an analytical plan for the measurements by PSAL.

2.0 INTRODUCTION

A glass variability study is underway at the Savannah River National Laboratory (SRNL) to support the processing of Sludge Batch 4 (SB4) with Frit 418 at the Defense Waste Processing Facility (DWPF). Thirteen (13) glasses have been selected to be batched and fabricated as part of this study. The chemical compositions of these glasses are to be analyzed by SRNL's Process Science Analytical Laboratory (PSAL). This memorandum provides an analytical plan for the measurements by PSAL.

3.0 ANALYTICAL PLAN

The analytical procedures used by PSAL to determine cation concentrations for a glass sample include steps for sample preparation and for instrument calibration. Each glass is to be prepared in duplicate by each of two dissolution methods: lithium metaborate fusion (LM) and sodium peroxide fusion (PF).

The primary measurements of interest are to be acquired as follows. The samples prepared by LM are to be measured for barium (Ba), calcium (Ca), cerium (Ce), chromium (Cr), copper (Cu), potassium (K), lanthanum (La), magnesium (Mg), manganese (Mn), sodium (Na), lead (Pb), sulfur (S), thorium (Th), titanium (Ti), zinc (Zn), and zirconium (Zr) concentrations. Samples prepared by PF are to be measured for aluminum (Al), boron (B), iron (Fe), lithium (Li), nickel (Ni), silicon (Si), and uranium (U) concentrations. Samples dissolved by both preparation methods are to be measured using Inductively Coupled Plasma – Atomic Emission Spectrometry (ICP-AES). It should be noted that some of these elements are minor components that may be near the detection limits for most, if not all, of the study glasses.

Randomizing the preparation steps and blocking and randomizing the measurements for the ICP-AES are of primary concern in the development of this analytical plan. The sources of uncertainty for the analytical procedure used by PSAL to determine the cation concentrations for the submitted glass samples are dominated by the dissolution step in the preparation of the sample and by the calibrations of the ICP-AES.

Samples of glass standards will be included in the analytical plan to provide an opportunity for checking the performance of the instrumentation over the course of the analyses and for potential bias correction. Specifically, several samples of Waste Compliance Plan (WCP) Batch 1 (BCH) [1] and a uranium standard glass (Ustd) are included in this analytical plan. The reference compositions of these glasses are provided in Table 1.

Table 1: Oxide Compositions of WCP Batch 1 (BCH) and Ustd

Oxide/ Anion	BCH (wt %)	Ustd (wt %)
Al_2O_3	4.877	4.1
B_2O_3	7.777	9.209
BaO	0.151	0
CaO	1.22	1.301
Cr_2O_3	0.107	0
Cs_2O	0.06	0
CuO	0.399	0
Fe_2O_3	12.839	13.196
K_2O	3.327	2.999
Li_2O	4.429	3.057
MgO	1.419	1.21
MnO	1.726	2.892
Na_2O	9.003	11.795
Nd_2O_3	0.147	0
NiO	0.751	1.12
RuO_2	0.0214	0
SO_4	0	0
SiO_2	50.22	45.353
TiO_2	0.677	1.049
U_3O_8	0	2.406
ZrO_2	0.098	0

Each glass sample submitted to PSAL will be prepared in duplicate by the LM and PF dissolution methods. Every prepared sample will be read twice by ICP-AES, with the instrument being calibrated before each of these two sets of readings. This will lead to four measurements for each cation of interest for each submitted glass.

Table 2 presents identifying codes, B01 through B13, for the 13 glasses fabricated for this study. The table provides a naming convention that is to be used in analyzing the glasses and reporting the measurements of their compositions.[a]

[a] Renaming these samples helps to ensure that they will be processed as blind samples within PSAL. Table 2 is not shown in its entirety in the copies going to PSAL.

Table 2: Glass Identifiers to Establish Blind Samples for PSAL

Glass ID	Sample ID
SB4VS-36	B10
SB4VS-37	B01
SB4VS-38	B02
SB4VS-39	B09
SB4VS-40	B03
SB4VS-41	B11
SB4VS-42	B05
SB4VS-43	B13
SB4VS-44	B08
SB4VS-45	B07
SB4VS-46	B12
SB4VS-47	B06
SB4VS-48	B04

3.1 PREPARATION OF THE SAMPLES

Each of the 13 glasses included in this analytical plan is to be prepared in duplicate by the LM and PF dissolution methods. Thus, the total number of prepared glass samples is determined by $13 \cdot 2 \cdot 2 = 52$, not including the samples of the BCH and Ustd glass standards.

Table 3 provides blocking and (random) sequencing schema for conducting the preparation steps of the analytical procedures. Two blocks of preparation work are provided for each preparation method to facilitate the scheduling of activities by work shift. The identifier for each of the prepared samples indicates the sample identifier (ID), preparation method, and duplicate number.

Table 3: Preparation Blocks by Dissolution Method

LM Preparation Blocks		PF Preparation Blocks	
1	2	1	2
B09LM1	B12LM1	B04PF1	B07PF1
B07LM1	B10LM1	B10PF1	B08PF1
B05LM1	B10LM2	B06PF1	B05PF1
B04LM1	B02LM1	B01PF1	B12PF1
B09LM2	B06LM1	B09PF1	B03PF1
B11LM1	B02LM2	B11PF1	B12PF2
B07LM2	B12LM2	B04PF2	B05PF2
B01LM1	B06LM2	B01PF2	B02PF1
B03LM1	B13LM1	B06PF2	B03PF2
B05LM2	B08LM1	B10PF2	B07PF2
B01LM2	B08LM2	B09PF2	B08PF2
B03LM2	B13LM2	B13PF1	B02PF2
B04LM2		B11PF2	
B11LM2		B13PF2	

3.2 ICP-AES CALIBRATION BLOCKS

The glass samples prepared by the LM and PF dissolution methods are to be analyzed using ICP-AES instrumentation calibrated for the particular preparation method. After the initial set of cation concentration measurements, the ICP-AES instrumentation is to be recalibrated and a second set of concentration measurements for the cations determined.

Randomized plans for measuring cation concentrations in the LM-prepared and PF-prepared samples are provided in Table 4. The cations to be measured are specified as part of the table. In the tables, the sample identifiers for the study glasses have been modified by the addition of a suffix (a "1"or a "2") to indicate whether the measurement was made during the first or second (respectively) calibration of the ICP-AES instrumentation. The identifiers for the BCH and Ustd samples have been modified to indicate the ICP-AES calibration block and sub-block and that each of these prepared samples is to be read 3 times (mirrored in the corresponding suffix of 1, 2, or 3) per calibration block.

Table 4: ICP-AES Blocks & Calibration Groups by Preparation Method

LM Glass Samples				**PF Glass Samples**			
Used to Measure Elemental Ba, Ca, Ce, Cr, Cu, K, La, Mg, Mn, Na, Pb, S, Th, Ti, Zn, & Zr				Used to Measure Elemental Al, B, Fe, Li, Ni, Si, & U			
Block 1-1	**Block 1-2**	**Block 2-1**	**Block 2-2**	**Block 1-1**	**Block 1-2**	**Block 2-1**	**Block 2-2**
BCHLM111	BCHLM121	BCHLM211	BCHLM221	BCHPF111	BCHPF121	BCHPF211	BCHPF221
UstdLM111	UstdLM121	UstdLM211	UstdLM221	UstdPF111	UstdPF121	UstdPF211	UstdPF221
B03LM21	B03LM22	B08LM11	B08LM22	B09PF21	B13PF22	B02PF21	B04PF12
B05LM11	B02LM22	B07LM21	B01LM12	B07PF21	B13PF12	B02PF11	B12PF22
B09LM11	B11LM12	B08LM21	B07LM12	B09PF11	B08PF12	B03PF21	B05PF12
B11LM21	B03LM12	B01LM11	B04LM22	B08PF21	B09PF12	B12PF21	B11PF22
B06LM21	B02LM12	B12LM11	B08LM12	B01PF11	B09PF22	B05PF11	B05PF22
B03LM11	B05LM22	B07LM11	B12LM12	B06PF11	B06PF22	B11PF21	B03PF22
B13LM11	B11LM22	B04LM11	B10LM12	B10PF21	B01PF22	B11PF11	B02PF12
BCHLM112	BCHLM122	BCHLM212	BCHLM222	BCHPF112	BCHPF122	BCHPF212	BCHPF222
UstdLM112	UstdLM122	UstdLM212	UstdLM222	UstdPF112	UstdPF122	UstdPF212	UstdPF222
B02LM11	B13LM12	B10LM11	B01LM22	B07PF11	B10PF22	B04PF21	B02PF22
B02LM21	B09LM22	B12LM21	B10LM22	B06PF21	B07PF22	B04PF11	B03PF12
B05LM21	B05LM12	B01LM21	B04LM12	B08PF11	B06PF12	B05PF21	B04PF22
B13LM21	B13LM22	B04LM21	B12LM22	B01PF21	B08PF22	B12PF11	B12PF12
B06LM11	B09LM12	B10LM21	B07LM22	B13PF21	B10PF12	B03PF11	B11PF12
B09LM21	B06LM12	BCHLM213	BCHLM223	B13PF11	B01PF12	BCHPF213	BCHPF223
B11LM11	B06LM22	UstdLM213	UstdLM223	B10PF11	B07PF12	UstdPF213	UstdPF223
BCHLM113	BCHLM123			BCHPF113	BCHPF123		
UstdLM113	UstdLM123			UstdPF113	UstdPF123		

4.0 CONCLUDING COMMENTS

In summary, this analytical plan identifies four preparation blocks in Table 3 and eight ICP-AES calibration blocks in Table 4 for use by PSAL. The sequencing of the activities associated with each of the steps in the analytical procedures has been randomized. The size of each of the blocks was selected so that it could be completed in a single work shift.

If a problem is discovered while measuring samples in a calibration block, the instrument should be re-calibrated and the block of samples re-measured in its entirety. If for some reason the measurements are not conducted in the sequences presented in this report, a record should be made of the actual order used along with any explanative comments.

The analytical plan indicated in the preceding tables should be modified by the personnel of PSAL to include any calibration check standards and/or other standards that are part of their routine operating procedures. It is also recommended that the solutions resulting from each of the prepared samples be archived for some period, considering the “shelf-life” of the solutions, in case questions arise during data analysis. This would allow for the solutions to be rerun without additional preparations, thus minimizing cost.

5.0 REFERENCE

[1] Jantzen, C.M., J.B. Pickett, K.G. Brown, T.B. Edwards, and D.C. Beam, “Process/ Product Models for the Defense Waste Processing Facility (DWPF): Part I. Predicting Glass Durability from Composition Using a Thermodynamic Hydration Energy Reaction Model (THERMO^{TM}) (U),” WSRC-TR-93-673, Revision 1, Volume 2, Table B.1, pp. B.9, 1995.

Appendix B

An Analytical Plan for Measuring the PCT Solutions for the SB4/Frit 418 Variability Study (U)

(SRNL-SCS-2006-00039)

SRNL
SAVANNAH RIVER NATIONAL LABORATORY

INTER-OFFICE MEMORANDUM

SRNL-SCS-2006-00039

October 30, 2006

To: K. M. Fox, SRNL

cc: R. A. Baker, SRNL
D. R. Best, SRNL (wo)
C. C. Herman, SRNL
D. K. Peeler, SRNL
I. A. Reamer, SRNL
P. A. Toole, SRNL (wo)
R. C. Tuckfield, SRNL
R. J. Workman, SRNL

From: T. B. Edwards, SRNL (819-8464)
Statistical Consulting Section

wo – without glass identifiers

R. A. Baker, Technical Reviewer — 10/30/2006 Date

R. C. Tuckfield, Manager, Statistical Consulting Section — 10/30/06 Date

An Analytical Plan for Measuring the PCT Solutions for the SB4/Frit 418 Variability Study (U)

1.0 EXECUTIVE SUMMARY

A glass variability study is underway at the Savannah River National Laboratory (SRNL) to support the processing of Sludge Batch 4 (SB4) with Frit 418 at the Defense Waste Processing Facility (DWPF). Thirteen (13) glasses have been selected to be batched and fabricated as part of this study. The durabilities of the glasses are to be measured using the Product Consistency Test (PCT) as defined in ASTM C-1285-2002. Two heat treatments are to be utilized during the fabrication of each of these glasses. Specifically, each of the glasses is to be quenched (i.e., rapidly cooled) and cooled in accordance with the centerline-canister-cooling (ccc) regime. Both heat treatments of each glass are to be subjected to the PCT. The PCT solutions are to be analyzed by SRNL's Process Science Analytical Laboratory (PSAL). This memorandum provides an analytical plan for the measurement of the PCTs by PSAL for these SB4/Frit 418 glasses.

2.0 INTRODUCTION

A glass variability study is underway at the Savannah River National Laboratory (SRNL) to support the processing of Sludge Batch 4 (SB4) with Frit 418 at the Defense Waste Processing Facility (DWPF). Thirteen (13) glasses have been selected to be batched and fabricated as part of this study. The durabilities of the glasses are to be measured using the Product Consistency Test (PCT) as defined in ASTM C-1285-2002 [1]. Two heat treatments are to be utilized during the fabrication of each of these glasses. Specifically, each of the glasses is to be quenched (i.e., rapidly cooled) and cooled in accordance with the centerline-canister-cooling (ccc) regime. Both heat treatments of each glass are to be subjected to the PCT. The PCT solutions are to be analyzed by SRNL's Process Science Analytical Laboratory (PSAL). This memorandum provides an analytical plan for the measurement of the PCTs by PSAL for these SB4/Frit 418 glasses. Table 1 presents a listing of the glasses covered by this memorandum.

Table 1: Identifiers for Glasses Covered by this Plan

SB4VS-36	SB4VS-43
SB4VS-36ccc	SB4VS-43ccc
SB4VS-37	SB4VS-44
SB4VS-37ccc	SB4VS-44ccc
SB4VS-38	SB4VS-45
SB4VS-38ccc	SB4VS-45ccc
SB4VS-39	SB4VS-46
SB4VS-39ccc	SB4VS-46ccc
SB4VS-40	SB4VS-47
SB4VS-40ccc	SB4VS-47ccc
SB4VS-41	SB4VS-48
SB4VS-41ccc	SB4VS-48ccc
SB4VS-42	
SB4VS-42ccc	

3.0 DISCUSSION

Each of the 26 study glasses of Table 1 is to be subjected to the PCT in triplicate. In addition to PCTs for the study glasses, triplicate PCTs are to be conducted on a sample of the Approved Reference Material – One (ARM-1) glass and a sample of the Environmental Assessment (EA) glass. Two reagent blank samples are also to be included in these tests. This results in 86 sample solutions being required to complete these PCTs.

The leachates from these tests will be diluted by adding 4 mL of 0.4 M HNO_3 to 6 mL of the leachate (a 6:10 volume to volume, v:v, dilution) before being submitted to PSAL. The leachates of EA will be further diluted (1:10 v:v) with deionized water prior to submission to PSAL in order to prevent problems with the nebulizer. Note that additional dilutions for the ccc versions of one or more of the study glasses may be needed due to a possible low durability of some of the glasses. Upon termination of the PCT, a decision is to be made (by the technicians and a PSAL representative, if called by the technician) as to whether any other dilutions are needed for these solutions to mitigate any potential gelling issues. Any extra dilutions are to be reported, and guidance is to be given as to how the dilutions are to be handled in the statistical assessment of the measurement data. More specifically, PSAL will be responsible for indicating if any additional dilutions were made and how they were, or how they should be, accounted for in the reported measurements.

Table 2 presents identifying codes, A01 through A86, for the individual solutions required for the PCTs of the select study glasses and of the standards (EA, ARM-1, and blanks). This provides a naming convention that is to be used by PSAL in analyzing the solutions and reporting the relevant concentration measurements.[a]

Table 2: Identifiers for the PCT Solutions Covered by this Plan

Original Sample	Solution Identifier	Original Sample	Solution Identifier	Original Sample	Solution Identifier
SB4VS-36	A70	SB4VS-41	A84	SB4VS-46	A66
SB4VS-36	A11	SB4VS-41	A82	SB4VS-46	A61
SB4VS-36	A03	SB4VS-41	A33	SB4VS-46	A09
SB4VS-36ccc	A06	SB4VS-41ccc	A69	SB4VS-46ccc	A81
SB4VS-36ccc	A47	SB4VS-41ccc	A04	SB4VS-46ccc	A73
SB4VS-36ccc	A64	SB4VS-41ccc	A56	SB4VS-46ccc	A78
SB4VS-37	A19	SB4VS-42	A18	SB4VS-47	A54
SB4VS-37	A24	SB4VS-42	A85	SB4VS-47	A67
SB4VS-37	A20	SB4VS-42	A07	SB4VS-47	A72
SB4VS-37ccc	A23	SB4VS-42ccc	A32	SB4VS-47ccc	A02
SB4VS-37ccc	A10	SB4VS-42ccc	A55	SB4VS-47ccc	A28
SB4VS-37ccc	A76	SB4VS-42ccc	A12	SB4VS-47ccc	A75
SB4VS-38	A27	SB4VS-43	A25	SB4VS-48	A71
SB4VS-38	A41	SB4VS-43	A34	SB4VS-48	A48
SB4VS-38	A52	SB4VS-43	A01	SB4VS-48	A46
SB4VS-38ccc	A14	SB4VS-43ccc	A53	SB4VS-48ccc	A43
SB4VS-38ccc	A79	SB4VS-43ccc	A26	SB4VS-48ccc	A51
SB4VS-38ccc	A17	SB4VS-43ccc	A62	SB4VS-48ccc	A45
SB4VS-39	A83	SB4VS-44	A57	EA	A44
SB4VS-39	A21	SB4VS-44	A49	EA	A60
SB4VS-39	A31	SB4VS-44	A22	EA	A65
SB4VS-39ccc	A50	SB4VS-44ccc	A37	ARM-1	A36
SB4VS-39ccc	A59	SB4VS-44ccc	A13	ARM-1	A15
SB4VS-39ccc	A80	SB4VS-44ccc	A68	ARM-1	A30
SB4VS-40	A05	SB4VS-45	A08	blank	A77
SB4VS-40	A58	SB4VS-45	A40	blank	A86
SB4VS-40	A74	SB4VS-45	A63		
SB4VS-40ccc	A29	SB4VS-45ccc	A39		
SB4VS-40ccc	A38	SB4VS-45ccc	A35		
SB4VS-40ccc	A42	SB4VS-45ccc	A16		

[a] Renaming these samples ensures that they will be processed as blind samples by PSAL. This table does not contain the solution identifiers for those on the distribution list with a "wo" following their names.

4.0 ANALYTICAL PLAN

The analytical plan for PSAL is provided in this section. Each of the solution samples submitted to PSAL is to be analyzed only once for each of the following: aluminum (Al), boron (B), iron (Fe), lithium (Li), sodium (Na), silicon (Si), thorium (Th), and uranium (U) concentrations. B, Li, Na, and Si are the elements that are to be used in the assessment of glass durability. The measurements are to be made in parts per million (ppm). The analytical procedure used by PSAL to determine the concentrations utilizes an Inductively Coupled Plasma – Atomic Emission Spectrometer (ICP-AES). The PCT solutions (as identified in Table 2) are grouped in six ICP-AES blocks for processing by PSAL in Table 3. Each block requires a different calibration of the ICP-AES.

Table 3: ICP-AES Calibration Blocks for Leachate Measurements

Block 1	Block 2	Block 3	Block 4	Block 5	Block 6
std-b1-1	std-b2-1	std-b3-1	std-b4-1	std-b5-1	std-b6-1
A43	A26	A03	A50	A38	A74
A23	A67	A64	A05	A73	A63
A25	A82	A45	A83	A85	A07
A06	A24	A01	A37	A21	A30
A19	A60	A56	A36	A59	A09
A02	A48	A65	A81	A15	A22
A71	A34	A76	A57	A49	A12
std-b1-2	std-b2-2	std-b3-2	std-b4-2	std-b5-2	std-b6-2
A77	A41	A46	A32	A58	A31
A14	A47	A75	A29	A61	A16
A44	A79	A52	A39	A40	A42
A27	A51	A72	A08	A35	A80
A70	A28	A62	A66	A55	A78
A84	A04	A33	A18	A13	A86
A53	A10	A17	std-b4-3	std-b5-3	A68
A69	A11	A20			std-b6-3
A54	std-b2-3	std-b3-3			
std-b1-3					

A multi-element solution standard (denoted by “std-bi-j” where i=1 to 6 represents the block number and j=1, 2, and 3 represents the position in the block) was added at the beginning, middle, and end of each of the six blocks. This standard may be useful in checking and correcting for bias in the concentration measurements arising from the ICP calibrations.

5.0 SUMMARY

In summary, this analytical plan provides identifiers for the PCT solutions in Table 2 and six ICP-AES calibration blocks in Table 3 for PSAL to use in conducting the aluminum (Al), boron (B), iron (Fe), lithium (Li), sodium (Na), silicon (Si), thorium (Th), and uranium (U) concentration measurements for this PCT study. The sequencing of the activities associated with each of the steps in the analytical procedure has been randomized. The size of the blocks was selected so that each block could be completed in a single work shift. If for some reason the measurements are not conducted in the sequence presented in this memorandum, the actual order should be recorded along with any explanative comments.

The analytical plan indicated in the preceding tables should be modified by the personnel of PSAL to include any calibration check standards and/or other standards that are part of their standard operating procedures.

6.0 REFERENCE

[1] ASTM C-1285-2002, "Standard Test Methods for Determining Chemical Durability of Nuclear Waste Glasses: The Product Consistency Test (PCT)," ASTM, 2002.

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Appendix C

Tables and Exhibits Supporting the Analysis of the Chemical Composition Measurements of the SB4-Frit 418 Variability Study Glasses

Table C1. Targeted Oxide Concentrations (in wt%) for the SB4-Frit 418 Variability Study Glasses

Glass #	Al_2O_3	B_2O_3	BaO	CaO	Ce_2O_3	Cr_2O_3	CuO	Fe_2O_3	K_2O	La_2O_3	Li_2O	MgO	MnO	Na_2O	NiO	PbO	SO_4	SiO_2	ThO_2	TiO_2	U_3O_8	ZnO	ZrO_2	Sum
SB4VS-36	9.4313	4.8000	0.0412	1.2060	0.0499	0.0691	0.0199	12.1980	0.1095	0.0352	4.8000	1.2095	2.1398	12.8442	0.5640	0.0302	0.3866	46.5846	0.0209	0.0087	3.3416	0.0325	0.0773	100.000
SB4VS-37	9.1517	5.2800	0.0350	0.8551	0.0424	0.0587	0.0169	10.5953	0.0931	0.0299	5.2800	0.8580	1.8189	11.1635	0.4794	0.0256	0.2606	50.9969	0.0177	0.0074	2.8404	0.0276	0.0657	100.000
SB4VS-38	10.4127	4.9600	0.0554	1.1457	0.0671	0.0929	0.0268	10.3517	0.1473	0.0474	4.9600	0.9590	2.3625	11.5357	0.5358	0.0406	0.3672	48.0553	0.0281	0.0117	3.6894	0.0437	0.1040	100.000
SB4VS-39	10.4127	4.9600	0.0554	0.9557	0.0671	0.0929	0.0268	10.1895	0.1473	0.0474	4.9600	1.1490	2.0329	11.9136	0.5358	0.0406	0.2912	48.2453	0.0281	0.0117	3.6894	0.0437	0.1040	100.000
SB4VS-40	9.7001	5.1200	0.0525	1.0854	0.0636	0.0880	0.0254	9.6532	0.1396	0.0449	5.1200	0.9085	1.9259	12.3598	0.6876	0.0384	0.2759	49.5261	0.0266	0.0111	3.0075	0.0414	0.0986	100.000
SB4VS-41	7.3932	5.7600	0.0288	0.7042	0.0349	0.0484	0.0139	7.5080	0.0767	0.0247	5.7600	0.7066	1.4979	11.3910	0.5348	0.0211	0.2706	55.4092	0.0146	0.0061	2.7185	0.0228	0.0541	100.000
SB4VS-42	7.0735	5.6000	0.0309	0.9045	0.0374	0.0518	0.0149	8.5418	0.0821	0.0264	5.6000	0.7571	1.8651	11.6332	0.4230	0.0226	0.2299	54.0884	0.0156	0.0065	2.9127	0.0244	0.0580	100.000
SB4VS-43	9.9029	4.6400	0.0613	1.0563	0.0741	0.1027	0.0296	12.4376	0.1628	0.0524	4.6400	1.0599	2.6112	13.0864	0.5922	0.0448	0.4059	45.3238	0.0310	0.0129	3.5087	0.0483	0.1150	100.000
SB4VS-44	7.5451	5.4400	0.0467	0.8048	0.0565	0.0783	0.0226	9.8447	0.1241	0.0399	5.4400	0.9676	1.9895	10.9774	0.6112	0.0342	0.2453	52.4676	0.0236	0.0098	3.1068	0.0368	0.0876	100.000
SB4VS-45	9.3166	5.2800	0.0350	1.0251	0.0424	0.0587	0.0169	9.3874	0.0931	0.0299	5.2800	1.0280	2.1138	11.1635	0.6494	0.0256	0.3286	51.1669	0.0177	0.0074	2.8404	0.0276	0.0657	100.000
SB4VS-46	7.0735	5.6000	0.0438	0.9045	0.0530	0.0734	0.0211	9.2797	0.1163	0.0374	5.6000	0.7571	1.6049	10.7913	0.5730	0.0320	0.2899	54.0884	0.0222	0.0092	2.9127	0.0345	0.0821	100.000
SB4VS-47	8.1340	5.4400	0.0398	0.8850	0.0482	0.0668	0.0193	9.2475	0.1059	0.0340	5.4400	0.8877	1.8508	11.3844	0.5313	0.0291	0.2769	52.5478	0.0202	0.0084	2.8967	0.0314	0.0748	100.000
SB4VS-48	9.1508	5.1200	0.0448	0.9956	0.0542	0.0751	0.0217	10.4034	0.1191	0.0383	5.1200	0.9987	2.0821	11.8075	0.5978	0.0328	0.3115	49.6163	0.0227	0.0094	3.2587	0.0354	0.0841	100.000

Table C2. Measured Elemental Concentrations (wt%) for Samples Prepared Using Lithium Metaborate

Glass ID	Laboratory ID	Block	Sub-Block	Analytical Sequence	Ba	Ca	Ce	Cr	Cu	Fe	K	La	Mg	Mn	Na	Pb	S	Th	Ti	Zn	Zr
Batch 1	BCHLM111	1	1	1	0.123	0.855	0.046	0.064	0.315	8.80	2.37	<0.010	0.793	1.29	7.20	<0.010	<0.050	<0.100	0.372	<0.010	0.062
Ustd	UstdLM111	1	1	2	<0.010	0.948	<0.010	0.145	<0.010	8.80	2.39	<0.010	0.625	2.08	8.72	<0.010	<0.050	<0.100	0.503	<0.010	<0.010
SB4VS-40	B03LM11	1	1	3	0.040	0.868	0.041	0.041	0.026	6.16	0.135	0.055	0.488	1.43	9.27	0.049	0.082	0.104	<0.010	0.061	0.055
SB4VS-42	B05LM11	1	1	4	0.021	0.669	0.023	0.034	0.012	5.83	0.079	0.029	0.408	1.46	8.66	0.020	0.079	<0.100	<0.010	0.016	0.036
SB4VS-39	B09LM11	1	1	5	0.040	0.689	0.026	0.046	0.023	6.85	0.140	0.040	0.621	1.6	9.29	0.033	0.093	0.128	<0.010	0.034	0.064
SB4VS-41	B11LM21	1	1	6	0.024	0.559	0.024	0.030	0.012	5.00	0.068	0.018	0.394	1.15	8.63	0.018	0.086	<0.100	<0.010	0.017	0.035
SB4VS-47	B06LM21	1	1	7	0.028	0.684	0.029	0.047	0.017	6.14	0.098	0.033	0.472	1.43	8.73	0.027	0.101	<0.100	<0.010	0.034	0.045
SB4VS-40	B03LM11	1	1	8	0.039	0.778	0.040	0.041	0.019	7.00	0.122	0.029	0.506	1.49	9.24	0.027	0.093	0.109	<0.010	0.032	0.061
SB4VS-43	B13LM11	1	1	9	0.046	0.769	0.049	0.050	0.023	8.47	0.145	0.040	0.594	2.05	10.1	0.035	0.134	0.134	<0.010	0.038	0.074
Batch 1	BCHLM112	1	1	10	0.123	0.855	0.047	0.064	0.316	9.09	2.39	<0.010	0.793	1.33	7.22	<0.010	<0.050	<0.100	0.378	<0.010	0.063
Ustd	USTDLM112	1	1	11	<0.010	0.949	<0.010	0.143	<0.010	9.17	2.39	<0.010	0.614	2.16	8.82	<0.010	<0.050	<0.100	0.499	<0.010	<0.010
SB4VS-38	B02LM11	1	1	12	0.040	0.823	0.044	0.045	0.023	6.81	0.129	0.035	0.532	1.87	9.00	0.036	0.107	0.131	<0.010	0.032	0.071
SB4VS-38	B02LM21	1	1	13	0.041	0.833	0.048	0.045	0.023	6.63	0.132	0.039	0.531	1.8	9.06	0.033	0.121	0.137	<0.010	0.035	0.072
SB4VS-42	B05LM21	1	1	14	0.021	0.731	0.024	0.034	0.012	5.84	0.082	0.019	0.413	1.4	9.77	0.018	0.077	<0.100	<0.010	0.018	0.038
SB4VS-43	B13LM21	1	1	15	0.045	0.808	0.050	0.053	0.024	8.11	0.158	0.033	0.57	1.96	10.5	0.031	0.118	0.126	<0.010	0.045	0.072
SB4VS-47	B06LM11	1	1	16	0.027	0.663	0.049	0.043	0.015	6.11	0.094	0.024	0.48	1.42	8.82	0.024	0.088	<0.100	<0.010	0.025	0.045
SB4VS-39	B09LM21	1	1	17	0.039	0.688	0.026	0.047	0.024	6.75	0.132	0.036	0.623	1.57	9.78	0.036	0.097	0.130	<0.010	0.030	0.066
SB4VS-41	B11LM11	1	1	18	0.024	0.543	0.024	0.028	0.012	5.02	0.068	0.020	0.391	1.15	9.16	0.021	0.082	<0.100	<0.010	0.017	0.035
Batch 1	BCHLM113	1	1	19	0.119	0.859	0.047	0.063	0.316	8.92	2.40	<0.010	0.773	1.31	7.27	<0.010	<0.050	<0.100	0.377	<0.010	0.062
Ustd	USTDLM113	1	1	20	<0.010	0.948	<0.010	0.140	<0.010	8.96	2.40	<0.010	0.603	2.11	9.14	<0.010	<0.050	<0.100	0.491	<0.010	<0.010
Batch 1	BCHLM121	1	2	1	0.126	0.840	0.044	0.066	0.313	8.76	2.34	<0.010	0.804	1.3	7.13	<0.010	<0.050	<0.100	0.379	<0.010	0.062
Ustd	USTDLM121	1	2	2	<0.010	0.942	<0.010	0.147	<0.010	8.76	2.37	<0.010	0.626	2.08	8.67	<0.010	<0.050	<0.100	0.513	<0.010	<0.010
SB4VS-40	B03LM22	1	2	3	0.041	0.865	0.040	0.041	0.025	6.12	0.133	0.056	0.487	1.44	9.29	0.043	0.079	0.106	<0.010	0.060	0.056
SB4VS-38	B02LM22	1	2	4	0.043	0.829	0.047	0.048	0.022	6.59	0.128	0.038	0.549	1.8	8.87	0.036	0.114	0.137	<0.010	0.036	0.073
SB4VS-41	B11LM12	1	2	5	0.025	0.534	0.022	0.029	0.011	4.89	0.064	0.020	0.408	1.13	8.78	0.022	0.086	<0.100	<0.010	0.017	0.035
SB4VS-40	B03LM12	1	2	6	0.040	0.771	0.038	0.042	0.018	6.67	0.118	0.029	0.508	1.43	9.28	0.023	0.101	0.112	<0.010	0.032	0.061
SB4VS-38	B02LM12	1	2	7	0.043	0.817	0.042	0.047	0.022	6.44	0.125	0.035	0.548	1.77	8.73	0.035	0.111	0.139	<0.010	0.034	0.073
SB4VS-42	B05LM22	1	2	8	0.023	0.719	0.021	0.037	0.012	5.68	0.077	0.019	0.43	1.38	9.46	0.020	0.078	<0.100	<0.010	0.019	0.039
SB4VS-41	B11LM22	1	2	9	0.025	0.549	0.022	0.032	0.011	4.79	0.065	0.020	0.401	1.11	8.59	0.019	0.091	<0.100	<0.010	0.017	0.035
Batch 1	BCHLM122	1	2	10	0.124	0.855	0.129	0.065	0.316	8.47	2.36	0.085	0.797	1.26	7.10	<0.010	<0.050	<0.100	0.382	<0.010	0.076
Ustd	USTDLM122	1	2	11	<0.010	0.944	<0.010	0.148	<0.010	8.53	2.35	<0.010	0.624	2.02	8.66	<0.010	<0.050	<0.100	0.513	<0.010	<0.010
SB4VS-43	B13LM12	1	2	12	0.048	0.758	0.047	0.052	0.022	7.89	0.140	<0.010	0.604	1.92	9.92	0.033	0.131	0.137	<0.010	0.038	0.075
SB4VS-39	B09LM22	1	2	13	0.041	0.679	0.023	0.049	0.023	6.37	0.127	0.038	0.64	1.48	9.41	0.038	0.101	0.135	<0.010	0.030	0.067
SB4VS-42	B05LM12	1	2	14	0.023	0.680	0.027	0.036	0.013	5.37	0.076	0.038	0.413	1.35	8.72	0.018	0.080	<0.100	<0.010	0.022	0.036
SB4VS-43	B13LM22	1	2	15	0.047	0.809	0.049	0.055	0.023	7.62	0.155	0.340	0.581	1.85	10.27	0.032	0.134	0.132	<0.010	0.045	0.073
SB4VS-39	B09LM12	1	2	16	0.041	0.687	0.024	0.048	0.022	6.29	0.135	0.040	0.624	1.47	9.22	0.032	0.106	0.131	<0.010	0.035	0.065
SB4VS-47	B06LM12	1	2	17	0.028	0.676	0.048	0.044	0.015	5.65	0.092	0.029	0.473	1.32	8.55	0.024	0.088	0.102	<0.010	0.025	0.045
SB4VS-47	B06LM22	1	2	18	0.028	0.691	0.026	0.047	0.016	5.64	0.096	0.033	0.464	1.33	8.72	0.026	0.098	0.100	<0.010	0.033	0.045
Batch 1	BCHLM123	1	2	19	0.121	0.860	0.045	0.064	0.318	8.24	2.39	<0.010	0.78	1.22	6.92	<0.010	<0.050	<0.100	0.373	<0.010	0.062
Ustd	USTDLM123	1	2	20	<0.010	0.946	<0.010	0.145	<0.010	8.29	2.37	<0.010	0.615	1.97	8.73	<0.010	<0.050	<0.100	0.506	<0.010	<0.010
Batch 1	BCHLM211	2	1	1	0.125	0.849	0.046	0.066	0.314	8.82	2.35	<0.010	0.81	1.33	6.97	<0.010	<0.050	<0.100	0.389	<0.010	0.063
Ustd	USTDLM211	2	1	2	<0.010	0.933	<0.010	0.147	<0.010	8.86	2.33	<0.010	0.628	2.11	8.66	<0.010	<0.050	<0.100	0.517	<0.010	<0.010

Table C2. Measured Elemental Concentrations (wt%) for Samples Prepared Using Lithium Metaborate (continued)

Glass ID	Laboratory ID	Block	Sub-Block	Analytical Sequence	Ba	Ca	Ce	Cr	Cu	Fe	K	La	Mg	Mn	Na	Pb	S	Th	Ti	Zn	Zr
SB4VS-44	B08LM11	2	1	3	0.037	0.623	0.034	0.042	0.018	6.38	0.123	0.032	0.519	1.52	8.25	0.022	0.076	0.109	<0.010	0.032	0.052
SB4VS-45	B07LM21	2	1	4	0.025	0.785	0.030	0.034	0.013	5.78	0.090	0.021	0.542	1.63	8.46	0.025	0.098	<0.100	<0.010	0.021	0.036
SB4VS-44	B08LM21	2	1	5	0.037	0.624	0.033	0.042	0.017	6.41	0.126	0.028	0.509	1.52	8.38	0.023	0.080	0.111	<0.010	0.028	0.051
SB4VS-37	B01LM11	2	1	6	0.026	0.638	0.029	0.040	0.013	7.06	0.077	0.021	0.472	1.41	8.33	0.020	0.084	0.100	<0.010	0.019	0.042
SB4VS-46	B12LM11	2	1	7	0.034	0.676	0.027	0.040	0.018	6.04	0.104	0.049	0.409	1.28	8.44	0.025	0.086	0.109	<0.010	0.027	0.052
SB4VS-45	B07LM11	2	1	8	0.025	0.782	0.025	0.034	0.015	5.69	0.088	0.020	0.54	1.6	8.37	0.025	0.089	0.101	<0.010	0.019	0.037
SB4VS-48	B04LM11	2	1	9	0.032	0.744	0.033	0.044	0.017	6.67	0.115	0.026	0.53	1.59	8.92	0.025	0.102	0.114	<0.010	0.030	0.052
Batch 1	BCHLM212	2	1	10	0.124	0.855	0.045	0.065	0.315	8.80	2.36	<0.010	0.792	1.32	6.91	<0.010	<0.050	<0.100	0.383	<0.010	0.062
Ustd	USTDLM212	2	1	11	<0.010	0.957	<0.010	0.142	<0.010	8.80	2.37	<0.010	0.603	2.09	8.82	<0.010	<0.050	<0.100	0.505	<0.010	<0.010
SB4VS-36	B10LM11	2	1	12	0.031	0.852	0.033	0.037	0.016	8.03	0.101	0.026	0.642	1.64	9.64	0.026	0.107	0.121	<0.010	0.024	0.046
SB4VS-46	B12LM21	2	1	13	0.033	0.681	0.026	0.037	0.018	5.89	0.110	0.026	0.402	1.24	8.45	0.026	0.093	0.107	<0.010	0.027	0.051
SB4VS-37	B01LM21	2	1	14	0.026	0.653	0.029	0.038	0.014	6.88	0.087	0.022	0.461	1.38	8.51	0.019	0.080	<0.100	<0.010	0.019	0.041
SB4VS-48	B04LM21	2	1	15	0.032	0.723	0.032	0.046	0.017	6.68	0.108	0.027	0.538	1.59	8.90	0.028	0.106	0.117	<0.010	0.031	0.053
SB4VS-36	B10LM21	2	1	16	0.031	0.859	0.033	0.037	0.016	7.91	0.100	0.026	0.651	1.62	9.69	0.026	0.121	0.121	<0.010	0.026	0.047
Batch 1	BCHLM213	2	1	17	0.122	0.853	0.045	0.064	0.313	8.80	2.35	<0.010	0.783	1.33	7.04	<0.010	<0.050	<0.100	0.378	<0.010	0.062
Ustd	USTDLM213	2	1	18	<0.010	0.952	<0.010	0.144	<0.010	8.83	2.37	<0.010	0.613	2.11	8.91	<0.010	<0.050	<0.100	0.514	<0.010	<0.010
Batch 1	BCHLM221	2	2	1	0.124	0.847	0.044	0.064	0.314	9.11	2.34	<0.010	0.803	1.37	6.98	<0.010	<0.050	<0.100	0.384	<0.010	0.062
Ustd	USTDLM221	2	2	2	<0.010	0.946	<0.010	0.146	<0.010	9.08	2.38	<0.010	0.626	2.17	8.81	<0.010	<0.050	<0.100	0.515	<0.010	<0.010
SB4VS-44	B08LM22	2	2	3	0.035	0.619	0.032	0.041	0.017	6.72	0.126	0.028	0.514	1.61	8.43	0.022	0.084	0.108	<0.010	0.026	0.052
SB4VS-37	B01LM12	2	2	4	0.025	0.628	0.028	0.039	0.014	7.25	0.075	0.020	0.484	1.46	8.52	0.024	0.064	0.102	<0.010	0.018	0.042
SB4VS-45	B07LM12	2	2	5	0.023	0.773	0.024	0.033	0.015	5.91	0.087	0.020	0.549	1.68	8.71	0.023	0.093	0.100	<0.010	0.019	0.037
SB4VS-48	B04LM22	2	2	6	0.032	0.710	0.032	0.046	0.018	6.86	0.105	0.027	0.562	1.64	9.08	0.029	0.104	0.122	<0.010	0.030	0.055
SB4VS-44	B08LM12	2	2	7	0.036	0.615	0.034	0.041	0.018	6.37	0.122	0.032	0.524	1.53	8.38	0.024	0.085	0.112	<0.010	0.031	0.053
SB4VS-46	B12LM12	2	2	8	0.034	0.668	0.026	0.040	0.019	6.23	0.102	0.051	0.427	1.31	8.52	0.023	0.093	0.115	<0.010	0.027	0.053
SB4VS-36	B10LM12	2	2	9	0.031	0.847	0.033	0.037	0.017	8.27	0.100	0.026	0.68	1.7	9.80	0.026	0.115	0.126	<0.010	0.024	0.048
Batch 1	BCHLM222	2	2	10	0.128	0.853	0.110	0.066	0.315	8.92	2.35	<0.010	0.823	1.35	7.12	<0.010	<0.050	<0.100	0.391	<0.010	0.074
Ustd	USTDLM222	2	2	11	<0.010	0.943	<0.010	0.149	<0.010	9.17	2.36	<0.010	0.638	2.19	8.86	<0.010	<0.050	<0.100	0.520	<0.010	<0.010
SB4VS-37	B01LM22	2	2	12	0.027	0.666	0.030	0.039	0.015	7.37	0.088	0.023	0.504	1.48	9.07	0.021	0.081	0.104	<0.010	0.019	0.044
SB4VS-36	B10LM22	2	2	13	0.031	0.853	0.032	0.037	0.016	8.00	0.098	0.026	0.684	1.64	9.78	0.025	0.126	0.127	<0.010	0.026	0.048
SB4VS-48	B04LM12	2	2	14	0.031	0.750	0.032	0.044	0.017	6.87	0.114	0.026	0.541	1.65	9.10	0.025	0.104	0.119	<0.010	0.026	0.054
SB4VS-46	B12LM22	2	2	15	0.033	0.674	0.025	0.036	0.019	6.10	0.108	0.026	0.417	1.3	8.42	0.023	0.101	0.111	<0.010	0.027	0.052
SB4VS-45	B07LM22	2	2	16	0.023	0.792	0.030	0.032	0.014	5.80	0.090	0.020	0.541	1.64	8.56	0.025	0.110	<0.100	<0.010	0.019	0.036
Batch 1	BCHLM223	2	2	17	0.123	0.855	0.044	0.063	0.312	8.93	2.36	<0.010	0.8	1.36	7.12	<0.010	<0.050	<0.100	0.381	<0.010	0.063
Ustd	USTDLM223	2	2	18	<0.010	0.959	<0.010	0.145	<0.010	9.06	2.39	<0.010	0.619	2.18	8.93	<0.010	<0.050	<0.100	0.517	<0.010	<0.010

Table C3. Measured Elemental Concentrations (wt%) for Samples Prepared Using Peroxide Fusion

Glass ID	PSAL ID	Block	Sub-Block	Analytical Sequence	Al	B	Li	Ni	Si	U
Batch 1	BCHPF111	1	1	1	2.59	2.44	2.08	0.524	23.0	<0.100
Ustd	USTDPF111	1	1	2	2.13	2.80	1.44	0.739	20.7	1.90
SB4VS-39	B09PF21	1	1	3	5.77	1.57	2.33	0.354	22.5	2.85
SB4VS-45	B07PF21	1	1	4	5.11	1.64	2.47	0.438	23.7	2.23
SB4VS-39	B09PF11	1	1	5	5.60	1.50	2.25	0.361	22.2	2.82
SB4VS-44	B08PF21	1	1	6	4.15	1.72	2.52	0.404	23.7	2.47
SB4VS-37	B01PF11	1	1	7	4.98	1.66	2.43	0.344	23.4	2.27
SB4VS-47	B06PF11	1	1	8	4.41	1.66	2.50	0.356	23.9	2.29
SB4VS-36	B10PF21	1	1	9	5.06	1.49	2.19	0.371	21.0	2.71
Batch 1	BCHPF112	1	1	10	2.57	2.31	2.07	0.501	22.8	<0.100
Ustd	USTDPF112	1	1	11	2.16	2.76	1.45	0.722	20.6	1.92
SB4VS-45	B07PF11	1	1	12	5.16	1.61	2.45	0.423	23.5	2.30
SB4VS-47	B06PF21	1	1	13	4.45	1.68	2.51	0.355	24.0	2.33
SB4VS-44	B08PF11	1	1	14	4.17	1.70	2.50	0.423	23.7	2.46
SB4VS-37	B01PF21	1	1	15	5.08	1.63	2.42	0.321	23.0	2.23
SB4VS-43	B13PF21	1	1	16	5.21	1.36	2.03	0.364	19.9	2.68
SB4VS-43	B13PF11	1	1	17	5.49	1.44	2.16	0.380	20.9	2.82
SB4VS-36	B10PF11	1	1	18	5.13	1.54	2.21	0.381	21.4	2.77
Batch 1	BCHPF113	1	1	19	2.59	2.27	2.08	0.489	22.5	<0.100
Ustd	USTDPF113	1	1	20	2.15	2.66	1.44	0.706	20.2	1.85
Batch 1	BCHPF121	1	2	1	2.57	2.37	2.06	0.496	23.0	<0.100
Ustd	USTDPF121	1	2	2	2.15	2.78	1.43	0.719	20.7	1.85
SB4VS-43	B13PF22	1	2	3	5.19	1.36	2.01	0.335	20.1	2.67
SB4VS-43	B13PF12	1	2	4	5.45	1.43	2.14	0.366	21.1	2.80
SB4VS-44	B08PF12	1	2	5	4.20	1.68	2.51	0.400	24.1	2.48
SB4VS-39	B09PF12	1	2	6	5.62	1.44	2.24	0.326	22.0	2.85
SB4VS-39	B09PF22	1	2	7	5.76	1.49	2.31	0.343	22.6	2.88
SB4VS-47	B06PF22	1	2	8	4.42	1.64	2.51	0.333	24.2	2.28
SB4VS-37	B01PF22	1	2	9	5.07	1.58	2.42	0.309	23.1	2.21
Batch 1	BCHPF122	1	2	10	2.56	2.28	2.07	0.486	22.9	<0.100
Ustd	USTDPF122	1	2	11	2.16	2.75	1.44	0.701	20.7	1.92
SB4VS-36	B10PF22	1	2	12	5.07	1.46	2.18	0.345	21.2	2.71
SB4VS-45	B07PF22	1	2	13	5.13	1.55	2.45	0.397	23.5	2.26
SB4VS-47	B06PF12	1	2	14	4.42	1.60	2.49	0.313	23.9	2.29
SB4VS-44	B08PF22	1	2	15	4.13	1.65	2.51	0.387	23.9	2.47
SB4VS-36	B10PF12	1	2	16	5.14	1.46	2.21	0.350	21.4	2.74
SB4VS-37	B01PF12	1	2	17	5.04	1.59	2.42	0.312	23.5	2.26
SB4VS-45	B07PF12	1	2	18	5.16	1.57	2.46	0.416	23.8	2.22
Batch 1	BCHPF123	1	2	19	2.58	2.29	2.08	0.479	22.9	<0.100
Ustd	USTDPF123	1	2	20	2.16	2.67	1.44	0.686	20.4	1.89
Batch 1	BCHPF211	2	1	1	2.58	2.35	2.06	0.524	23.1	<0.100
Ustd	USTDPF211	2	1	2	2.14	2.73	1.42	0.730	20.6	1.93
SB4VS-38	B02PF21	2	1	3	5.65	1.52	2.25	0.359	22.3	2.95
SB4VS-38	B02PF11	2	1	4	5.90	1.50	2.26	0.494	22.1	2.87
SB4VS-40	B03PF21	2	1	5	5.33	1.55	2.35	0.467	22.9	2.42
SB4VS-46	B12PF21	2	1	6	3.94	1.69	2.60	0.388	25.4	2.35
SB4VS-42	B05PF11	2	1	7	3.89	1.68	2.56	0.285	25.0	2.34
SB4VS-41	B11PF21	2	1	8	4.13	1.75	2.65	0.347	25.9	1.86
SB4VS-41	B11PF11	2	1	9	4.14	1.70	2.62	0.358	25.5	1.89
Batch 1	BCHPF212	2	1	10	2.55	2.30	2.05	0.515	23.0	<0.100
Ustd	USTDPF212	2	1	11	2.15	2.79	1.43	0.759	20.8	1.96
SB4VS-48	B04PF21	2	1	12	4.91	1.59	2.33	0.462	22.9	2.66
SB4VS-48	B04PF11	2	1	13	4.96	1.56	2.34	0.416	23.0	2.58
SB4VS-42	B05PF21	2	1	14	3.90	1.69	2.58	0.288	25.1	2.40
SB4VS-46	B12PF11	2	1	15	3.93	1.70	2.58	0.395	25.2	2.40
SB4VS-40	B03PF11	2	1	16	5.33	1.52	2.34	0.475	22.8	2.46
Batch 1	BCHPF213	2	1	17	2.56	2.28	2.04	0.510	22.9	<0.100
Ustd	USTDPF213	2	1	18	2.16	2.73	1.43	0.736	20.8	1.96
Batch 1	BCHPF221	2	2	1	2.57	2.41	2.08	0.544	23.1	<0.100
Ustd	USTDPF221	2	2	2	2.14	2.79	1.44	0.736	20.7	1.88
SB4VS-48	B04PF12	2	2	3	4.97	1.61	2.37	0.418	22.8	2.53

Table C3. Measured Elemental Concentrations (wt%) for Samples Prepared Using Peroxide Fusion (continued)

Glass ID	PSAL ID	Block	Sub-Block	Analytical Sequence	Al	B	Li	Ni	Si	U
SB4VS-46	B12PF22	2	2	4	3.94	1.76	2.61	0.401	25.4	2.28
SB4VS-42	B05PF12	2	2	5	3.90	1.75	2.59	0.302	25.0	2.31
SB4VS-41	B11PF22	2	2	6	4.14	1.79	2.68	0.357	25.8	1.78
SB4VS-42	B05PF22	2	2	7	3.88	1.72	2.58	0.292	24.7	2.26
SB4VS-40	B03PF22	2	2	8	5.30	1.61	2.37	0.500	23.0	2.32
SB4VS-38	B02PF12	2	2	9	5.97	1.55	2.30	0.500	22.2	2.81
Batch 1	BCHPF222	2	2	10	2.56	2.36	2.08	0.522	23.0	<0.100
Ustd	USTDPF222	2	2	11	2.21	2.89	1.48	0.747	21.1	1.91
SB4VS-38	B02PF22	2	2	12	5.77	1.63	2.31	0.391	22.8	2.95
SB4VS-40	B03PF12	2	2	13	5.41	1.64	2.40	0.492	23.4	2.39
SB4VS-48	B04PF22	2	2	14	4.98	1.63	2.37	0.484	23.2	2.60
SB4VS-46	B12PF12	2	2	15	3.98	1.78	2.64	0.415	25.7	2.34
SB4VS-41	B11PF12	2	2	16	4.19	1.78	2.67	0.360	26.0	1.88
Batch 1	BCHPF223	2	2	17	2.61	2.39	2.10	0.535	23.5	<0.100
Ustd	USTDPF223	2	2	18	2.21	2.83	1.48	0.757	21.1	1.96

Table C4. Average Measured and Bias-Corrected Chemical Compositions Versus Targeted Compositions by Oxide by SB4 Variability Study Glass

(100 -Batch 1; 200 -U std; 300 - LRM)

Glass ID	Oxide	Measured (wt%)	Measured bc (wt%)	Targeted (wt%)	Diff. of Measured	Diff. of Meas. bc	% Diff. of Meas.	% Diff. of Meas. bc
SB4VS-36	Al_2O_3	9.6365	9.6531	9.4313	0.2051	0.2218	2.2%	2.4%
SB4VS-36	B_2O_3	4.7896	4.9717	4.8000	-0.0104	0.1717	-0.2%	3.6%
SB4VS-36	BaO	0.0346	0.0376	0.0412	-0.0066	-0.0036	-16.0%	-8.6%
SB4VS-36	CaO	1.1932	1.2211	1.2060	-0.0128	0.0151	-1.1%	1.3%
SB4VS-36	Ce_2O_3	0.0384	0.0384	0.0499	-0.0115	-0.0115	-23.1%	-23.1%
SB4VS-36	Cr_2O_3	0.0541	0.0612	0.0691	-0.0150	-0.0079	-21.7%	-11.4%
SB4VS-36	CuO	0.0203	0.0207	0.0199	0.0004	0.0008	2.2%	3.8%
SB4VS-36	Fe_2O_3	11.5127	11.6208	12.1980	-0.6853	-0.5772	-5.6%	-4.7%
SB4VS-36	K_2O	0.1202	0.1411	0.1095	0.0106	0.0316	9.7%	28.9%
SB4VS-36	La_2O_3	0.0305	0.0305	0.0352	-0.0047	-0.0047	-13.4%	-13.4%
SB4VS-36	Li_2O	4.7310	4.6942	4.8000	-0.0690	-0.1058	-1.4%	-2.2%
SB4VS-36	MgO	1.1015	1.1753	1.2095	-0.1079	-0.0341	-8.9%	-2.8%
SB4VS-36	MnO	2.1305	2.1200	2.1399	-0.0094	-0.0198	-0.4%	-0.9%
SB4VS-36	Na_2O	13.1127	12.4695	12.8442	0.2684	-0.3748	2.1%	-2.9%
SB4VS-36	NiO	0.4603	0.5477	0.5640	-0.1037	-0.0163	-18.4%	-2.9%
SB4VS-36	PbO	0.0277	0.0277	0.0302	-0.0024	-0.0024	-8.0%	-8.0%
SB4VS-36	SiO_2	45.4601	46.7037	46.5846	-1.1244	0.1192	-2.4%	0.3%
SB4VS-36	SO_4	0.3513	0.3513	0.3866	-0.0353	-0.0353	-9.1%	-9.1%
SB4VS-36	ThO_2	0.1408	0.1408	0.0209	0.1200	0.1200	575.0%	575.0%
SB4VS-36	TiO_2	0.0083	0.0088	0.0087	-0.0004	0.0001	-4.0%	1.4%
SB4VS-36	U_3O_8	3.2222	3.4816	3.3417	-0.1195	0.1399	-3.6%	4.2%
SB4VS-36	ZnO	0.0311	0.0311	0.0325	-0.0014	-0.0014	-4.3%	-4.3%
SB4VS-36	ZrO_2	0.0638	0.0638	0.0774	-0.0135	-0.0135	-17.5%	-17.5%
SB4VS-36	Sum	98.2713	99.6118	100.0000	-1.7287	-0.3882	-1.7%	-0.4%
SB4VS-37	Al_2O_3	9.5278	9.5443	9.1517	0.3761	0.3927	4.1%	4.3%
SB4VS-37	B_2O_3	5.2001	5.3978	5.2800	-0.0799	0.1178	-1.5%	2.2%
SB4VS-37	BaO	0.0290	0.0316	0.0350	-0.0060	-0.0035	-17.1%	-9.9%
SB4VS-37	CaO	0.9042	0.9254	0.8551	0.0491	0.0703	5.7%	8.2%
SB4VS-37	Ce_2O_3	0.0340	0.0340	0.0424	-0.0084	-0.0084	-19.9%	-19.9%
SB4VS-37	Cr_2O_3	0.0570	0.0645	0.0587	-0.0017	0.0058	-2.9%	9.9%
SB4VS-37	CuO	0.0175	0.0178	0.0169	0.0006	0.0009	3.5%	5.1%
SB4VS-37	Fe_2O_3	10.2081	10.3025	10.5953	-0.3873	-0.2928	-3.7%	-2.8%
SB4VS-37	K_2O	0.0985	0.1157	0.0931	0.0054	0.0226	5.8%	24.2%
SB4VS-37	La_2O_3	0.0252	0.0252	0.0299	-0.0047	-0.0047	-15.8%	-15.8%
SB4VS-37	Li_2O	5.2154	5.1749	5.2800	-0.0646	-0.1051	-1.2%	-2.0%
SB4VS-37	MgO	0.7964	0.8498	0.8580	-0.0616	-0.0083	-7.2%	-1.0%
SB4VS-37	MnO	1.8496	1.8403	1.8189	0.0308	0.0214	1.7%	1.2%
SB4VS-37	Na_2O	11.6029	11.0325	11.1635	0.4394	-0.1310	3.9%	-1.2%
SB4VS-37	NiO	0.4091	0.4868	0.4794	-0.0703	0.0074	-14.7%	1.5%
SB4VS-37	PbO	0.0226	0.0226	0.0256	-0.0030	-0.0030	-11.7%	-11.7%
SB4VS-37	SiO_2	49.7387	51.0994	50.9969	-1.2581	0.1025	-2.5%	0.2%
SB4VS-37	SO_4	0.2314	0.2314	0.2606	-0.0292	-0.0292	-11.2%	-11.2%
SB4VS-37	ThO_2	0.1013	0.1013	0.0177	0.0835	0.0835	471.2%	471.2%
SB4VS-37	TiO_2	0.0083	0.0088	0.0074	0.0010	0.0014	13.0%	19.3%
SB4VS-37	U_3O_8	2.6444	2.8572	2.8404	-0.1960	0.0168	-6.9%	0.6%
SB4VS-37	ZnO	0.0233	0.0233	0.0276	-0.0043	-0.0043	-15.6%	-15.6%
SB4VS-37	ZrO_2	0.0571	0.0571	0.0658	-0.0087	-0.0087	-13.2%	-13.2%
SB4VS-37	Sum	98.8021	100.2442	100.0000	-1.1979	0.2442	-1.2%	0.2%
SB4VS-38	Al_2O_3	11.0016	11.0418	10.4127	0.5889	0.6291	5.7%	6.0%
SB4VS-38	B_2O_3	4.9908	5.1324	4.9600	0.0308	0.1724	0.6%	3.5%
SB4VS-38	BaO	0.0466	0.0514	0.0554	-0.0088	-0.0040	-15.9%	-7.3%
SB4VS-38	CaO	1.1550	1.1793	1.1457	0.0093	0.0336	0.8%	2.9%
SB4VS-38	Ce_2O_3	0.0530	0.0530	0.0671	-0.0141	-0.0141	-21.0%	-21.0%
SB4VS-38	Cr_2O_3	0.0676	0.0769	0.0929	-0.0253	-0.0160	-27.3%	-17.2%
SB4VS-38	CuO	0.0282	0.0284	0.0268	0.0014	0.0016	5.1%	6.2%
SB4VS-38	Fe_2O_3	9.4610	9.7533	10.3517	-0.8907	-0.5984	-8.6%	-5.8%

Table C4. Average Measured and Bias-Corrected Chemical Compositions Versus Targeted Compositions by Oxide by SB4 Variability Study Glass (continued)
(100 -Batch 1; 200 -U std; 300 - LRM)

Glass ID	Oxide	Measured (wt%)	Measured bc (wt%)	Targeted (wt%)	Diff. of Measured	Diff. of Meas. bc	% Diff. of Meas.	% Diff. of Meas. bc
SB4VS-38	K_2O	0.1548	0.1800	0.1473	0.0075	0.0327	5.1%	22.2%
SB4VS-38	La_2O_3	0.0431	0.0431	0.0474	-0.0043	-0.0043	-9.0%	-9.0%
SB4VS-38	Li_2O	4.9086	4.8822	4.9600	-0.0514	-0.0778	-1.0%	-1.6%
SB4VS-38	MgO	0.8955	0.9699	0.9590	-0.0635	0.0109	-6.6%	1.1%
SB4VS-38	MnO	2.3371	2.4314	2.3625	-0.0254	0.0689	-1.1%	2.9%
SB4VS-38	Na_2O	12.0174	11.2411	11.5357	0.4817	-0.2946	4.2%	-2.6%
SB4VS-38	NiO	0.5548	0.6236	0.5358	0.0190	0.0879	3.6%	16.4%
SB4VS-38	PbO	0.0377	0.0377	0.0406	-0.0029	-0.0029	-7.0%	-7.0%
SB4VS-38	SiO_2	47.8134	48.5890	48.0553	-0.2420	0.5336	-0.5%	1.1%
SB4VS-38	SO_4	0.3393	0.3393	0.3672	-0.0279	-0.0279	-7.6%	-7.6%
SB4VS-38	ThO_2	0.1548	0.1548	0.0281	0.1267	0.1267	451.5%	451.5%
SB4VS-38	TiO_2	0.0083	0.0090	0.0117	-0.0033	-0.0027	-28.6%	-23.1%
SB4VS-38	U_3O_8	3.4138	3.6029	3.6894	-0.2756	-0.0865	-7.5%	-2.3%
SB4VS-38	ZnO	0.0426	0.0426	0.0437	-0.0011	-0.0011	-2.5%	-2.5%
SB4VS-38	ZrO_2	0.0976	0.0976	0.1040	-0.0064	-0.0064	-6.2%	-6.2%
SB4VS-38	Sum	99.6227	100.5606	100.0000	-0.3773	0.5607	-0.4%	0.6%
SB4VS-39	Al_2O_3	10.7465	10.7651	10.4127	0.3338	0.3524	3.2%	3.4%
SB4VS-39	B_2O_3	4.8299	5.0133	4.9600	-0.1302	0.0533	-2.6%	1.1%
SB4VS-39	BaO	0.0449	0.0495	0.0554	-0.0105	-0.0059	-18.9%	-10.6%
SB4VS-39	CaO	0.9595	0.9796	0.9557	0.0038	0.0239	0.4%	2.5%
SB4VS-39	Ce_2O_3	0.0290	0.0290	0.0671	-0.0381	-0.0381	-56.8%	-56.8%
SB4VS-39	Cr_2O_3	0.0694	0.0790	0.0929	-0.0235	-0.0139	-25.3%	-15.0%
SB4VS-39	CuO	0.0288	0.0291	0.0268	0.0020	0.0023	7.5%	8.5%
SB4VS-39	Fe_2O_3	9.3860	9.6709	10.1895	-0.8035	-0.5186	-7.9%	-5.1%
SB4VS-39	K_2O	0.1608	0.1870	0.1473	0.0135	0.0397	9.2%	26.9%
SB4VS-39	La_2O_3	0.0452	0.0452	0.0474	-0.0022	-0.0022	-4.7%	-4.7%
SB4VS-39	Li_2O	4.9140	4.8758	4.9600	-0.0460	-0.0842	-0.9%	-1.7%
SB4VS-39	MgO	1.0398	1.1262	1.1490	-0.1092	-0.0228	-9.5%	-2.0%
SB4VS-39	MnO	1.9755	2.0544	2.0329	-0.0573	0.0216	-2.8%	1.1%
SB4VS-39	Na_2O	12.7049	11.8844	11.9136	0.7913	-0.0292	6.6%	-0.2%
SB4VS-39	NiO	0.4403	0.5239	0.5358	-0.0955	-0.0119	-17.8%	-2.2%
SB4VS-39	PbO	0.0374	0.0374	0.0406	-0.0031	-0.0031	-7.7%	-7.7%
SB4VS-39	SiO_2	47.7599	49.0670	48.2453	-0.4855	0.8217	-1.0%	1.7%
SB4VS-39	SO_4	0.2973	0.2973	0.2912	0.0061	0.0061	2.1%	2.1%
SB4VS-39	ThO_2	0.1491	0.1491	0.0281	0.1210	0.1210	431.2%	431.2%
SB4VS-39	TiO_2	0.0083	0.0090	0.0117	-0.0033	-0.0027	-28.6%	-23.1%
SB4VS-39	U_3O_8	3.3607	3.6313	3.6894	-0.3286	-0.0580	-8.9%	-1.6%
SB4VS-39	ZnO	0.0401	0.0401	0.0437	-0.0036	-0.0036	-8.2%	-8.2%
SB4VS-39	ZrO_2	0.0885	0.0885	0.1040	-0.0156	-0.0156	-15.0%	-15.0%
SB4VS-39	Sum	99.1158	100.6322	100.0000	-0.8841	0.6322	-0.9%	0.6%
SB4VS-40	Al_2O_3	10.0947	10.1317	9.7002	0.3945	0.4316	4.1%	4.4%
SB4VS-40	B_2O_3	5.0874	5.2315	5.1200	-0.0326	0.1115	-0.6%	2.2%
SB4VS-40	BaO	0.0447	0.0492	0.0525	-0.0079	-0.0033	-14.9%	-6.2%
SB4VS-40	CaO	1.1480	1.1721	1.0854	0.0626	0.0867	5.8%	8.0%
SB4VS-40	Ce_2O_3	0.0466	0.0466	0.0636	-0.0170	-0.0170	-26.7%	-26.7%
SB4VS-40	Cr_2O_3	0.0603	0.0686	0.0880	-0.0277	-0.0194	-31.5%	-22.1%
SB4VS-40	CuO	0.0275	0.0278	0.0254	0.0022	0.0024	8.5%	9.6%
SB4VS-40	Fe_2O_3	9.2752	9.5620	9.6532	-0.3780	-0.0912	-3.9%	-0.9%
SB4VS-40	K_2O	0.1530	0.1779	0.1396	0.0134	0.0383	9.6%	27.5%
SB4VS-40	La_2O_3	0.0496	0.0496	0.0449	0.0047	0.0047	10.4%	10.4%
SB4VS-40	Li_2O	5.0916	5.0643	5.1200	-0.0284	-0.0557	-0.6%	-1.1%
SB4VS-40	MgO	0.8246	0.8932	0.9085	-0.0839	-0.0153	-9.2%	-1.7%
SB4VS-40	MnO	1.8690	1.9447	1.9259	-0.0568	0.0188	-3.0%	1.0%
SB4VS-40	Na_2O	12.4960	11.6909	12.3598	0.1362	-0.6689	1.1%	-5.4%
SB4VS-40	NiO	0.6153	0.6915	0.6876	-0.0723	0.0039	-10.5%	0.6%
SB4VS-40	PbO	0.0382	0.0382	0.0384	-0.0002	-0.0002	-0.5%	-0.5%
SB4VS-40	SiO_2	49.2574	50.0562	49.5261	-0.2687	0.5301	-0.5%	1.1%
SB4VS-40	SO_4	0.2659	0.2659	0.2759	-0.0100	-0.0100	-3.6%	-3.6%

Table C4. Average Measured and Bias-Corrected Chemical Compositions Versus Targeted Compositions by Oxide by SB4 Variability Study Glass (continued)
(100 -Batch 1; 200 -U std; 300 - LRM)

Glass ID	Oxide	Measured (wt%)	Measured bc (wt%)	Targeted (wt%)	Diff. of Measured	Diff. of Meas. bc	% Diff. of Meas.	% Diff. of Meas. bc
SB4VS-40	ThO_2	0.1226	0.1226	0.0266	0.0960	0.0960	361.1%	361.1%
SB4VS-40	TiO_2	0.0083	0.0090	0.0111	-0.0027	-0.0021	-24.7%	-18.9%
SB4VS-40	U_3O_8	2.8271	2.9834	3.0075	-0.1803	-0.0241	-6.0%	-0.8%
SB4VS-40	ZnO	0.0576	0.0576	0.0414	0.0161	0.0161	39.0%	39.0%
SB4VS-40	ZrO_2	0.0787	0.0787	0.0986	-0.0199	-0.0199	-20.2%	-20.2%
SB4VS-40	Sum	99.5392	100.4132	100.0000	-0.4608	0.4132	-0.5%	0.4%
SB4VS-41	Al_2O_3	7.8414	7.8702	7.3932	0.4483	0.4770	6.1%	6.5%
SB4VS-41	B_2O_3	5.6509	5.8120	5.7600	-0.1091	0.0520	-1.9%	0.9%
SB4VS-41	BaO	0.0274	0.0302	0.0289	-0.0015	0.0013	-5.2%	4.5%
SB4VS-41	CaO	0.7643	0.7803	0.7042	0.0601	0.0761	8.5%	10.8%
SB4VS-41	Ce_2O_3	0.0269	0.0269	0.0349	-0.0080	-0.0080	-22.8%	-22.8%
SB4VS-41	Cr_2O_3	0.0435	0.0495	0.0484	-0.0049	0.0011	-10.1%	2.3%
SB4VS-41	CuO	0.0144	0.0145	0.0139	0.0005	0.0006	3.3%	4.3%
SB4VS-41	Fe_2O_3	7.0413	7.2585	7.5080	-0.4668	-0.2496	-6.2%	-3.3%
SB4VS-41	K_2O	0.0798	0.0928	0.0767	0.0031	0.0161	4.1%	21.0%
SB4VS-41	La_2O_3	0.0229	0.0229	0.0247	-0.0018	-0.0018	-7.2%	-7.2%
SB4VS-41	Li_2O	5.7159	5.6853	5.7600	-0.0441	-0.0747	-0.8%	-1.3%
SB4VS-41	MgO	0.6608	0.7158	0.7066	-0.0458	0.0091	-6.5%	1.3%
SB4VS-41	MnO	1.4655	1.5247	1.4979	-0.0324	0.0268	-2.2%	1.8%
SB4VS-41	Na_2O	11.8489	11.0836	11.3910	0.4580	-0.3073	4.0%	-2.7%
SB4VS-41	NiO	0.4524	0.5086	0.5348	-0.0824	-0.0262	-15.4%	-4.9%
SB4VS-41	PbO	0.0215	0.0215	0.0211	0.0004	0.0004	2.1%	2.1%
SB4VS-41	SiO_2	55.1939	56.0900	55.4092	-0.2153	0.6808	-0.4%	1.2%
SB4VS-41	SO_4	0.2584	0.2584	0.2706	-0.0122	-0.0122	-4.5%	-4.5%
SB4VS-41	ThO_2	0.0569	0.0569	0.0146	0.0423	0.0423	289.4%	289.4%
SB4VS-41	TiO_2	0.0083	0.0090	0.0061	0.0023	0.0029	37.2%	47.7%
SB4VS-41	U_3O_8	2.1845	2.3053	2.7185	-0.5340	-0.4131	-19.6%	-15.2%
SB4VS-41	ZnO	0.0212	0.0212	0.0228	-0.0016	-0.0016	-7.0%	-7.0%
SB4VS-41	ZrO_2	0.0473	0.0473	0.0541	-0.0069	-0.0069	-12.7%	-12.7%
SB4VS-41	Sum	99.4484	100.2853	100.0000	-0.5516	0.2853	-0.6%	0.3%
SB4VS-42	Al_2O_3	7.3549	7.3820	7.0735	0.2814	0.3085	4.0%	4.4%
SB4VS-42	B_2O_3	5.5060	5.6632	5.6000	-0.0940	0.0632	-1.7%	1.1%
SB4VS-42	BaO	0.0246	0.0271	0.0309	-0.0063	-0.0038	-20.5%	-12.4%
SB4VS-42	CaO	0.9791	0.9997	0.9045	0.0746	0.0952	8.2%	10.5%
SB4VS-42	Ce_2O_3	0.0278	0.0278	0.0374	-0.0096	-0.0096	-25.6%	-25.6%
SB4VS-42	Cr_2O_3	0.0515	0.0586	0.0518	-0.0003	0.0068	-0.6%	13.1%
SB4VS-42	CuO	0.0153	0.0155	0.0149	0.0004	0.0005	2.6%	3.6%
SB4VS-42	Fe_2O_3	8.1207	8.3690	8.5418	-0.4211	-0.1728	-4.9%	-2.0%
SB4VS-42	K_2O	0.0946	0.1100	0.0821	0.0124	0.0278	15.1%	33.9%
SB4VS-42	La_2O_3	0.0308	0.0308	0.0264	0.0044	0.0044	16.6%	16.6%
SB4VS-42	Li_2O	5.5491	5.5196	5.6000	-0.0509	-0.0804	-0.9%	-1.4%
SB4VS-42	MgO	0.6899	0.7472	0.7571	-0.0672	-0.0099	-8.9%	-1.3%
SB4VS-42	MnO	1.8045	1.8770	1.8651	-0.0607	0.0118	-3.3%	0.6%
SB4VS-42	Na_2O	12.3376	11.5415	11.6332	0.7044	-0.0917	6.1%	-0.8%
SB4VS-42	NiO	0.3713	0.4173	0.4230	-0.0517	-0.0056	-12.2%	-1.3%
SB4VS-42	PbO	0.0205	0.0205	0.0226	-0.0022	-0.0022	-9.5%	-9.5%
SB4VS-42	SiO_2	53.3755	54.2439	54.0884	-0.7129	0.1555	-1.3%	0.3%
SB4VS-42	SO_4	0.2352	0.2352	0.2299	0.0053	0.0053	2.3%	2.3%
SB4VS-42	ThO_2	0.0569	0.0569	0.0157	0.0412	0.0412	263.5%	263.5%
SB4VS-42	TiO_2	0.0083	0.0090	0.0065	0.0018	0.0025	27.9%	37.8%
SB4VS-42	U_3O_8	2.7446	2.8963	2.9127	-0.1681	-0.0164	-5.8%	-0.6%
SB4VS-42	ZnO	0.0233	0.0233	0.0244	-0.0010	-0.0010	-4.3%	-4.3%
SB4VS-42	ZrO_2	0.0503	0.0503	0.0580	-0.0077	-0.0077	-13.3%	-13.3%
SB4VS-42	Sum	99.4722	100.3214	100.0000	-0.5278	0.3215	-0.5%	0.3%
SB4VS-43	Al_2O_3	10.0805	10.0978	9.9029	0.1776	0.1949	1.8%	2.0%
SB4VS-43	B_2O_3	4.4998	4.6713	4.6400	-0.1402	0.0313	-3.0%	0.7%
SB4VS-43	BaO	0.0519	0.0572	0.0613	-0.0093	-0.0040	-15.3%	-6.6%
SB4VS-43	CaO	1.0998	1.1229	1.0563	0.0435	0.0666	4.1%	6.3%

Table C4. Average Measured and Bias-Corrected Chemical Compositions Versus Targeted Compositions by Oxide by SB4 Variability Study Glass (continued)
(100 -Batch 1; 200 -U std; 300 - LRM)

Glass ID	Oxide	Measured (wt%)	Measured bc (wt%)	Targeted (wt%)	Diff. of Measured	Diff. of Meas. bc	% Diff. of Meas.	% Diff. of Meas. bc
SB4VS-43	Ce_2O_3	0.0571	0.0571	0.0742	-0.0170	-0.0170	-23.0%	-23.0%
SB4VS-43	Cr_2O_3	0.0767	0.0873	0.1027	-0.0260	-0.0154	-25.3%	-15.0%
SB4VS-43	CuO	0.0288	0.0291	0.0296	-0.0008	-0.0005	-2.8%	-1.8%
SB4VS-43	Fe_2O_3	11.4698	11.8187	12.4376	-0.9679	-0.6190	-7.8%	-5.0%
SB4VS-43	K_2O	0.1801	0.2094	0.1628	0.0173	0.0466	10.6%	28.6%
SB4VS-43	La_2O_3	0.1226	0.1226	0.0524	0.0702	0.0702	134.1%	134.1%
SB4VS-43	Li_2O	4.4888	4.4539	4.6400	-0.1512	-0.1861	-3.3%	-4.0%
SB4VS-43	MgO	0.9738	1.0548	1.0599	-0.0861	-0.0051	-8.1%	-0.5%
SB4VS-43	MnO	2.5114	2.6119	2.6112	-0.0998	0.0007	-3.8%	0.0%
SB4VS-43	Na_2O	13.7462	12.8587	13.0864	0.6598	-0.2277	5.0%	-1.7%
SB4VS-43	NiO	0.4597	0.5470	0.5922	-0.1325	-0.0451	-22.4%	-7.6%
SB4VS-43	PbO	0.0353	0.0353	0.0448	-0.0096	-0.0096	-21.3%	-21.3%
SB4VS-43	SiO_2	43.8557	45.0549	45.3238	-1.4681	-0.2688	-3.2%	-0.6%
SB4VS-43	SO_4	0.3872	0.3872	0.4059	-0.0187	-0.0187	-4.6%	-4.6%
SB4VS-43	ThO_2	0.1505	0.1505	0.0310	0.1195	0.1195	385.1%	385.1%
SB4VS-43	TiO_2	0.0083	0.0090	0.0129	-0.0046	-0.0039	-35.4%	-30.4%
SB4VS-43	U_3O_8	3.2340	3.4943	3.5087	-0.2748	-0.0144	-7.8%	-0.4%
SB4VS-43	ZnO	0.0517	0.0517	0.0483	0.0033	0.0033	6.9%	6.9%
SB4VS-43	ZrO_2	0.0993	0.0993	0.1150	-0.0157	-0.0157	-13.7%	-13.7%
SB4VS-43	Sum	97.6688	99.0819	100.0000	-2.3311	-0.9181	-2.3%	-0.9%
SB4VS-44	Al_2O_3	7.8650	7.8787	7.5451	0.3200	0.3336	4.2%	4.4%
SB4VS-44	B_2O_3	5.4336	5.6403	5.4400	-0.0064	0.2003	-0.1%	3.7%
SB4VS-44	BaO	0.0405	0.0440	0.0467	-0.0062	-0.0026	-13.3%	-5.7%
SB4VS-44	CaO	0.8679	0.8882	0.8048	0.0631	0.0834	7.8%	10.4%
SB4VS-44	Ce_2O_3	0.0389	0.0389	0.0565	-0.0175	-0.0175	-31.1%	-31.1%
SB4VS-44	Cr_2O_3	0.0607	0.0687	0.0783	-0.0176	-0.0096	-22.5%	-12.3%
SB4VS-44	CuO	0.0219	0.0222	0.0226	-0.0007	-0.0003	-2.9%	-1.4%
SB4VS-44	Fe_2O_3	9.2502	9.3369	9.8448	-0.5946	-0.5079	-6.0%	-5.2%
SB4VS-44	K_2O	0.1497	0.1758	0.1241	0.0256	0.0517	20.6%	41.7%
SB4VS-44	La_2O_3	0.0352	0.0352	0.0399	-0.0047	-0.0047	-11.8%	-11.8%
SB4VS-44	Li_2O	5.4038	5.3618	5.4400	-0.0362	-0.0782	-0.7%	-1.4%
SB4VS-44	MgO	0.8565	0.9141	0.9676	-0.1111	-0.0535	-11.5%	-5.5%
SB4VS-44	MnO	1.9949	1.9850	1.9895	0.0054	-0.0045	0.3%	-0.2%
SB4VS-44	Na_2O	11.2693	10.7166	10.9774	0.2919	-0.2609	2.7%	-2.4%
SB4VS-44	NiO	0.5135	0.6111	0.6112	-0.0977	-0.0001	-16.0%	0.0%
SB4VS-44	PbO	0.0245	0.0245	0.0342	-0.0096	-0.0096	-28.2%	-28.2%
SB4VS-44	SiO_2	51.0223	52.4173	52.4676	-1.4453	-0.0503	-2.8%	-0.1%
SB4VS-44	SO_4	0.2434	0.2434	0.2453	-0.0019	-0.0019	-0.8%	-0.8%
SB4VS-44	ThO_2	0.1252	0.1252	0.0236	0.1015	0.1015	429.7%	429.7%
SB4VS-44	TiO_2	0.0083	0.0088	0.0098	-0.0015	-0.0010	-15.2%	-10.5%
SB4VS-44	U_3O_8	2.9126	3.1471	3.1068	-0.1942	0.0403	-6.3%	1.3%
SB4VS-44	ZnO	0.0364	0.0364	0.0368	-0.0004	-0.0004	-1.1%	-1.1%
SB4VS-44	ZrO_2	0.0702	0.0702	0.0876	-0.0174	-0.0174	-19.8%	-19.8%
SB4VS-44	Sum	98.2444	99.7904	100.0001	-1.7556	-0.2096	-1.8%	-0.2%
SB4VS-45	Al_2O_3	9.7120	9.7288	9.3166	0.3954	0.4122	4.2%	4.4%
SB4VS-45	B_2O_3	5.1277	5.3226	5.2800	-0.1523	0.0426	-2.9%	0.8%
SB4VS-45	BaO	0.0268	0.0292	0.0350	-0.0082	-0.0059	-23.5%	-16.8%
SB4VS-45	CaO	1.0956	1.1212	1.0251	0.0705	0.0961	6.9%	9.4%
SB4VS-45	Ce_2O_3	0.0319	0.0319	0.0424	-0.0105	-0.0105	-24.7%	-24.7%
SB4VS-45	Cr_2O_3	0.0486	0.0550	0.0587	-0.0101	-0.0037	-17.3%	-6.3%
SB4VS-45	CuO	0.0178	0.0181	0.0169	0.0009	0.0012	5.4%	7.0%
SB4VS-45	Fe_2O_3	8.2851	8.3629	9.3874	-1.1023	-1.0245	-11.7%	-10.9%
SB4VS-45	K_2O	0.1069	0.1256	0.0931	0.0138	0.0325	14.8%	34.9%
SB4VS-45	La_2O_3	0.0237	0.0237	0.0299	-0.0062	-0.0062	-20.7%	-20.7%
SB4VS-45	Li_2O	5.2908	5.2497	5.2800	0.0108	-0.0303	0.2%	-0.6%
SB4VS-45	MgO	0.9005	0.9610	1.0280	-0.1276	-0.0671	-12.4%	-6.5%
SB4VS-45	MnO	2.1143	2.1039	2.1138	0.0005	-0.0099	0.0%	-0.5%
SB4VS-45	Na_2O	11.4917	10.9275	11.1635	0.3282	-0.2360	2.9%	-2.1%

Table C4. Average Measured and Bias-Corrected Chemical Compositions Versus Targeted Compositions by Oxide by SB4 Variability Study Glass (continued)
(100 -Batch 1; 200 -U std; 300 - LRM)

Glass ID	Oxide	Measured (wt%)	Measured bc (wt%)	Targeted (wt%)	Diff. of Measured	Diff. of Meas. bc	% Diff. of Meas.	% Diff. of Meas. bc
SB4VS-45	NiO	0.5325	0.6337	0.6494	-0.1168	-0.0156	-18.0%	-2.4%
SB4VS-45	PbO	0.0264	0.0264	0.0256	0.0008	0.0008	3.0%	3.0%
SB4VS-45	SiO_2	50.5410	51.9238	51.1669	-0.6259	0.7569	-1.2%	1.5%
SB4VS-45	SO_4	0.2921	0.2921	0.3286	-0.0365	-0.0365	-11.1%	-11.1%
SB4VS-45	ThO_2	0.0856	0.0856	0.0177	0.0679	0.0679	382.9%	382.9%
SB4VS-45	TiO_2	0.0083	0.0088	0.0074	0.0010	0.0014	13.0%	19.3%
SB4VS-45	U_3O_8	2.6561	2.8700	2.8404	-0.1843	0.0296	-6.5%	1.0%
SB4VS-45	ZnO	0.0243	0.0243	0.0276	-0.0034	-0.0034	-12.2%	-12.2%
SB4VS-45	ZrO_2	0.0493	0.0493	0.0658	-0.0164	-0.0164	-25.0%	-25.0%
SB4VS-45	Sum	98.4892	99.9751	100.0000	-1.5108	-0.0249	-1.5%	0.0%
SB4VS-46	Al_2O_3	7.4588	7.4862	7.0735	0.3853	0.4127	5.4%	5.8%
SB4VS-46	B_2O_3	5.5785	5.7370	5.6000	-0.0215	0.1370	-0.4%	2.4%
SB4VS-46	BaO	0.0374	0.0407	0.0438	-0.0064	-0.0031	-14.5%	-7.0%
SB4VS-46	CaO	0.9441	0.9662	0.9045	0.0396	0.0617	4.4%	6.8%
SB4VS-46	Ce_2O_3	0.0305	0.0305	0.0530	-0.0225	-0.0225	-42.5%	-42.5%
SB4VS-46	Cr_2O_3	0.0559	0.0633	0.0734	-0.0175	-0.0101	-23.8%	-13.7%
SB4VS-46	CuO	0.0232	0.0235	0.0212	0.0020	0.0024	9.5%	11.2%
SB4VS-46	Fe_2O_3	8.6711	8.7520	9.2797	-0.6086	-0.5277	-6.6%	-5.7%
SB4VS-46	K_2O	0.1277	0.1500	0.1163	0.0114	0.0337	9.8%	28.9%
SB4VS-46	La_2O_3	0.0446	0.0446	0.0374	0.0072	0.0072	19.2%	19.2%
SB4VS-46	Li_2O	5.6137	5.5836	5.6000	0.0137	-0.0164	0.2%	-0.3%
SB4VS-46	MgO	0.6861	0.7321	0.7571	-0.0710	-0.0250	-9.4%	-3.3%
SB4VS-46	MnO	1.6560	1.6477	1.6049	0.0511	0.0428	3.2%	2.7%
SB4VS-46	Na_2O	11.4007	10.8419	10.7913	0.6094	0.0505	5.6%	0.5%
SB4VS-46	NiO	0.5087	0.5718	0.5730	-0.0643	-0.0012	-11.2%	-0.2%
SB4VS-46	PbO	0.0261	0.0261	0.0320	-0.0059	-0.0059	-18.4%	-18.4%
SB4VS-46	SiO_2	54.3917	55.2744	54.0884	0.3033	1.1860	0.6%	2.2%
SB4VS-46	SO_4	0.2794	0.2794	0.2899	-0.0105	-0.0105	-3.6%	-3.6%
SB4VS-46	ThO_2	0.1257	0.1257	0.0222	0.1036	0.1036	467.4%	467.4%
SB4VS-46	TiO_2	0.0083	0.0088	0.0092	-0.0009	-0.0004	-9.5%	-4.5%
SB4VS-46	U_3O_8	2.7623	2.9151	2.9127	-0.1504	0.0024	-5.2%	0.1%
SB4VS-46	ZnO	0.0336	0.0336	0.0345	-0.0009	-0.0009	-2.6%	-2.6%
SB4VS-46	ZrO_2	0.0702	0.0702	0.0821	-0.0119	-0.0119	-14.5%	-14.5%
SB4VS-46	Sum	100.5343	101.4045	100.0000	0.5343	1.4045	0.5%	1.4%
SB4VS-47	Al_2O_3	8.3610	8.3755	8.1340	0.2270	0.2415	2.8%	3.0%
SB4VS-47	B_2O_3	5.2967	5.4982	5.4400	-0.1433	0.0582	-2.6%	1.1%
SB4VS-47	BaO	0.0310	0.0342	0.0398	-0.0089	-0.0057	-22.2%	-14.3%
SB4VS-47	CaO	0.9494	0.9693	0.8850	0.0644	0.0844	7.3%	9.5%
SB4VS-47	Ce_2O_3	0.0445	0.0445	0.0482	-0.0037	-0.0037	-7.7%	-7.7%
SB4VS-47	Cr_2O_3	0.0661	0.0753	0.0668	-0.0007	0.0085	-1.0%	12.7%
SB4VS-47	CuO	0.0197	0.0199	0.0193	0.0005	0.0007	2.4%	3.4%
SB4VS-47	Fe_2O_3	8.4138	8.6681	9.2475	-0.8337	-0.5794	-9.0%	-6.3%
SB4VS-47	K_2O	0.1144	0.1331	0.1059	0.0086	0.0272	8.1%	25.7%
SB4VS-47	La_2O_3	0.0349	0.0349	0.0340	0.0009	0.0009	2.5%	2.5%
SB4VS-47	Li_2O	5.3876	5.3458	5.4400	-0.0524	-0.0942	-1.0%	-1.7%
SB4VS-47	MgO	0.7831	0.8483	0.8877	-0.1046	-0.0394	-11.8%	-4.4%
SB4VS-47	MnO	1.7754	1.8463	1.8508	-0.0753	-0.0045	-4.1%	-0.2%
SB4VS-47	Na_2O	11.7343	10.9770	11.3844	0.3499	-0.4074	3.1%	-3.6%
SB4VS-47	NiO	0.4317	0.5136	0.5314	-0.0997	-0.0178	-18.8%	-3.3%
SB4VS-47	PbO	0.0272	0.0272	0.0292	-0.0020	-0.0020	-6.7%	-6.7%
SB4VS-47	SiO_2	51.3432	52.7478	52.5478	-1.2046	0.2000	-2.3%	0.4%
SB4VS-47	SO_4	0.2809	0.2809	0.2769	0.0040	0.0040	1.4%	1.4%
SB4VS-47	ThO_2	0.0859	0.0859	0.0202	0.0657	0.0657	325.9%	325.9%
SB4VS-47	TiO_2	0.0083	0.0090	0.0084	-0.0001	0.0006	-0.7%	6.9%
SB4VS-47	U_3O_8	2.7092	2.9273	2.8967	-0.1874	0.0307	-6.5%	1.1%
SB4VS-47	ZnO	0.0364	0.0364	0.0314	0.0050	0.0050	15.8%	15.8%
SB4VS-47	ZrO_2	0.0608	0.0608	0.0748	-0.0140	-0.0140	-18.7%	-18.7%
SB4VS-47	Sum	97.9957	99.5590	100.0000	-2.0043	-0.4410	-2.0%	-0.4%

Table C4. Average Measured and Bias-Corrected Chemical Compositions Versus Targeted Compositions by Oxide by SB4 Variability Study Glass (continued)
(100 -Batch 1; 200 -U std; 300 - LRM)

Glass ID	Oxide	Measured (wt%)	Measured bc (wt%)	Targeted (wt%)	Diff. of Measured	Diff. of Meas. bc	% Diff. of Meas.	% Diff. of Meas. bc
SB4VS-48	Al_2O_3	9.3625	9.3968	9.1508	0.2117	0.2461	2.3%	2.7%
SB4VS-48	B_2O_3	5.1438	5.2906	5.1200	0.0238	0.1706	0.5%	3.3%
SB4VS-48	BaO	0.0354	0.0386	0.0448	-0.0094	-0.0063	-20.9%	-14.0%
SB4VS-48	CaO	1.0239	1.0478	0.9956	0.0283	0.0522	2.8%	5.2%
SB4VS-48	Ce_2O_3	0.0378	0.0378	0.0542	-0.0165	-0.0165	-30.4%	-30.4%
SB4VS-48	Cr_2O_3	0.0658	0.0745	0.0751	-0.0094	-0.0007	-12.5%	-0.9%
SB4VS-48	CuO	0.0216	0.0219	0.0217	-0.0001	0.0003	-0.3%	1.3%
SB4VS-48	Fe_2O_3	9.6791	9.7696	10.4034	-0.7244	-0.6339	-7.0%	-6.1%
SB4VS-48	K_2O	0.1331	0.1563	0.1191	0.0140	0.0372	11.8%	31.2%
SB4VS-48	La_2O_3	0.0311	0.0311	0.0383	-0.0072	-0.0072	-18.9%	-18.9%
SB4VS-48	Li_2O	5.0647	5.0376	5.1200	-0.0553	-0.0824	-1.1%	-1.6%
SB4VS-48	MgO	0.9000	0.9604	0.9987	-0.0987	-0.0383	-9.9%	-3.8%
SB4VS-48	MnO	2.0885	2.0782	2.0821	0.0064	-0.0039	0.3%	-0.2%
SB4VS-48	Na_2O	12.1320	11.5366	11.8075	0.3246	-0.2709	2.7%	-2.3%
SB4VS-48	NiO	0.5663	0.6366	0.5978	-0.0315	0.0388	-5.3%	6.5%
SB4VS-48	PbO	0.0288	0.0288	0.0328	-0.0040	-0.0040	-12.1%	-12.1%
SB4VS-48	SiO_2	49.1504	49.9489	49.6163	-0.4659	0.3326	-0.9%	0.7%
SB4VS-48	SO_4	0.3116	0.3116	0.3115	0.0001	0.0001	0.0%	0.0%
SB4VS-48	ThO_2	0.1343	0.1343	0.0227	0.1116	0.1116	491.8%	491.8%
SB4VS-48	TiO_2	0.0083	0.0088	0.0095	-0.0011	-0.0006	-11.7%	-6.8%
SB4VS-48	U_3O_8	3.0571	3.2263	3.2587	-0.2017	-0.0325	-6.2%	-1.0%
SB4VS-48	ZnO	0.0364	0.0364	0.0354	0.0011	0.0011	3.0%	3.0%
SB4VS-48	ZrO_2	0.0723	0.0723	0.0841	-0.0119	-0.0119	-14.1%	-14.1%
SB4VS-48	Sum	99.0847	99.8817	100.0000	-0.9153	-0.1183	-0.9%	-0.1%
Batch 1	Al_2O_3	4.8639	4.8770	4.8770	-0.0131	0.0000	-0.3%	0.0%
Batch 1	B_2O_3	7.5265	7.7770	7.7770	-0.2505	0.0000	-3.2%	0.0%
Batch 1	BaO	0.1379	0.1510	0.1510	-0.0131	0.0000	-8.7%	0.0%
Batch 1	CaO	1.1935	1.2200	1.2200	-0.0265	0.0000	-2.2%	0.0%
Batch 1	Ce_2O_3	0.0675	0.0675	0.0000	0.0675	0.0675		
Batch 1	Cr_2O_3	0.0943	0.1070	0.1070	-0.0127	0.0000	-11.9%	0.0%
Batch 1	CuO	0.3940	0.3990	0.3990	-0.0050	0.0000	-1.3%	0.0%
Batch 1	Fe_2O_3	12.5885	12.8390	12.8390	-0.2505	0.0000	-2.0%	0.0%
Batch 1	K_2O	2.8469	3.3270	3.3270	-0.4801	0.0000	-14.4%	0.0%
Batch 1	La_2O_3	0.0137	0.0137	0.0000	0.0137	0.0137		
Batch 1	Li_2O	4.4583	4.4290	4.4290	0.0293	0.0000	0.7%	0.0%
Batch 1	MgO	1.3199	1.4190	1.4190	-0.0991	0.0000	-7.0%	0.0%
Batch 1	MnO	1.6969	1.7260	1.7260	-0.0291	0.0000	-1.7%	0.0%
Batch 1	Na_2O	9.5461	9.0030	9.0030	0.5431	0.0000	6.0%	0.0%
Batch 1	NiO	0.6495	0.7510	0.7510	-0.1015	0.0000	-13.5%	0.0%
Batch 1	PbO	0.0054	0.0054	0.0000	0.0054	0.0054		
Batch 1	SiO_2	49.1504	50.2200	50.2200	-1.0696	0.0000	-2.1%	0.0%
Batch 1	SO_4	0.0749	0.0749	0.0000	0.0749	0.0749		
Batch 1	ThO_2	0.0569	0.0569	0.0000	0.0569	0.0569		
Batch 1	TiO_2	0.6348	0.6770	0.6770	-0.0422	0.0000	-6.2%	0.0%
Batch 1	U_3O_8	0.0590	0.0630	0.0000	0.0590	0.0630		
Batch 1	ZnO	0.0062	0.0062	0.0000	0.0062	0.0062		
Batch 1	ZrO_2	0.0870	0.0870	0.0980	-0.0110	-0.0110	-11.2%	-11.2%
Batch 1	Sum	97.4719	99.2966	99.0200	-1.5481	0.2766	-1.6%	0.3%
U std	Al_2O_3	4.0813	4.0923	4.1000	-0.0187	-0.0077	-0.5%	-0.2%
U std	B_2O_3	8.9030	9.1993	9.2090	-0.3060	-0.0097	-3.3%	-0.1%
U std	BaO	0.0056	0.0061	0.0000	0.0056	0.0061		
U std	CaO	1.3254	1.3548	1.3010	0.0244	0.0538	1.9%	4.1%
U std	Ce_2O_3	0.0059	0.0059	0.0000	0.0059	0.0059		
U std	Cr_2O_3	0.2121	0.2407	0.0000	0.2121	0.2407		
U std	CuO	0.0063	0.0063	0.0000	0.0063	0.0063		
U std	Fe_2O_3	12.6660	12.9174	13.1960	-0.5300	-0.2786	-4.0%	-2.1%
U std	K_2O	2.8579	3.3399	2.9990	-0.1411	0.3409	-4.7%	11.4%
U std	La_2O_3	0.0059	0.0059	0.0000	0.0059	0.0059		

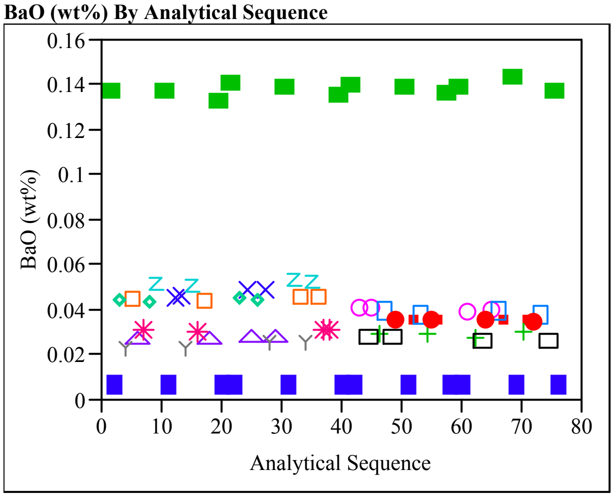
Table C4. Average Measured and Bias-Corrected Chemical Compositions Versus Targeted Compositions by Oxide by SB4 Variability Study Glass (continued)

(100 -Batch 1; 200 -U std; 300 - LRM)

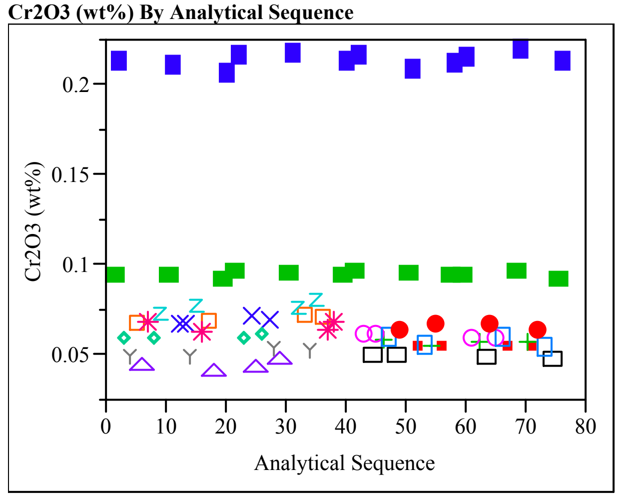
Glass ID	Oxide	Measured (wt%)	Measured bc (wt%)	Targeted (wt%)	Diff. of Measured	Diff. of Meas. bc	% Diff. of Meas.	% Diff. of Meas. bc
U std	Li_2O	3.1074	3.0869	3.0570	0.0504	0.0299	1.6%	1.0%
U std	MgO	1.0273	1.1045	1.2100	-0.1827	-0.1055	-15.1%	-8.7%
U std	MnO	2.7191	2.7659	2.8920	-0.1729	-0.1261	-6.0%	-4.4%
U std	Na_2O	11.8770	11.2025	11.7950	0.0820	-0.5925	0.7%	-5.0%
U std	NiO	0.9266	1.0717	1.1200	-0.1934	-0.0483	-17.3%	-4.3%
U std	PbO	0.0054	0.0054	0.0000	0.0054	0.0054		
U std	SiO_2	44.2835	45.2467	45.3530	-1.0695	-0.1063	-2.4%	-0.2%
U std	SO_4	0.0749	0.0749	0.0000	0.0749	0.0749		
U std	ThO_2	0.0569	0.0569	0.0000	0.0569	0.0569		
U std	TiO_2	0.8497	0.9062	1.0490	-0.1993	-0.1428	-19.0%	-13.6%
U std	U_3O_8	2.2533	2.4060	2.4060	-0.1527	0.0000	-6.3%	0.0%
U std	ZnO	0.0062	0.0062	0.0000	0.0062	0.0062		
U std	ZrO_2	0.0068	0.0068	0.0000	0.0068	0.0068		
U std	Sum	97.2632	99.1091	99.6870	-2.4238	-0.5779	-2.4%	-0.6%

Exhibit C1. Oxide Measurements in Analytical Sequence for Samples Prepared Using the LM Method

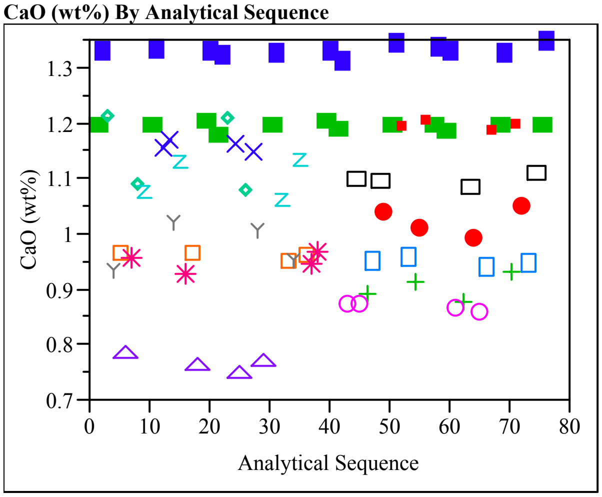
BaO (wt%) By Analytical Sequence



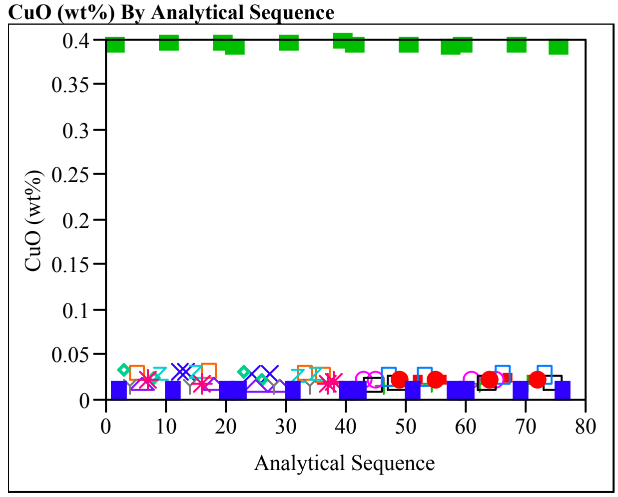
Cr2O3 (wt%) By Analytical Sequence



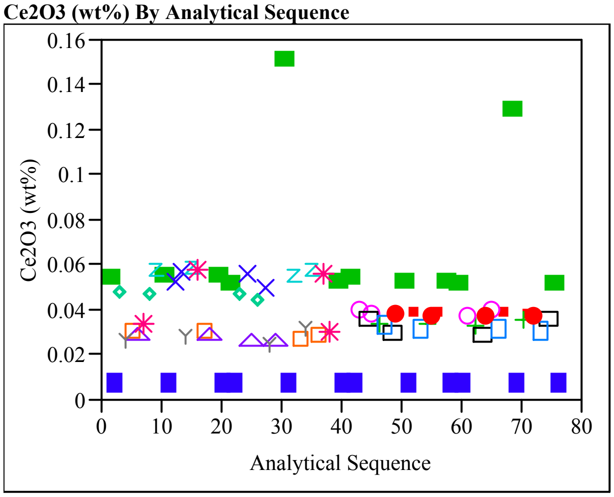
CaO (wt%) By Analytical Sequence



CuO (wt%) By Analytical Sequence



Ce2O3 (wt%) By Analytical Sequence



Fe2O3 (wt%) By Analytical Sequence

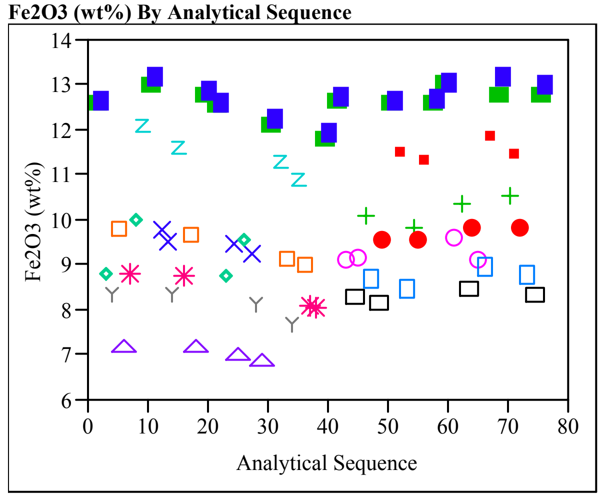
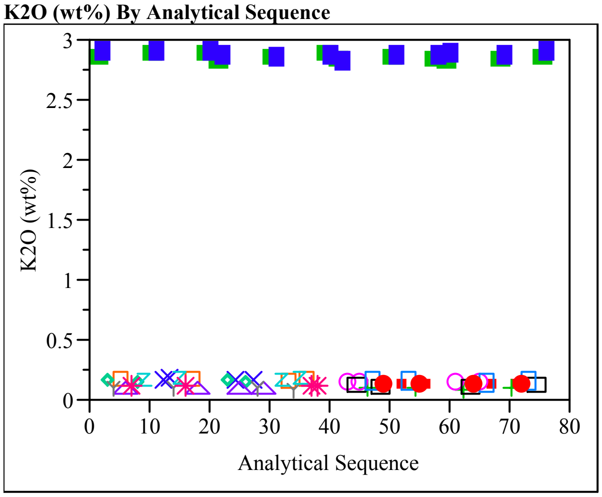
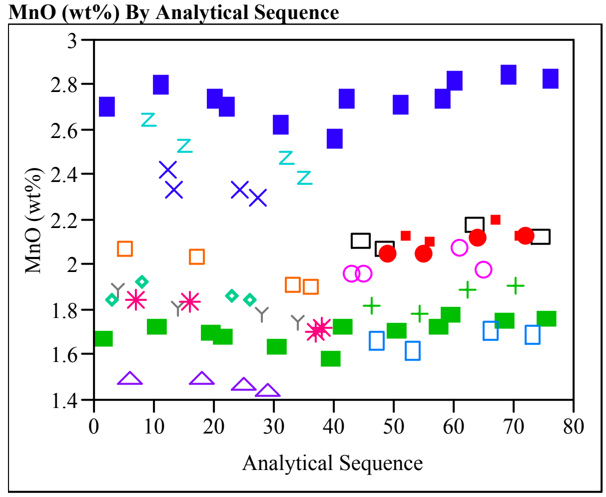


Exhibit C1. Oxide Measurements in Analytical Sequence for Samples Prepared Using the LM Method (continued)

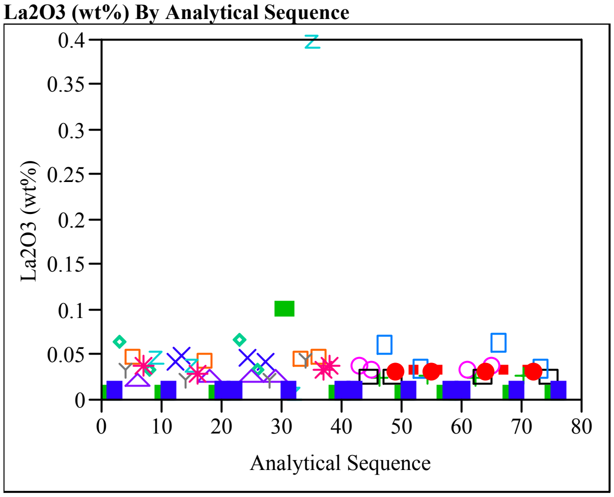
K2O (wt%) By Analytical Sequence



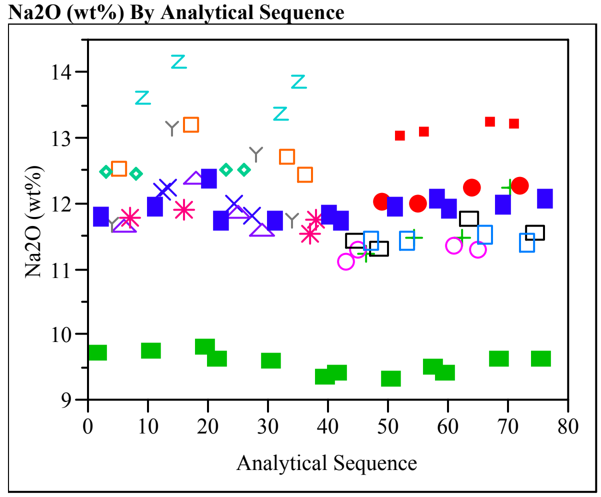
MnO (wt%) By Analytical Sequence



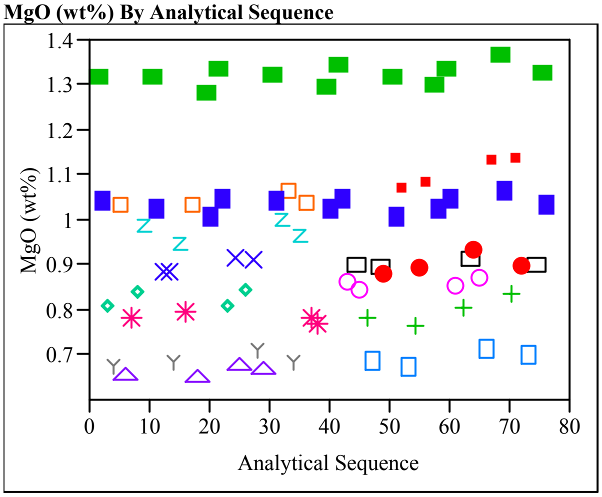
La2O3 (wt%) By Analytical Sequence



Na2O (wt%) By Analytical Sequence



MgO (wt%) By Analytical Sequence



PbO (wt%) By Analytical Sequence

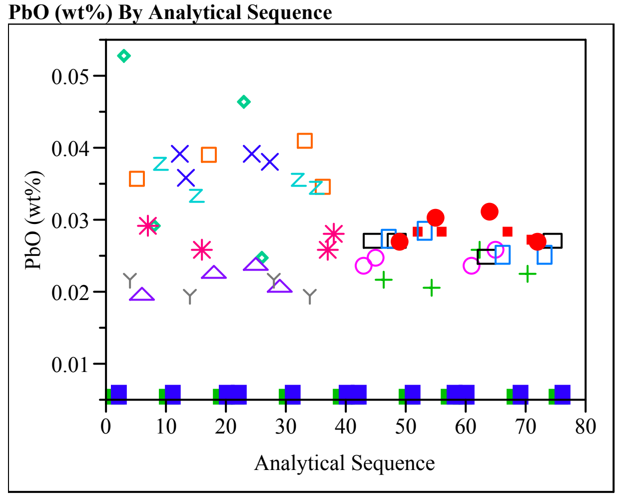
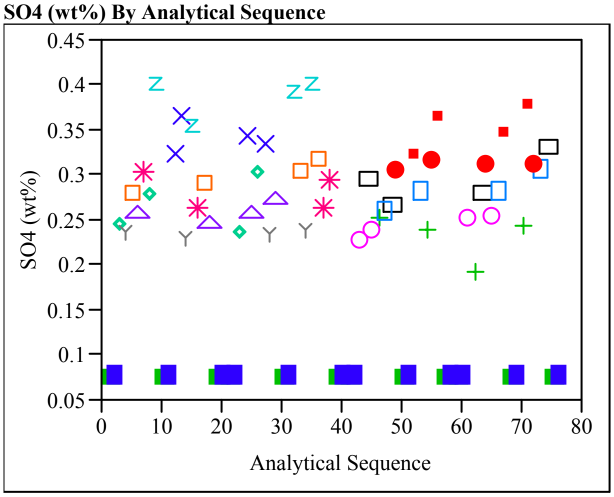
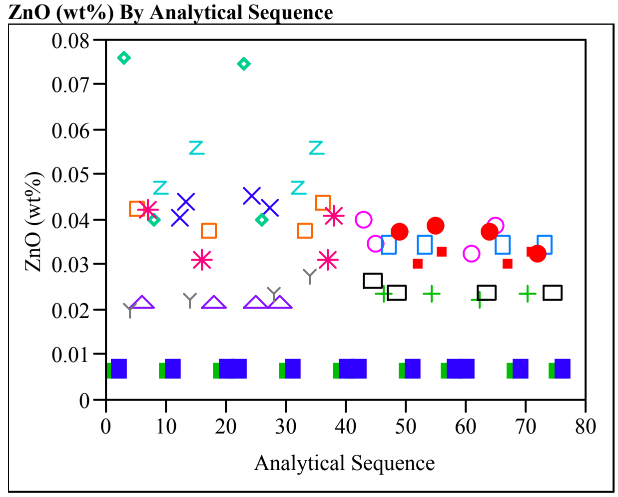


Exhibit C1. Oxide Measurements in Analytical Sequence for Samples Prepared Using the LM Method (continued)

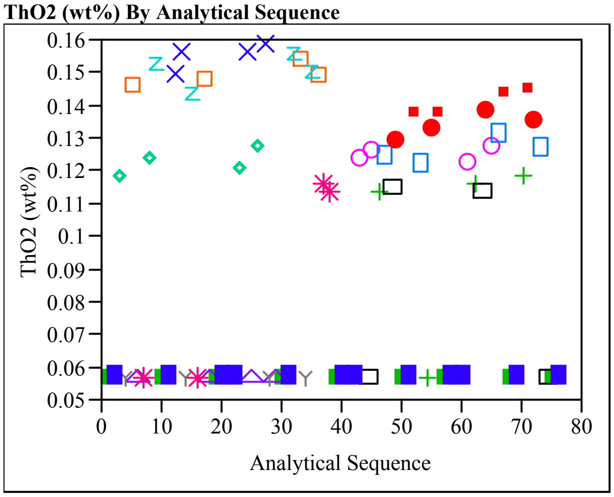
SO4 (wt%) By Analytical Sequence



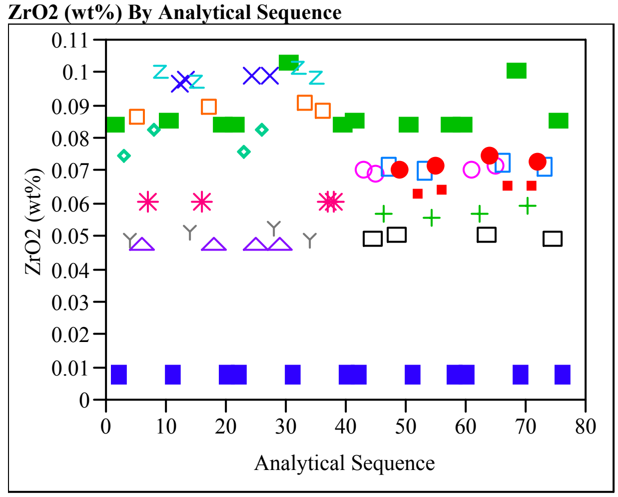
ZnO (wt%) By Analytical Sequence



ThO2 (wt%) By Analytical Sequence



ZrO2 (wt%) By Analytical Sequence



TiO2 (wt%) By Analytical Sequence

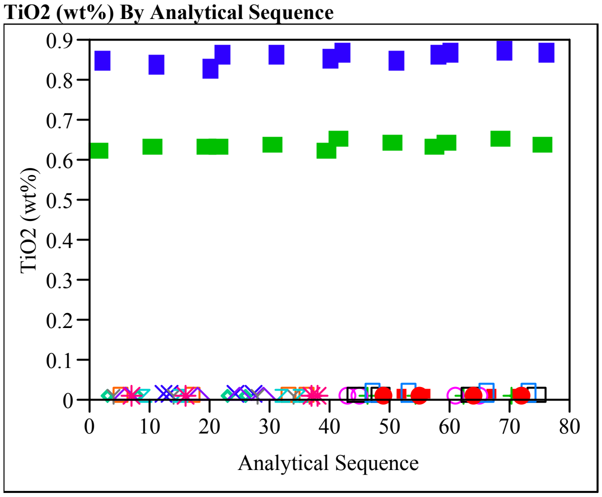
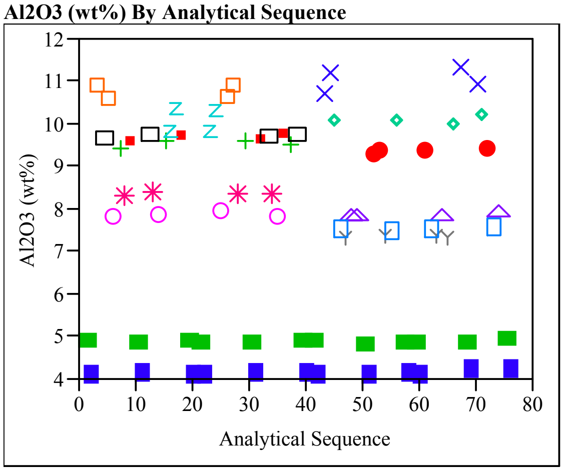
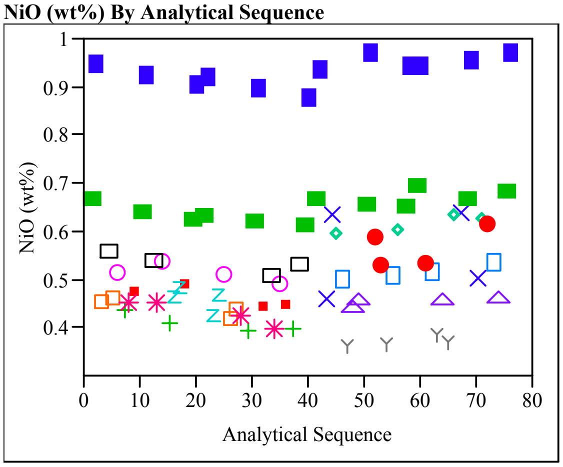


Exhibit C2. Oxide Measurements in Analytical Sequence for Samples Prepared Using the PF Method

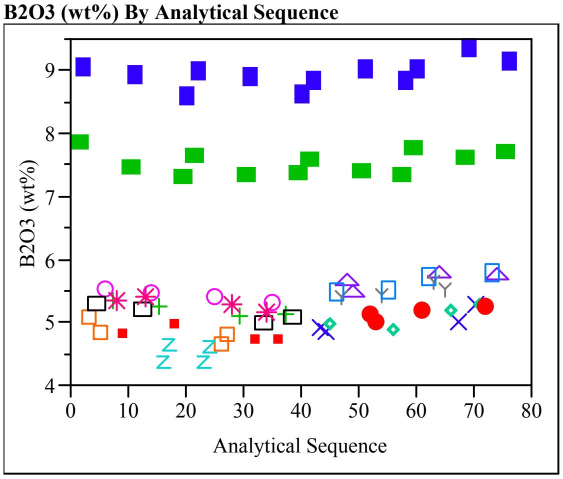
Al2O3 (wt%) By Analytical Sequence



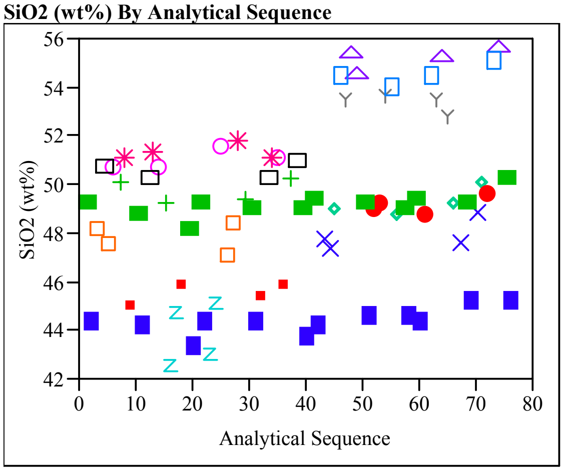
NiO (wt%) By Analytical Sequence



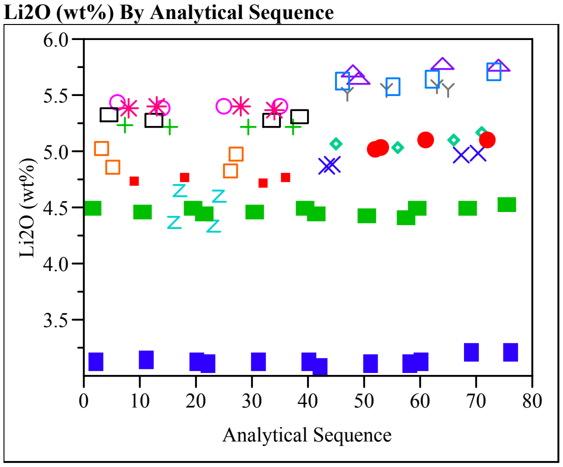
B2O3 (wt%) By Analytical Sequence



SiO2 (wt%) By Analytical Sequence



Li2O (wt%) By Analytical Sequence



U3O8 (wt%) By Analytical Sequence

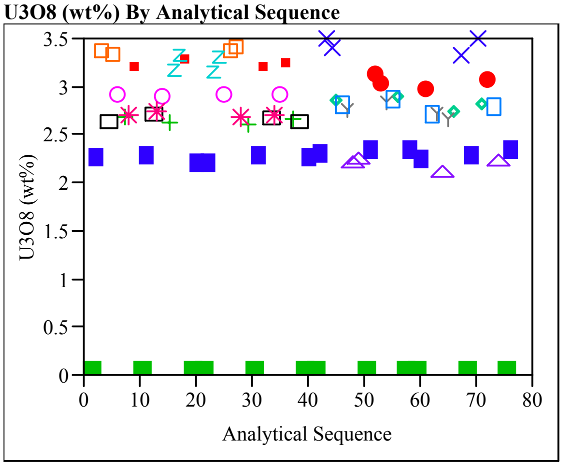
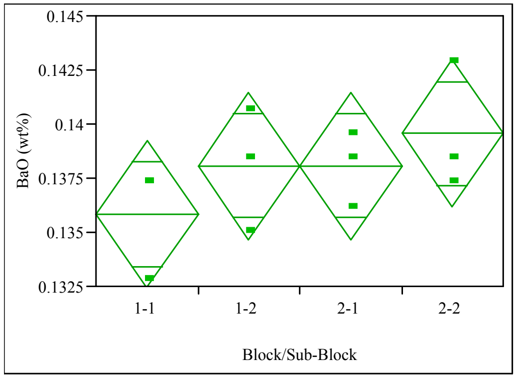


Exhibit C3. PSAL Measurements by Analytical Block for Samples of the Standard Glasses Prepared Using the LM Method

(Batch 1 – Glass #100; U std – Glass #200)

Glass #=100
Oneway Analysis of BaO (wt%) By Block/Sub-Block
Reference Value: 0.151 wt%



Oneway Anova
Summary of Fit

Rsquare	0.288136
Adj Rsquare	0.021186
Root Mean Square Error	0.002558
Mean of Response	0.137888
Observations (or Sum Wgts)	12

Analysis of Variance

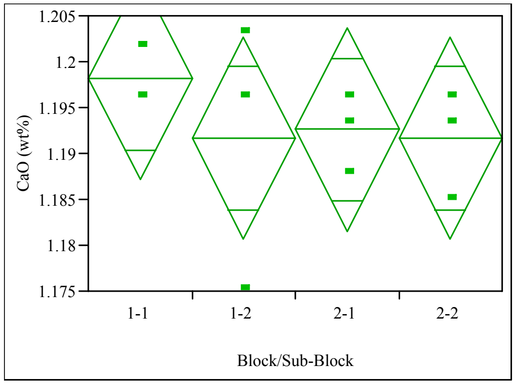
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	3	0.00002119	7.0639e-6	1.0794	0.4112
Error	8	0.00005236	6.5445e-6		
C. Total	11	0.00007355			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.135841	0.00148	0.13243	0.13925
1-2	3	0.138074	0.00148	0.13467	0.14148
2-1	3	0.138074	0.00148	0.13467	0.14148
2-2	3	0.139563	0.00148	0.13616	0.14297

Std Error uses a pooled estimate of error variance

Glass #=100
Oneway Analysis of CaO (wt%) By Block/Sub-Block
Reference Value: 1.220 wt%



Oneway Anova
Summary of Fit

Rsquare	0.139059
Adj Rsquare	-0.18379
Root Mean Square Error	0.008288
Mean of Response	1.193518
Observations (or Sum Wgts)	12

Analysis of Variance

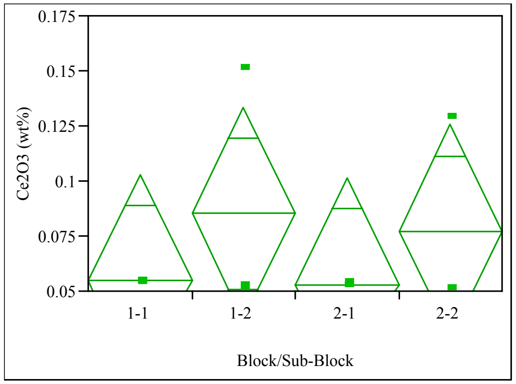
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	3	0.00008875	0.000030	0.4307	0.7367
Error	8	0.00054948	0.000069		
C. Total	11	0.00063823			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	1.19818	0.00478	1.1871	1.2092
1-2	3	1.19165	0.00478	1.1806	1.2027
2-1	3	1.19258	0.00478	1.1816	1.2036
2-2	3	1.19165	0.00478	1.1806	1.2027

Std Error uses a pooled estimate of error variance

Glass #=100
Oneway Analysis of Ce2O3 (wt%) By Block/Sub-Block
Reference Value: 0.0 wt%



Oneway Anova
Summary of Fit

Rsquare	0.181741
Adj Rsquare	-0.12511
Root Mean Square Error	0.036258
Mean of Response	0.067545
Observations (or Sum Wgts)	12

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	3	0.00233596	0.000779	0.5923	0.6373
Error	8	0.01051732	0.001315		
C. Total	11	0.01285328			

Means for Oneway Anova

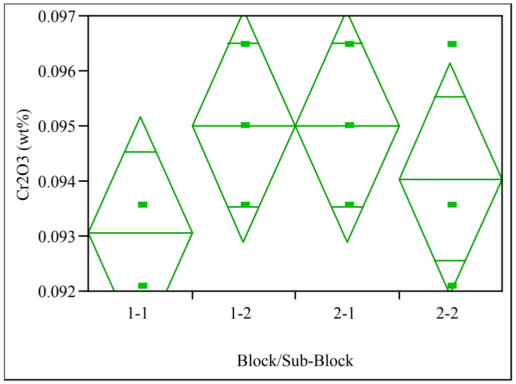
Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.054661	0.02093	0.00639	0.10293
1-2	3	0.085114	0.02093	0.03684	0.13339
2-1	3	0.053099	0.02093	0.00483	0.10137
2-2	3	0.077306	0.02093	0.02903	0.12558

Std Error uses a pooled estimate of error variance

Exhibit C3. PSAL Measurements by Analytical Block for Samples of the Standard Glasses Prepared Using the LM Method (continued)

(Batch 1 – Glass #100; U std – Glass #200)

Glass #=100
Oneway Analysis of Cr2O3 (wt%) By Block/Sub-Block
Reference Value: 0.107 wt%



Oneway Anova
Summary of Fit

Rsquare	0.282051
Adj Rsquare	0.012821
Root Mean Square Error	0.001579
Mean of Response	0.094273
Observations (or Sum Wgts)	12

Analysis of Variance

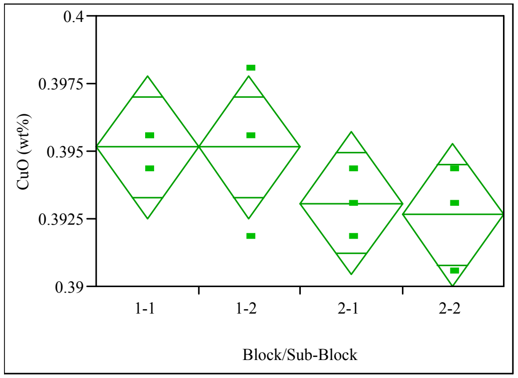
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	3	0.00000783	2.611e-6	1.0476	0.4229
Error	8	0.00001994	2.4923e-6		
C. Total	11	0.00002777			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.093055	0.00091	0.09095	0.09516
1-2	3	0.095004	0.00091	0.09290	0.09711
2-1	3	0.095004	0.00091	0.09290	0.09711
2-2	3	0.094030	0.00091	0.09193	0.09613

Std Error uses a pooled estimate of error variance

Glass #=100
Oneway Analysis of CuO (wt%) By Block/Sub-Block
Reference Value: 0.399 wt%



Oneway Anova
Summary of Fit

Rsquare	0.338843
Adj Rsquare	0.090909
Root Mean Square Error	0.001979
Mean of Response	0.394004
Observations (or Sum Wgts)	12

Analysis of Variance

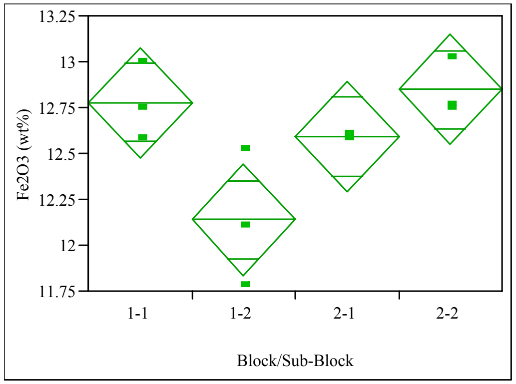
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	3	0.00001606	5.3539e-6	1.3667	0.3208
Error	8	0.00003134	3.9175e-6		
C. Total	11	0.00004740			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.395152	0.00114	0.39252	0.39779
1-2	3	0.395152	0.00114	0.39252	0.39779
2-1	3	0.393065	0.00114	0.39043	0.39570
2-2	3	0.392648	0.00114	0.39001	0.39528

Std Error uses a pooled estimate of error variance

Glass #=100
Oneway Analysis of Fe2O3 (wt%) By Block/Sub-Block
Reference Value: 12.839 wt%



Oneway Anova
Summary of Fit

Rsquare	0.690202
Adj Rsquare	0.574027
Root Mean Square Error	0.226845
Mean of Response	12.58851
Observations (or Sum Wgts)	12

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	3	0.9171617	0.305721	5.9411	0.0196
Error	8	0.4116701	0.051459		
C. Total	11	1.3288318			

Means for Oneway Anova

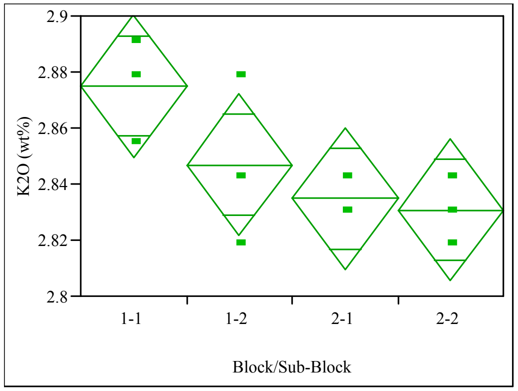
Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	12.7768	0.13097	12.475	13.079
1-2	3	12.1382	0.13097	11.836	12.440
2-1	3	12.5909	0.13097	12.289	12.893
2-2	3	12.8482	0.13097	12.546	13.150

Std Error uses a pooled estimate of error variance

Exhibit C3. PSAL Measurements by Analytical Block for Samples of the Standard Glasses Prepared Using the LM Method (continued)

(Batch 1 – Glass #100; U std – Glass #200)

Glass #=100
Oneway Analysis of K2O (wt%) By Block/Sub-Block
Reference Value: 3.327 wt%



Oneway Anova
Summary of Fit

Rsquare	0.552239
Adj Rsquare	0.384328
Root Mean Square Error	0.019046
Mean of Response	2.846871
Observations (or Sum Wgts)	12

Analysis of Variance

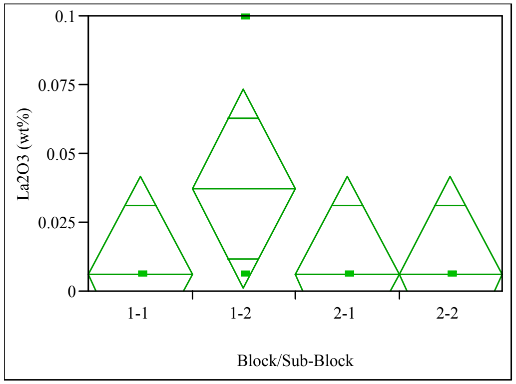
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	3	0.00357928	0.001193	3.2889	0.0791
Error	8	0.00290212	0.000363		
C. Total	11	0.00648141			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	2.87498	0.01100	2.8496	2.9003
1-2	3	2.84687	0.01100	2.8215	2.8722
2-1	3	2.83483	0.01100	2.8095	2.8602
2-2	3	2.83081	0.01100	2.8055	2.8562

Std Error uses a pooled estimate of error variance

Glass #=100
Oneway Analysis of La2O3 (wt%) By Block/Sub-Block
Reference Value: 0.0 wt%



Oneway Anova
Summary of Fit

Rsquare	0.272727
Adj Rsquare	-2.2e-16
Root Mean Square Error	0.027085
Mean of Response	0.013683
Observations (or Sum Wgts)	12

Analysis of Variance

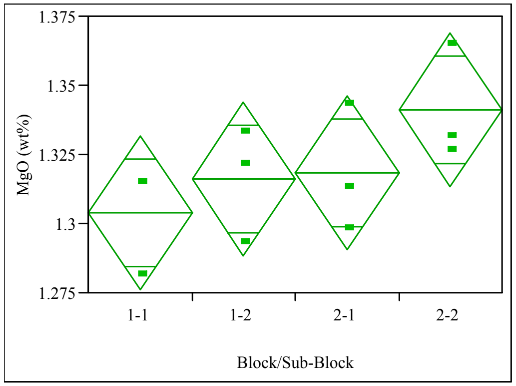
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	3	0.00220074	0.000734	1.0000	0.4411
Error	8	0.00586863	0.000734		
C. Total	11	0.00806936			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.005864	0.01564	-0.0302	0.04192
1-2	3	0.037139	0.01564	0.0011	0.07320
2-1	3	0.005864	0.01564	-0.0302	0.04192
2-2	3	0.005864	0.01564	-0.0302	0.04192

Std Error uses a pooled estimate of error variance

Glass #=100
Oneway Analysis of MgO (wt%) By Block/Sub-Block
Reference Value: 1.419wt%



Oneway Anova
Summary of Fit

Rsquare	0.382256
Adj Rsquare	0.150602
Root Mean Square Error	0.020828
Mean of Response	1.319869
Observations (or Sum Wgts)	12

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	3	0.00214749	0.000716	1.6501	0.2537
Error	8	0.00347045	0.000434		
C. Total	11	0.00561794			

Means for Oneway Anova

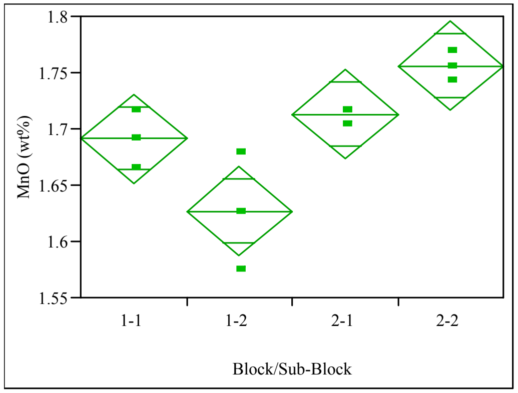
Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	1.30398	0.01203	1.2762	1.3317
1-2	3	1.31614	0.01203	1.2884	1.3439
2-1	3	1.31835	0.01203	1.2906	1.3461
2-2	3	1.34101	0.01203	1.3133	1.3687

Std Error uses a pooled estimate of error variance

Exhibit C3. PSAL Measurements by Analytical Block for Samples of the Standard Glasses Prepared Using the LM Method (continued)

(Batch 1 – Glass #100; U std – Glass #200)

Glass #=100
Oneway Analysis of MnO (wt%) By Block/Sub-Block
Reference Value: 1.726 wt%



Oneway Anova
Summary of Fit

Rsquare	0.785505
Adj Rsquare	0.705069
Root Mean Square Error	0.029819
Mean of Response	1.696852
Observations (or Sum Wgts)	12

Analysis of Variance

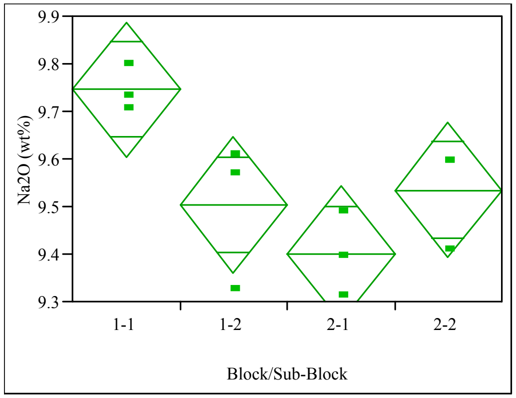
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	3	0.02604996	0.008683	9.7656	0.0047
Error	8	0.00711338	0.000889		
C. Total	11	0.03316334			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	1.69147	0.01722	1.6518	1.7312
1-2	3	1.62691	0.01722	1.5872	1.6666
2-1	3	1.71299	0.01722	1.6733	1.7527
2-2	3	1.75603	0.01722	1.7163	1.7957

Std Error uses a pooled estimate of error variance

Glass #=100
Oneway Analysis of Na2O (wt%) By Block/Sub-Block
Reference Value: 9.003 wt%



Oneway Anova
Summary of Fit

Rsquare	0.676528
Adj Rsquare	0.555226
Root Mean Square Error	0.106498
Mean of Response	9.546087
Observations (or Sum Wgts)	12

Analysis of Variance

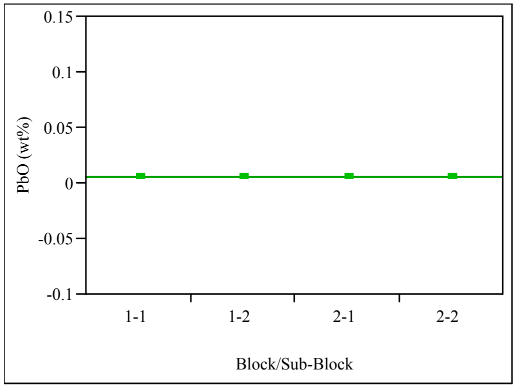
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	3	0.18976623	0.063255	5.5772	0.0232
Error	8	0.09073406	0.011342		
C. Total	11	0.28050029			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	9.74604	0.06149	9.6043	9.8878
1-2	3	9.50340	0.06149	9.3616	9.6452
2-1	3	9.40005	0.06149	9.2583	9.5418
2-2	3	9.53485	0.06149	9.3931	9.6766

Std Error uses a pooled estimate of error variance

Glass #=100
Oneway Analysis of PbO (wt%) By Block/Sub-Block
Reference Value: 0.0 wt%



Oneway Anova
Summary of Fit

Rsquare	0
Adj Rsquare	-0.375
Root Mean Square Error	1.06e-18
Mean of Response	0.005386
Observations (or Sum Wgts)	12

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	3	0	0	0.0000	1.0000
Error	8	9.0278e-36	1.128e-36		
C. Total	11	9.0278e-36			

Means for Oneway Anova

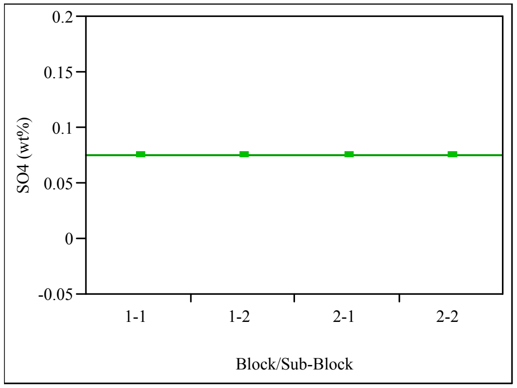
Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.005386	6.133e-19	0.00539	0.00539
1-2	3	0.005386	6.133e-19	0.00539	0.00539
2-1	3	0.005386	6.133e-19	0.00539	0.00539
2-2	3	0.005386	6.133e-19	0.00539	0.00539

Std Error uses a pooled estimate of error variance

Exhibit C3. PSAL Measurements by Analytical Block for Samples of the Standard Glasses Prepared Using the LM Method (continued)

(Batch 1 – Glass #100; U std – Glass #200)

Glass #=100
Oneway Analysis of SO4 (wt%) By Block/Sub-Block
Reference Value: 0.0 wt%



Oneway Anova
Summary of Fit

Rsquare	.
Adj Rsquare	.
Root Mean Square Error	0
Mean of Response	0.074898
Observations (or Sum Wgts)	12

Analysis of Variance

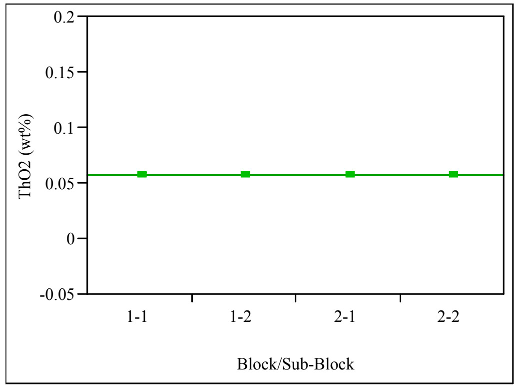
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	3	0	0	.	.
Error	8	0	0		
C. Total	11	0			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.074898	0	0.07490	0.07490
1-2	3	0.074898	0	0.07490	0.07490
2-1	3	0.074898	0	0.07490	0.07490
2-2	3	0.074898	0	0.07490	0.07490

Std Error uses a pooled estimate of error variance

Glass #=100
Oneway Analysis of ThO2 (wt%) By Block/Sub-Block
Reference Value: 0.0 wt%



Oneway Anova
Summary of Fit

Rsquare	.
Adj Rsquare	.
Root Mean Square Error	0
Mean of Response	0.056895
Observations (or Sum Wgts)	12

Analysis of Variance

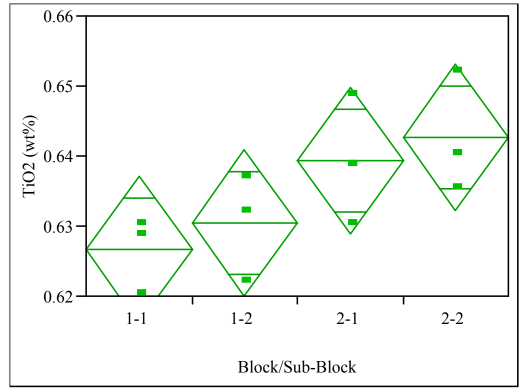
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	3	0	0	.	.
Error	8	0	0		
C. Total	11	0			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.056895	0	0.05690	0.05690
1-2	3	0.056895	0	0.05690	0.05690
2-1	3	0.056895	0	0.05690	0.05690
2-2	3	0.056895	0	0.05690	0.05690

Std Error uses a pooled estimate of error variance

Glass #=100
Oneway Analysis of TiO2 (wt%) By Block/Sub-Block
Reference Value: 0.677 wt%



Oneway Anova
Summary of Fit

Rsquare	0.509635
Adj Rsquare	0.325749
Root Mean Square Error	0.007824
Mean of Response	0.634813
Observations (or Sum Wgts)	12

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	3	0.00050892	0.000170	2.7715	0.1107
Error	8	0.00048967	0.000061		
C. Total	11	0.00099859			

Means for Oneway Anova

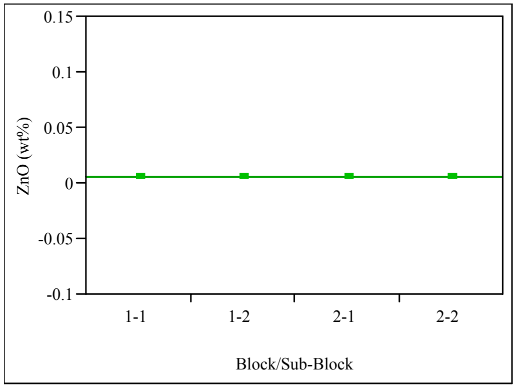
Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.626612	0.00452	0.61620	0.63703
1-2	3	0.630504	0.00452	0.62009	0.64092
2-1	3	0.639400	0.00452	0.62898	0.64982
2-2	3	0.642736	0.00452	0.63232	0.65315

Std Error uses a pooled estimate of error variance

Exhibit C3. PSAL Measurements by Analytical Block for Samples of the Standard Glasses Prepared Using the LM Method (continued)

(Batch 1 – Glass #100; U std – Glass #200)

Glass #=100
Oneway Analysis of ZnO (wt%) By Block/Sub-Block
Reference Value: 0.0 wt%



Oneway Anova
Summary of Fit

Rsquare	.
Adj Rsquare	.
Root Mean Square Error	0
Mean of Response	0.006224
Observations (or Sum Wgts)	12

Analysis of Variance

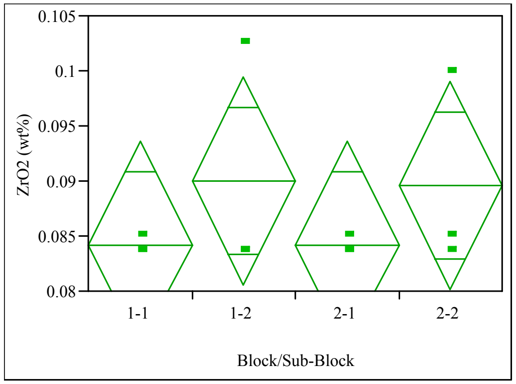
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	3	0	0	.	.
Error	8	0	0		
C. Total	11	0			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.006224	0	0.00622	0.00622
1-2	3	0.006224	0	0.00622	0.00622
2-1	3	0.006224	0	0.00622	0.00622
2-2	3	0.006224	0	0.00622	0.00622

Std Error uses a pooled estimate of error variance

Glass #=100
Oneway Analysis of ZrO2 (wt%) By Block/Sub-Block
Reference Value: 0.098 wt%



Oneway Anova
Summary of Fit

Rsquare	0.19145
Adj Rsquare	-0.11176
Root Mean Square Error	0.007094
Mean of Response	0.087014
Observations (or Sum Wgts)	12

Analysis of Variance

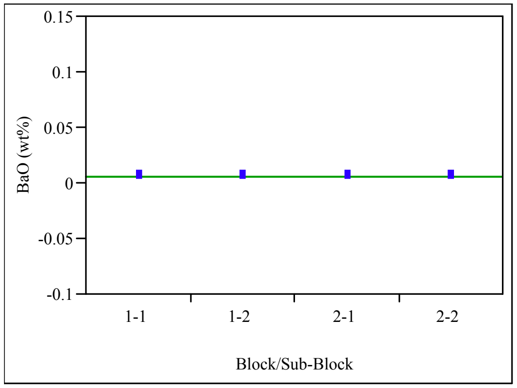
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	3	0.00009534	0.000032	0.6314	0.6151
Error	8	0.00040264	0.000050		
C. Total	11	0.00049798			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.084200	0.00410	0.07475	0.09365
1-2	3	0.090053	0.00410	0.08061	0.09950
2-1	3	0.084200	0.00410	0.07475	0.09365
2-2	3	0.089603	0.00410	0.08016	0.09905

Std Error uses a pooled estimate of error variance

Glass # 200
Oneway Analysis of BaO (wt%) By Block/Sub-Block
Reference Value: 0.0 wt%



Oneway Anova
Summary of Fit

Rsquare	.
Adj Rsquare	.
Root Mean Square Error	0
Mean of Response	0.005583
Observations (or Sum Wgts)	12

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	3	0	0	.	.
Error	8	0	0		
C. Total	11	0			

Means for Oneway Anova

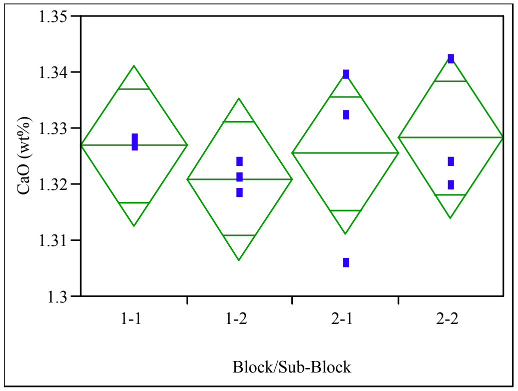
Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.005583	0	0.00558	0.00558
1-2	3	0.005583	0	0.00558	0.00558
2-1	3	0.005583	0	0.00558	0.00558
2-2	3	0.005583	0	0.00558	0.00558

Std Error uses a pooled estimate of error variance

Exhibit C3. PSAL Measurements by Analytical Block for Samples of the Standard Glasses Prepared Using the LM Method (continued)

(Batch 1 – Glass #100; U std – Glass #200)

Glass # 200
Oneway Analysis of CaO (wt%) By Block/Sub-Block
Reference Value: 1.301 wt%



Oneway Anova
Summary of Fit

Rsquare	0.092389
Adj Rsquare	-0.24797
Root Mean Square Error	0.01077
Mean of Response	1.325392
Observations (or Sum Wgts)	12

Analysis of Variance

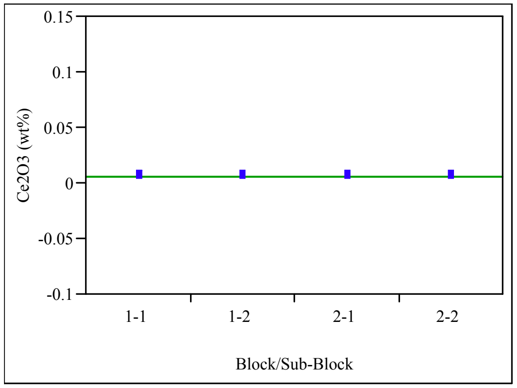
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	3	0.00009446	0.000031	0.2714	0.8444
Error	8	0.00092798	0.000116		
C. Total	11	0.00102244			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	1.32691	0.00622	1.3126	1.3412
1-2	3	1.32084	0.00622	1.3065	1.3352
2-1	3	1.32551	0.00622	1.3112	1.3398
2-2	3	1.32831	0.00622	1.3140	1.3426

Std Error uses a pooled estimate of error variance

Glass # 200
Oneway Analysis of Ce2O3 (wt%) By Block/Sub-Block
Reference Value: 0.0 wt%



Oneway Anova
Summary of Fit

Rsquare	.
Adj Rsquare	.
Root Mean Square Error	0
Mean of Response	0.005857
Observations (or Sum Wgts)	12

Analysis of Variance

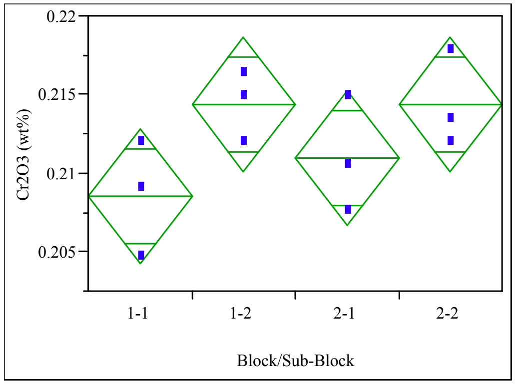
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	3	0	0	.	.
Error	8	0	0		
C. Total	11	0			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.005857	0	0.00586	0.00586
1-2	3	0.005857	0	0.00586	0.00586
2-1	3	0.005857	0	0.00586	0.00586
2-2	3	0.005857	0	0.00586	0.00586

Std Error uses a pooled estimate of error variance

Glass # 200
Oneway Analysis of Cr2O3 (wt%) By Block/Sub-Block
Reference Value: 0.0 wt%



Oneway Anova
Summary of Fit

Rsquare	0.469714
Adj Rsquare	0.270857
Root Mean Square Error	0.003213
Mean of Response	0.212054
Observations (or Sum Wgts)	12

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	3	0.00007317	0.000024	2.3621	0.1473
Error	8	0.00008260	0.000010		
C. Total	11	0.00015577			

Means for Oneway Anova

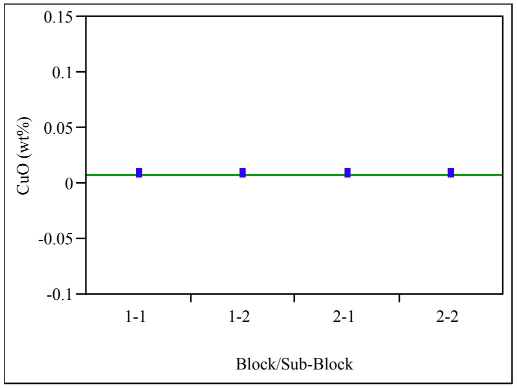
Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.208522	0.00186	0.20424	0.21280
1-2	3	0.214368	0.00186	0.21009	0.21865
2-1	3	0.210958	0.00186	0.20668	0.21524
2-2	3	0.214368	0.00186	0.21009	0.21865

Std Error uses a pooled estimate of error variance

Exhibit C3. PSAL Measurements by Analytical Block for Samples of the Standard Glasses Prepared Using the LM Method (continued)

(Batch 1 – Glass #100; U std – Glass #200)

Glass # 200
Oneway Analysis of CuO (wt%) By Block/Sub-Block
Reference Value: 0.0 wt%



Oneway Anova
Summary of Fit

Rsquare	.
Adj Rsquare	.
Root Mean Square Error	0
Mean of Response	0.006259
Observations (or Sum Wgts)	12

Analysis of Variance

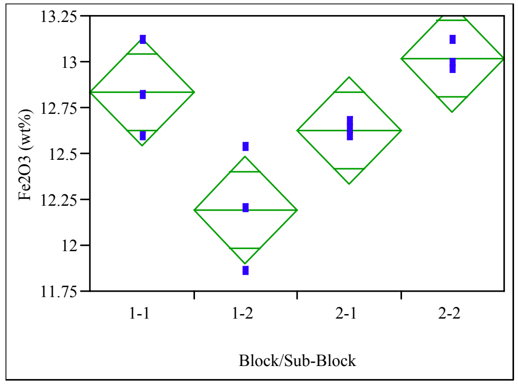
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	3	0	0	.	.
Error	8	0	0		
C. Total	11	0			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.006259	0	0.00626	0.00626
1-2	3	0.006259	0	0.00626	0.00626
2-1	3	0.006259	0	0.00626	0.00626
2-2	3	0.006259	0	0.00626	0.00626

Std Error uses a pooled estimate of error variance

Glass # 200
Oneway Analysis of Fe2O3 (wt%) By Block/Sub-Block
Reference Value: 13.196 wt%



Oneway Anova
Summary of Fit

Rsquare	0.746799
Adj Rsquare	0.651848
Root Mean Square Error	0.219169
Mean of Response	12.66595
Observations (or Sum Wgts)	12

Analysis of Variance

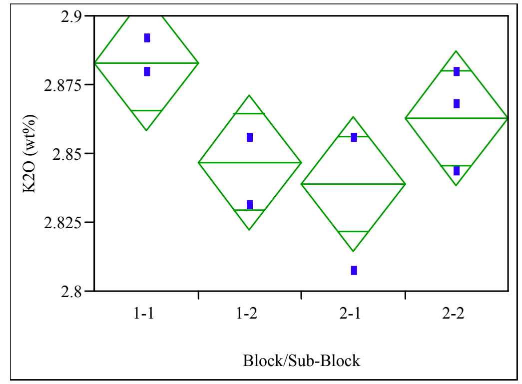
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	3	1.1334043	0.377801	7.8651	0.0090
Error	8	0.3842799	0.048035		
C. Total	11	1.5176842			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	12.8339	0.12654	12.542	13.126
1-2	3	12.1906	0.12654	11.899	12.482
2-1	3	12.6243	0.12654	12.332	12.916
2-2	3	13.0150	0.12654	12.723	13.307

Std Error uses a pooled estimate of error variance

Glass # 200
Oneway Analysis of K2O (wt%) By Block/Sub-Block
Reference Value: 2.999 wt%



Oneway Anova
Summary of Fit

Rsquare	0.558185
Adj Rsquare	0.392505
Root Mean Square Error	0.018401
Mean of Response	2.857914
Observations (or Sum Wgts)	12

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	3	0.00342209	0.001141	3.3690	0.0753
Error	8	0.00270865	0.000339		
C. Total	11	0.00613073			

Means for Oneway Anova

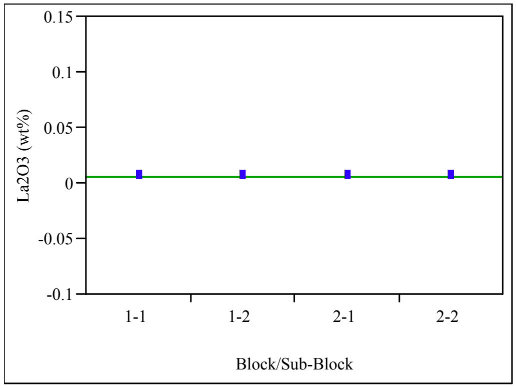
Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	2.88301	0.01062	2.8585	2.9075
1-2	3	2.84687	0.01062	2.8224	2.8714
2-1	3	2.83884	0.01062	2.8143	2.8633
2-2	3	2.86293	0.01062	2.8384	2.8874

Std Error uses a pooled estimate of error variance

Exhibit C3. PSAL Measurements by Analytical Block for Samples of the Standard Glasses Prepared Using the LM Method (continued)

(Batch 1 – Glass #100; U std – Glass #200)

Glass # 200
Oneway Analysis of La2O3 (wt%) By Block/Sub-Block
Reference Value: 0.0 wt%



Oneway Anova
Summary of Fit

Rsquare	.
Adj Rsquare	.
Root Mean Square Error	0
Mean of Response	0.005864
Observations (or Sum Wgts)	12

Analysis of Variance

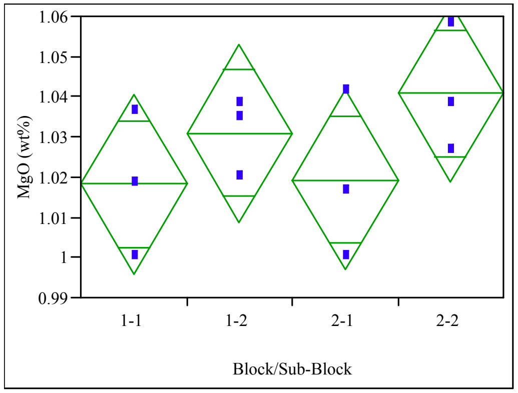
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	3	0	0	.	.
Error	8	0	0		
C. Total	11	0			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.005864	0	0.00586	0.00586
1-2	3	0.005864	0	0.00586	0.00586
2-1	3	0.005864	0	0.00586	0.00586
2-2	3	0.005864	0	0.00586	0.00586

Std Error uses a pooled estimate of error variance

Glass # 200
Oneway Analysis of MgO (wt%) By Block/Sub-Block
Reference Value: 1.21 wt%



Oneway Anova
Summary of Fit

Rsquare	0.315922
Adj Rsquare	0.059393
Root Mean Square Error	0.016707
Mean of Response	1.027317
Observations (or Sum Wgts)	12

Analysis of Variance

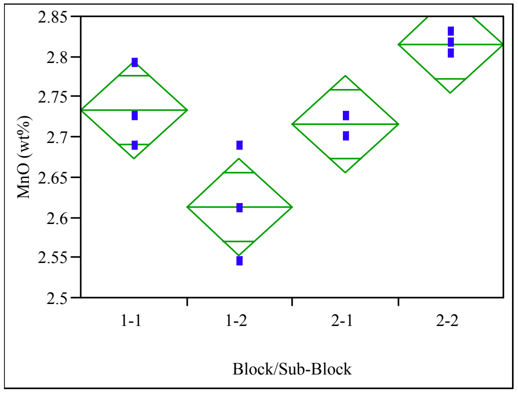
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	3	0.00103123	0.000344	1.2315	0.3601
Error	8	0.00223297	0.000279		
C. Total	11	0.00326420			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	1.01820	0.00965	0.9960	1.0404
1-2	3	1.03091	0.00965	1.0087	1.0532
2-1	3	1.01930	0.00965	0.9971	1.0415
2-2	3	1.04086	0.00965	1.0186	1.0631

Std Error uses a pooled estimate of error variance

Glass # 200
Oneway Analysis of MnO (wt%) By Block/Sub-Block
Reference Value: 2.892 wt%



Oneway Anova
Summary of Fit

Rsquare	0.791895
Adj Rsquare	0.713856
Root Mean Square Error	0.045192
Mean of Response	2.719052
Observations (or Sum Wgts)	12

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	3	0.06217257	0.020724	10.1474	0.0042
Error	8	0.01633853	0.002042		
C. Total	11	0.07851111			

Means for Oneway Anova

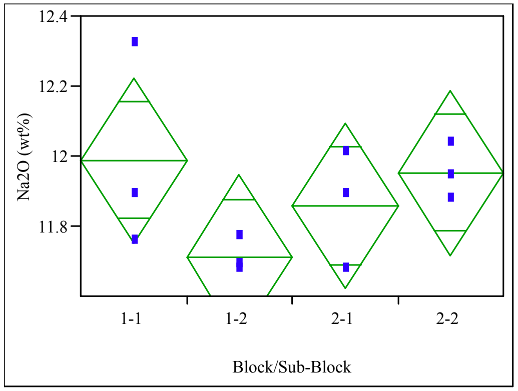
Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	2.73304	0.02609	2.6729	2.7932
1-2	3	2.61253	0.02609	2.5524	2.6727
2-1	3	2.71582	0.02609	2.6557	2.7760
2-2	3	2.81482	0.02609	2.7546	2.8750

Std Error uses a pooled estimate of error variance

Exhibit C3. PSAL Measurements by Analytical Block for Samples of the Standard Glasses Prepared Using the LM Method (continued)

(Batch 1 – Glass #100; U std – Glass #200)

Glass # 200
Oneway Analysis of Na2O (wt%) By Block/Sub-Block
Reference Value: 11.795 wt%



Oneway Anova
Summary of Fit

Rsquare	0.356243
Adj Rsquare	0.114835
Root Mean Square Error	0.177344
Mean of Response	11.877
Observations (or Sum Wgts)	12

Analysis of Variance

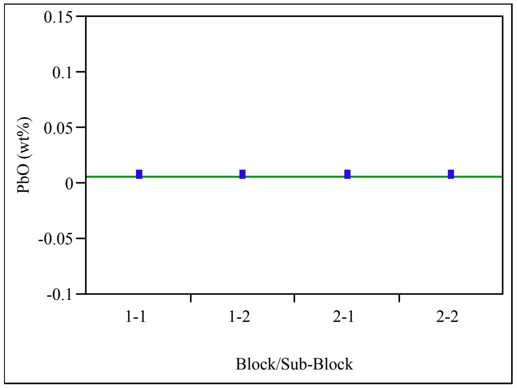
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	3	0.13923559	0.046412	1.4757	0.2927
Error	8	0.25160833	0.031451		
C. Total	11	0.39084393			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	11.9882	0.10239	11.752	12.224
1-2	3	11.7096	0.10239	11.474	11.946
2-1	3	11.8579	0.10239	11.622	12.094
2-2	3	11.9523	0.10239	11.716	12.188

Std Error uses a pooled estimate of error variance

Glass # 200
Oneway Analysis of PbO (wt%) By Block/Sub-Block
Reference Value: 0.0 wt%



Oneway Anova
Summary of Fit

Rsquare	0
Adj Rsquare	-0.375
Root Mean Square Error	1.06e-18
Mean of Response	0.005386
Observations (or Sum Wgts)	12

Analysis of Variance

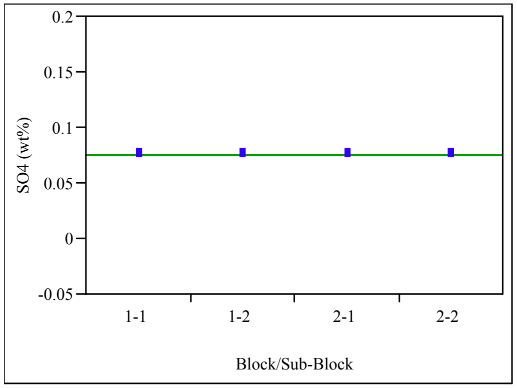
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	3	0	0	0.0000	1.0000
Error	8	9.0278e-36	1.128e-36		
C. Total	11	9.0278e-36			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.005386	6.133e-19	0.00539	0.00539
1-2	3	0.005386	6.133e-19	0.00539	0.00539
2-1	3	0.005386	6.133e-19	0.00539	0.00539
2-2	3	0.005386	6.133e-19	0.00539	0.00539

Std Error uses a pooled estimate of error variance

Glass # 200
Oneway Analysis of SO4 (wt%) By Block/Sub-Block
Reference Value: 0.0 wt%



Oneway Anova
Summary of Fit

Rsquare	.
Adj Rsquare	.
Root Mean Square Error	0
Mean of Response	0.074898
Observations (or Sum Wgts)	12

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	3	0	0	.	.
Error	8	0	0		
C. Total	11	0			

Means for Oneway Anova

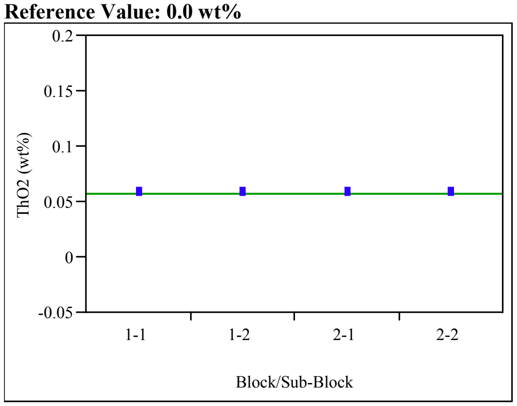
Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.074898	0	0.07490	0.07490
1-2	3	0.074898	0	0.07490	0.07490
2-1	3	0.074898	0	0.07490	0.07490
2-2	3	0.074898	0	0.07490	0.07490

Std Error uses a pooled estimate of error variance

Exhibit C3. PSAL Measurements by Analytical Block for Samples of the Standard Glasses Prepared Using the LM Method (continued)

(Batch 1 – Glass #100; U std – Glass #200)

Glass # 200
Oneway Analysis of ThO2 (wt%) By Block/Sub-Block
Reference Value: 0.0 wt%



Oneway Anova
Summary of Fit

Rsquare	.
Adj Rsquare	.
Root Mean Square Error	0
Mean of Response	0.056895
Observations (or Sum Wgts)	12

Analysis of Variance

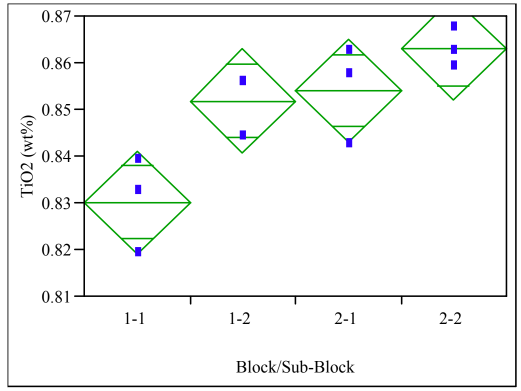
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	3	0	0	.	.
Error	8	0	0		
C. Total	11	0			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.056895	0	0.05690	0.05690
1-2	3	0.056895	0	0.05690	0.05690
2-1	3	0.056895	0	0.05690	0.05690
2-2	3	0.056895	0	0.05690	0.05690

Std Error uses a pooled estimate of error variance

Glass # 200
Oneway Analysis of TiO2 (wt%) By Block/Sub-Block
Reference Value: 1.049 wt%



Oneway Anova
Summary of Fit

Rsquare	0.759976
Adj Rsquare	0.669967
Root Mean Square Error	0.008298
Mean of Response	0.849707
Observations (or Sum Wgts)	12

Analysis of Variance

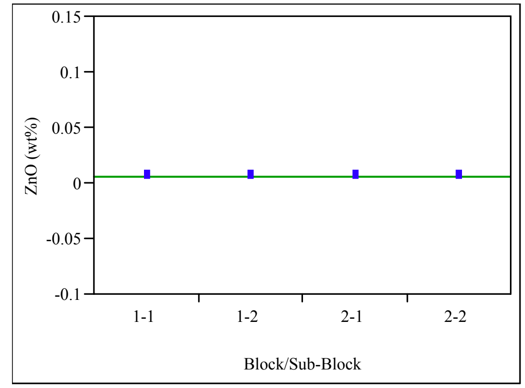
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	3	0.00174422	0.000581	8.4433	0.0073
Error	8	0.00055088	0.000069		
C. Total	11	0.00229510			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.830108	0.00479	0.81906	0.84116
1-2	3	0.851792	0.00479	0.84074	0.86284
2-1	3	0.854016	0.00479	0.84297	0.86506
2-2	3	0.862912	0.00479	0.85186	0.87396

Std Error uses a pooled estimate of error variance

Glass # 200
Oneway Analysis of ZnO (wt%) By Block/Sub-Block
Reference Value: 0.0 wt%



Oneway Anova
Summary of Fit

Rsquare	.
Adj Rsquare	.
Root Mean Square Error	0
Mean of Response	0.006224
Observations (or Sum Wgts)	12

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	3	0	0	.	.
Error	8	0	0		
C. Total	11	0			

Means for Oneway Anova

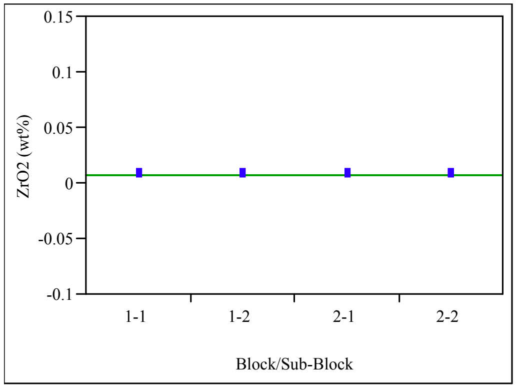
Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.006224	0	0.00622	0.00622
1-2	3	0.006224	0	0.00622	0.00622
2-1	3	0.006224	0	0.00622	0.00622
2-2	3	0.006224	0	0.00622	0.00622

Std Error uses a pooled estimate of error variance

Exhibit C3. PSAL Measurements by Analytical Block for Samples of the Standard Glasses Prepared Using the LM Method (continued)

(Batch 1 – Glass #100; U std – Glass #200)

Glass # 200
Oneway Analysis of ZrO2 (wt%) By Block/Sub-Block
Reference Value: 0.0 wt%



Oneway Anova
Summary of Fit

Rsquare	.
Adj Rsquare	.
Root Mean Square Error	0
Mean of Response	0.006754
Observations (or Sum Wgts)	12

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	3	0	0	.	.
Error	8	0	0		
C. Total	11	0			

Means for Oneway Anova

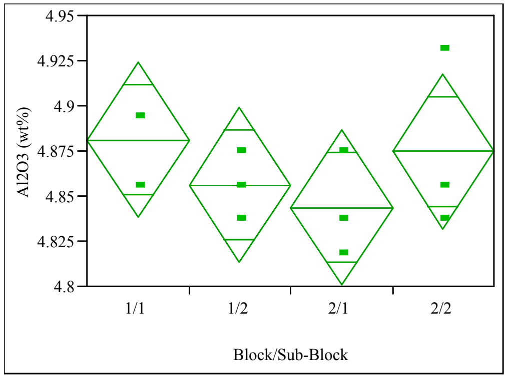
Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.006754	0	0.00675	0.00675
1-2	3	0.006754	0	0.00675	0.00675
2-1	3	0.006754	0	0.00675	0.00675
2-2	3	0.006754	0	0.00675	0.00675

Std Error uses a pooled estimate of error variance

Exhibit C4: PSAL Measurements by Analytical Block for Samples of the Standard Glasses Prepared Using the PF Method

(Batch 1 – Glass #100; U std – Glass #200)

Glass #=100
Oneway Analysis of Al2O3 (wt%) By Block/Sub-Blk
Reference Value: 4.877 wt%



Oneway Anova
Summary of Fit

Rsquare	0.245283
Adj Rsquare	-0.03774
Root Mean Square Error	0.032269
Mean of Response	4.863888
Observations (or Sum Wgts)	12

Analysis of Variance

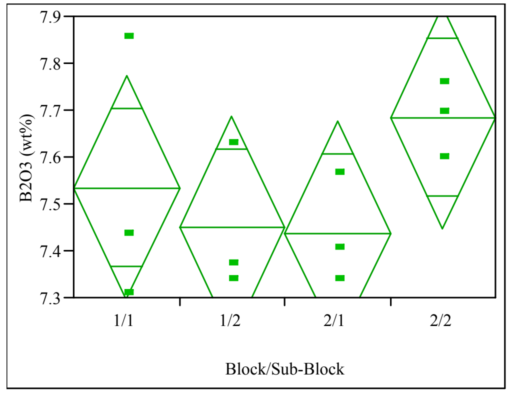
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	3	0.00270741	0.000902	0.8667	0.4970
Error	8	0.00833049	0.001041		
C. Total	11	0.01103790			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1/1	3	4.88121	0.01863	4.8382	4.9242
1/2	3	4.85602	0.01863	4.8131	4.8990
2/1	3	4.84342	0.01863	4.8005	4.8864
2/2	3	4.87491	0.01863	4.8319	4.9179

Std Error uses a pooled estimate of error variance

Glass #=100
Oneway Analysis of B2O3 (wt%) By Block/Sub-Block
Reference Value: 7.777 wt%



Oneway Anova
Summary of Fit

Rsquare	0.31519
Adj Rsquare	0.058386
Root Mean Square Error	0.17831
Mean of Response	7.526516
Observations (or Sum Wgts)	12

Analysis of Variance

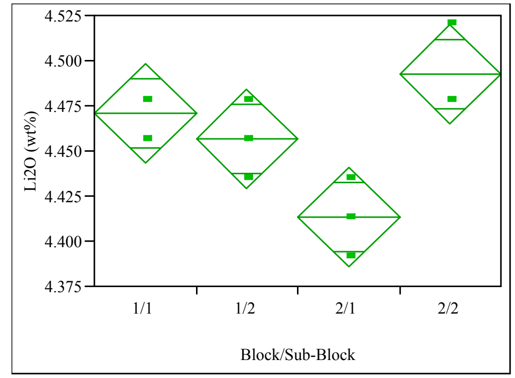
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	3	0.11706924	0.039023	1.2274	0.3614
Error	8	0.25435561	0.031794		
C. Total	11	0.37142486			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1/1	3	7.53457	0.10295	7.2972	7.7720
1/2	3	7.44870	0.10295	7.2113	7.6861
2/1	3	7.43797	0.10295	7.2006	7.6754
2/2	3	7.68483	0.10295	7.4474	7.9222

Std Error uses a pooled estimate of error variance

Glass #=100
Oneway Analysis of Li2O (wt%) By Block/Sub-Block
Reference Value: 4.429 wt%



Oneway Anova
Summary of Fit

Rsquare	0.746398
Adj Rsquare	0.651297
Root Mean Square Error	0.020612
Mean of Response	4.458297
Observations (or Sum Wgts)	12

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	3	0.01000383	0.003335	7.8485	0.0091
Error	8	0.00339898	0.000425		
C. Total	11	0.01340281			

Means for Oneway Anova

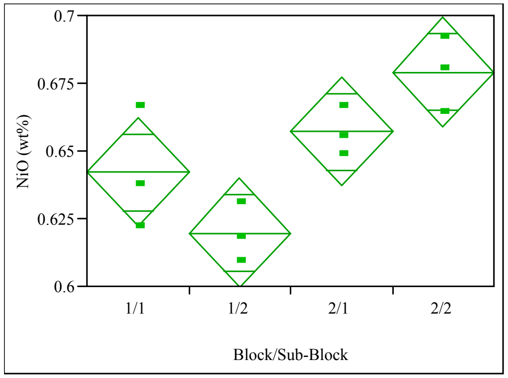
Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1/1	3	4.47086	0.01190	4.4434	4.4983
1/2	3	4.45650	0.01190	4.4291	4.4839
2/1	3	4.41345	0.01190	4.3860	4.4409
2/2	3	4.49238	0.01190	4.4649	4.5198

Std Error uses a pooled estimate of error variance

Exhibit C4: PSAL Measurements by Analytical Block for Samples of the Standard Glasses Prepared Using the PF Method (continued)

(Batch 1 – Glass #100; U std – Glass #200)

Glass #=100
Oneway Analysis of NiO (wt%) By Block/Sub-Block
Reference Value: 0.751 wt%



Oneway Anova
Summary of Fit

Rsquare	0.755382
Adj Rsquare	0.66365
Root Mean Square Error	0.015083
Mean of Response	0.649505
Observations (or Sum Wgts)	12

Analysis of Variance

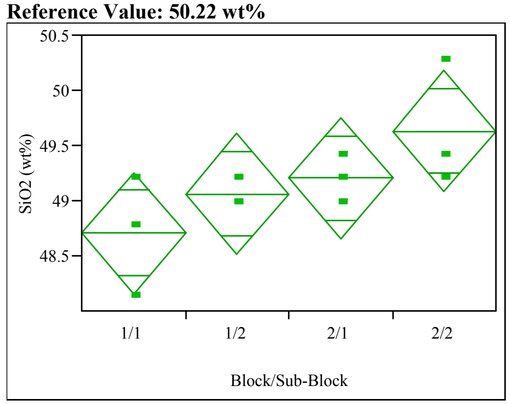
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	3	0.00562030	0.001873	8.2347	0.0079
Error	8	0.00182004	0.000228		
C. Total	11	0.00744035			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1/1	3	0.642188	0.00871	0.62211	0.66227
1/2	3	0.619708	0.00871	0.59963	0.63979
2/1	3	0.657034	0.00871	0.63695	0.67712
2/2	3	0.679091	0.00871	0.65901	0.69917

Std Error uses a pooled estimate of error variance

Glass #=100
Oneway Analysis of SiO2 (wt%) By Block/Sub-Block
Reference Value: 50.22 wt%



Oneway Anova
Summary of Fit

Rsquare	0.496423
Adj Rsquare	0.307582
Root Mean Square Error	0.409645
Mean of Response	49.15042
Observations (or Sum Wgts)	12

Analysis of Variance

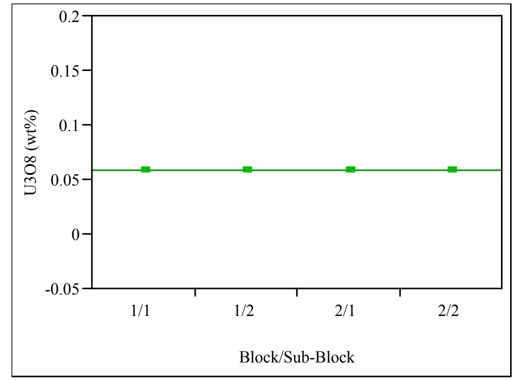
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	3	1.3234015	0.441134	2.6288	0.1220
Error	8	1.3424707	0.167809		
C. Total	11	2.6658721			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1/1	3	48.7047	0.23651	48.159	49.250
1/2	3	49.0613	0.23651	48.516	49.607
2/1	3	49.2039	0.23651	48.659	49.749
2/2	3	49.6318	0.23651	49.086	50.177

Std Error uses a pooled estimate of error variance

Glass #=100
Oneway Analysis of U3O8 (wt%) By Block/Sub-Block
Reference Value: 0.0 wt%



Oneway Anova
Summary of Fit

Rsquare	.
Adj Rsquare	.
Root Mean Square Error	0
Mean of Response	0.05896
Observations (or Sum Wgts)	12

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	3	0	0	.	.
Error	8	0	0		
C. Total	11	0			

Means for Oneway Anova

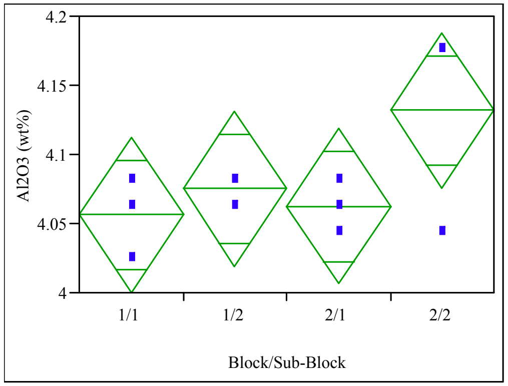
Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1/1	3	0.058960	0	0.05896	0.05896
1/2	3	0.058960	0	0.05896	0.05896
2/1	3	0.058960	0	0.05896	0.05896
2/2	3	0.058960	0	0.05896	0.05896

Std Error uses a pooled estimate of error variance

Exhibit C4: PSAL Measurements by Analytical Block for Samples of the Standard Glasses Prepared Using the PF Method (continued)

(Batch 1 – Glass #100; U std – Glass #200)

Glass #=200
Oneway Analysis of Al2O3 (wt%) By Block/Sub-Block
Reference Value: 4.1 wt%



Oneway Anova
Summary of Fit

Rsquare	0.428571
Adj Rsquare	0.214286
Root Mean Square Error	0.042251
Mean of Response	4.08132
Observations (or Sum Wgts)	12

Analysis of Variance

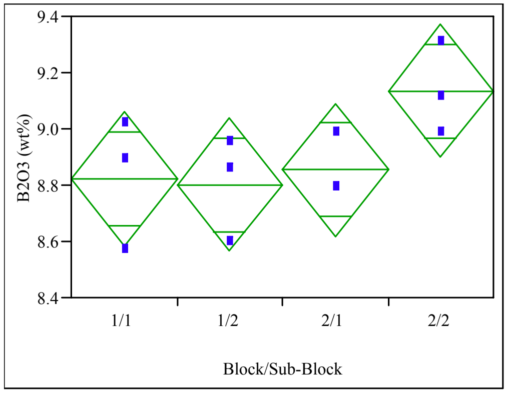
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	3	0.01071063	0.003570	2.0000	0.1927
Error	8	0.01428084	0.001785		
C. Total	11	0.02499147			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1/1	3	4.05613	0.02439	3.9999	4.1124
1/2	3	4.07502	0.02439	4.0188	4.1313
2/1	3	4.06243	0.02439	4.0062	4.1187
2/2	3	4.13171	0.02439	4.0755	4.1880

Std Error uses a pooled estimate of error variance

Glass #=200
Oneway Analysis of B2O3 (wt%) By Block/Sub-Block
Reference Value: 9.209 wt%



Oneway Anova
Summary of Fit

Rsquare	0.46284
Adj Rsquare	0.261405
Root Mean Square Error	0.177582
Mean of Response	8.903024
Observations (or Sum Wgts)	12

Analysis of Variance

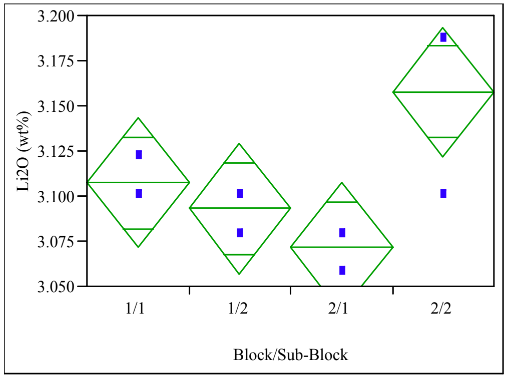
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	3	0.21737728	0.072459	2.2977	0.1543
Error	8	0.25228206	0.031535		
C. Total	11	0.46965935			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1/1	3	8.82253	0.10253	8.5861	9.0590
1/2	3	8.80106	0.10253	8.5646	9.0375
2/1	3	8.85473	0.10253	8.6183	9.0912
2/2	3	9.13378	0.10253	8.8974	9.3702

Std Error uses a pooled estimate of error variance

Glass #=200
Oneway Analysis of Li2O (wt%) By Block/Sub-Block
Reference Value: 3.057 wt%



Oneway Anova
Summary of Fit

Rsquare	0.672414
Adj Rsquare	0.549569
Root Mean Square Error	0.02709
Mean of Response	3.107352
Observations (or Sum Wgts)	12

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	3	0.01205094	0.004017	5.4737	0.0243
Error	8	0.00587097	0.000734		
C. Total	11	0.01792192			

Means for Oneway Anova

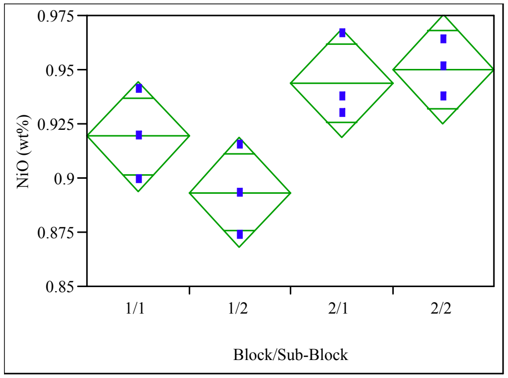
Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1/1	3	3.10735	0.01564	3.0713	3.1434
1/2	3	3.09300	0.01564	3.0569	3.1291
2/1	3	3.07147	0.01564	3.0354	3.1075
2/2	3	3.15759	0.01564	3.1215	3.1937

Std Error uses a pooled estimate of error variance

Exhibit C4: PSAL Measurements by Analytical Block for Samples of the Standard Glasses Prepared Using the PF Method (continued)

(Batch 1 – Glass #100; U std – Glass #200)

Glass #=200
Oneway Analysis of NiO (wt%) By Block/Sub-Block
Reference Value: 1.12 wt%



Oneway Anova
Summary of Fit

Rsquare	0.676931
Adj Rsquare	0.555781
Root Mean Square Error	0.018981
Mean of Response	0.926592
Observations (or Sum Wgts)	12

Analysis of Variance

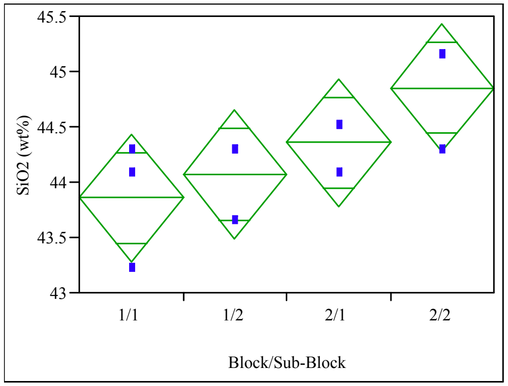
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	3	0.00603929	0.002013	5.5875	0.0231
Error	8	0.00288228	0.000360		
C. Total	11	0.00892156			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1/1	3	0.919169	0.01096	0.89390	0.94444
1/2	3	0.893295	0.01096	0.86802	0.91857
2/1	3	0.943771	0.01096	0.91850	0.96904
2/2	3	0.950133	0.01096	0.92486	0.97540

Std Error uses a pooled estimate of error variance

Glass #=200
Oneway Analysis of SiO2 (wt%) By Block/Sub-Block
Reference Value: 45.353 wt%



Oneway Anova
Summary of Fit

Rsquare	0.52381
Adj Rsquare	0.345238
Root Mean Square Error	0.436683
Mean of Response	44.28351
Observations (or Sum Wgts)	12

Analysis of Variance

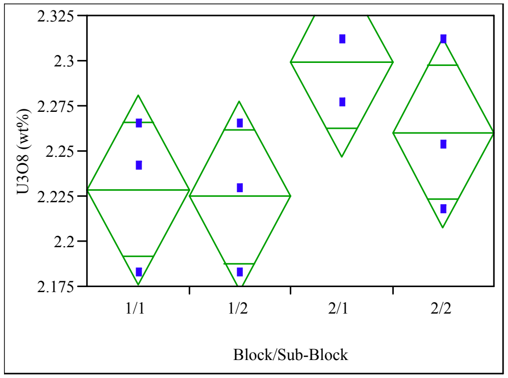
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	3	1.6780883	0.559363	2.9333	0.0994
Error	8	1.5255348	0.190692		
C. Total	11	3.2036231			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1/1	3	43.8557	0.25212	43.274	44.437
1/2	3	44.0696	0.25212	43.488	44.651
2/1	3	44.3548	0.25212	43.773	44.936
2/2	3	44.8540	0.25212	44.273	45.435

Std Error uses a pooled estimate of error variance

Glass #=200
Oneway Analysis of U3O8 (wt%) By Block/Sub-Block
Reference Value: 2.406 wt%



Oneway Anova
Summary of Fit

Rsquare	0.464803
Adj Rsquare	0.264104
Root Mean Square Error	0.039405
Mean of Response	2.253255
Observations (or Sum Wgts)	12

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	3	0.01078806	0.003596	2.3159	0.1523
Error	8	0.01242191	0.001553		
C. Total	11	0.02320997			

Means for Oneway Anova

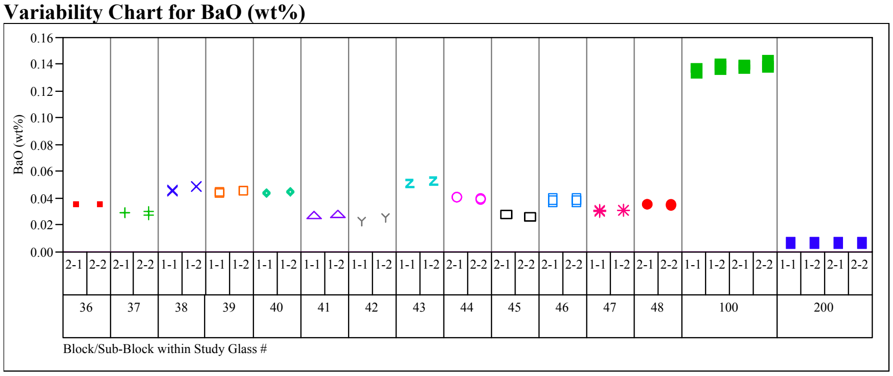
Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1/1	3	2.22869	0.02275	2.1762	2.2812
1/2	3	2.22476	0.02275	2.1723	2.2772
2/1	3	2.29944	0.02275	2.2470	2.3519
2/2	3	2.26013	0.02275	2.2077	2.3126

Std Error uses a pooled estimate of error variance

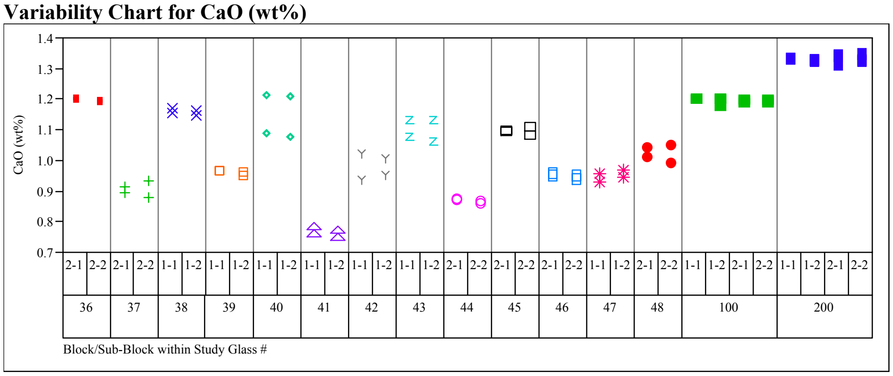
Exhibit C5. Measured and Measured Bias-Corrected Oxide Weight Percents by Glass ID for the Glasses Prepared Using the LM Method

(100 – Batch 1; 200 – Ustd)

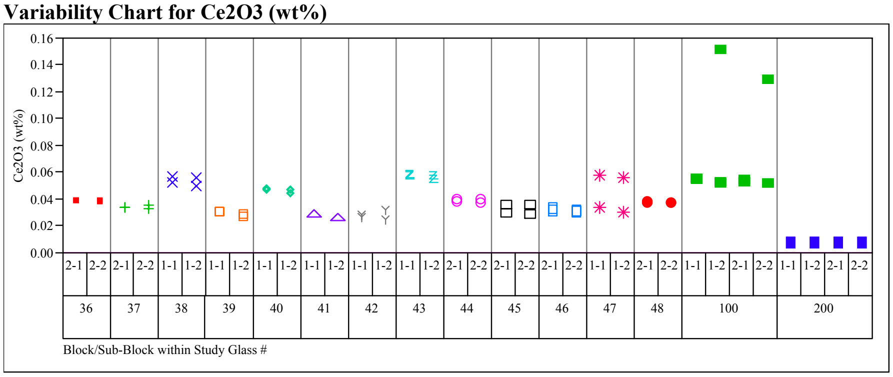
Variability Chart for BaO (wt%)



Variability Chart for CaO (wt%)



Variability Chart for Ce2O3 (wt%)



Variability Chart for Cr2O3 (wt%)

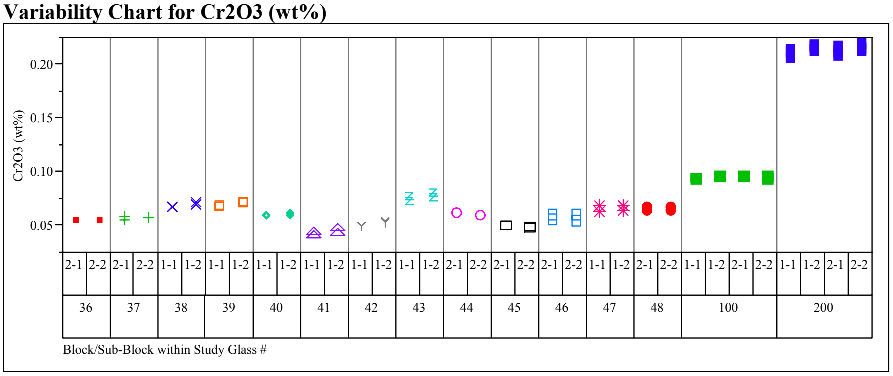
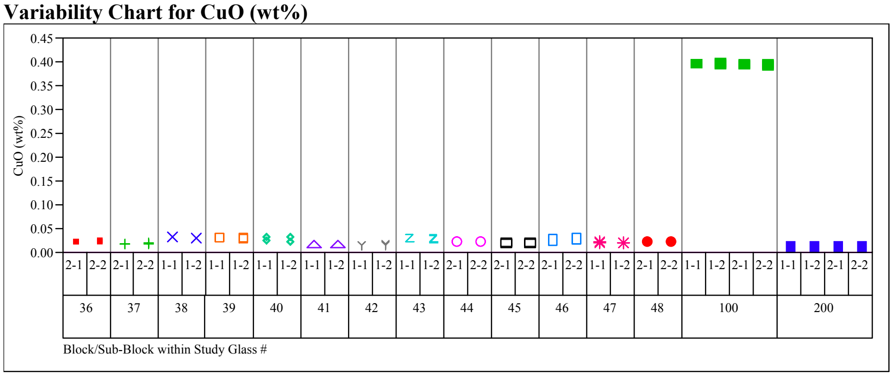


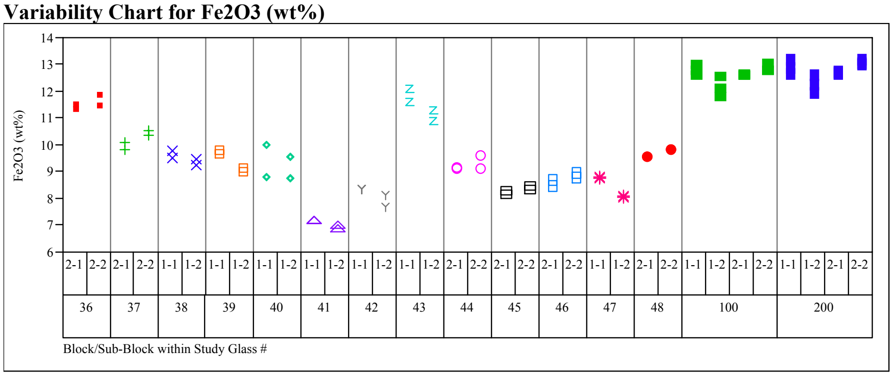
Exhibit C5. Measured and Measured Bias-Corrected Oxide Weight Percents by Glass ID for the Glasses Prepared Using the LM Method (continued)

(100 – Batch 1; 200 – Ustd)

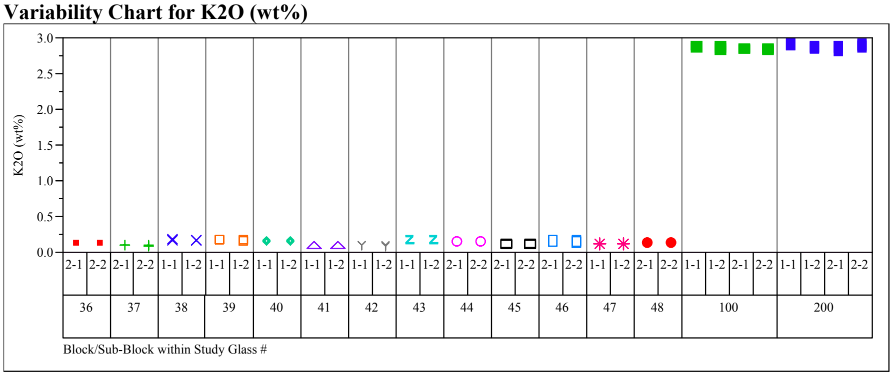
Variability Chart for CuO (wt%)



Variability Chart for Fe2O3 (wt%)



Variability Chart for K2O (wt%)



Variability Chart for La2O3 (wt%)

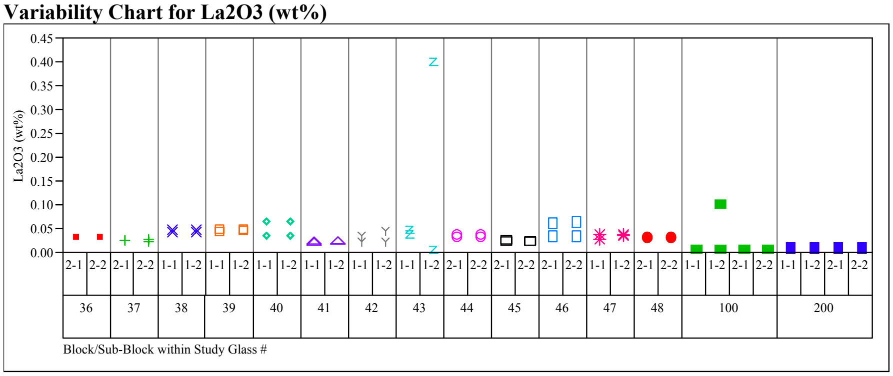
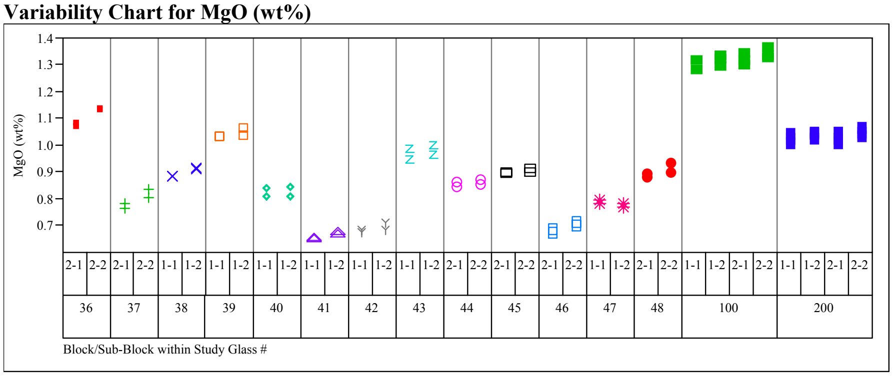


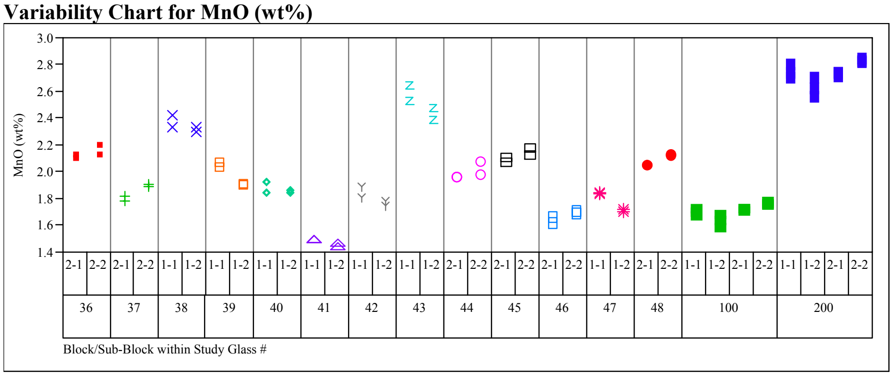
Exhibit C5. Measured and Measured Bias-Corrected Oxide Weight Percents by Glass ID for the Glasses Prepared Using the LM Method (continued)

(100 – Batch 1; 200 – Ustd)

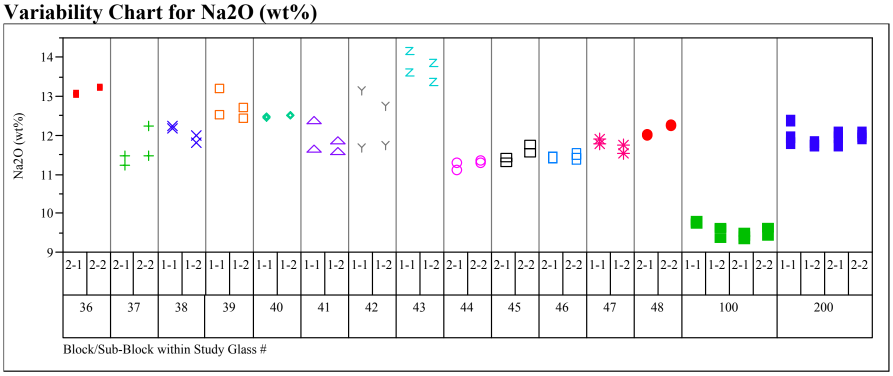
Variability Chart for MgO (wt%)



Variability Chart for MnO (wt%)



Variability Chart for Na2O (wt%)



Variability Chart for PbO (wt%)

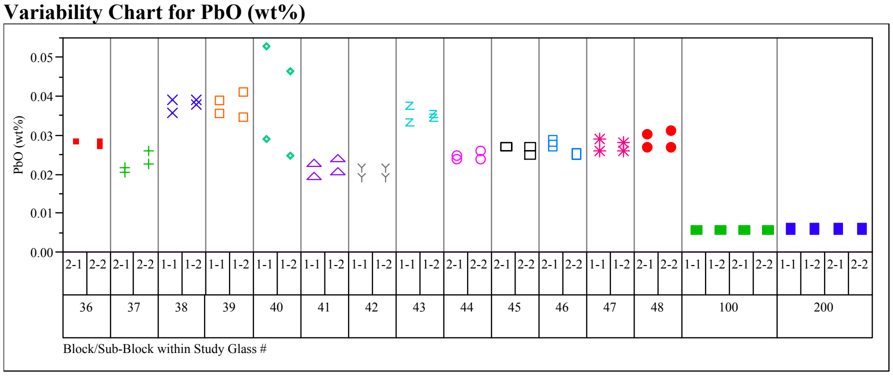
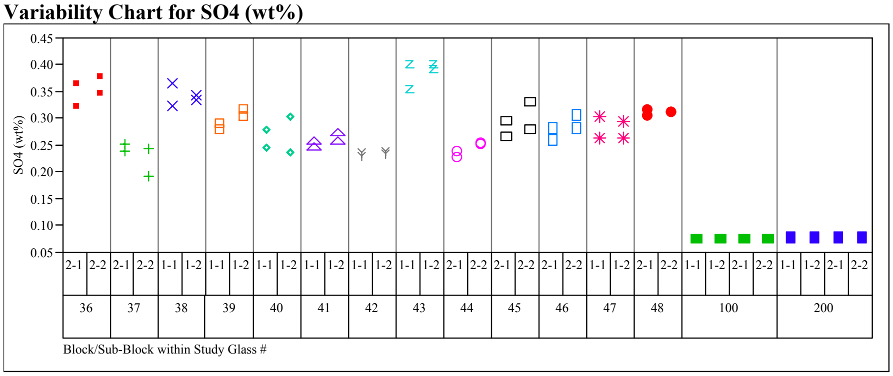


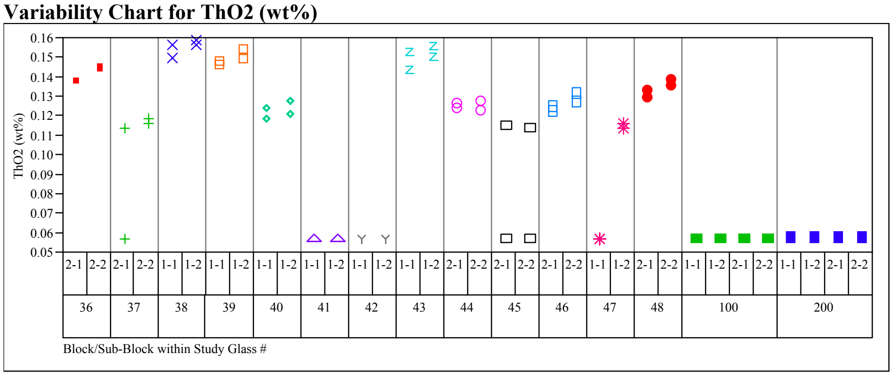
Exhibit C5. Measured and Measured Bias-Corrected Oxide Weight Percents by Glass ID for the Glasses Prepared Using the LM Method (continued)

(100 – Batch 1; 200 – Ustd)

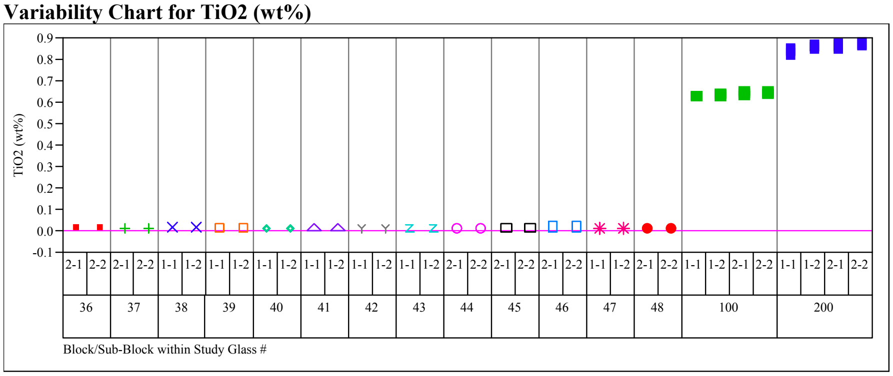
Variability Chart for SO4 (wt%)



Variability Chart for ThO2 (wt%)



Variability Chart for TiO2 (wt%)



Variability Chart for ZnO (wt%)

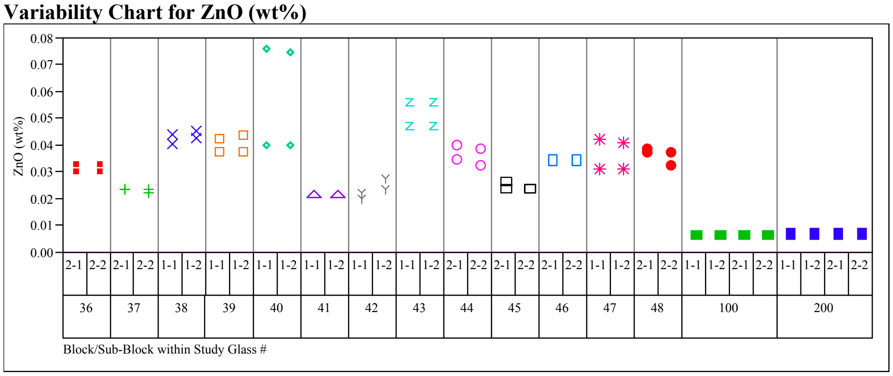
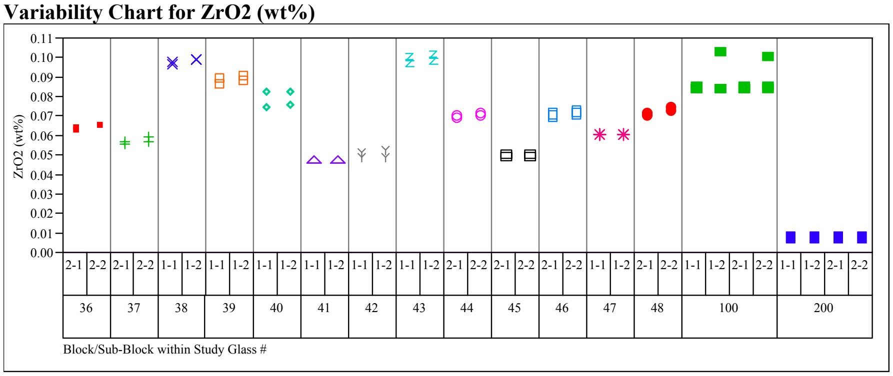


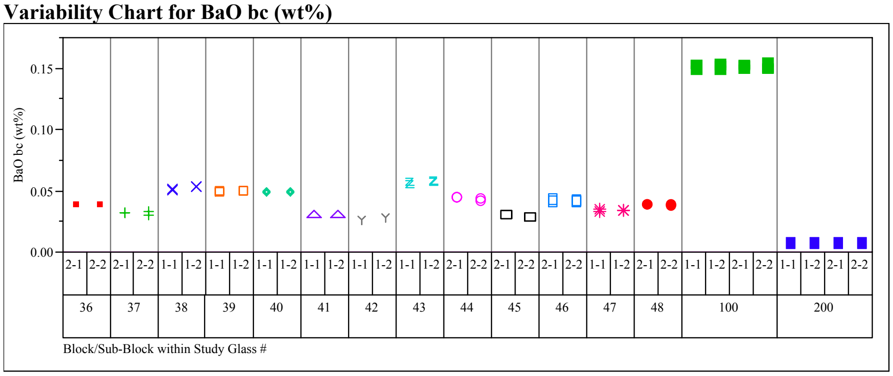
Exhibit C5. Measured and Measured Bias-Corrected Oxide Weight Percents by Glass ID for the Glasses Prepared Using the LM Method (continued)

(100 – Batch 1; 200 – Ustd)

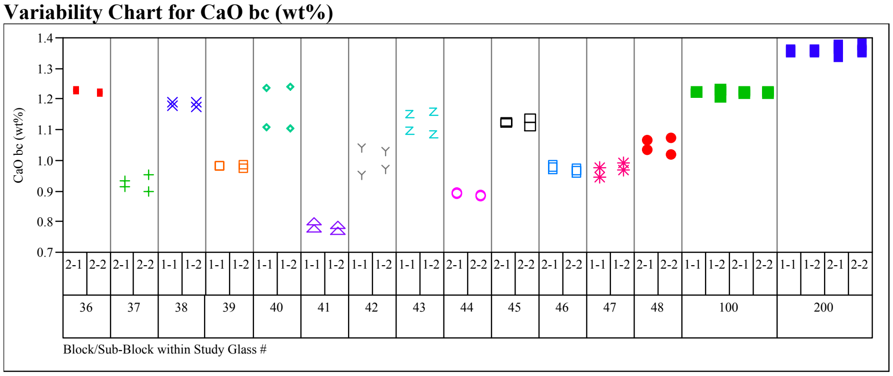
Variability Chart for ZrO2 (wt%)



Variability Chart for BaO bc (wt%)



Variability Chart for CaO bc (wt%)



Variability Chart for Ce2O3 bc (wt%)

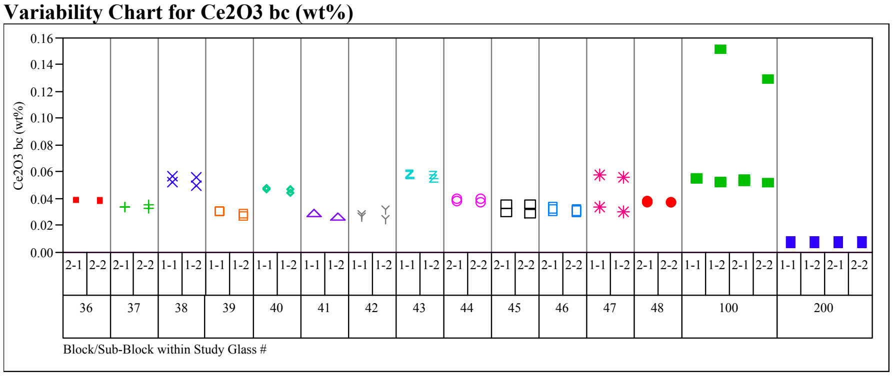
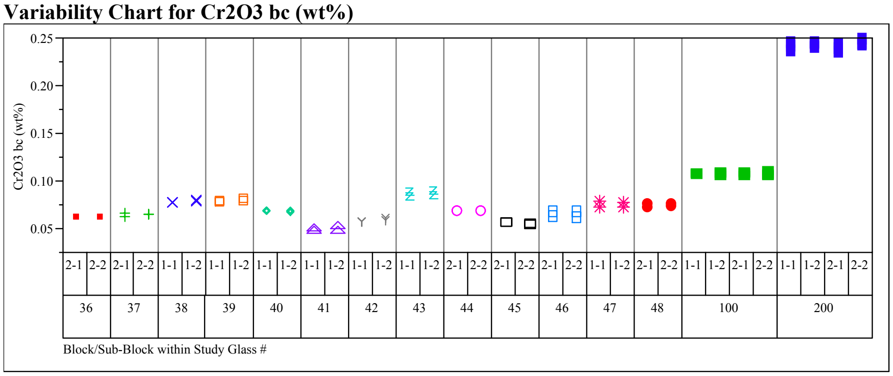


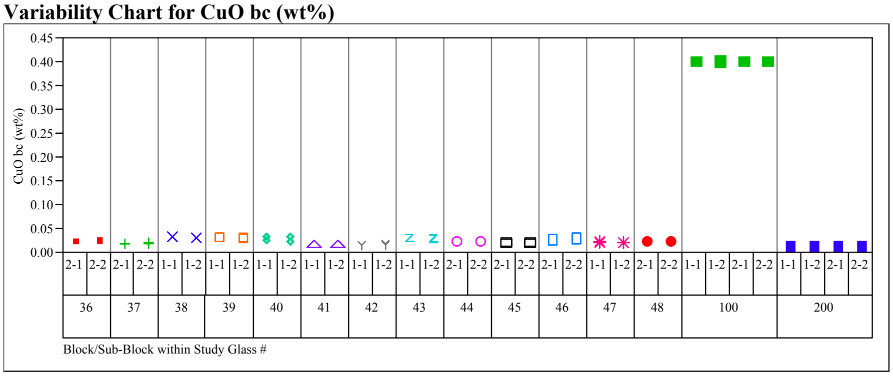
Exhibit C5. Measured and Measured Bias-Corrected Oxide Weight Percents by Glass ID for the Glasses Prepared Using the LM Method (continued)

(100 – Batch 1; 200 – Ustd)

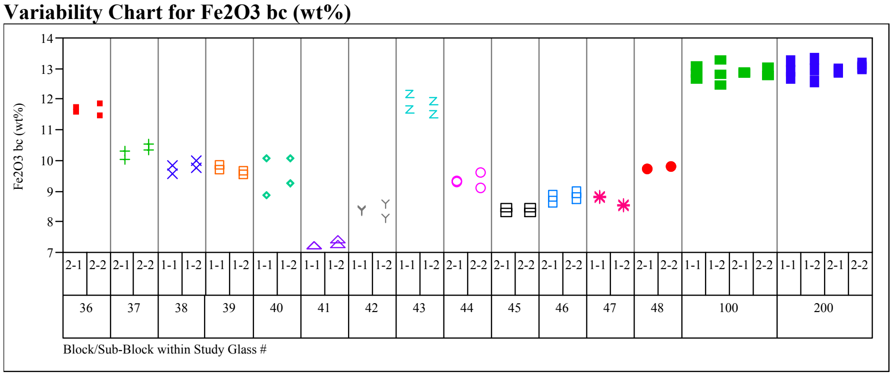
Variability Chart for Cr2O3 bc (wt%)



Variability Chart for CuO bc (wt%)



Variability Chart for Fe2O3 bc (wt%)



Variability Chart for K2O bc (wt%)

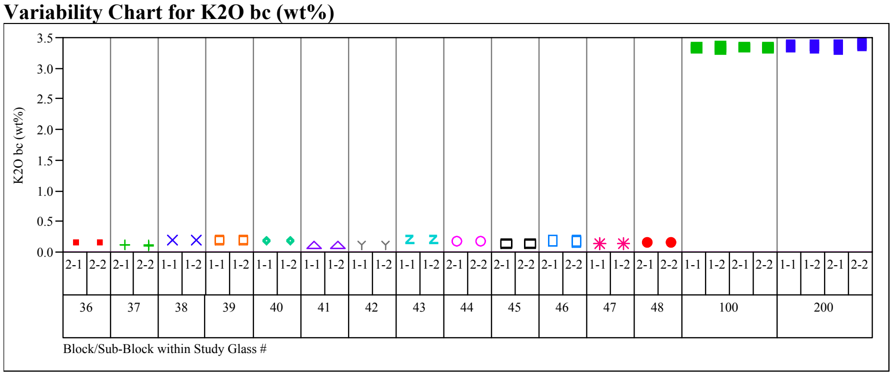
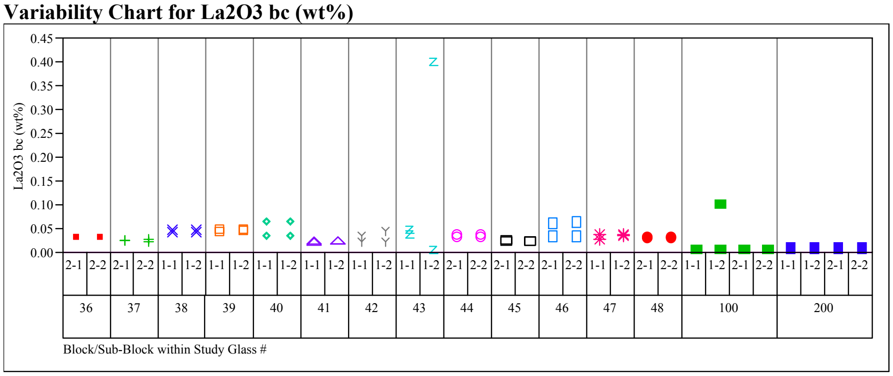


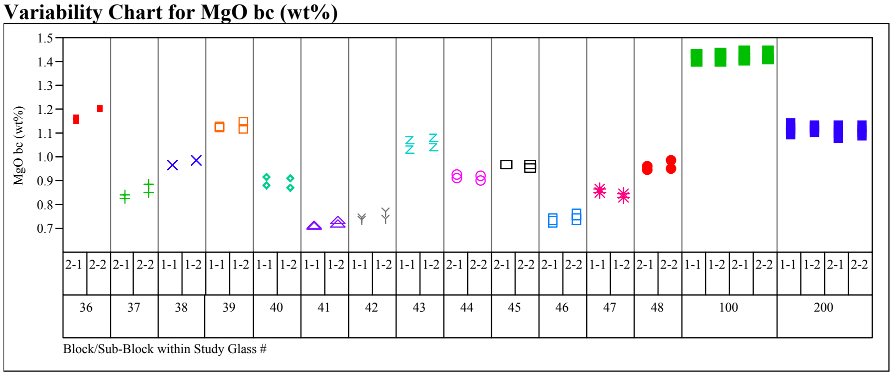
Exhibit C5. Measured and Measured Bias-Corrected Oxide Weight Percents by Glass ID for the Glasses Prepared Using the LM Method (continued)

(100 – Batch 1; 200 – Ustd)

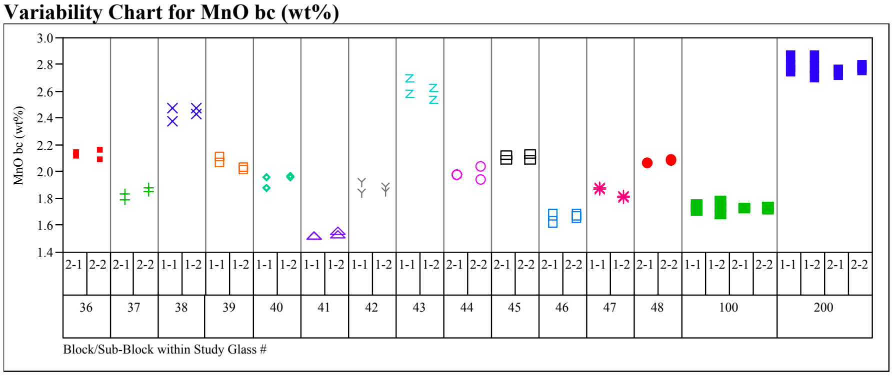
Variability Chart for La2O3 bc (wt%)



Variability Chart for MgO bc (wt%)



Variability Chart for MnO bc (wt%)



Variability Chart for Na2O bc (wt%)

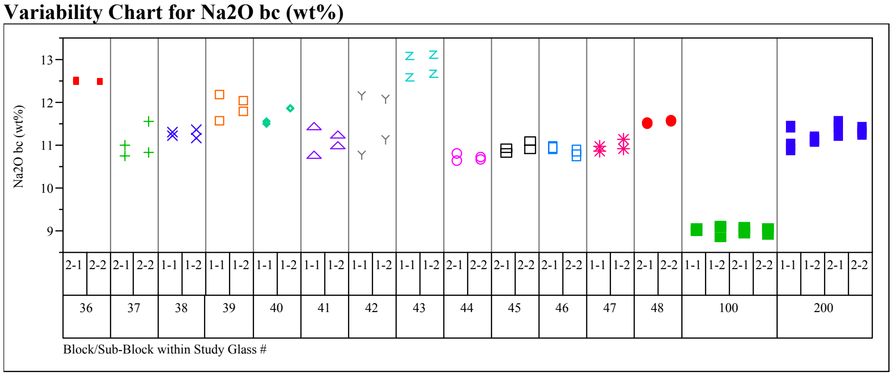
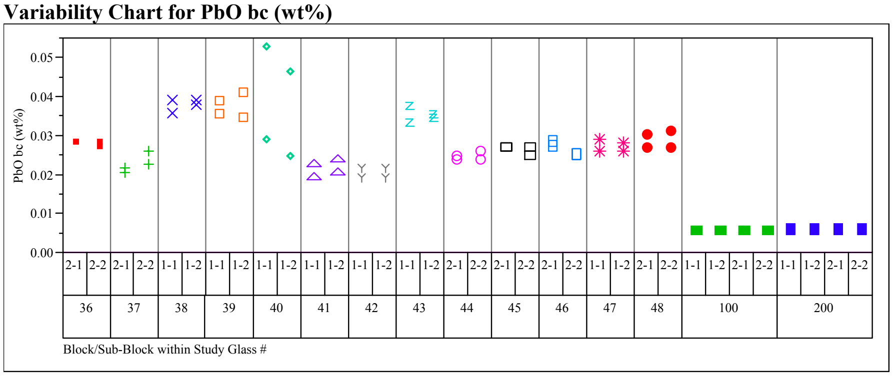


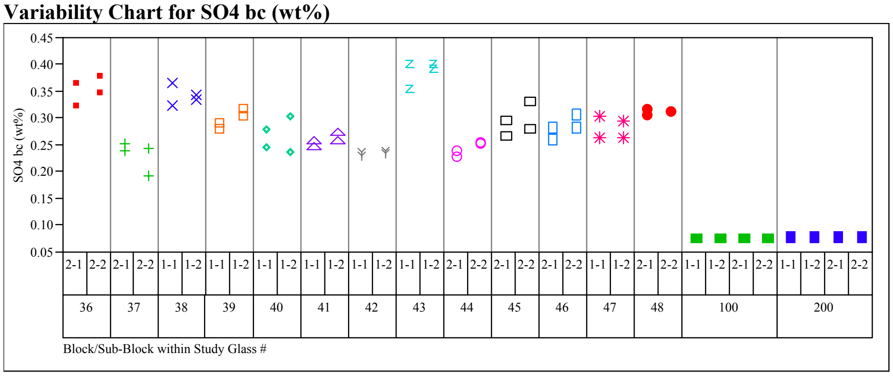
Exhibit C5. Measured and Measured Bias-Corrected Oxide Weight Percents by Glass ID for the Glasses Prepared Using the LM Method (continued)

(100 – Batch 1; 200 – Ustd)

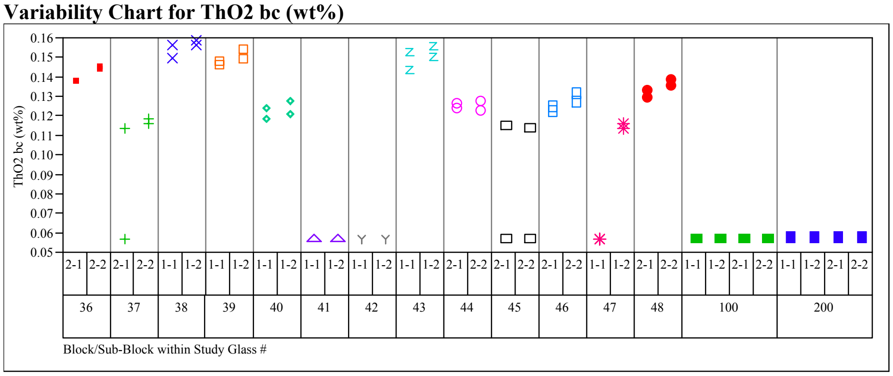
Variability Chart for PbO bc (wt%)



Variability Chart for SO4 bc (wt%)



Variability Chart for ThO2 bc (wt%)



Variability Chart for TiO2 bc (wt%)

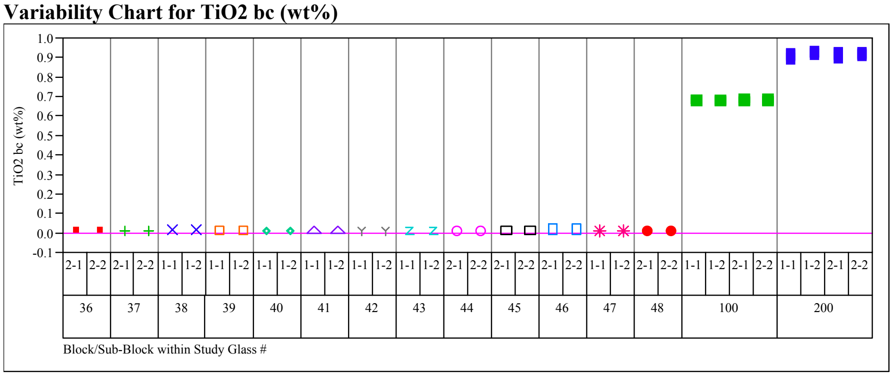
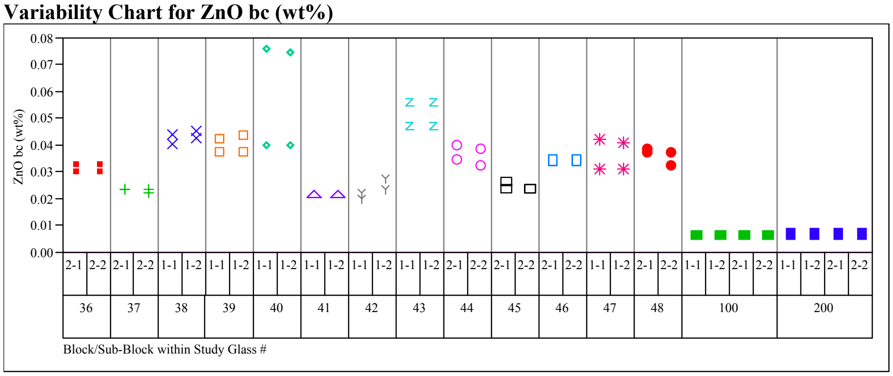


Exhibit C5. Measured and Measured Bias-Corrected Oxide Weight Percents by Glass ID for the Glasses Prepared Using the LM Method (continued)

(100 – Batch 1; 200 – Ustd)

Variability Chart for ZnO bc (wt%)



Variability Chart for ZrO2 bc (wt%)

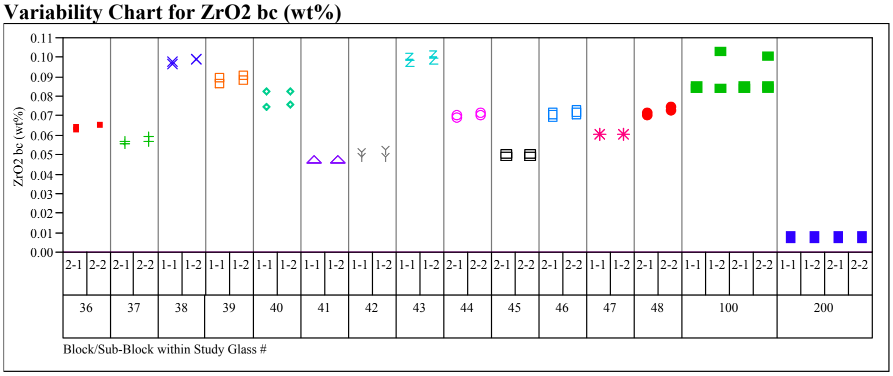
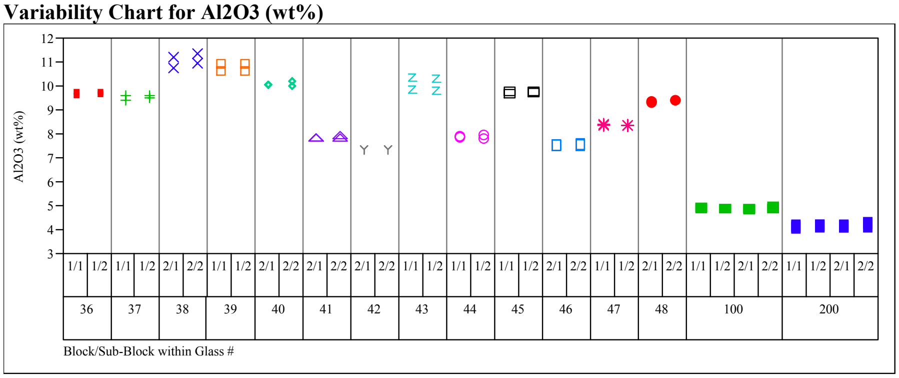


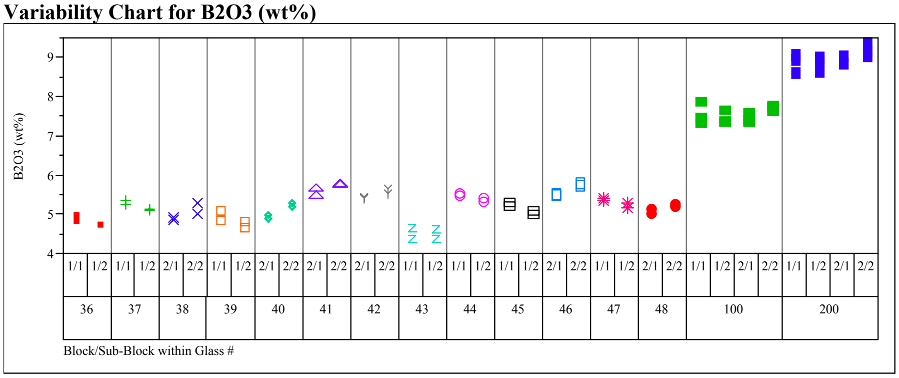
Exhibit C6. Measured and Measured Bias-Corrected Oxide Weight Percents by Glass # for the Glasses Prepared Using the PF Method

(100 – Batch 1; 200 – Ustd)

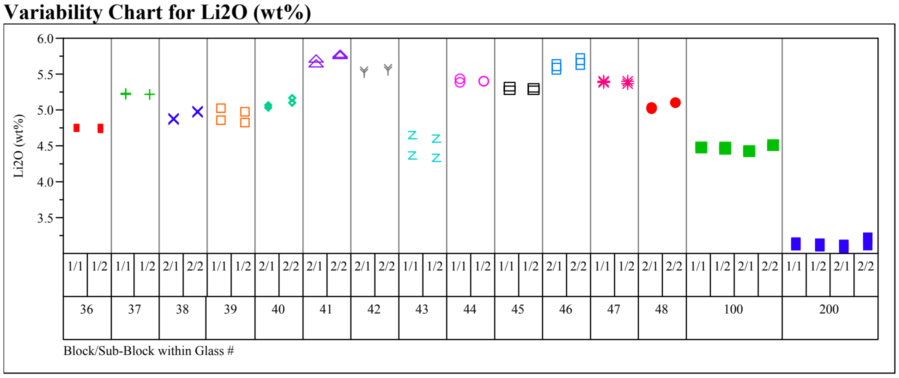
Variability Chart for Al2O3 (wt%)



Variability Chart for B2O3 (wt%)



Variability Chart for Li2O (wt%)



Variability Chart for NiO (wt%)

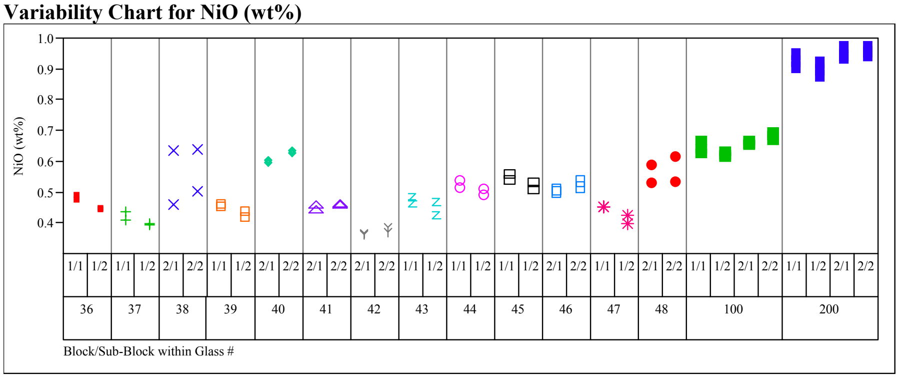
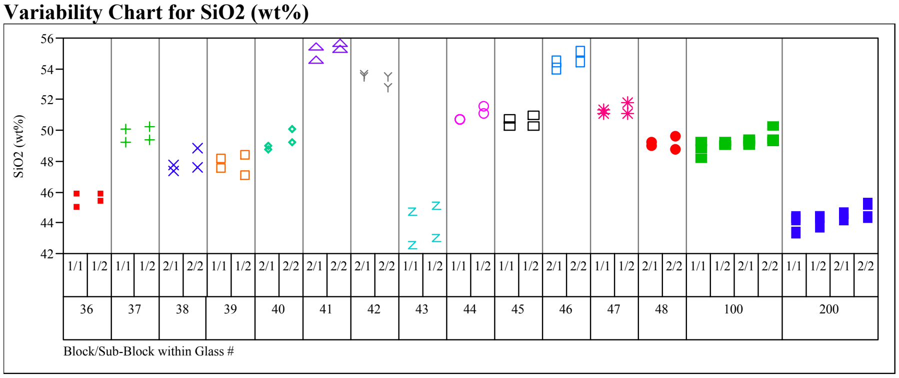


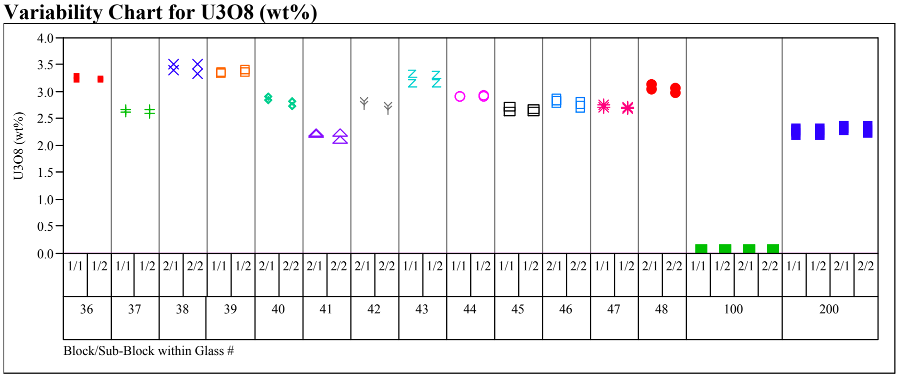
Exhibit C6. Measured and Measured Bias-Corrected Oxide Weight Percents by Glass # for the Glasses Prepared Using the PF Method (continued)

(100 – Batch 1; 200 – Ustd)

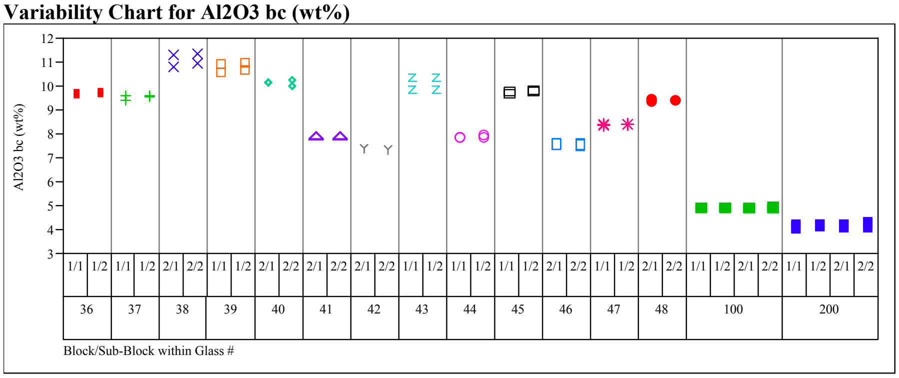
Variability Chart for SiO2 (wt%)



Variability Chart for U3O8 (wt%)



Variability Chart for Al2O3 bc (wt%)



Variability Chart for B2O3 bc (wt%)

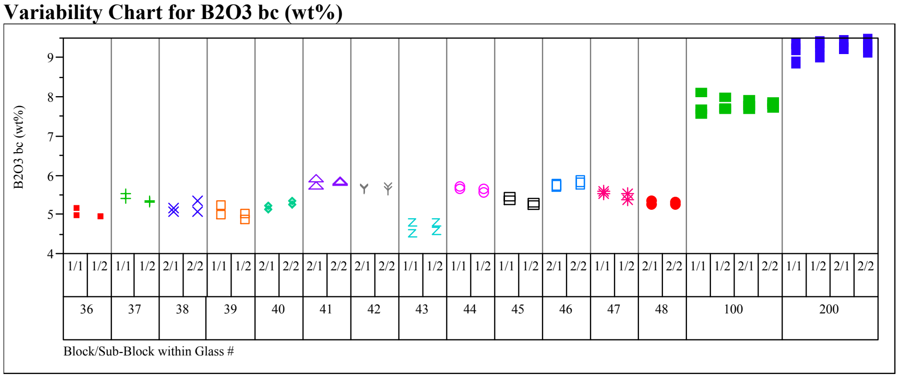
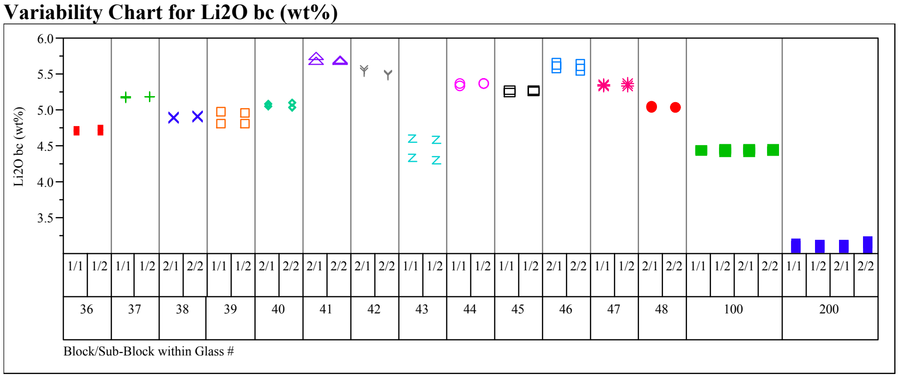


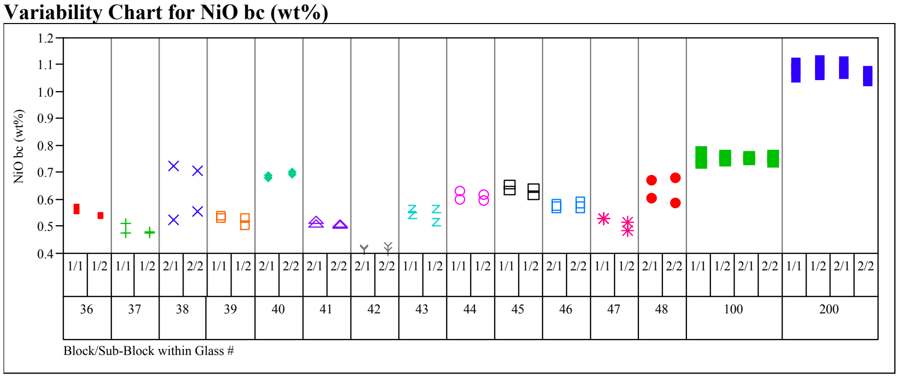
Exhibit C6. Measured and Measured Bias-Corrected Oxide Weight Percents by Glass # for the Glasses Prepared Using the PF Method (continued)

(100 – Batch 1; 200 – Ustd)

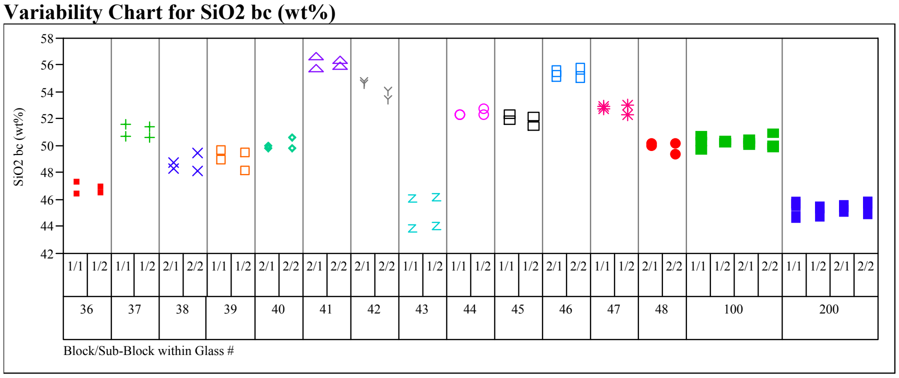
Variability Chart for Li2O bc (wt%)



Variability Chart for NiO bc (wt%)



Variability Chart for SiO2 bc (wt%)



Variability Chart for U3O8 bc (wt%)

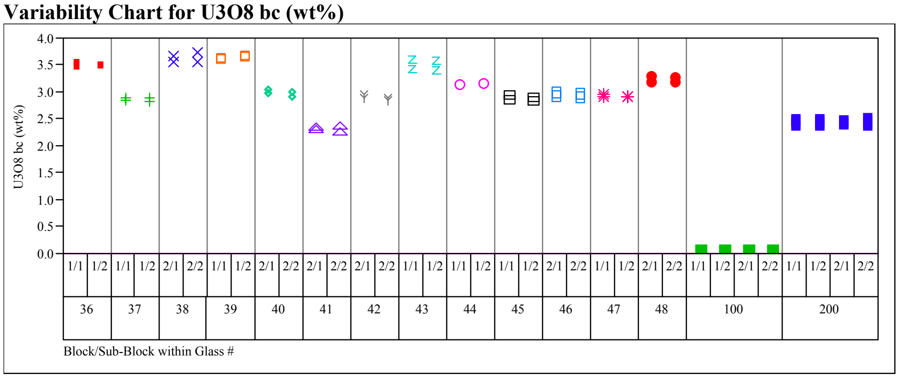
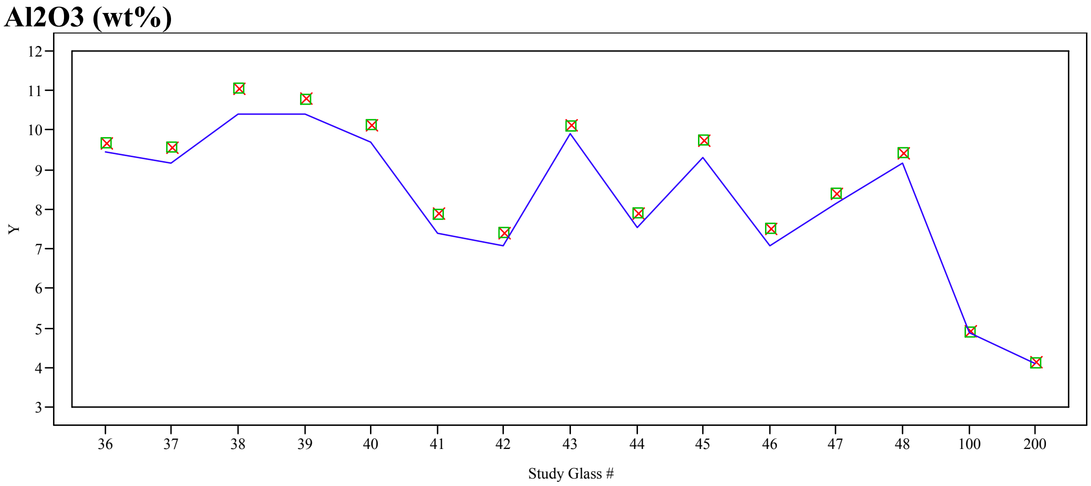
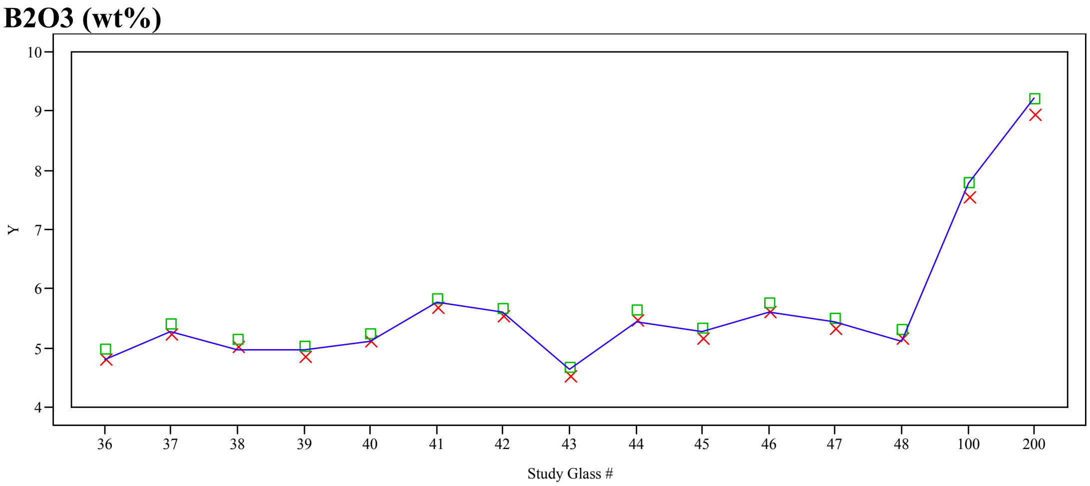


Exhibit C7. Average Measured and Bias-Corrected (bc) Versus Targeted Compositions by Glass # by Oxide
(100 – Batch 1; 200 – Ustd)





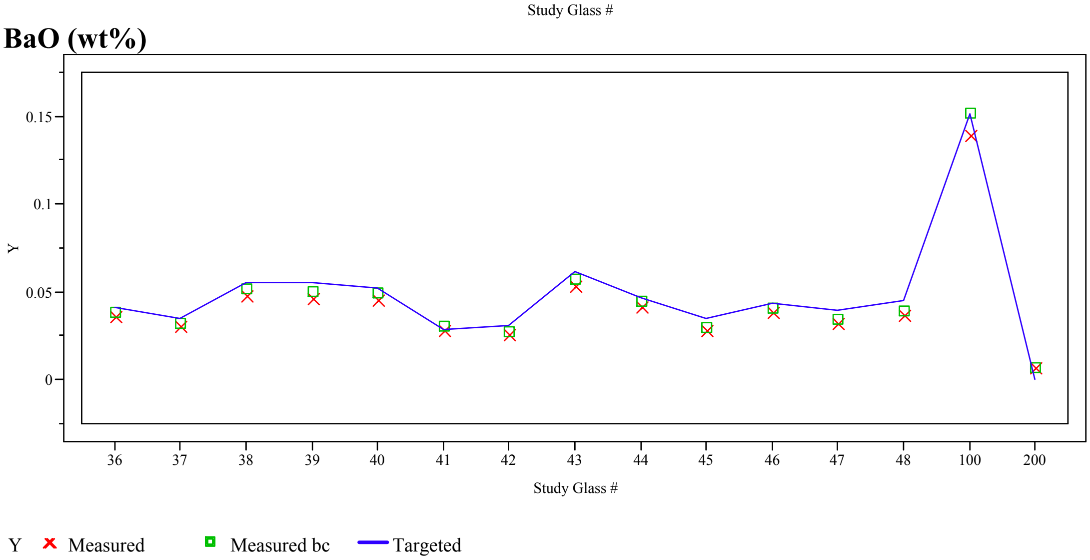
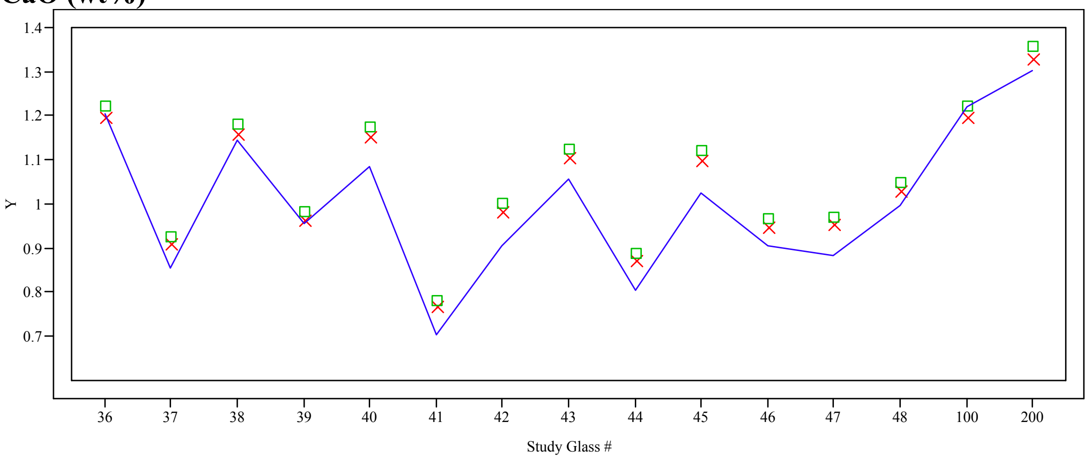
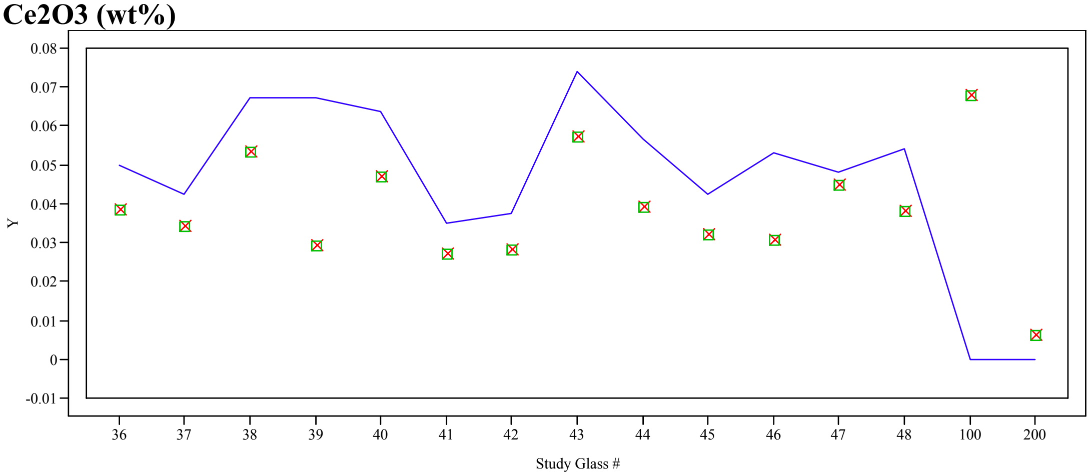


Exhibit C7. Average Measured and Bias-Corrected (bc) Versus Targeted Compositions by Glass # by Oxide (continued)
(100 – Batch 1; 200 – Ustd)

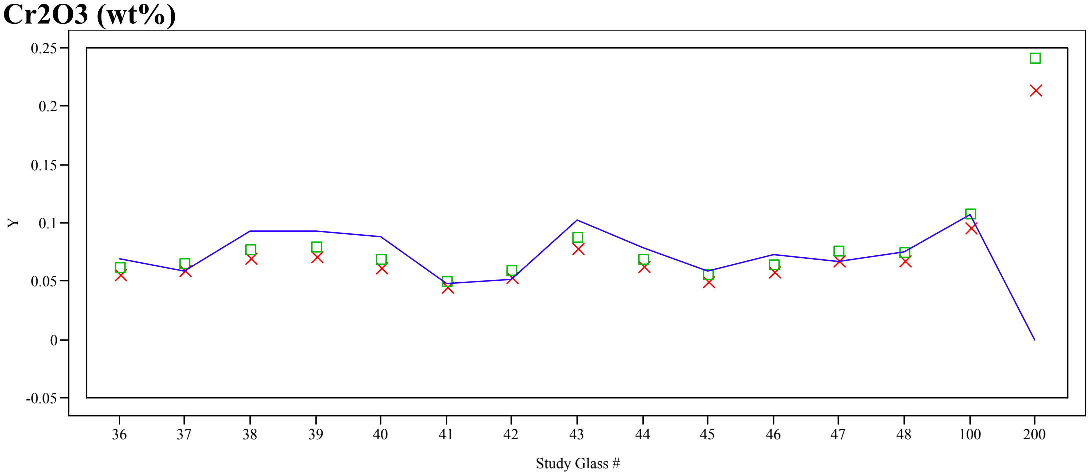
CaO (wt%)



Ce2O3 (wt%)



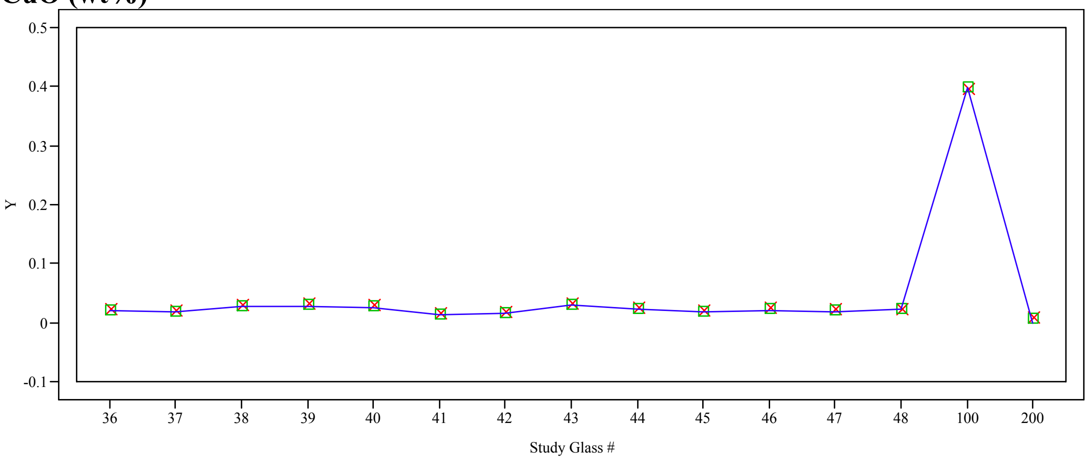
Cr2O3 (wt%)



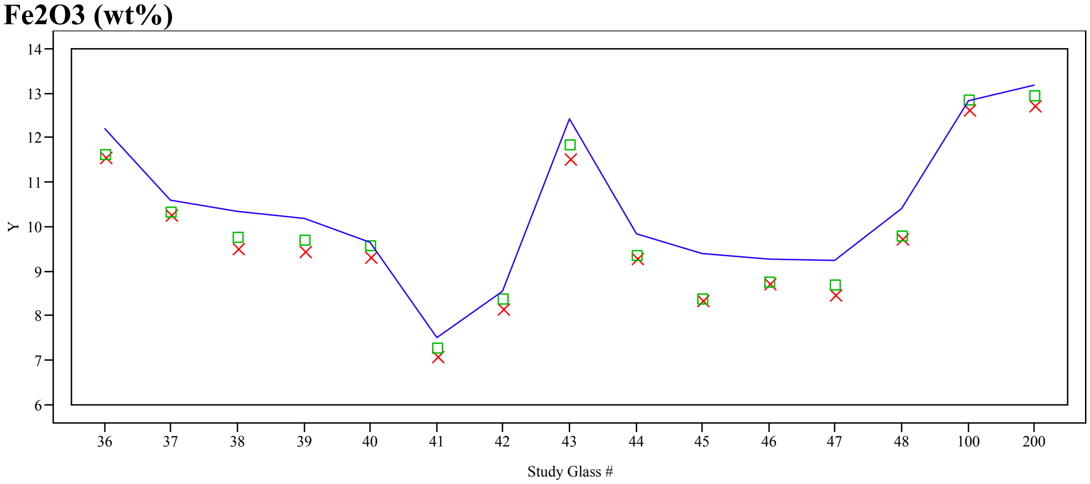
Y ✕ Measured ▫ Measured bc — Targeted

Exhibit C7. Average Measured and Bias-Corrected (bc) Versus Targeted Compositions by Glass # by Oxide (continued)
(100 – Batch 1; 200 – Ustd)

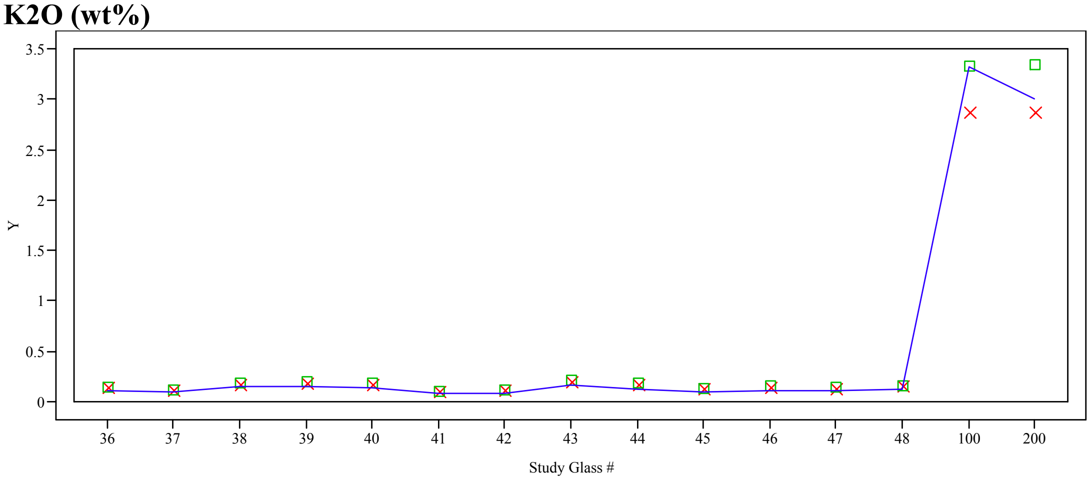
CuO (wt%)



Fe2O3 (wt%)



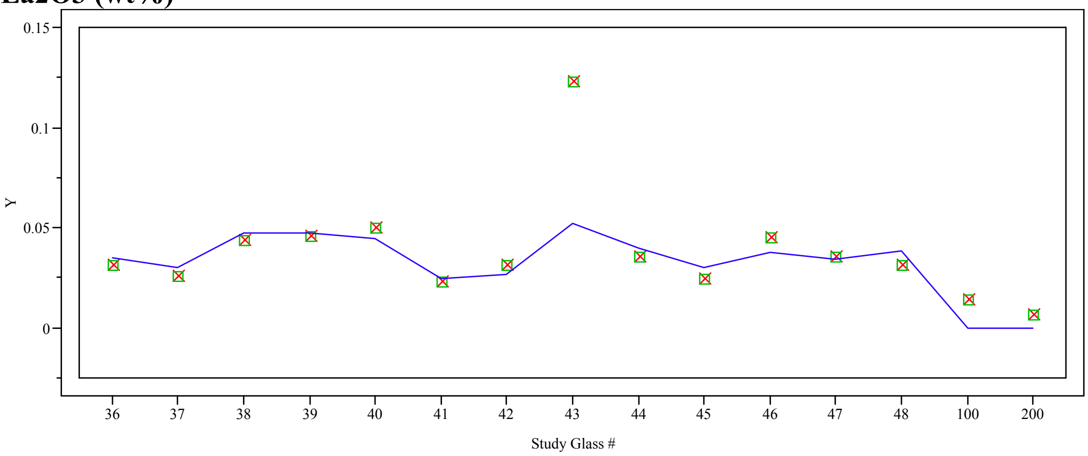
K2O (wt%)



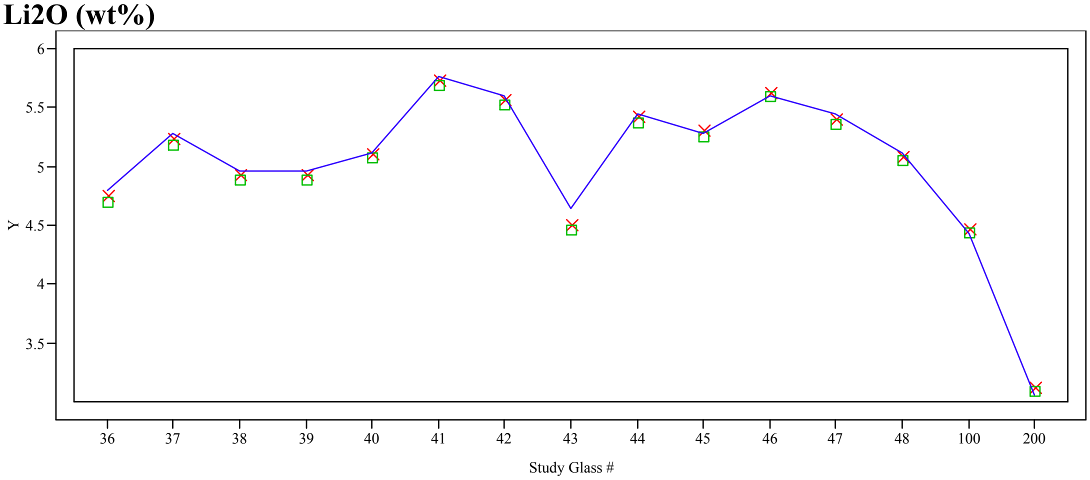
Y × Measured ▫ Measured bc — Targeted

Exhibit C7. Average Measured and Bias-Corrected (bc) Versus Targeted Compositions by Glass # by Oxide (continued)
(100 – Batch 1; 200 – Ustd)

La2O3 (wt%)



Li2O (wt%)



MgO (wt%)

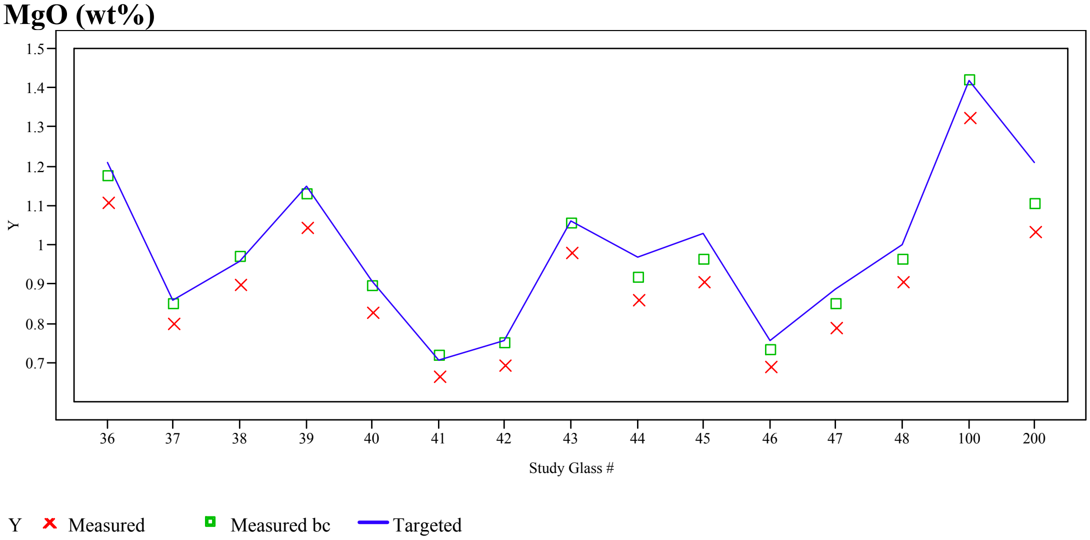
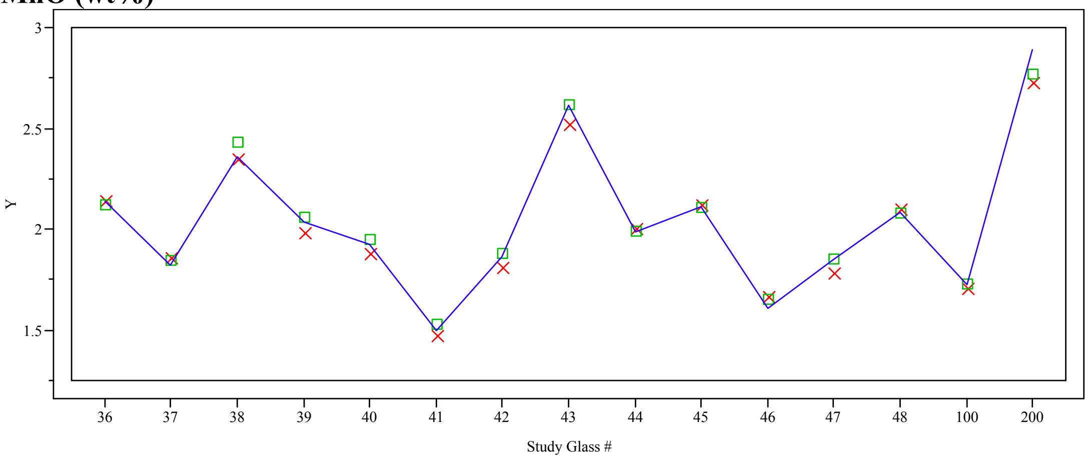
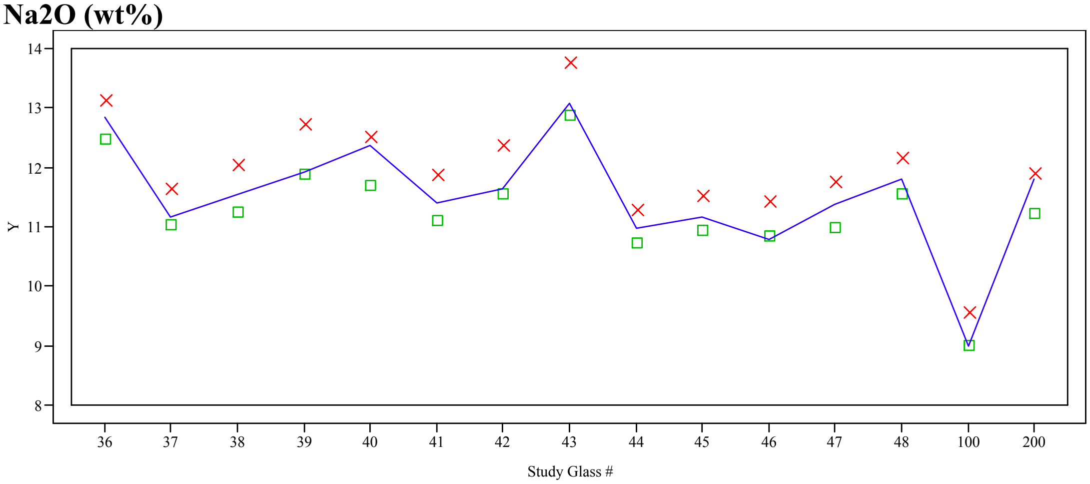


Exhibit C7. Average Measured and Bias-Corrected (bc) Versus Targeted Compositions by Glass # by Oxide (continued)
(100 – Batch 1; 200 – Ustd)

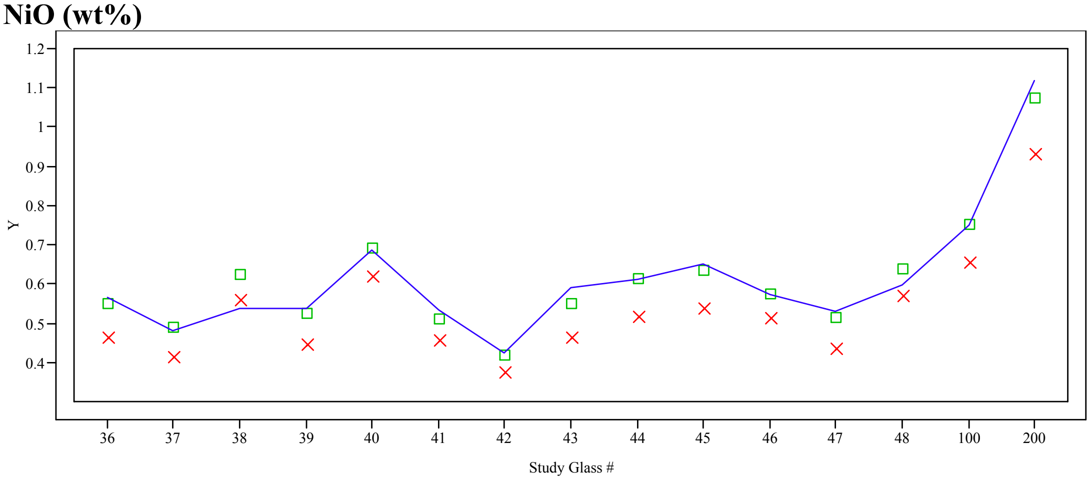
MnO (wt%)



Na2O (wt%)



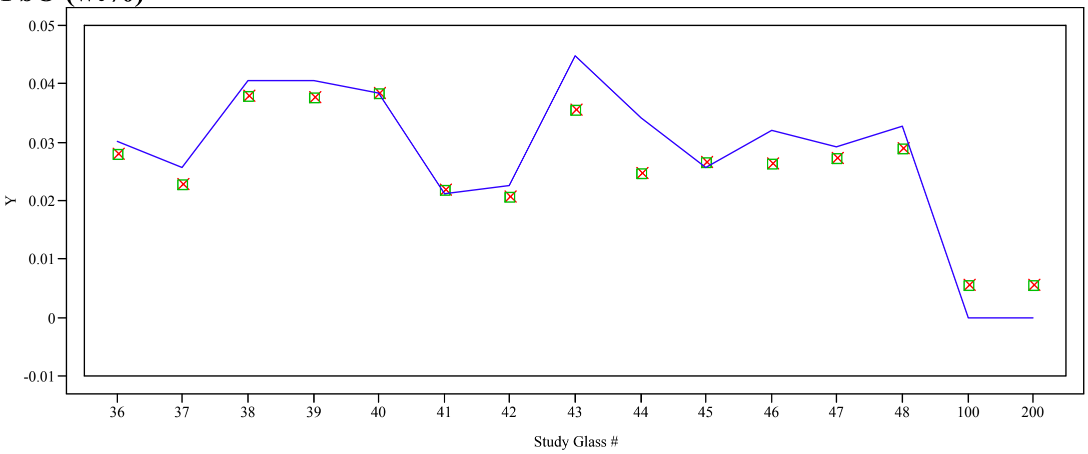
NiO (wt%)



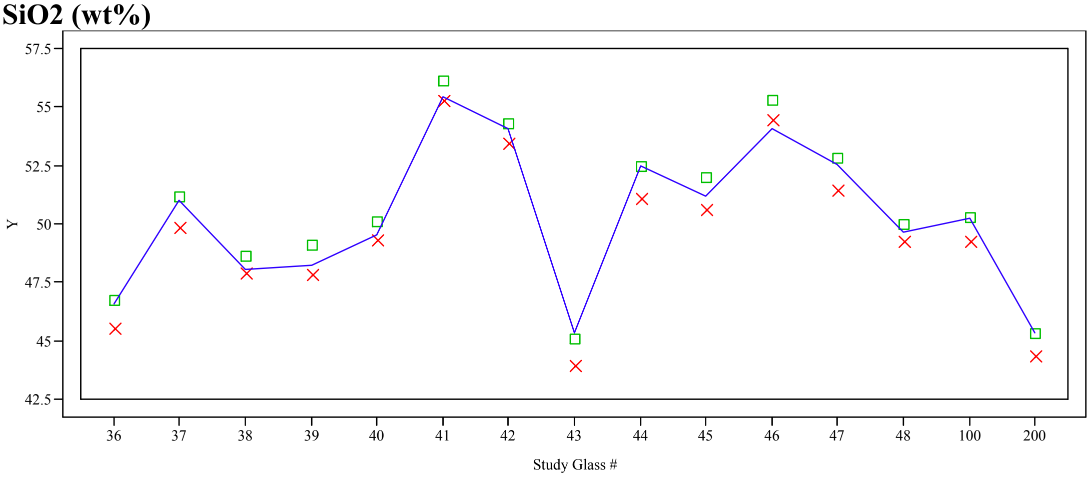
Y × Measured ▫ Measured bc — Targeted

Exhibit C7. Average Measured and Bias-Corrected (bc) Versus Targeted Compositions by Glass # by Oxide (continued)
(100 – Batch 1; 200 – Ustd)

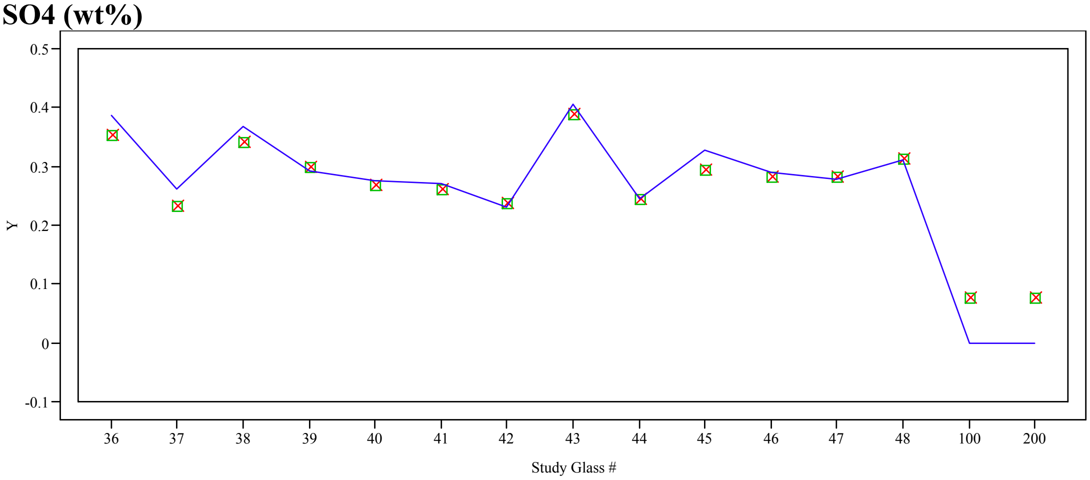
PbO (wt%)



SiO2 (wt%)



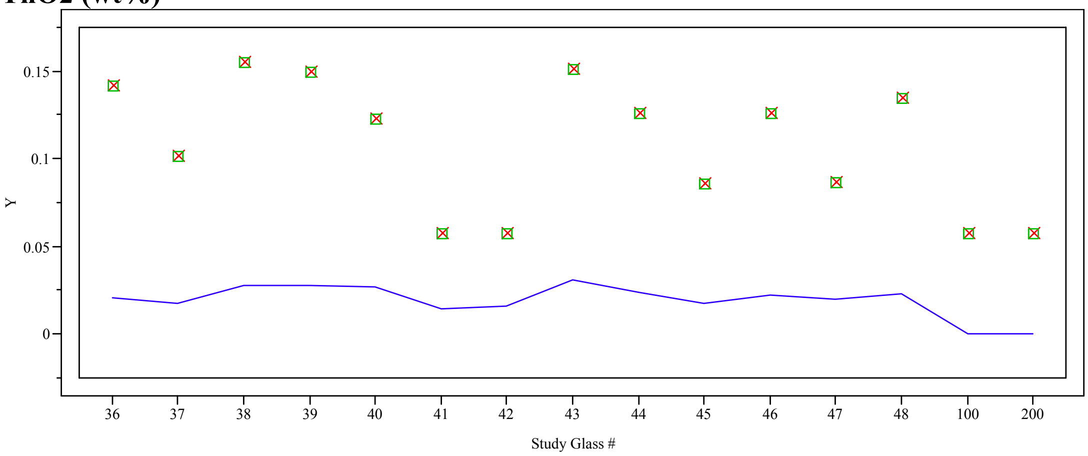
SO4 (wt%)



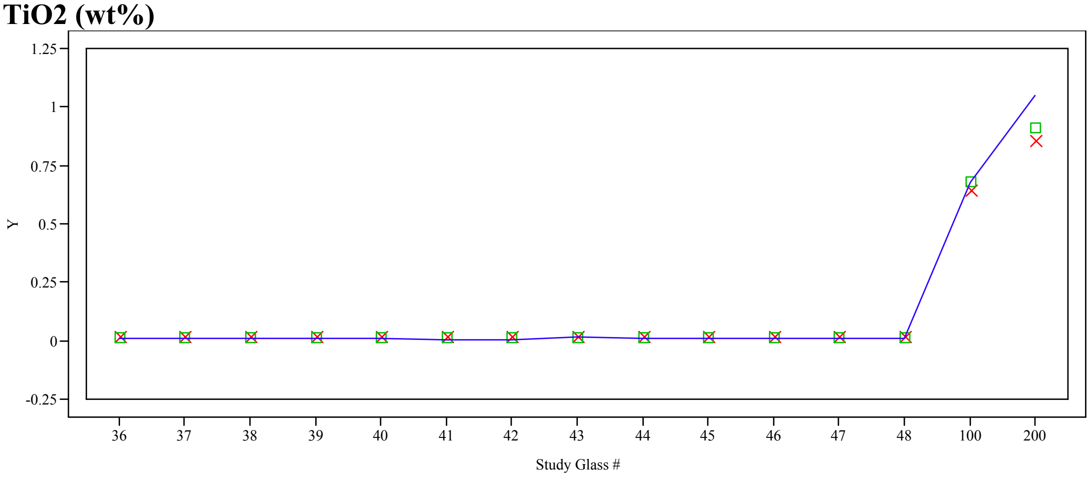
Y × Measured ▫ Measured bc — Targeted

Exhibit C7. Average Measured and Bias-Corrected (bc) Versus Targeted Compositions by Glass # by Oxide (continued)
(100 – Batch 1; 200 – Ustd)

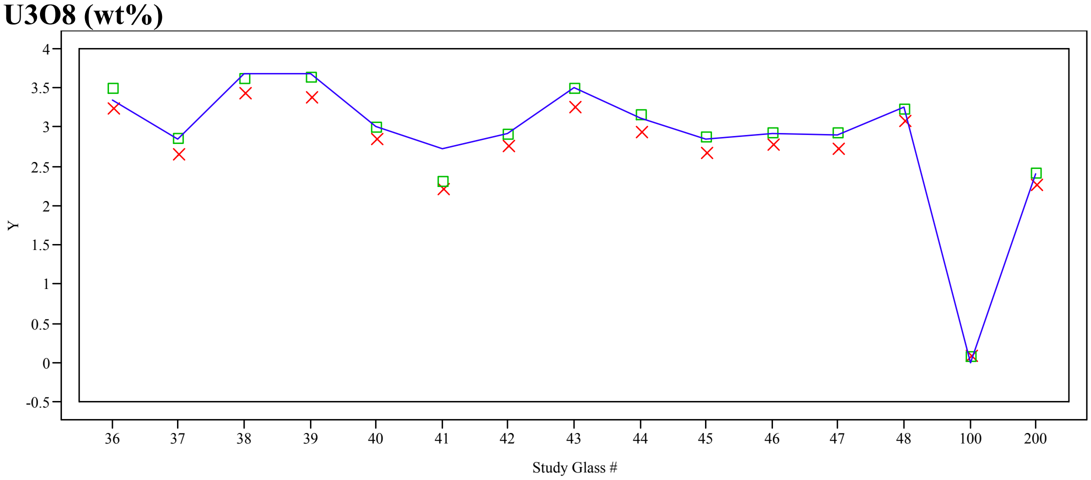
ThO2 (wt%)



TiO2 (wt%)



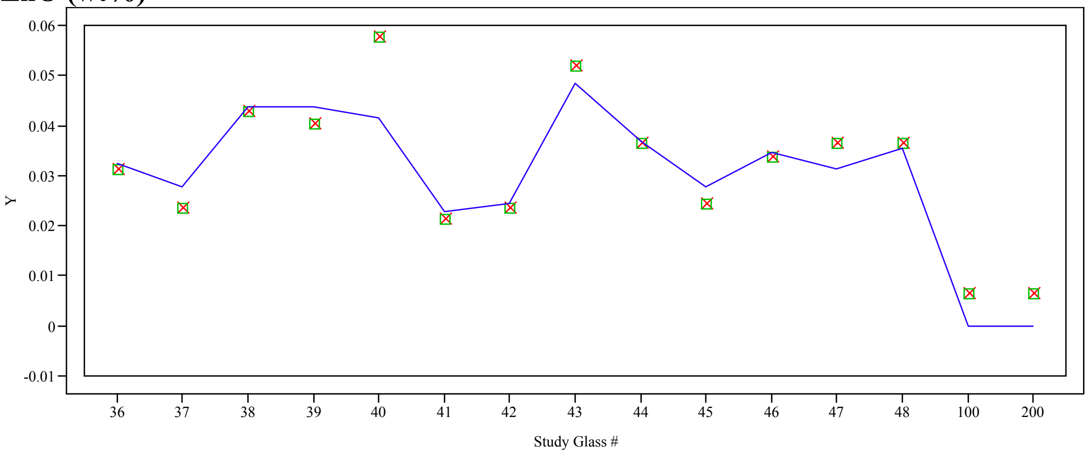
U3O8 (wt%)



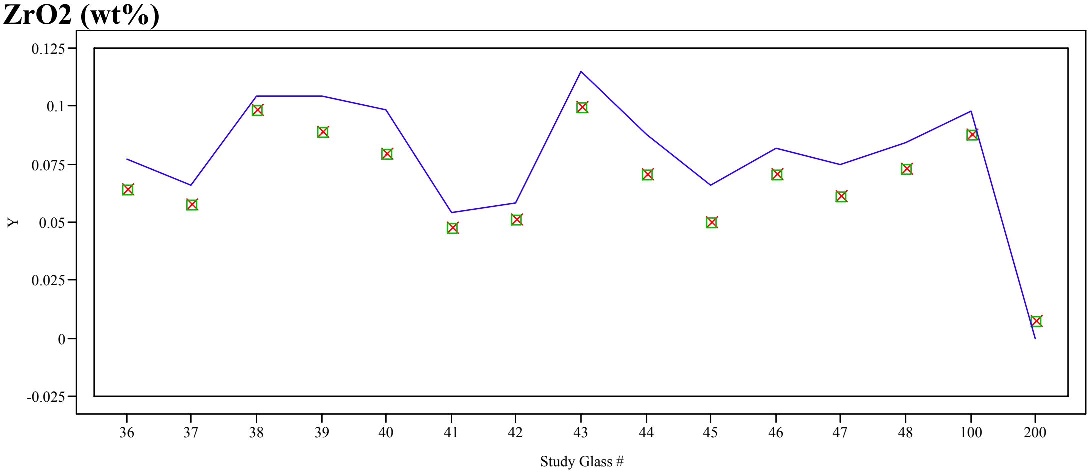
Y ✕ Measured ◘ Measured bc — Targeted

Exhibit C7. Average Measured and Bias-Corrected (bc) Versus Targeted Compositions by Glass # by Oxide (continued)
(100 – Batch 1; 200 – Ustd)

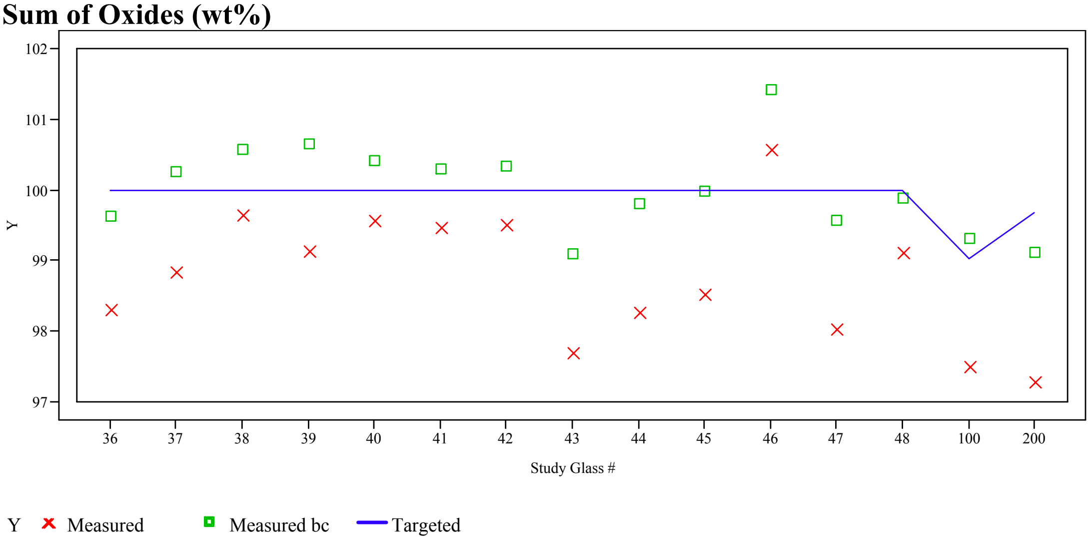
ZnO (wt%)



ZrO2 (wt%)



Sum of Oxides (wt%)



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Appendix D

Tables and Exhibits Supporting the Analysis of the PCT Results for the SB4-Frit 418 Variability Study Glasses

Table D1. Laboratory Measurements of the PCT Solutions for the Nepheline Study Glasses

Glass ID	Heat Treatment	Laboratory ID	Block	Seq	Al (ppm)	B (ppm)	Fe (ppm)	Li (ppm)	Na (ppm)	Si (ppm)	Th (ppm)	U (ppm)
Soln Std		STD-B1-1	1	1	3.87	20.1	3.62	9.75	81.7	49.3	<1.00	<1.00
SB4VS-48ccc	ccc	A43	1	2	12.4	6.24	3.70	11.0	36.2	70.1	<1.00	1.96
SB4VS-37ccc	ccc	A23	1	3	13.1	5.78	4.27	11.1	31.6	68.3	<1.00	2.45
SB4VS-43	quenched	A25	1	4	15.0	6.10	3.46	10.3	49.9	63.6	<1.00	2.01
SB4VS-36ccc	ccc	A06	1	5	14.5	6.59	3.97	11.7	48.8	68.8	<1.00	2.03
SB4VS-37	quenched	A19	1	6	13.0	5.59	4.15	11.0	32.1	66.9	<1.00	2.49
SB4VS-47ccc	ccc	A02	1	7	10.7	5.75	3.83	11.2	32.9	70.1	<1.00	2.27
SB4VS-48	quenched	A71	1	8	12.7	5.86	3.57	11.1	38.5	67.3	<1.00	2.04
Soln Std		STD-B1-2	1	9	3.78	18.4	3.45	9.54	81.6	47.9	<1.00	<1.00
blank		A77	1	10	<0.100	<0.100	<0.100	<0.500	<0.100	<0.100	<1.00	<1.00
SB4VS-38ccc	ccc	A14	1	11	14.5	5.39	2.67	10.7	33.2	61.1	<1.00	1.86
EA		A44	1	12	<0.100	31.5	<0.100	9.95	91.8	48.3	<1.00	<1.00
SB4VS-38	quenched	A27	1	13	13.9	5.26	2.44	9.74	32.5	58.2	<1.00	1.75
SB4VS-36	quenched	A70	1	14	14.0	6.82	3.31	11.0	51.3	67.2	<1.00	1.92
SB4VS-41	quenched	A84	1	15	10.4	5.44	7.47	11.4	31.7	72.6	<1.00	3.63
SB4VS-43ccc	ccc	A53	1	16	15.4	6.35	3.79	11.3	48.7	65.5	<1.00	1.93
SB4VS-41ccc	ccc	A69	1	17	10.6	5.35	7.16	11.5	31.1	73.9	<1.00	4.39
SB4VS-47	quenched	A54	1	18	11.0	5.70	4.11	11.4	34.2	70.7	<1.00	<1.00
Soln Std		STD-B1-3	1	19	3.79	18.5	3.50	9.58	81.8	47.7	<1.00	<1.00
Soln Std		STD-B2-1	2	1	3.69	20.6	3.92	9.83	83.1	49.0	<1.00	<1.00
SB4VS-43ccc	ccc	A26	2	2	16.0	7.59	4.10	11.7	52.0	67.4	<1.00	1.70
SB4VS-47	quenched	A67	2	3	11.3	6.85	4.55	11.9	35.5	73.1	<1.00	2.23
SB4VS-41	quenched	A82	2	4	11.4	6.36	9.11	12.2	35.1	77.9	<1.00	3.76
SB4VS-37	quenched	A24	2	5	13.1	6.25	4.44	11.2	32.1	68.5	<1.00	2.38
EA		A60	2	6	<0.100	35.7	<0.100	10.6	98.5	51.1	<1.00	<1.00
SB4VS-48	quenched	A48	2	7	12.7	6.65	3.76	11.3	39.3	67.4	<1.00	1.91
SB4VS-43	quenched	A34	2	8	15.5	6.85	4.55	10.6	51.2	64.9	<1.00	1.80
Soln Std		STD-B2-2	2	9	3.68	19.9	3.94	9.85	83.1	49.4	<1.00	<1.00
SB4VS-38	quenched	A41	2	10	14.1	5.83	2.98	10.2	32.7	61.1	<1.00	1.52
SB4VS-36ccc	ccc	A47	2	11	14.0	6.81	3.86	11.4	46.9	66.2	<1.00	1.75
SB4VS-38ccc	ccc	A79	2	12	15.0	6.05	2.78	11.0	34.9	62.6	<1.00	1.65
SB4VS-48ccc	ccc	A51	2	13	12.6	6.16	3.44	10.8	37.5	66.4	<1.00	1.69
SB4VS-47ccc	ccc	A28	2	14	11.1	6.39	3.83	11.4	34.9	70.4	<1.00	2.14
SB4VS-41ccc	ccc	A04	2	15	10.2	5.64	7.35	11.2	30.8	70.8	<1.00	3.64
SB4VS-37ccc	ccc	A10	2	16	13.2	6.11	4.27	11.2	31.9	68.1	<1.00	2.52
SB4VS-36	quenched	A11	2	17	14.4	7.19	4.28	11.2	51.8	68.1	<1.00	1.70
Soln Std		STD-B2-3	2	18	3.75	19.8	3.89	9.89	84.4	49.2	<1.00	<1.00

Table D1. Laboratory Measurements of the PCT Solutions for the Nepheline Study Glasses (continued)

Glass ID	Heat Treatment	Laboratory ID	Block	Seq	Al (ppm)	B (ppm)	Fe (ppm)	Li (ppm)	Na (ppm)	Si (ppm)	Th (ppm)	U (ppm)
Soln Std		STD-B3-1	3	1	3.98	21.0	4.10	10.0	81.6	50.3	<1.00	<1.00
SB4VS-36	quenched	A03	3	2	14.1	8.01	3.80	11.2	56.1	68.1	<1.00	1.61
SB4VS-36ccc	ccc	A64	3	3	14.3	7.57	4.21	11.6	46.6	69.1	<1.00	1.73
SB4VS-48ccc	ccc	A45	3	4	12.9	7.05	4.30	11.2	36.3	69.7	<1.00	1.68
SB4VS-43	quenched	A01	3	5	15.1	7.19	4.43	10.6	48.5	66.3	<1.00	1.70
SB4VS-41ccc	ccc	A56	3	6	10.4	6.24	7.70	11.3	29.5	73.2	<1.00	3.55
EA		A65	3	7	0.163	37.0	<0.100	11.3	98.0	53.9	<1.00	<1.00
SB4VS-37ccc	ccc	A76	3	8	13.1	6.90	4.47	11.3	30.3	70.2	<1.00	2.60
Soln Std		STD-B3-2	3	9	3.92	20.2	4.00	10.0	80.9	50.1	<1.00	<1.00
SB4VS-48	quenched	A46	3	10	12.6	7.18	3.67	11.3	36.9	69.1	<1.00	1.70
SB4VS-47ccc	ccc	A75	3	11	10.8	6.84	3.98	11.3	32.8	71.4	<1.00	2.05
SB4VS-38	quenched	A52	3	12	14.0	6.04	3.22	10.0	31.6	59.7	<1.00	1.54
SB4VS-47	quenched	A72	3	13	10.8	6.69	4.35	11.7	33.4	71.7	<1.00	2.24
SB4VS-43ccc	ccc	A62	3	14	15.5	7.28	4.32	11.6	47.7	68.0	<1.00	<1.00
SB4VS-41	quenched	A33	3	15	10.4	6.31	8.03	11.8	31.4	75.0	<1.00	<1.00
SB4VS-38ccc	ccc	A17	3	16	14.4	6.11	3.16	10.9	32.2	62.7	<1.00	1.62
SB4VS-37	quenched	A20	3	17	13.0	6.58	4.42	11.3	30.8	70.2	<1.00	2.24
Soln Std		STD-B3-3	3	18	3.96	20.1	4.04	10.0	80.8	50.3	<1.00	<1.00
Soln Std		STD-B4-1	4	1	3.87	20.4	3.89	9.78	81.7	50.1	<1.00	<1.00
SB4VS-39ccc	ccc	A50	4	2	14.6	6.40	3.49	10.4	34.5	63.4	<1.00	2.22
SB4VS-40	quenched	A05	4	3	13.0	6.17	2.98	10.4	38.1	64.8	<1.00	1.74
SB4VS-39	quenched	A83	4	4	14.7	5.99	3.08	10.2	35.3	63.1	<1.00	1.66
SB4VS-44ccc	ccc	A37	4	5	10.2	6.65	4.20	11.8	31.2	73.2	<1.00	2.22
ARM-1		A36	4	6	2.93	13.1	<0.100	9.91	26.0	42.9	<1.00	<1.00
SB4VS-46ccc	ccc	A81	4	7	9.51	6.56	4.73	12.3	31.0	75.5	<1.00	2.45
SB4VS-44	quenched	A57	4	8	9.58	5.96	3.85	10.8	30.6	67.4	<1.00	2.11
Soln Std		STD-B4-2	4	9	3.99	20.2	4.07	10.0	83.4	50.9	<1.00	<1.00
SB4VS-42ccc	ccc	A32	4	10	9.70	7.00	4.68	12.1	35.8	76.0	<1.00	2.36
SB4VS-40ccc	ccc	A29	4	11	13.6	6.10	2.98	10.4	39.5	65.1	<1.00	1.81
SB4VS-45ccc	ccc	A39	4	12	11.7	5.88	3.03	10.6	30.5	64.0	<1.00	1.75
SB4VS-45	quenched	A08	4	13	11.7	5.61	3.07	10.3	30.9	62.5	<1.00	1.89
SB4VS-46	quenched	A66	4	14	9.38	6.32	4.69	11.8	30.6	73.5	<1.00	2.48
SB4VS-42	quenched	A18	4	15	9.93	6.77	4.55	12.3	37.1	77.0	<1.00	2.39
Soln Std		STD-B4-3	4	16	3.96	19.8	3.86	10.0	84.6	50.2	<1.00	<1.00
Soln Std		STD-B5-1	5	1	4.06	20.7	4.20	10.0	83.0	50.3	<1.00	<1.00
SB4VS-40ccc	ccc	A38	5	2	13.4	6.63	3.38	10.5	37.6	65.0	<1.00	1.82
SB4VS-46ccc	ccc	A73	5	3	9.75	7.07	5.19	12.4	31.3	77.0	<1.00	2.48
SB4VS-42	quenched	A85	5	4	9.94	6.79	5.29	12.0	36.2	74.6	<1.00	2.35
SB4VS-39	quenched	A21	5	5	14.9	6.17	3.19	10.4	36.3	63.1	<1.00	1.78

Table D1. Laboratory Measurements of the PCT Solutions for the Nepheline Study Glasses (continued)

Glass ID	Heat Treatment	Laboratory ID	Block	Seq	Al (ppm)	B (ppm)	Fe (ppm)	Li (ppm)	Na (ppm)	Si (ppm)	Th (ppm)	U (ppm)
SB4VS-39ccc	ccc	A59	5	6	14.8	6.20	3.39	10.6	34.8	63.3	<1.00	1.76
ARM-1		A15	5	7	3.09	12.8	<0.100	9.74	25.7	41.5	<1.00	<1.00
SB4VS-44	quenched	A49	5	8	10.1	6.47	4.28	11.4	31.6	70.1	<1.00	2.22
Soln Std		STD-B5-2	5	9	4.04	19.7	4.11	9.84	82.3	49.7	<1.00	<1.00
SB4VS-40	quenched	A58	5	10	12.9	6.07	3.73	9.81	37.5	61.3	<1.00	2.16
SB4VS-46	quenched	A61	5	11	9.13	6.22	4.97	11.2	29.2	69.6	<1.00	2.55
SB4VS-45	quenched	A40	5	12	11.7	5.76	3.15	10.4	30.2	63.0	<1.00	1.90
SB4VS-45ccc	ccc	A35	5	13	12.1	5.92	3.42	10.9	30.5	64.1	<1.00	1.85
SB4VS-42ccc	ccc	A55	5	14	9.63	6.51	4.58	12.0	34.9	73.7	<1.00	2.29
SB4VS-44ccc	ccc	A13	5	15	10.0	6.28	3.96	11.4	30.7	68.4	<1.00	2.15
Soln Std		STD-B5-3	5	16	4.05	19.2	3.91	9.76	82.8	48.4	<1.00	<1.00
Soln Std		STD-B6-1	6	1	4.07	20.8	3.69	9.91	82.2	49.9	<1.00	<1.00
SB4VS-40	quenched	A74	6	2	12.9	6.48	3.29	9.93	37.3	62.2	<1.00	2.14
SB4VS-45	quenched	A63	6	3	11.9	6.25	2.84	10.4	29.8	63.6	<1.00	1.99
SB4VS-42	quenched	A07	6	4	9.17	6.52	4.21	11.3	34.3	69.5	<1.00	2.17
ARM-1		A30	6	5	3.18	10.9	<0.100	8.8	23.8	38.4	<1.00	<1.00
SB4VS-46	quenched	A09	6	6	9.20	6.60	4.55	11.7	29.8	72.4	<1.00	2.52
SB4VS-44	quenched	A22	6	7	10.2	6.62	3.97	11.5	31.2	70.9	<1.00	2.36
SB4VS-42ccc	ccc	A12	6	8	9.29	6.49	3.80	11.5	33.9	71.2	<1.00	2.32
Soln Std		STD-B6-2	6	9	4.39	19.9	3.90	9.71	79.8	49.6	<1.00	<1.00
SB4VS-39	quenched	A31	6	10	14.9	6.49	2.66	10.2	36.1	62.8	<1.00	1.92
SB4VS-45ccc	ccc	A16	6	11	12.0	6.22	2.86	10.8	31.8	64.9	<1.00	1.82
SB4VS-40ccc	ccc	A42	6	12	13.3	6.09	2.82	10.3	37.6	63.5	<1.00	1.89
SB4VS-39ccc	ccc	A80	6	13	14.7	6.19	2.77	10.5	34.4	62.7	<1.00	1.79
SB4VS-46ccc	ccc	A78	6	14	9.69	6.77	4.21	12.2	31.5	75.3	<1.00	2.63
blank		A86	6	15	<0.100	<0.100	<0.100	<0.500	<0.100	<0.100	<1.00	<1.00
SB4VS-44ccc	ccc	A68	6	16	10.2	6.65	3.84	11.7	31.3	71.0	<1.00	2.28
Soln Std		STD-B6-3	6	17	4.11	20.2	3.85	9.99	85.0	50.6	<1.00	<1.00

Table D2. PSAL Measurements of the PCT Solutions for the Study Glasses After Appropriate Adjustments

Glass ID	Heat Treatment	Laboratory ID	Block	Seq	Al (ppm)	B (ppm)	Fe (ppm)	Li (ppm)	Na (ppm)	Si (ppm)	Th (ppm)	U (ppm)
Soln Std		STD-B1-1	1	1	3.87	20.1	3.62	9.75	81.7	49.3	0.5	0.5
SB4VS-48ccc	ccc	A43	1	2	20.66708	10.400208	6.16679	18.3337	60.33454	116.83567	0.83335	3.266732
SB4VS-37ccc	ccc	A23	1	3	21.83377	9.633526	7.116809	18.50037	52.66772	113.83561	0.83335	4.083415
SB4VS-43	quenched	A25	1	4	25.0005	10.16687	5.766782	17.16701	83.16833	106.00212	0.83335	3.350067
SB4VS-36ccc	ccc	A06	1	5	24.16715	10.983553	6.616799	19.50039	81.33496	114.66896	0.83335	3.383401
SB4VS-37	quenched	A19	1	6	21.6671	9.316853	6.916805	18.3337	53.50107	111.50223	0.83335	4.150083
SB4VS-47ccc	ccc	A02	1	7	17.83369	9.583525	6.383461	18.66704	54.83443	116.83567	0.83335	3.783409
SB4VS-48	quenched	A71	1	8	21.16709	9.766862	5.950119	18.50037	64.16795	112.16891	0.83335	3.400068
Soln Std		STD-B1-2	1	9	3.78	18.4	3.45	9.54	81.6	47.9	0.5	0.5
blank		A77	1	10	0.083335	0.083335	0.083335	0.416675	0.083335	0.083335	0.83335	0.83335
SB4VS-38ccc	ccc	A14	1	11	24.16715	8.983513	4.450089	17.83369	55.33444	101.83537	0.83335	3.100062
EA		A44	1	12	0.833335	525.00105	0.833335	165.833665	1530.00306	805.00161	8.33335	8.33335
SB4VS-38	quenched	A27	1	13	23.16713	8.766842	4.066748	16.233658	54.16775	97.00194	0.83335	2.916725
SB4VS-36	quenched	A70	1	14	23.3338	11.366894	5.516777	18.3337	85.50171	112.00224	0.83335	3.200064
SB4VS-41	quenched	A84	1	15	17.33368	9.066848	12.450249	19.00038	52.83439	121.00242	0.83335	6.050121
SB4VS-43ccc	ccc	A53	1	16	25.66718	10.583545	6.316793	18.83371	81.16829	109.16885	0.83335	3.216731
SB4VS-41ccc	ccc	A69	1	17	17.66702	8.916845	11.933572	19.16705	51.83437	123.16913	0.83335	7.316813
SB4VS-47	quenched	A54	1	18	18.3337	9.50019	6.850137	19.00038	57.00114	117.83569	0.83335	0.83335
Soln Std		STD-B1-3	1	19	3.79	18.5	3.5	9.58	81.8	47.7	0.5	0.5
Soln Std		STD-B2-1	2	1	3.69	20.6	3.92	9.83	83.1	49	0.5	0.5
SB4VS-43ccc	ccc	A26	2	2	26.6672	12.650253	6.83347	19.50039	86.6684	112.33558	0.83335	2.83339
SB4VS-47	quenched	A67	2	3	18.83371	11.416895	7.583485	19.83373	59.16785	121.83577	0.83335	3.716741
SB4VS-41	quenched	A82	2	4	19.00038	10.600212	15.183637	20.33374	58.50117	129.83593	0.83335	6.266792
SB4VS-37	quenched	A24	2	5	21.83377	10.416875	7.400148	18.66704	53.50107	114.16895	0.83335	3.966746
EA		A60	2	6	0.833335	595.00119	0.833335	176.66702	1641.66995	851.66837	8.33335	8.33335
SB4VS-48	quenched	A48	2	7	21.16709	11.083555	6.266792	18.83371	65.50131	112.33558	0.83335	3.183397
SB4VS-43	quenched	A34	2	8	25.83385	11.416895	7.583485	17.66702	85.33504	108.16883	0.83335	3.00006

Table D2. PSAL Measurements of the PCT Solutions for the Study Glasses After Appropriate Adjustments (continued)

Glass ID	Heat Treatment	Laboratory ID	Block	Seq	Al (ppm)	B (ppm)	Fe (ppm)	Li (ppm)	Na (ppm)	Si (ppm)	Th (ppm)	U (ppm)
Soln Std		STD-B2-2	2	9	3.68	19.9	3.94	9.85	83.1	49.4	0.5	0.5
SB4VS-38	quenched	A41	2	10	23.50047	9.716861	4.966766	17.00034	54.50109	101.83537	0.83335	2.533384
SB4VS-36ccc	ccc	A47	2	11	23.3338	11.350227	6.433462	19.00038	78.16823	110.33554	0.83335	2.916725
SB4VS-38ccc	ccc	A79	2	12	25.0005	10.083535	4.633426	18.3337	58.16783	104.33542	0.83335	2.750055
SB4VS-48ccc	ccc	A51	2	13	21.00042	10.266872	5.733448	18.00036	62.50125	110.66888	0.83335	2.816723
SB4VS-47ccc	ccc	A28	2	14	18.50037	10.650213	6.383461	19.00038	58.16783	117.33568	0.83335	3.566738
SB4VS-41ccc	ccc	A04	2	15	17.00034	9.400188	12.250245	18.66704	51.33436	118.00236	0.83335	6.066788
SB4VS-37ccc	ccc	A10	2	16	22.00044	10.183537	7.116809	18.66704	53.16773	113.50227	0.83335	4.200084
SB4VS-36	quenched	A11	2	17	24.00048	11.983573	7.133476	18.66704	86.33506	113.50227	0.83335	2.83339
Soln Std		STD-B2-3	2	18	3.75	19.8	3.89	9.89	84.4	49.2	0.5	0.5
Soln Std		STD-B3-1	3	1	3.98	21	4.1	10	81.6	50.3	0.5	0.5
SB4VS-36	quenched	A03	3	2	23.50047	13.350267	6.33346	18.66704	93.50187	113.50227	0.83335	2.683387
SB4VS-36ccc	ccc	A64	3	3	23.83381	12.616919	7.016807	19.33372	77.66822	115.16897	0.83335	2.883391
SB4VS-48ccc	ccc	A45	3	4	21.50043	11.750235	7.16681	18.66704	60.50121	116.16899	0.83335	2.800056
SB4VS-43	quenched	A01	3	5	25.16717	11.983573	7.383481	17.66702	80.83495	110.50221	0.83335	2.83339
SB4VS-41ccc	ccc	A56	3	6	17.33368	10.400208	12.83359	18.83371	49.16765	122.00244	0.83335	5.916785
EA		A65	3	7	2.7166721	616.6679	0.833335	188.33371	1633.3366	898.33513	8.33335	8.33335
SB4VS-37ccc	ccc	A76	3	8	21.83377	11.50023	7.450149	18.83371	50.50101	117.00234	0.83335	4.33342
Soln Std		STD-B3-2	3	9	3.92	20.2	4	10	80.9	50.1	0.5	0.5
SB4VS-48	quenched	A46	3	10	21.00042	11.966906	6.116789	18.83371	61.50123	115.16897	0.83335	2.83339
SB4VS-47ccc	ccc	A75	3	11	18.00036	11.400228	6.633466	18.83371	54.66776	119.00238	0.83335	3.416735
SB4VS-38	quenched	A52	3	12	23.3338	10.066868	5.366774	16.667	52.66772	99.50199	0.83335	2.566718
SB4VS-47	quenched	A72	3	13	18.00036	11.150223	7.250145	19.50039	55.66778	119.50239	0.83335	3.733408
SB4VS-43ccc	ccc	A62	3	14	25.83385	12.133576	7.200144	19.33372	79.50159	113.3356	0.83335	0.83335
SB4VS-41	quenched	A33	3	15	17.33368	10.516877	13.383601	19.66706	52.33438	125.0025	0.83335	0.83335
SB4VS-38ccc	ccc	A17	3	16	24.00048	10.183537	5.266772	18.16703	53.66774	104.50209	0.83335	2.700054
SB4VS-37	quenched	A20	3	17	21.6671	10.966886	7.366814	18.83371	51.33436	117.00234	0.83335	3.733408
Soln Std		STD-B3-3	3	18	3.96	20.1	4.04	10	80.8	50.3	0.5	0.5
Soln Std		STD-B4-1	4	1	3.87	20.4	3.89	9.78	81.7	50.1	0.5	0.5

Table D2. PSAL Measurements of the PCT Solutions for the Study Glasses After Appropriate Adjustments (continued)

Glass ID	Heat Treatment	Laboratory ID	Block	Seq	Al (ppm)	B (ppm)	Fe (ppm)	Li (ppm)	Na (ppm)	Si (ppm)	Th (ppm)	U (ppm)
SB4VS-39ccc	ccc	A50	4	2	24.33382	10.66688	5.816783	17.33368	57.50115	105.66878	0.83335	3.700074
SB4VS-40	quenched	A05	4	3	21.6671	10.283539	4.966766	17.33368	63.50127	108.00216	0.83335	2.900058
SB4VS-39	quenched	A83	4	4	24.50049	9.983533	5.133436	17.00034	58.83451	105.16877	0.83335	2.766722
SB4VS-44ccc	ccc	A37	4	5	17.00034	11.083555	7.00014	19.66706	52.00104	122.00244	0.83335	3.700074
ARM-1		A36	4	6	4.883431	21.83377	0.083335	16.516997	43.3342	71.50143	0.83335	0.83335
SB4VS-46ccc	ccc	A81	4	7	15.850317	10.933552	7.883491	20.50041	51.6677	125.83585	0.83335	4.083415
SB4VS-44	quenched	A57	4	8	15.966986	9.933532	6.416795	18.00036	51.00102	112.33558	0.83335	3.516737
Soln Std		STD-B4-2	4	9	3.99	20.2	4.07	10	83.4	50.9	0.5	0.5
SB4VS-42ccc	ccc	A32	4	10	16.16699	11.6669	7.800156	20.16707	59.66786	126.6692	0.83335	3.933412
SB4VS-40ccc	ccc	A29	4	11	22.66712	10.16687	4.966766	17.33368	65.83465	108.50217	0.83335	3.016727
SB4VS-45ccc	ccc	A39	4	12	19.50039	9.800196	5.050101	17.66702	50.83435	106.6688	0.83335	2.916725
SB4VS-45	quenched	A08	4	13	19.50039	9.350187	5.116769	17.16701	51.50103	104.16875	0.83335	3.150063
SB4VS-46	quenched	A66	4	14	15.633646	10.533544	7.816823	19.66706	51.00102	122.50245	0.83335	4.133416
SB4VS-42	quenched	A18	4	15	16.550331	11.283559	7.583485	20.50041	61.83457	128.3359	0.83335	3.983413
Soln Std		STD-B4-3	4	16	3.96	19.8	3.86	10	84.6	50.2	0.5	0.5
Soln Std		STD-B5-1	5	1	4.06	20.7	4.2	10	83	50.3	0.5	0.5
SB4VS-40ccc	ccc	A38	5	2	22.33378	11.050221	5.633446	17.50035	62.66792	108.3355	0.83335	3.033394
SB4VS-46ccc	ccc	A73	5	3	16.250325	11.783569	8.650173	20.66708	52.16771	128.3359	0.83335	4.133416
SB4VS-42	quenched	A85	5	4	16.566998	11.316893	8.816843	20.0004	60.33454	124.33582	0.83335	3.916745
SB4VS-39	quenched	A21	5	5	24.83383	10.283539	5.316773	17.33368	60.50121	105.16877	0.83335	2.966726
SB4VS-39ccc	ccc	A59	5	6	24.66716	10.33354	5.650113	17.66702	58.00116	105.50211	0.83335	2.933392
ARM-1		A15	5	7	5.150103	21.33376	0.083335	16.233658	42.83419	69.16805	0.83335	0.83335
SB4VS-44	quenched	A49	5	8	16.83367	10.783549	7.133476	19.00038	52.66772	116.83567	0.83335	3.700074
Soln Std		STD-B5-2	5	9	4.04	19.7	4.11	9.84	82.3	49.7	0.5	0.5
SB4VS-40	quenched	A58	5	10	21.50043	10.116869	6.216791	16.350327	62.50125	102.16871	0.83335	3.600072
SB4VS-46	quenched	A61	5	11	15.216971	10.366874	8.283499	18.66704	48.66764	116.00232	0.83335	4.250085
SB4VS-45	quenched	A40	5	12	19.50039	9.600192	5.250105	17.33368	50.33434	105.0021	0.83335	3.16673
SB4VS-45ccc	ccc	A35	5	13	20.16707	9.866864	5.700114	18.16703	50.83435	106.83547	0.83335	3.083395
SB4VS-42ccc	ccc	A55	5	14	16.050321	10.850217	7.633486	20.0004	58.16783	122.83579	0.83335	3.816743

Table D2. PSAL Measurements of the PCT Solutions for the Study Glasses After Appropriate Adjustments (continued)

Glass ID	Heat Treatment	Laboratory ID	Block	Seq	Al (ppm)	B (ppm)	Fe (ppm)	Li (ppm)	Na (ppm)	Si (ppm)	Th (ppm)	U (ppm)
SB4VS-44ccc	ccc	A13	5	15	16.667	10.466876	6.600132	19.00038	51.16769	114.00228	0.83335	3.583405
Soln Std		STD-B5-3	5	16	4.05	19.2	3.91	9.76	82.8	48.4	0.5	0.5
Soln Std		STD-B6-1	6	1	4.07	20.8	3.69	9.91	82.2	49.9	0.5	0.5
SB4VS-40	quenched	A74	6	2	21.50043	10.800216	5.483443	16.550331	62.16791	103.66874	0.83335	3.566738
SB4VS-45	quenched	A63	6	3	19.83373	10.416875	4.733428	17.33368	49.66766	106.00212	0.83335	3.316733
SB4VS-42	quenched	A07	6	4	15.283639	10.866884	7.016807	18.83371	57.16781	115.83565	0.83335	3.616739
ARM-1		A30	6	5	5.300106	18.16703	0.083335	14.66696	39.66746	64.00128	0.83335	0.83335
SB4VS-46	quenched	A09	6	6	15.33364	11.00022	7.583485	19.50039	49.66766	120.66908	0.83335	4.200084
SB4VS-44	quenched	A22	6	7	17.00034	11.033554	6.616799	19.16705	52.00104	118.16903	0.83335	3.933412
SB4VS-42ccc	ccc	A12	6	8	15.483643	10.816883	6.33346	19.16705	56.50113	118.66904	0.83335	3.866744
Soln Std		STD-B6-2	6	9	4.39	19.9	3.9	9.71	79.8	49.6	0.5	0.5
SB4VS-39	quenched	A31	6	10	24.83383	10.816883	4.433422	17.00034	60.16787	104.66876	0.83335	3.200064
SB4VS-45ccc	ccc	A16	6	11	20.0004	10.366874	4.766762	18.00036	53.00106	108.16883	0.83335	3.033394
SB4VS-40ccc	ccc	A42	6	12	22.16711	10.150203	4.700094	17.16701	62.66792	105.83545	0.83335	3.150063
SB4VS-39ccc	ccc	A80	6	13	24.50049	10.316873	4.616759	17.50035	57.33448	104.50209	0.83335	2.983393
SB4VS-46ccc	ccc	A78	6	14	16.150323	11.283559	7.016807	20.33374	52.50105	125.50251	0.83335	4.383421
blank		A86	6	15	0.083335	0.083335	0.083335	0.416675	0.083335	0.083335	0.83335	0.83335
SB4VS-44ccc	ccc	A68	6	16	17.00034	11.083555	6.400128	19.50039	52.16771	118.3357	0.83335	3.800076
Soln Std		STD-B6-3	6	17	4.11	20.2	3.85	9.99	85	50.6	0.5	0.5

Exhibit D1. Laboratory PCT Measurements in Analytical Sequence for Study Glasses, EA, ARM, Blanks, and Solution Standards

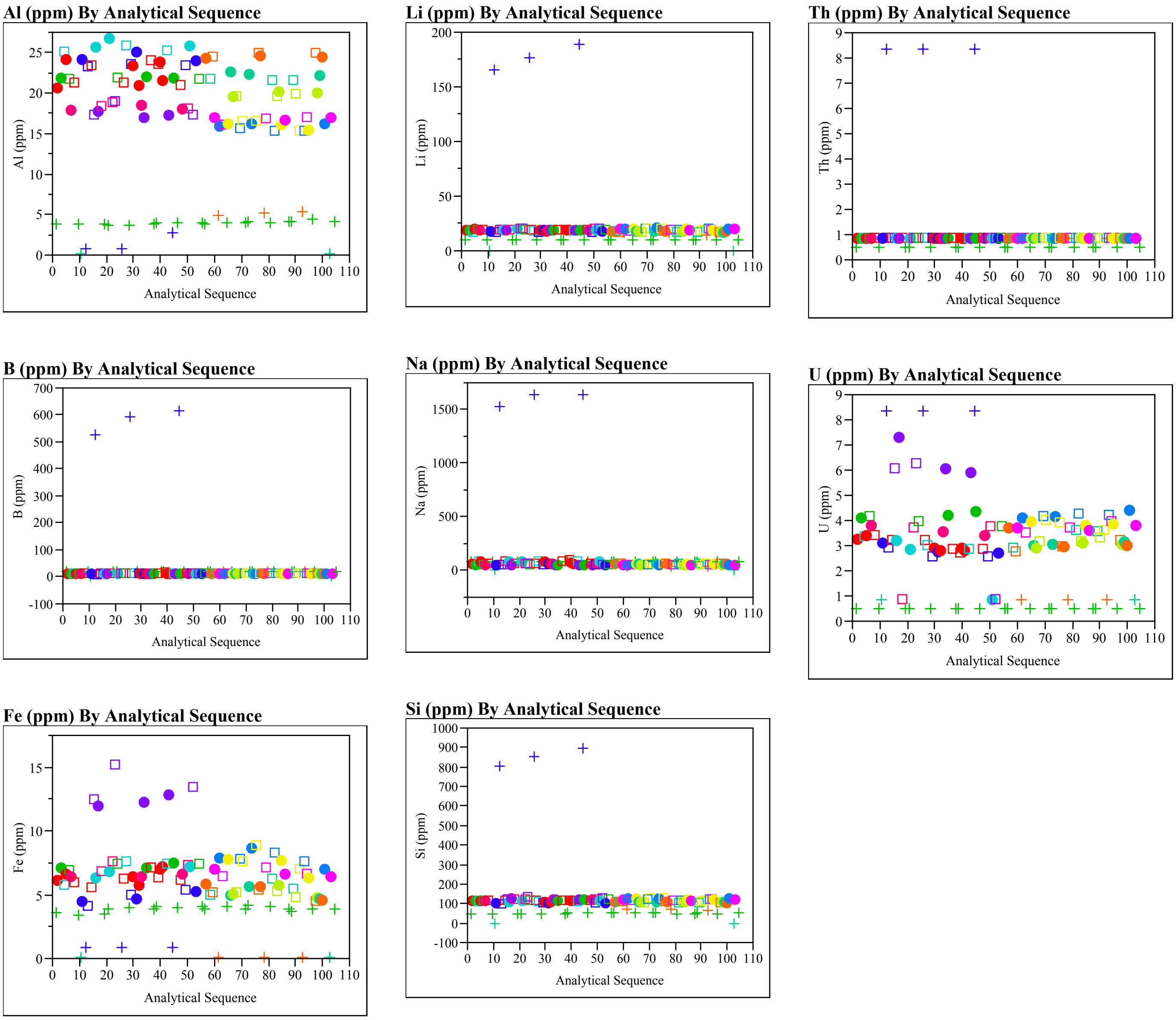


Exhibit D2. Laboratory PCT Measurements in Analytical Sequence for Study Glasses

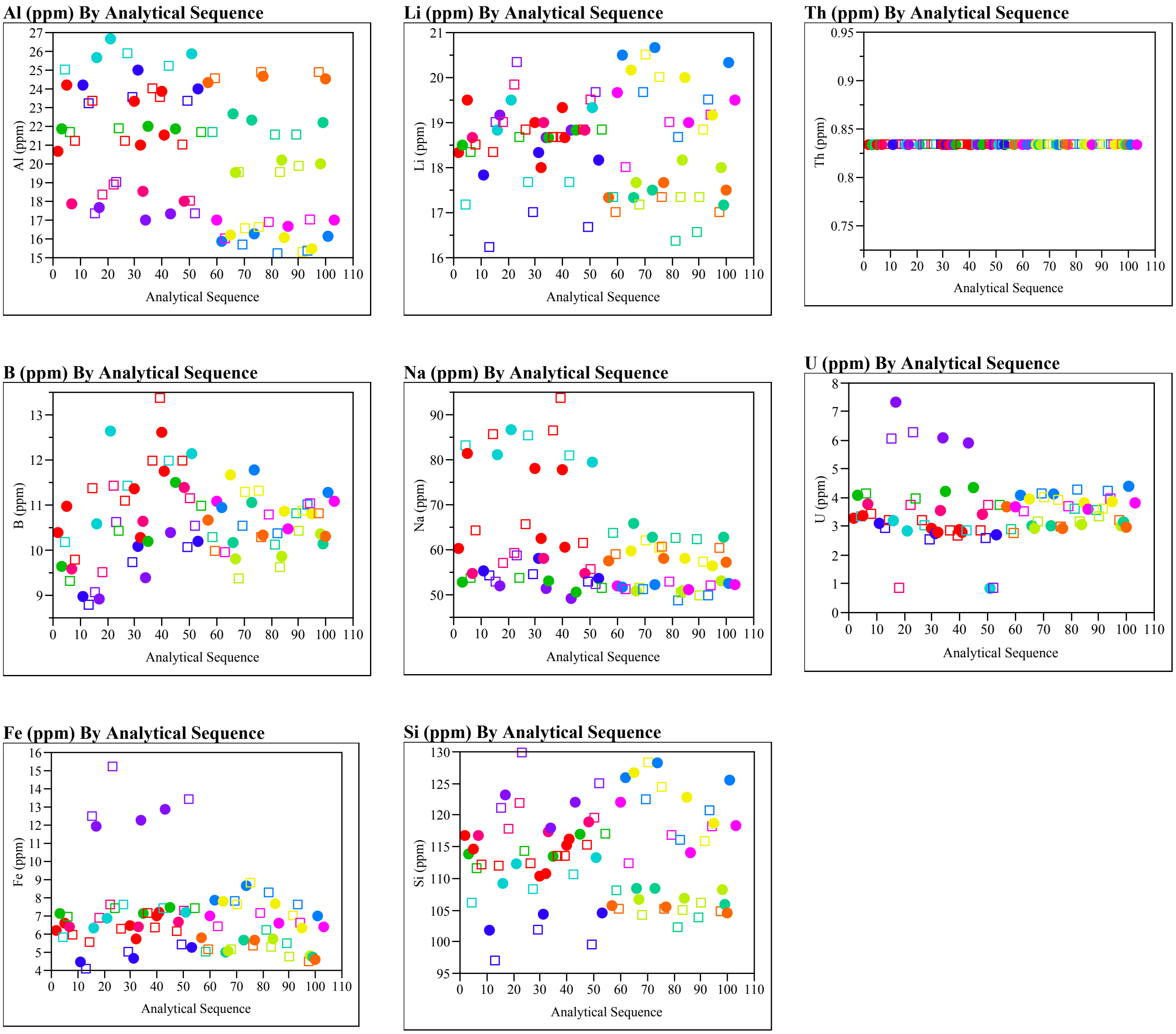
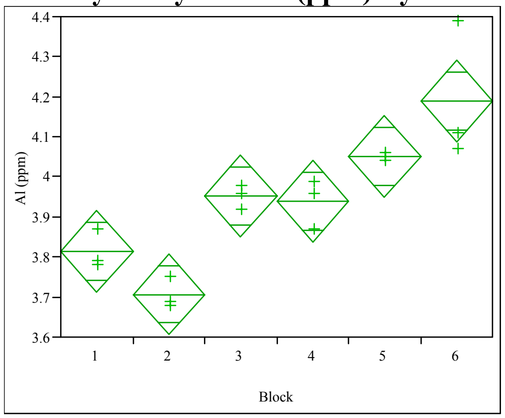


Exhibit D3. Measurements of the Multi-Element Solution Standard by ICP Block

Oneway Analysis of Al (ppm) By Block



Oneway Anova
Summary of Fit

Rsquare	0.847504
Adj Rsquare	0.783964
Root Mean Square Error	0.080829
Mean of Response	3.942222
Observations (or Sum Wgts)	18

Analysis of Variance

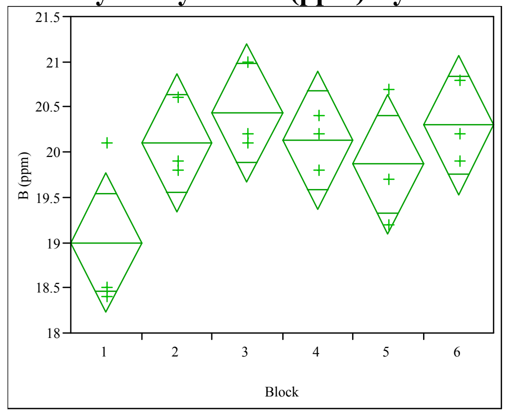
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block	5	0.43571111	0.087142	13.3381	0.0001
Error	12	0.07840000	0.006533		
C. Total	17	0.51411111			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1	3	3.81333	0.04667	3.7117	3.9150
2	3	3.70667	0.04667	3.6050	3.8083
3	3	3.95333	0.04667	3.8517	4.0550
4	3	3.94000	0.04667	3.8383	4.0417
5	3	4.05000	0.04667	3.9483	4.1517
6	3	4.19000	0.04667	4.0883	4.2917

Std Error uses a pooled estimate of error variance

Oneway Analysis of B (ppm) By Block



Oneway Anova
Summary of Fit

Rsquare	0.470064
Adj Rsquare	0.249257
Root Mean Square Error	0.609645
Mean of Response	19.97222
Observations (or Sum Wgts)	18

Analysis of Variance

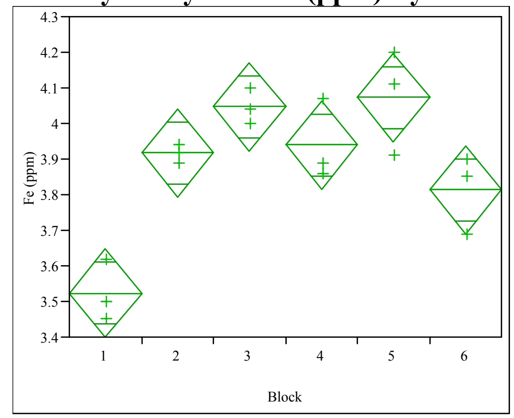
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block	5	3.9561111	0.791222	2.1288	0.1316
Error	12	4.4600000	0.371667		
C. Total	17	8.4161111			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1	3	19.0000	0.35198	18.233	19.767
2	3	20.1000	0.35198	19.333	20.867
3	3	20.4333	0.35198	19.666	21.200
4	3	20.1333	0.35198	19.366	20.900
5	3	19.8667	0.35198	19.100	20.634
6	3	20.3000	0.35198	19.533	21.067

Std Error uses a pooled estimate of error variance

Oneway Analysis of Fe (ppm) By Block



Oneway Anova
Summary of Fit

Rsquare	0.839591
Adj Rsquare	0.772755
Root Mean Square Error	0.098121
Mean of Response	3.885556
Observations (or Sum Wgts)	18

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block	5	0.60471111	0.120942	12.5618	0.0002
Error	12	0.11553333	0.009628		
C. Total	17	0.72024444			

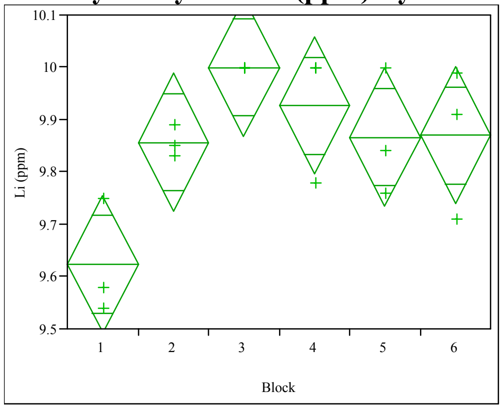
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1	3	3.52333	0.05665	3.3999	3.6468
2	3	3.91667	0.05665	3.7932	4.0401
3	3	4.04667	0.05665	3.9232	4.1701
4	3	3.94000	0.05665	3.8166	4.0634
5	3	4.07333	0.05665	3.9499	4.1968
6	3	3.81333	0.05665	3.6899	3.9368

Std Error uses a pooled estimate of error variance

Exhibit D3. Measurements of the Multi-Element Solution Standard by ICP Block (continued)

Oneway Analysis of Li (ppm) By Block



Oneway Anova
Summary of Fit

Rsquare	0.648301
Adj Rsquare	0.50176
Root Mean Square Error	0.10427
Mean of Response	9.857222
Observations (or Sum Wgts)	18

Analysis of Variance

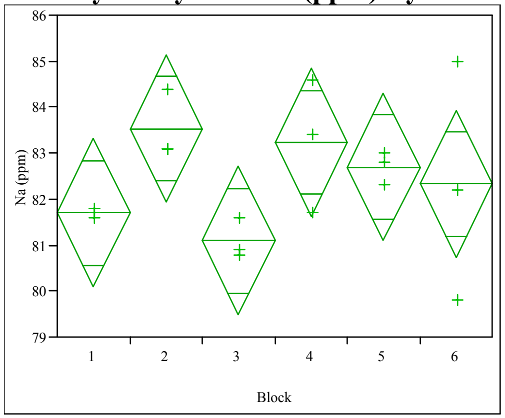
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block	5	0.24049444	0.048099	4.4240	0.0162
Error	12	0.13046667	0.010872		
C. Total	17	0.37096111			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1	3	9.6233	0.06020	9.4922	9.754
2	3	9.8567	0.06020	9.7255	9.988
3	3	10.0000	0.06020	9.8688	10.131
4	3	9.9267	0.06020	9.7955	10.058
5	3	9.8667	0.06020	9.7355	9.998
6	3	9.8700	0.06020	9.7388	10.001

Std Error uses a pooled estimate of error variance

Oneway Analysis of Na (ppm) By Block



Oneway Anova
Summary of Fit

Rsquare	0.394183
Adj Rsquare	0.141759
Root Mean Square Error	1.277367
Mean of Response	82.43333
Observations (or Sum Wgts)	18

Analysis of Variance

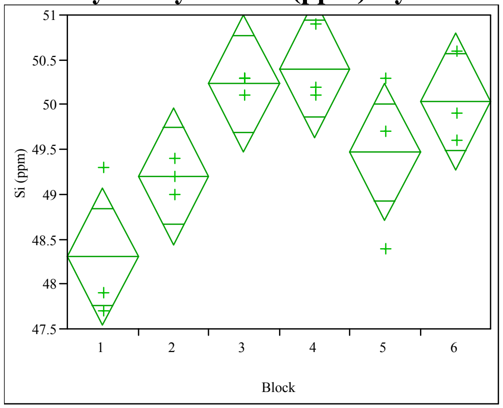
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block	5	12.740000	2.54800	1.5616	0.2438
Error	12	19.580000	1.63167		
C. Total	17	32.320000			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1	3	81.7000	0.73749	80.093	83.307
2	3	83.5333	0.73749	81.926	85.140
3	3	81.1000	0.73749	79.493	82.707
4	3	83.2333	0.73749	81.626	84.840
5	3	82.7000	0.73749	81.093	84.307
6	3	82.3333	0.73749	80.726	83.940

Std Error uses a pooled estimate of error variance

Oneway Analysis of Si (ppm) By Block



Oneway Anova
Summary of Fit

Rsquare	0.677595
Adj Rsquare	0.543259
Root Mean Square Error	0.606905
Mean of Response	49.60556
Observations (or Sum Wgts)	18

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block	5	9.289444	1.85789	5.0440	0.0101
Error	12	4.420000	0.36833		
C. Total	17	13.709444			

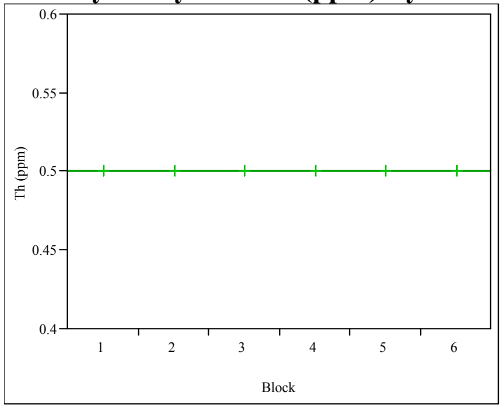
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1	3	48.3000	0.35040	47.537	49.063
2	3	49.2000	0.35040	48.437	49.963
3	3	50.2333	0.35040	49.470	50.997
4	3	50.4000	0.35040	49.637	51.163
5	3	49.4667	0.35040	48.703	50.230
6	3	50.0333	0.35040	49.270	50.797

Std Error uses a pooled estimate of error variance

Exhibit D3. Measurements of the Multi-Element Solution Standard by ICP Block (continued)

Oneway Analysis of Th (ppm) By Block



Oneway Anova
Summary of Fit

Rsquare	.
Adj Rsquare	.
Root Mean Square Error	0
Mean of Response	0.5
Observations (or Sum Wgts)	18

Analysis of Variance

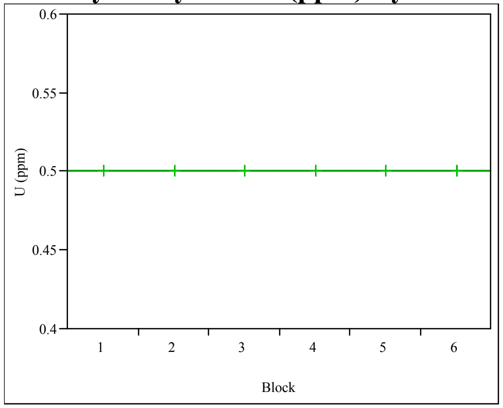
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block	5	0	0	.	.
Error	12	0	0		
C. Total	17	0			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1	3	0.500000	0	0.50000	0.50000
2	3	0.500000	0	0.50000	0.50000
3	3	0.500000	0	0.50000	0.50000
4	3	0.500000	0	0.50000	0.50000
5	3	0.500000	0	0.50000	0.50000
6	3	0.500000	0	0.50000	0.50000

Std Error uses a pooled estimate of error variance

Oneway Analysis of U (ppm) By Block



Oneway Anova
Summary of Fit

Rsquare	.
Adj Rsquare	.
Root Mean Square Error	0
Mean of Response	0.5
Observations (or Sum Wgts)	18

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block	5	0	0	.	.
Error	12	0	0		
C. Total	17	0			

Means for Oneway Anova

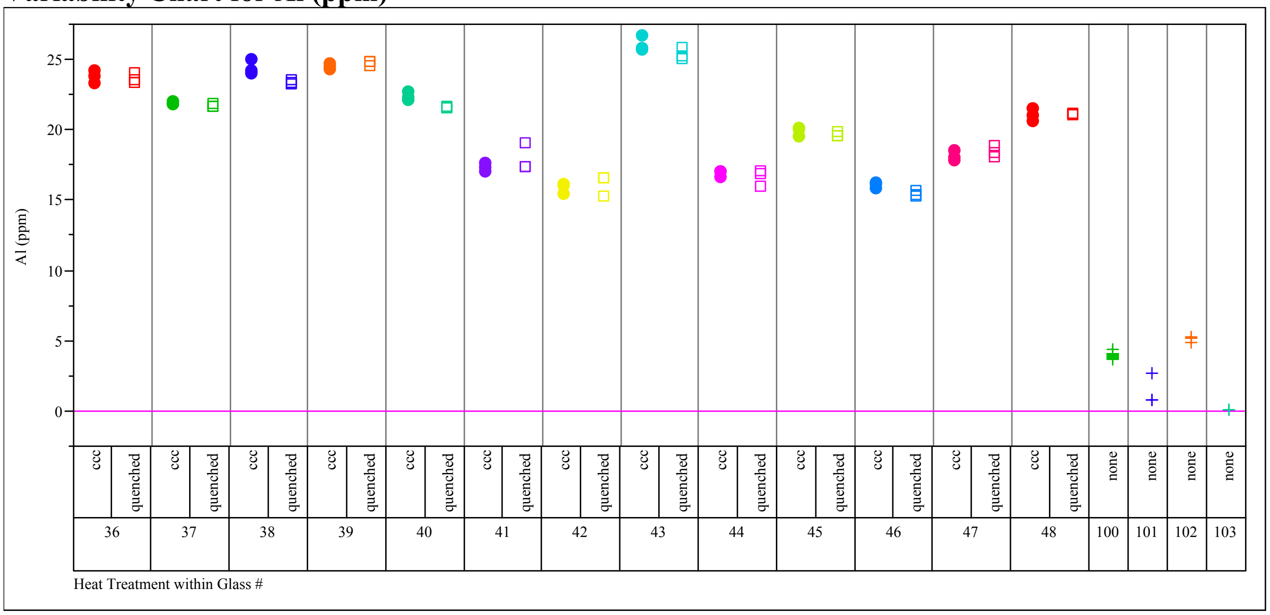
Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1	3	0.500000	0	0.50000	0.50000
2	3	0.500000	0	0.50000	0.50000
3	3	0.500000	0	0.50000	0.50000
4	3	0.500000	0	0.50000	0.50000
5	3	0.500000	0	0.50000	0.50000
6	3	0.500000	0	0.50000	0.50000

Std Error uses a pooled estimate of error variance

Exhibit D4. Laboratory PCT Measurements by Glass Number for Study Glasses and Standards

(100 – Solution Standard; 101 – EA; 102 – ARM; 103 – Blanks)

Variability Chart for Al (ppm)



Variability Chart for B (ppm)

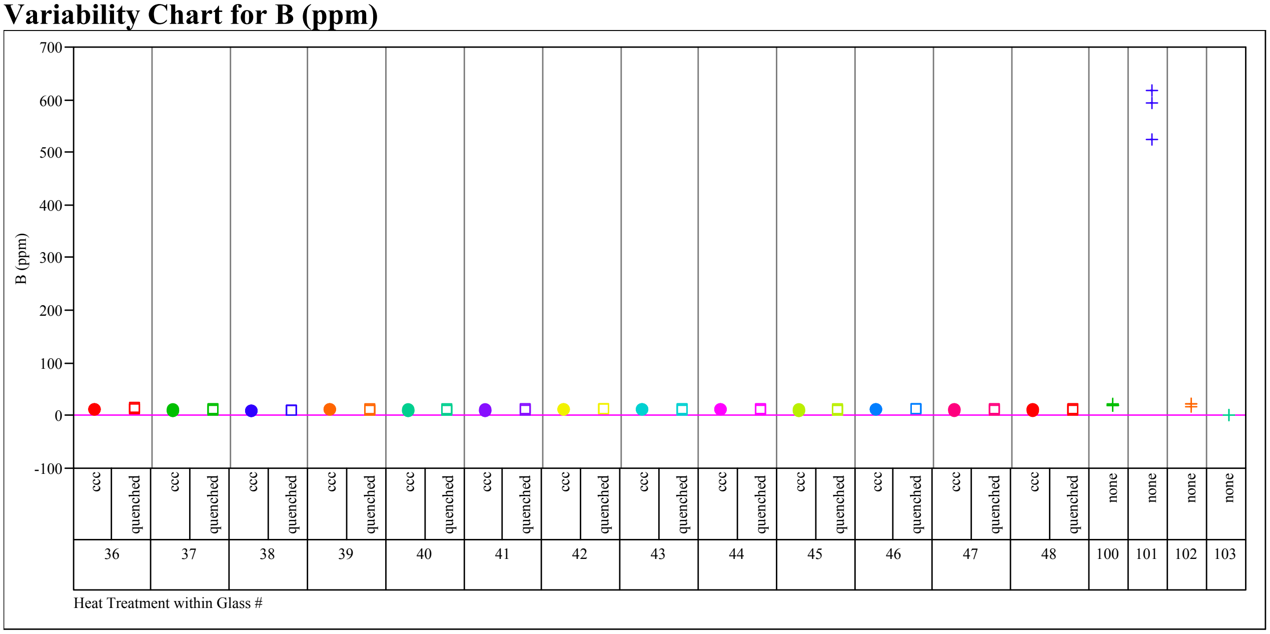
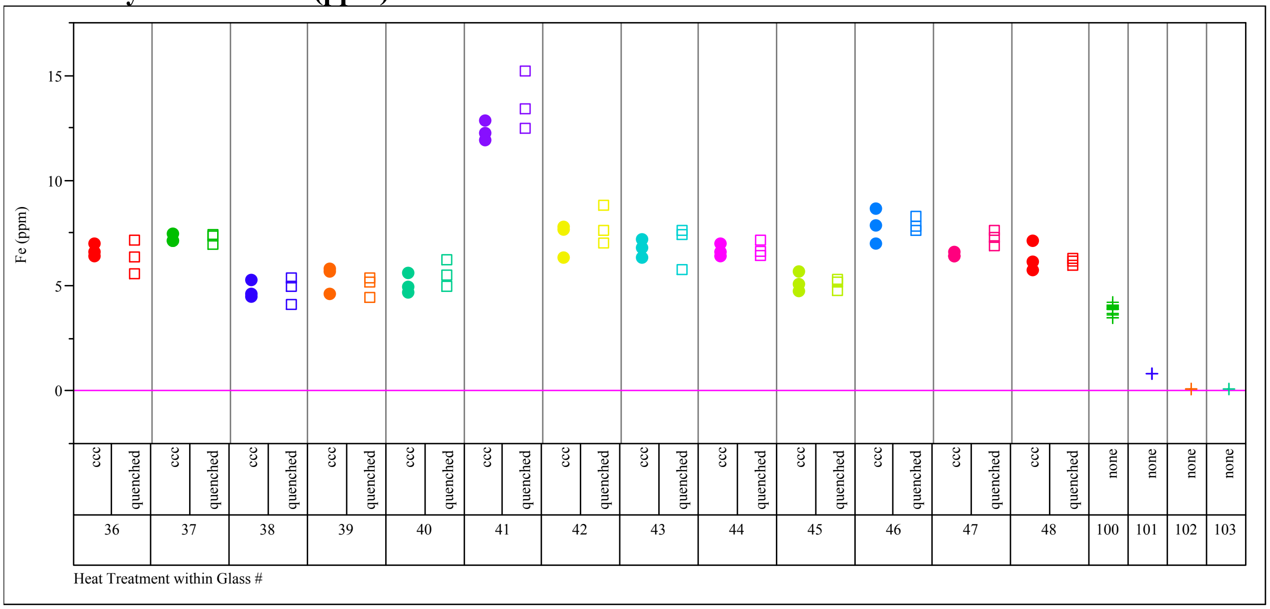


Exhibit D4. Laboratory PCT Measurements by Glass Number for Study Glasses and Standards (continued)
(100 – Solution Standard; 101 – EA; 102 – ARM; 103 – Blanks)

Variability Chart for Fe (ppm)



Variability Chart for Li (ppm)

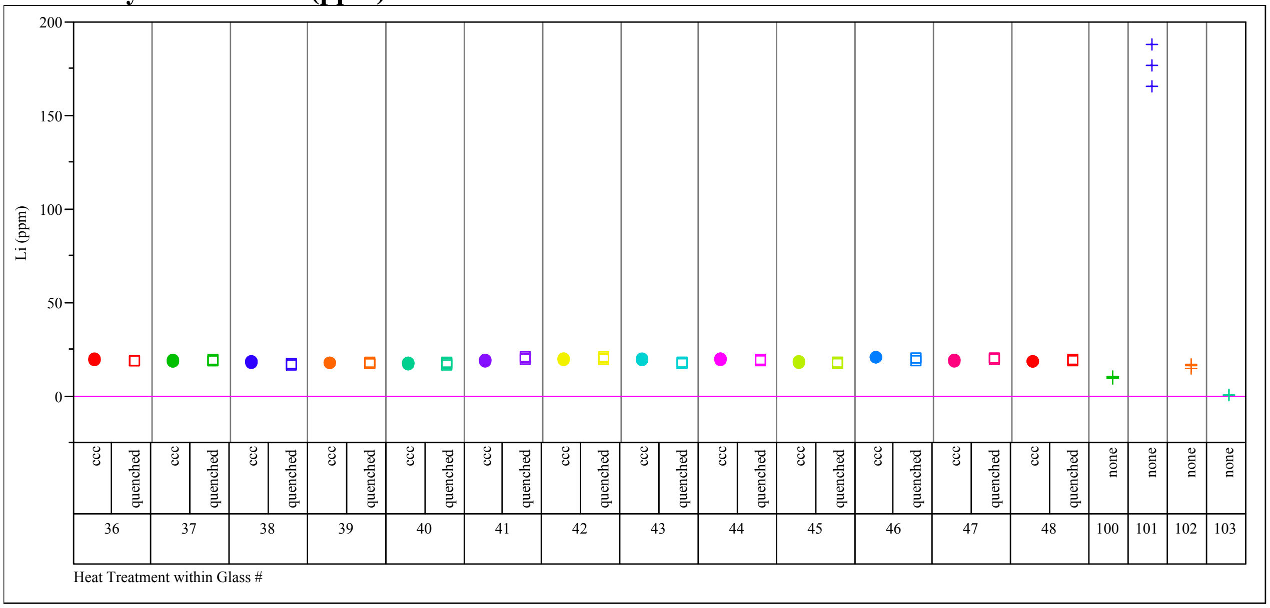
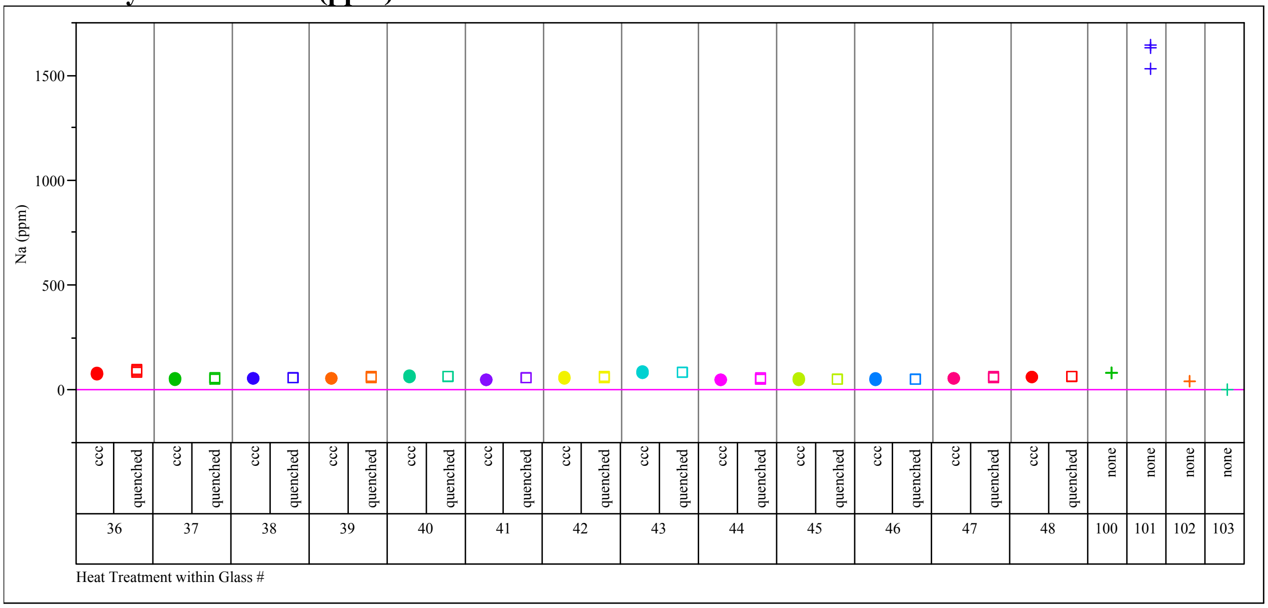


Exhibit D4. Laboratory PCT Measurements by Glass Number for Study Glasses and Standards (continued)
(100 – Solution Standard; 101 – EA; 102 – ARM; 103 – Blanks)

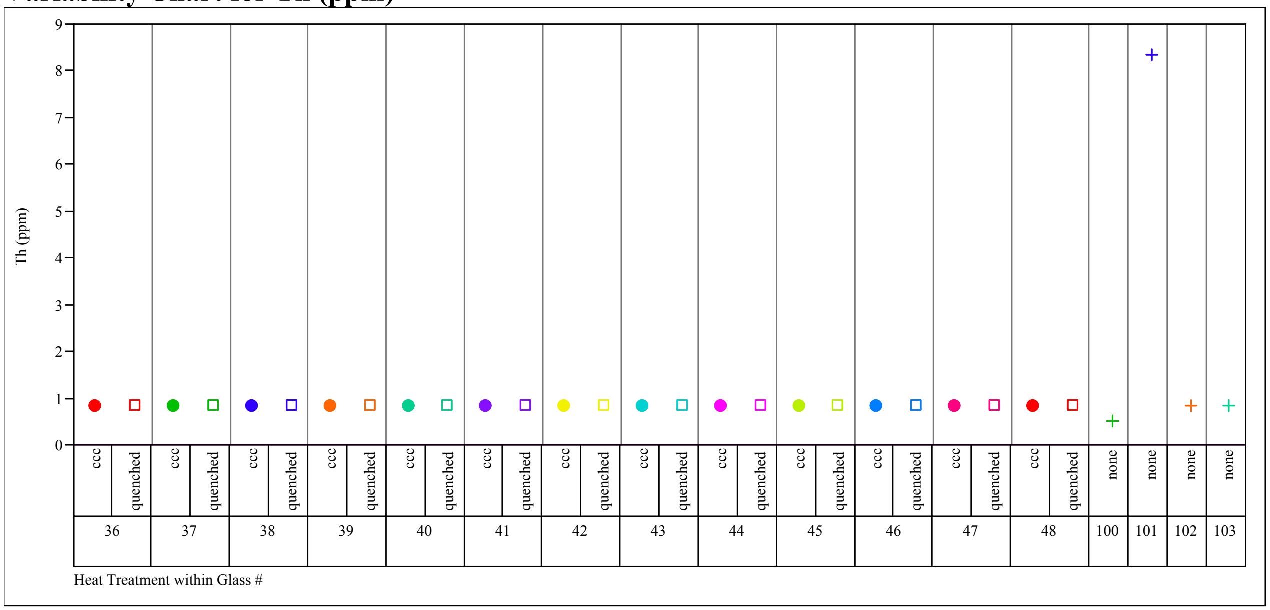
Variability Chart for Na (ppm)



Variability Chart for Si (ppm)

Exhibit D4. Laboratory PCT Measurements by Glass Number for Study Glasses and Standards (continued)
(100 – Solution Standard; 101 – EA; 102 – ARM; 103 – Blanks)

Variability Chart for Th (ppm)



Variability Chart for U (ppm)

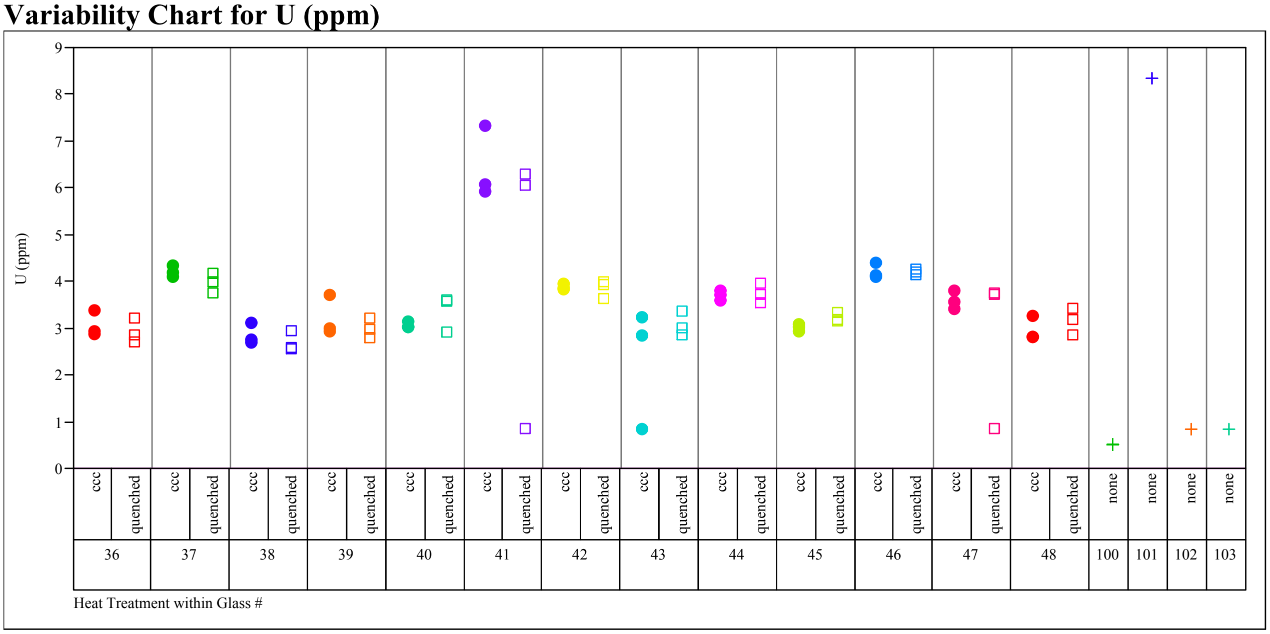
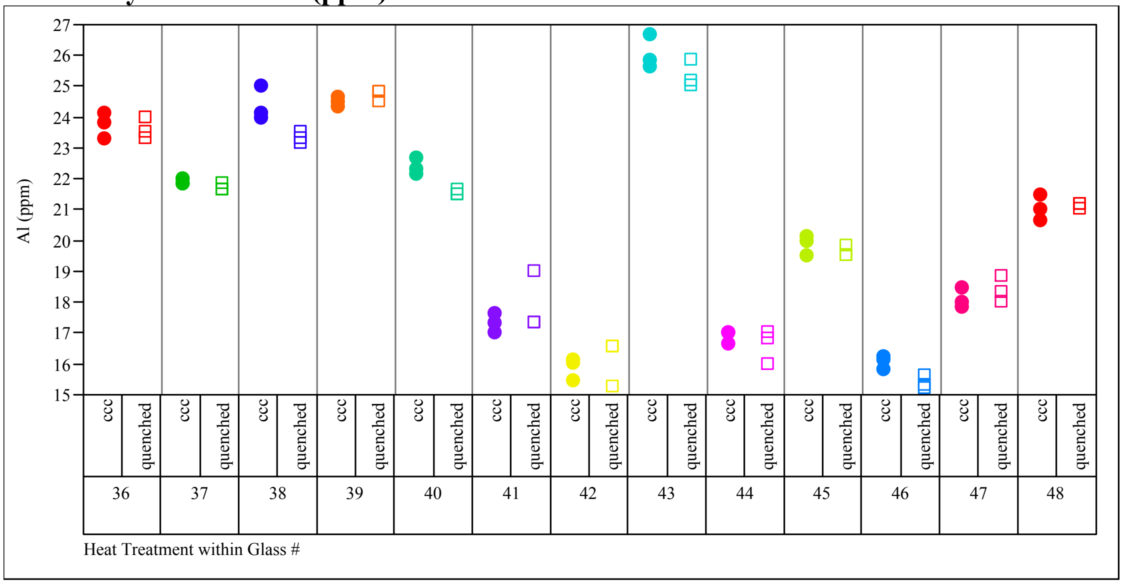


Exhibit D5. Laboratory PCT Measurements by Glass Number for Study Glasses

Variability Chart for Al (ppm)



Variability Chart for B (ppm)

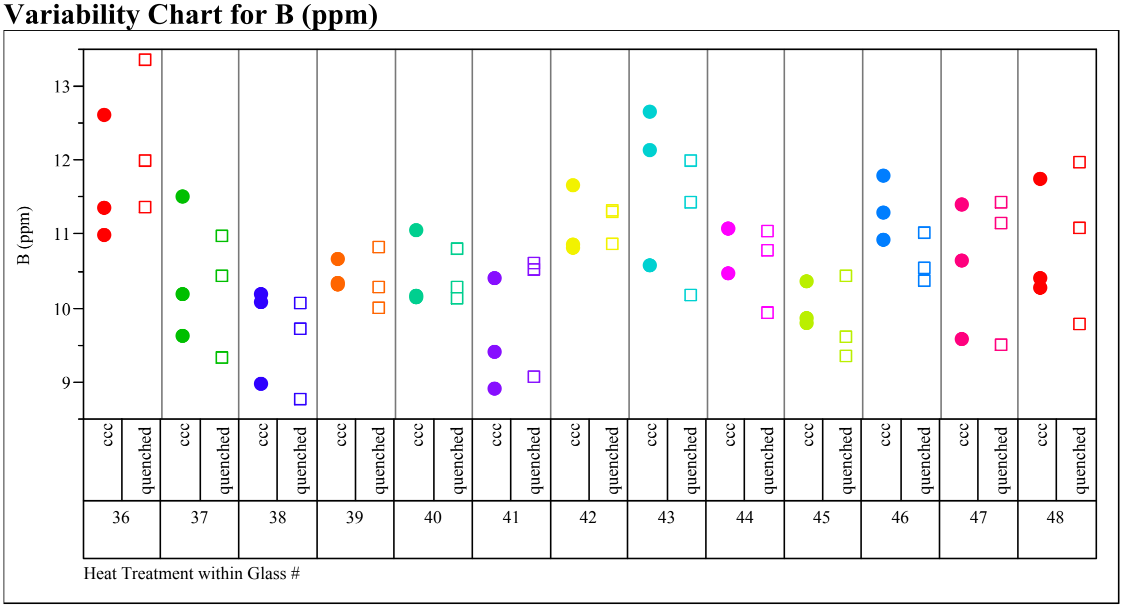
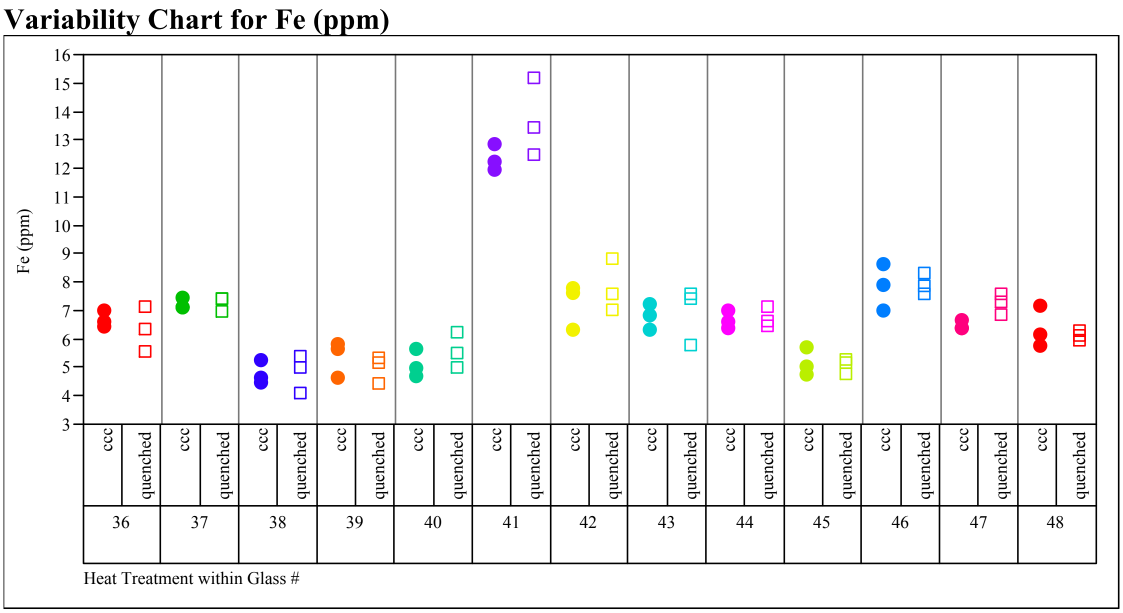


Exhibit D5. Laboratory PCT Measurements by Glass Number for Study Glasses
(continued)



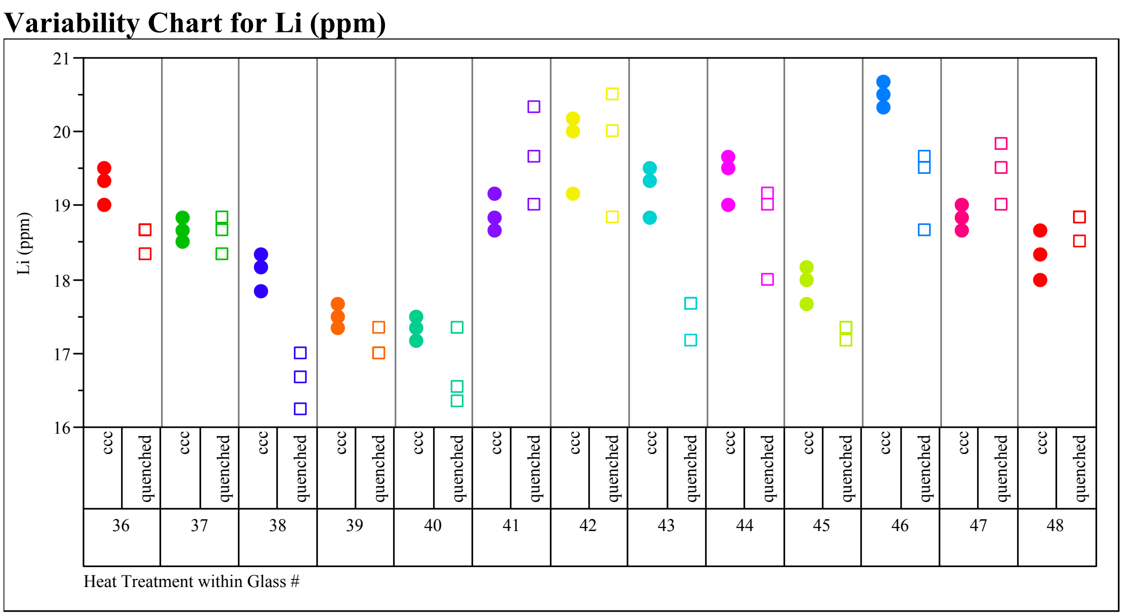
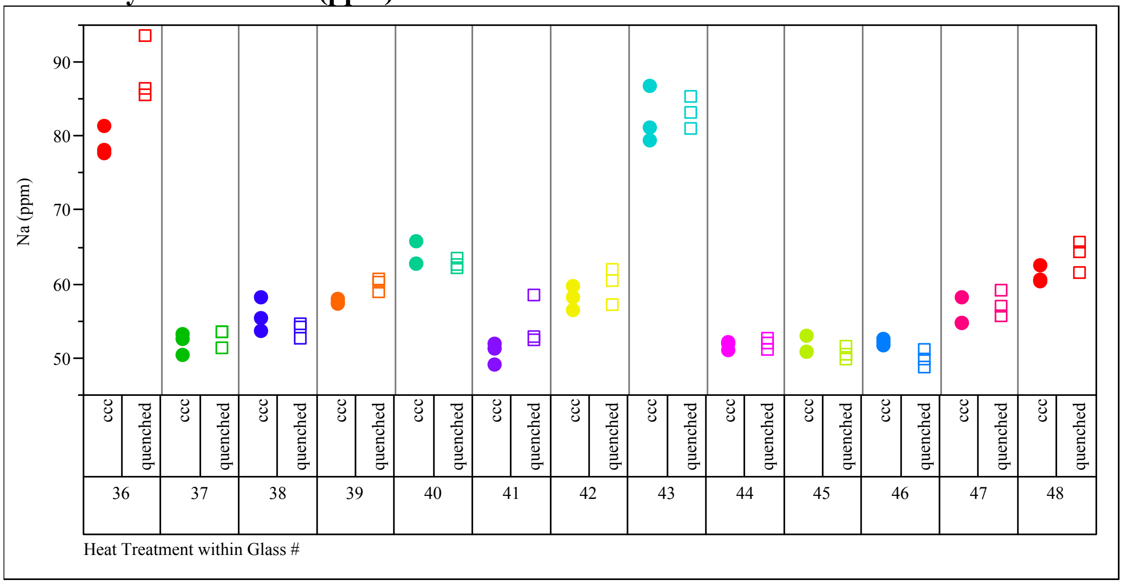


Exhibit D5. Laboratory PCT Measurements by Glass Number for Study Glasses
(continued)

Variability Chart for Na (ppm)



Variability Chart for Si (ppm)

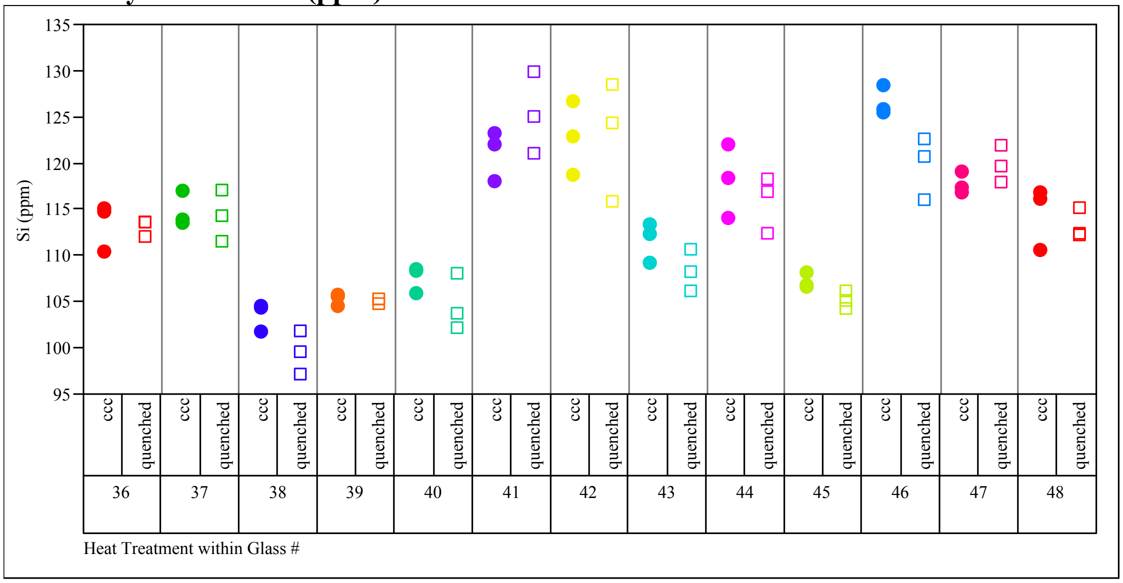
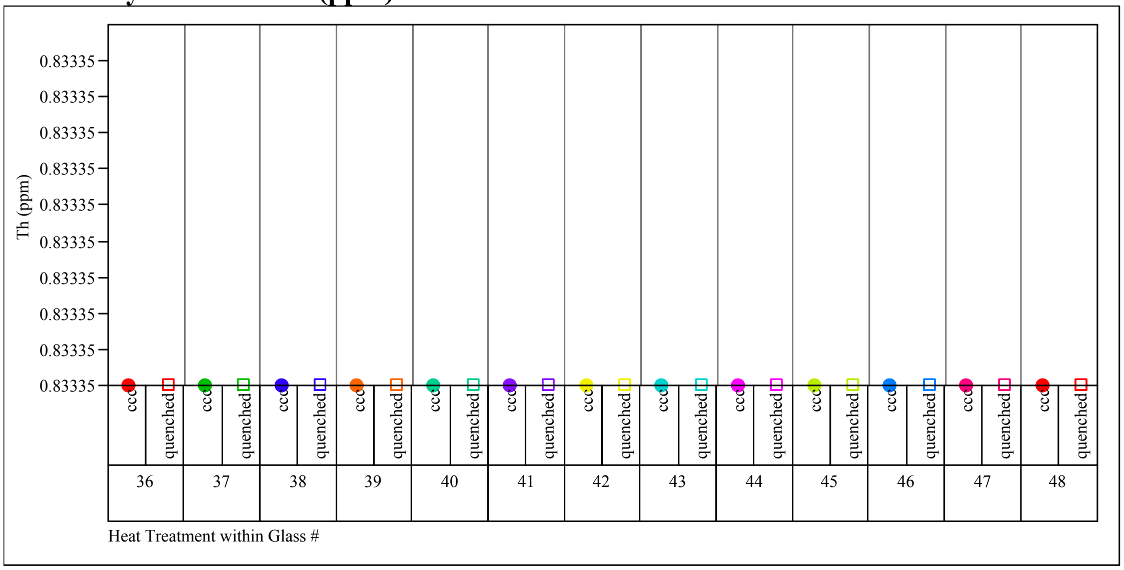


Exhibit D5. Laboratory PCT Measurements by Glass Number for Study Glasses
(continued)

Variability Chart for Th (ppm)



Variability Chart for U (ppm)

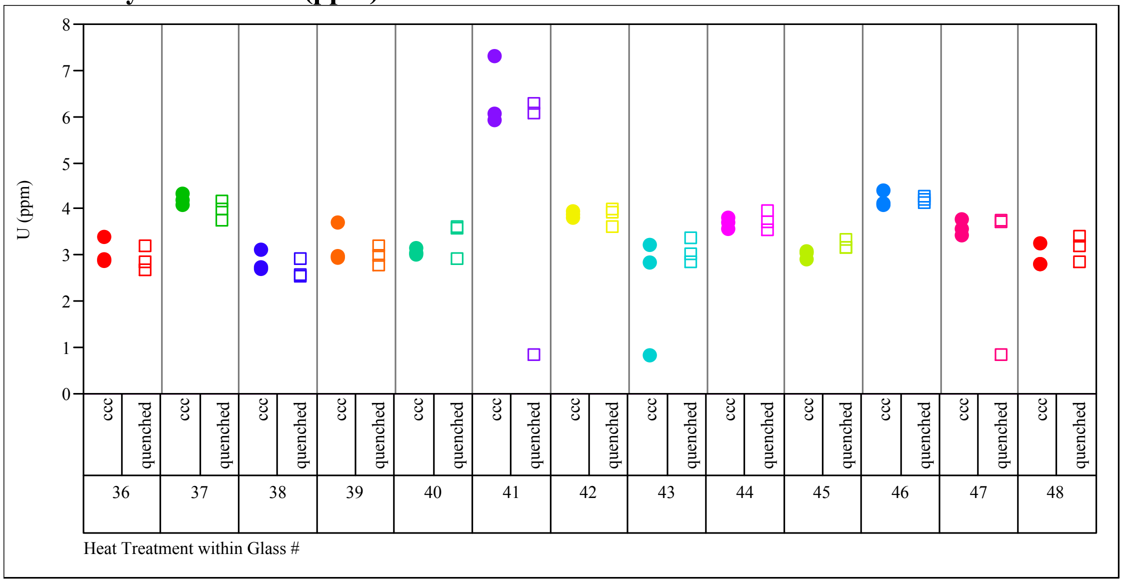


Exhibit D6. Correlations and Scatter Plots of Normalized PCTs Over All Compositional Views and Heat Treatments

Correlations

	log NL[B (g/L)]	log NL[Li (g/L)]	log NL[Na (g/L)]	log NL[Si (g/L)]
log NL[B (g/L)]	1.0000	0.9884	0.9846	0.9695
log NL[Li (g/L)]	0.9884	1.0000	0.9769	0.9831
log NL[Na (g/L)]	0.9846	0.9769	1.0000	0.9602
log NL[Si (g/L)]	0.9695	0.9831	0.9602	1.0000

Scatterplot Matrix

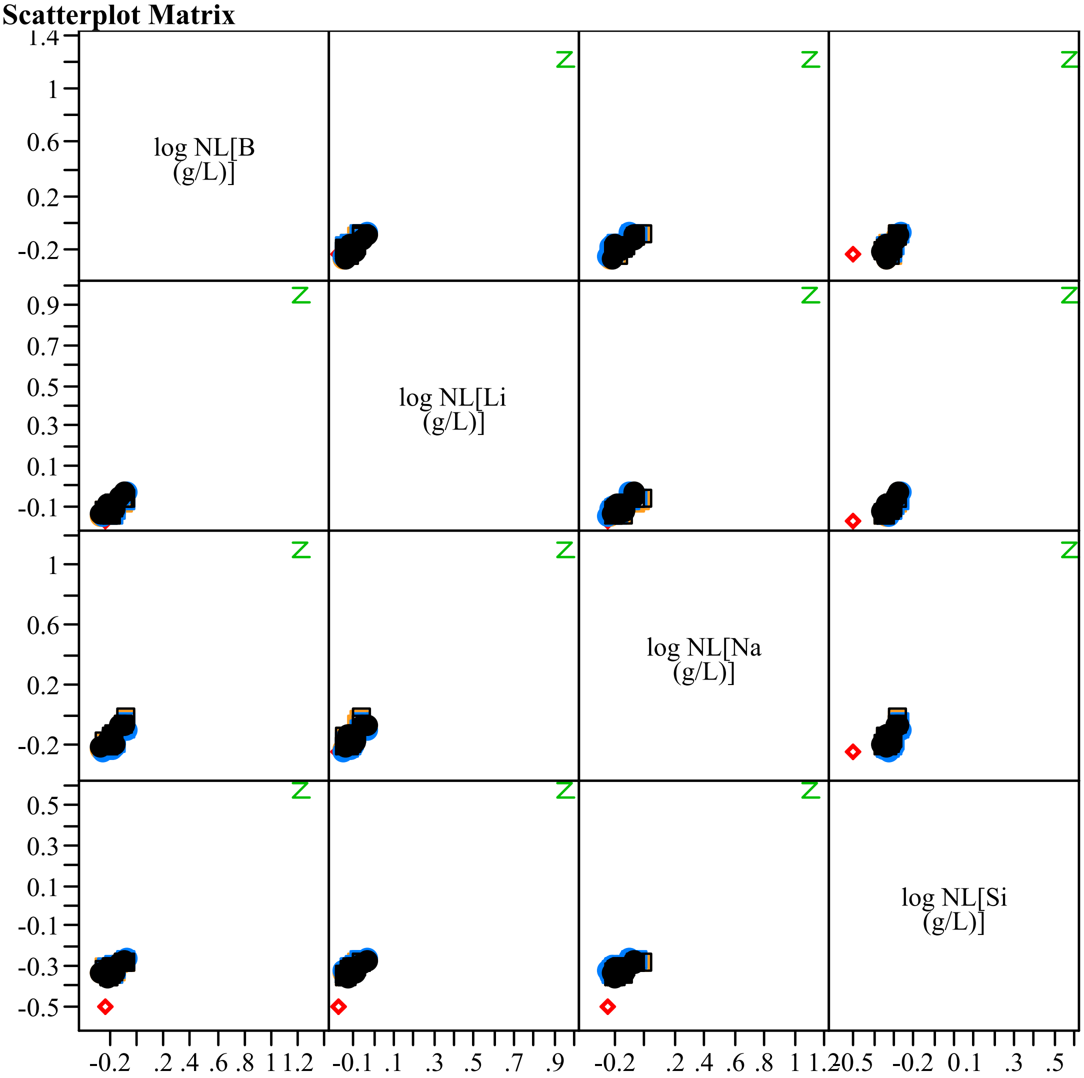
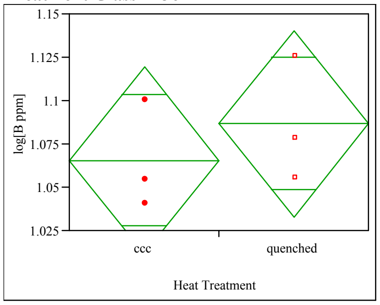


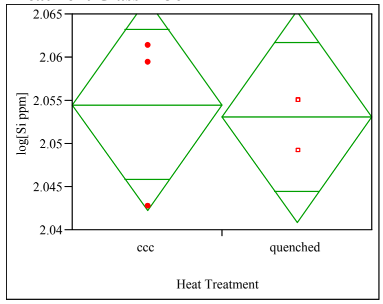
Exhibit D7. Effects of Heat Treatment on PCT log(ppm)-Response of Study Glasses

Oneway Analysis of log[B ppm] By Heat Treatment Glass #=36



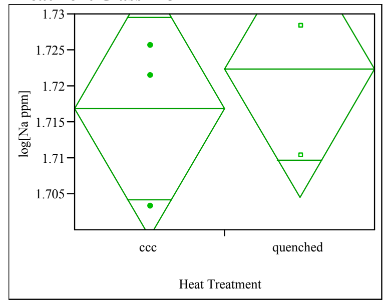
Difference	0.02101	t Ratio	0.765744
Std Err Dif	0.02743	DF	4
Upper CL Dif	0.09717	Prob > |t|	0.4865
Lower CL Dif	-0.05516	Prob > t	0.2433
Confidence	0.95	Prob < t	0.7567

Oneway Analysis of log[Si ppm] By Heat Treatment Glass #=36



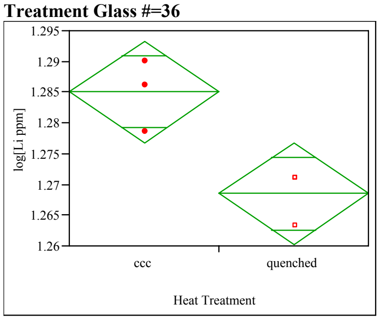
Difference	-0.00142	t Ratio	-0.22826
Std Err Dif	0.00622	DF	4
Upper CL Dif	0.01586	Prob > |t|	0.8306
Lower CL Dif	-0.01870	Prob > t	0.5847
Confidence	0.95	Prob < t	0.4153

Oneway Analysis of log[Na ppm] By Heat Treatment Glass #=37



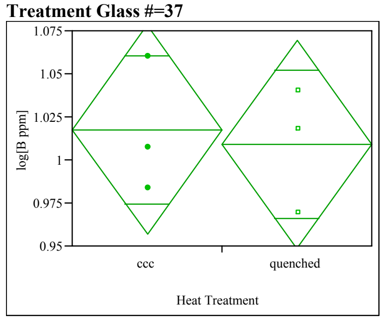
Difference	0.00555	t Ratio	0.60887
Std Err Dif	0.00911	DF	4
Upper CL Dif	0.03084	Prob > |t|	0.5755
Lower CL Dif	-0.01975	Prob > t	0.2877
Confidence	0.95	Prob < t	0.7123

Oneway Analysis of log[Li ppm] By Heat Treatment Glass #=36



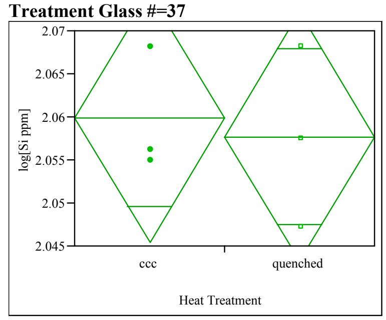
Difference	-0.01657	t Ratio	-3.92654
Std Err Dif	0.00422	DF	4
Upper CL Dif	-0.00485	Prob > |t|	0.0172
Lower CL Dif	-0.02829	Prob > t	0.9914
Confidence	0.95	Prob < t	0.0086

Oneway Analysis of log[B ppm] By Heat Treatment Glass #=37



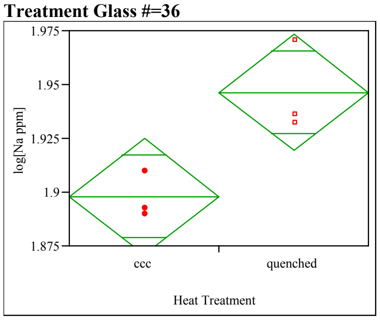
Difference	-0.00843	t Ratio	-0.27322
Std Err Dif	0.03087	DF	4
Upper CL Dif	0.07727	Prob > |t|	0.7982
Lower CL Dif	-0.09413	Prob > t	0.6009
Confidence	0.95	Prob < t	0.3991

Oneway Analysis of log[Si ppm] By Heat Treatment Glass #=37



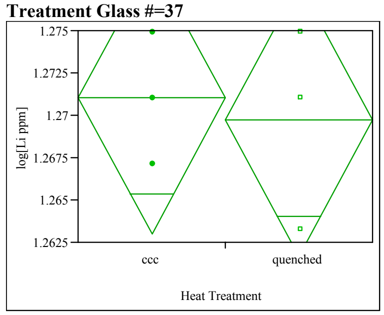
Difference	-0.00215	t Ratio	-0.29239
Std Err Dif	0.00735	DF	4
Upper CL Dif	0.01827	Prob > |t|	0.7845
Lower CL Dif	-0.02257	Prob > t	0.6077
Confidence	0.95	Prob < t	0.3923

Oneway Analysis of log[Na ppm] By Heat Treatment Glass #=36



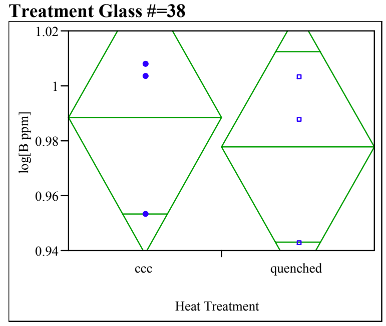
Difference	0.048477	t Ratio	3.510363
Std Err Dif	0.013810	DF	4
Upper CL Dif	0.086819	Prob > |t|	0.0247
Lower CL Dif	0.010135	Prob > t	0.0123
Confidence	0.95	Prob < t	0.9877

Oneway Analysis of log[Li ppm] By Heat Treatment Glass #=37



Difference	-0.00131	t Ratio	-0.31936
Std Err Dif	0.00410	DF	4
Upper CL Dif	0.01008	Prob > |t|	0.7654
Lower CL Dif	-0.01270	Prob > t	0.6173
Confidence	0.95	Prob < t	0.3827

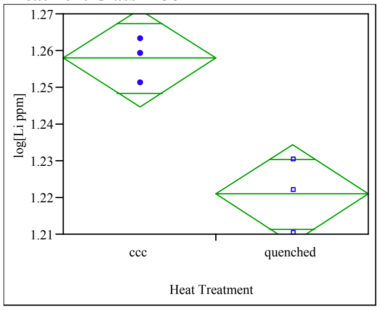
Oneway Analysis of log[B ppm] By Heat Treatment Glass #=38



Difference	-0.01056	t Ratio	-0.42093
Std Err Dif	0.02510	DF	4
Upper CL Dif	0.05912	Prob > |t|	0.6954
Lower CL Dif	-0.08025	Prob > t	0.6523
Confidence	0.95	Prob < t	0.3477

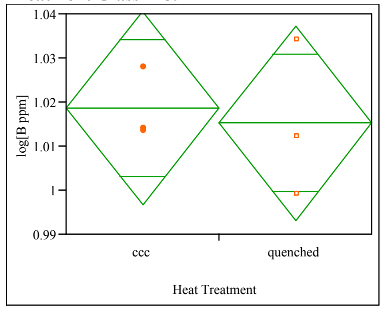
Exhibit D7. Effects of Heat Treatment on PCT log(ppm)-Response of Study Glasses
(continued)

Oneway Analysis of log[Li ppm] By Heat Treatment Glass #=38



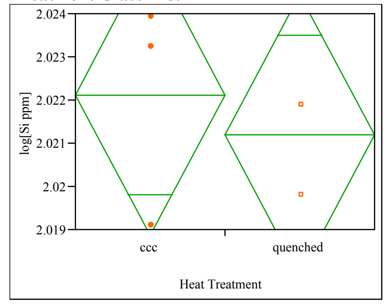
Difference	-0.03701	t Ratio	-5.44719
Std Err Dif	0.00680	DF	4
Upper CL Dif	-0.01815	Prob > |t|	0.0055
Lower CL Dif	-0.05588	Prob > t	0.9972
Confidence	0.95	Prob < t	0.0028

Oneway Analysis of log[B ppm] By Heat Treatment Glass #=39



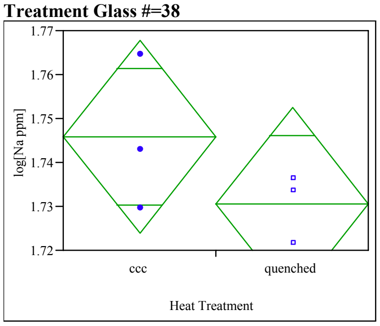
Difference	-0.00344	t Ratio	-0.30655
Std Err Dif	0.01121	DF	4
Upper CL Dif	0.02768	Prob > |t|	0.7745
Lower CL Dif	-0.03455	Prob > t	0.6128
Confidence	0.95	Prob < t	0.3872

Oneway Analysis of log[Si ppm] By Heat Treatment Glass #=39



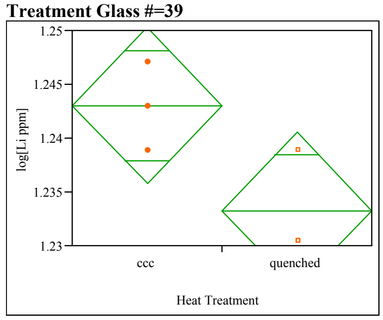
Difference	-0.00091	t Ratio	-0.55178
Std Err Dif	0.00166	DF	4
Upper CL Dif	0.00369	Prob > |t|	0.6105
Lower CL Dif	-0.00551	Prob > t	0.6948
Confidence	0.95	Prob < t	0.3052

Oneway Analysis of log[Na ppm] By Heat Treatment Glass #=38



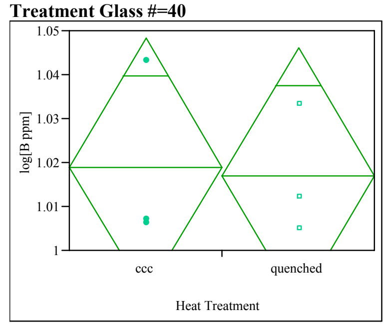
Difference	-0.01523	t Ratio	-1.36366
Std Err Dif	0.01117	DF	4
Upper CL Dif	0.01578	Prob > |t|	0.2444
Lower CL Dif	-0.04625	Prob > t	0.8778
Confidence	0.95	Prob < t	0.1222

Oneway Analysis of log[Li ppm] By Heat Treatment Glass #=39



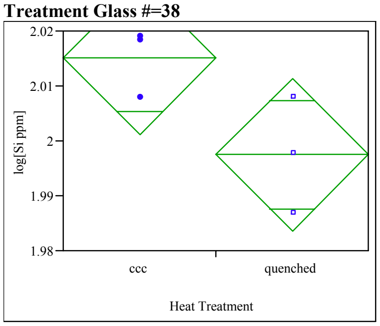
Difference	-0.00976	t Ratio	-2.64741
Std Err Dif	0.00369	DF	4
Upper CL Dif	0.00048	Prob > |t|	0.0571
Lower CL Dif	-0.02001	Prob > t	0.9714
Confidence	0.95	Prob < t	0.0286

Oneway Analysis of log[B ppm] By Heat Treatment Glass #=40



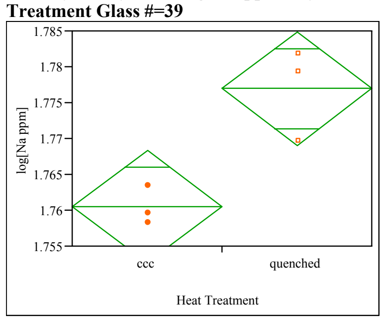
Difference	-0.00214	t Ratio	-0.14372
Std Err Dif	0.01487	DF	4
Upper CL Dif	0.03915	Prob > |t|	0.8927
Lower CL Dif	-0.04343	Prob > t	0.5537
Confidence	0.95	Prob < t	0.4463

Oneway Analysis of log[Si ppm] By Heat Treatment Glass #=38



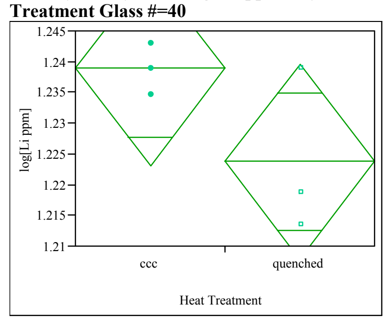
Difference	-0.01765	t Ratio	-2.4863
Std Err Dif	0.00710	DF	4
Upper CL Dif	0.00206	Prob > |t|	0.0678
Lower CL Dif	-0.03736	Prob > t	0.9661
Confidence	0.95	Prob < t	0.0339

Oneway Analysis of log[Na ppm] By Heat Treatment Glass #=39



Difference	0.016411	t Ratio	4.098389
Std Err Dif	0.004004	DF	4
Upper CL Dif	0.027528	Prob > |t|	0.0149
Lower CL Dif	0.005293	Prob > t	0.0074
Confidence	0.95	Prob < t	0.9926

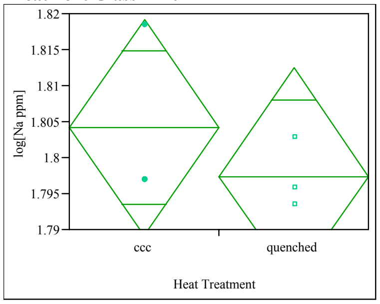
Oneway Analysis of log[Li ppm] By Heat Treatment Glass #=40



Difference	-0.01514	t Ratio	-1.87003
Std Err Dif	0.00809	DF	4
Upper CL Dif	0.00734	Prob > |t|	0.1348
Lower CL Dif	-0.03761	Prob > t	0.9326
Confidence	0.95	Prob < t	0.0674

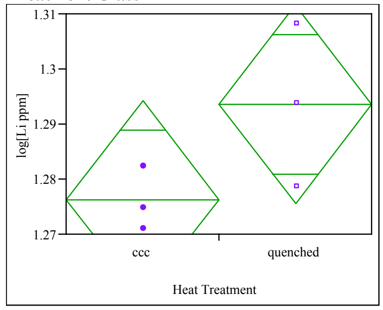
Exhibit D7. Effects of Heat Treatment on PCT log(ppm)-Response of Study Glasses
(continued)

Oneway Analysis of log[Na ppm] By Heat Treatment Glass #=40



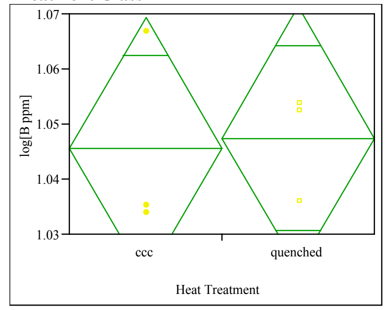
Difference	-0.00677	t Ratio	-0.88438
Std Err Dif	0.00765	DF	4
Upper CL Dif	0.01448	Prob > |t|	0.4264
Lower CL Dif	-0.02802	Prob > t	0.7868
Confidence	0.95	Prob < t	0.2132

Oneway Analysis of log[Li ppm] By Heat Treatment Glass #=41



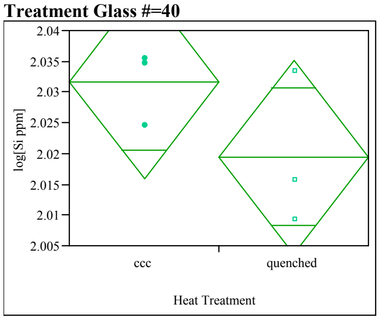
Difference	0.01738	t Ratio	1.900373
Std Err Dif	0.00915	DF	4
Upper CL Dif	0.04278	Prob > |t|	0.1302
Lower CL Dif	-0.00801	Prob > t	0.0651
Confidence	0.95	Prob < t	0.9349

Oneway Analysis of log[B ppm] By Heat Treatment Glass #=42



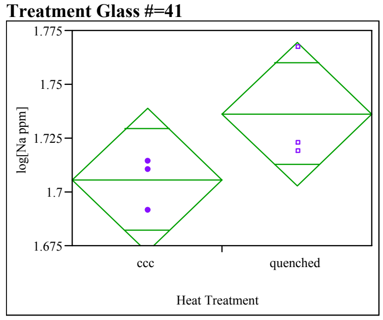
Difference	0.00193	t Ratio	0.158743
Std Err Dif	0.01214	DF	4
Upper CL Dif	0.03564	Prob > |t|	0.8816
Lower CL Dif	-0.03178	Prob > t	0.4408
Confidence	0.95	Prob < t	0.5592

Oneway Analysis of log[Si ppm] By Heat Treatment Glass #=40



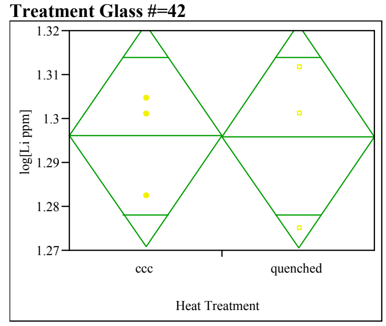
Difference	-0.01215	t Ratio	-1.51453
Std Err Dif	0.00802	DF	4
Upper CL Dif	0.01012	Prob > |t|	0.2045
Lower CL Dif	-0.03442	Prob > t	0.8978
Confidence	0.95	Prob < t	0.1022

Oneway Analysis of log[Na ppm] By Heat Treatment Glass #=41



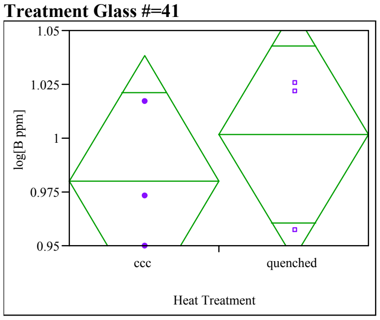
Difference	0.03072	t Ratio	1.805735
Std Err Dif	0.01701	DF	4
Upper CL Dif	0.07796	Prob > |t|	0.1453
Lower CL Dif	-0.01651	Prob > t	0.0726
Confidence	0.95	Prob < t	0.9274

Oneway Analysis of log[Li ppm] By Heat Treatment Glass #=42



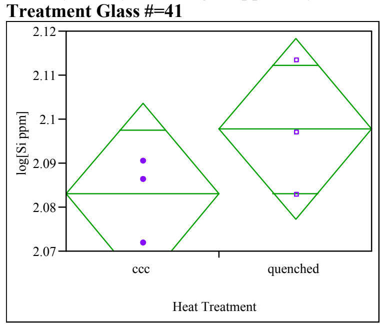
Difference	-0.00017	t Ratio	-0.01291
Std Err Dif	0.01290	DF	4
Upper CL Dif	0.03565	Prob > |t|	0.9903
Lower CL Dif	-0.03598	Prob > t	0.5048
Confidence	0.95	Prob < t	0.4952

Oneway Analysis of log[B ppm] By Heat Treatment Glass #=41



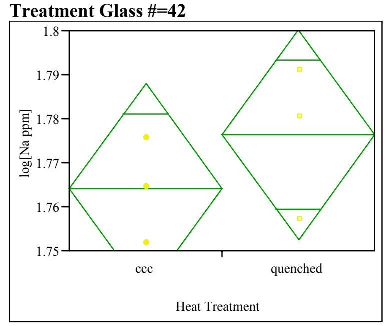
Difference	0.02142	t Ratio	0.725661
Std Err Dif	0.02952	DF	4
Upper CL Dif	0.10339	Prob > |t|	0.5082
Lower CL Dif	-0.06054	Prob > t	0.2541
Confidence	0.95	Prob < t	0.7459

Oneway Analysis of log[Si ppm] By Heat Treatment Glass #=41



Difference	0.01478	t Ratio	1.409266
Std Err Dif	0.01049	DF	4
Upper CL Dif	0.04391	Prob > |t|	0.2316
Lower CL Dif	-0.01434	Prob > t	0.1158
Confidence	0.95	Prob < t	0.8842

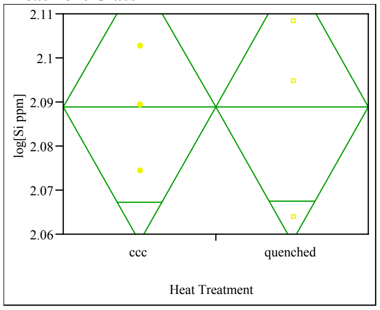
Oneway Analysis of log[Na ppm] By Heat Treatment Glass #=42



Difference	0.01216	t Ratio	0.998855
Std Err Dif	0.01217	DF	4
Upper CL Dif	0.04595	Prob > |t|	0.3744
Lower CL Dif	-0.02163	Prob > t	0.1872
Confidence	0.95	Prob < t	0.8128

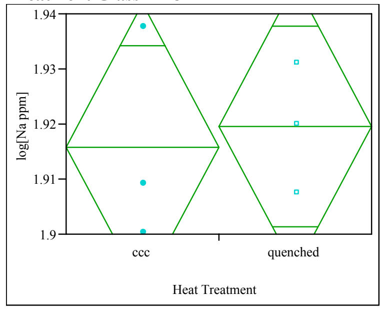
Exhibit D7. Effects of Heat Treatment on PCT log(ppm)-Response of Study Glasses
(continued)

Oneway Analysis of log[Si ppm] By Heat Treatment Glass #=42



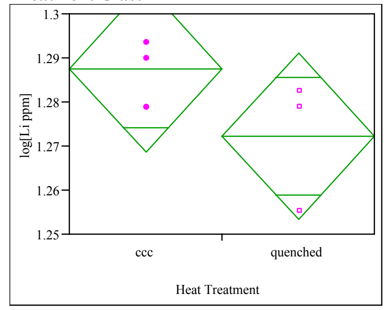
Difference	0.00015	t Ratio	0.009752
Std Err Dif	0.01549	DF	4
Upper CL Dif	0.04317	Prob > |t|	0.9927
Lower CL Dif	-0.04287	Prob > t	0.4963
Confidence	0.95	Prob < t	0.5037

Oneway Analysis of log[Na ppm] By Heat Treatment Glass #=43



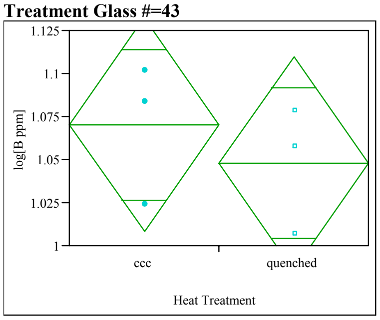
Difference	0.00369	t Ratio	0.279696
Std Err Dif	0.01318	DF	4
Upper CL Dif	0.04029	Prob > |t|	0.7936
Lower CL Dif	-0.03291	Prob > t	0.3968
Confidence	0.95	Prob < t	0.6032

Oneway Analysis of log[Li ppm] By Heat Treatment Glass #=44



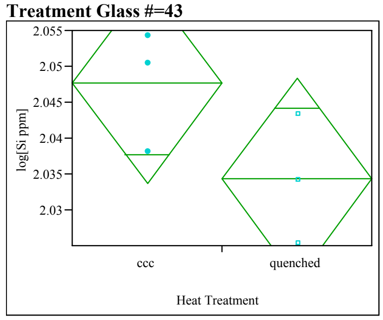
Difference	-0.01532	t Ratio	-1.58773
Std Err Dif	0.00965	DF	4
Upper CL Dif	0.01147	Prob > |t|	0.1875
Lower CL Dif	-0.04210	Prob > t	0.9062
Confidence	0.95	Prob < t	0.0938

Oneway Analysis of log[B ppm] By Heat Treatment Glass #=43



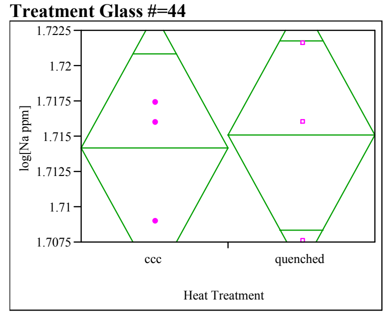
Difference	-0.02247	t Ratio	-0.71183
Std Err Dif	0.03156	DF	4
Upper CL Dif	0.06516	Prob > |t|	0.5159
Lower CL Dif	-0.11009	Prob > t	0.7421
Confidence	0.95	Prob < t	0.2579

Oneway Analysis of log[Si ppm] By Heat Treatment Glass #=43



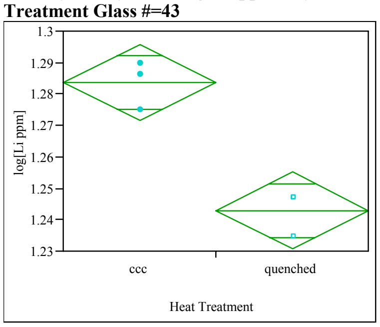
Difference	-0.01340	t Ratio	-1.87121
Std Err Dif	0.00716	DF	4
Upper CL Dif	0.00648	Prob > |t|	0.1346
Lower CL Dif	-0.03328	Prob > t	0.9327
Confidence	0.95	Prob < t	0.0673

Oneway Analysis of log[Na ppm] By Heat Treatment Glass #=44



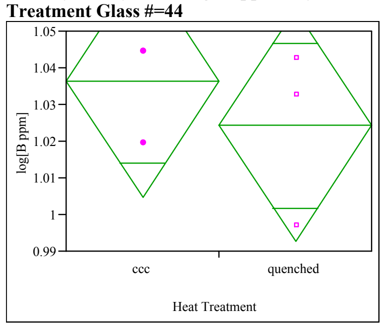
Difference	0.00091	t Ratio	0.188415
Std Err Dif	0.00482	DF	4
Upper CL Dif	0.01430	Prob > |t|	0.8597
Lower CL Dif	-0.01248	Prob > t	0.4299
Confidence	0.95	Prob < t	0.5701

Oneway Analysis of log[Li ppm] By Heat Treatment Glass #=43



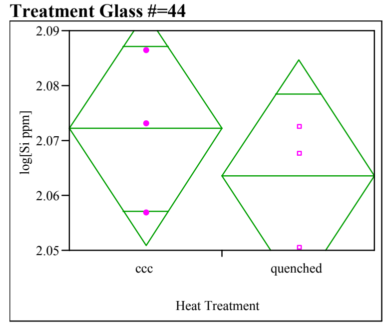
Difference	-0.04076	t Ratio	-6.61876
Std Err Dif	0.00616	DF	4
Upper CL Dif	-0.02366	Prob > |t|	0.0027
Lower CL Dif	-0.05785	Prob > t	0.9986
Confidence	0.95	Prob < t	0.0014

Oneway Analysis of log[B ppm] By Heat Treatment Glass #=44



Difference	-0.01220	t Ratio	-0.75591
Std Err Dif	0.01614	DF	4
Upper CL Dif	0.03261	Prob > |t|	0.4918
Lower CL Dif	-0.05700	Prob > t	0.7541
Confidence	0.95	Prob < t	0.2459

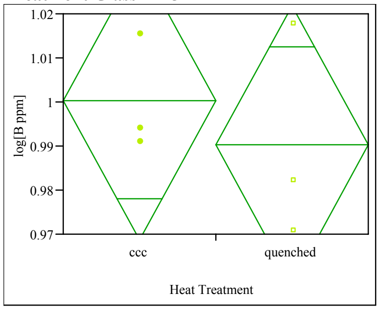
Oneway Analysis of log[Si ppm] By Heat Treatment Glass #=44



Difference	-0.00860	t Ratio	-0.79541
Std Err Dif	0.01081	DF	4
Upper CL Dif	0.02142	Prob > |t|	0.4709
Lower CL Dif	-0.03862	Prob > t	0.7645
Confidence	0.95	Prob < t	0.2355

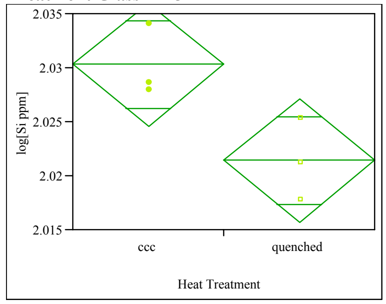
Exhibit D7. Effects of Heat Treatment on PCT log(ppm)-Response of Study Glasses
(continued)

Oneway Analysis of log[B ppm] By Heat Treatment Glass #=45



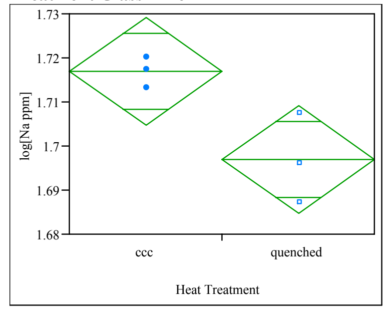
Difference	-0.01007	t Ratio	-0.62646
Std Err Dif	0.01608	DF	4
Upper CL Dif	0.03458	Prob > |t|	0.5650
Lower CL Dif	-0.05473	Prob > t	0.7175
Confidence	0.95	Prob < t	0.2825

Oneway Analysis of log[Si ppm] By Heat Treatment Glass #=45



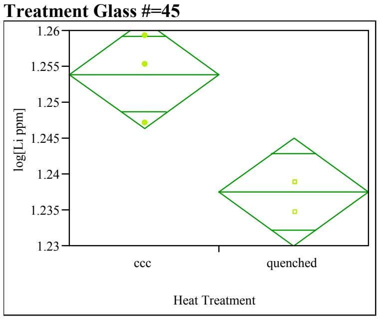
Difference	-0.00887	t Ratio	-3.04589
Std Err Dif	0.00291	DF	4
Upper CL Dif	-0.00078	Prob > |t|	0.0382
Lower CL Dif	-0.01695	Prob > t	0.9809
Confidence	0.95	Prob < t	0.0191

Oneway Analysis of log[Na ppm] By Heat Treatment Glass #=46



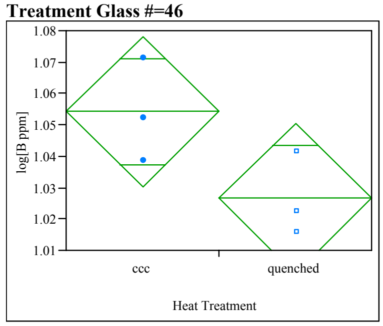
Difference	-0.01997	t Ratio	-3.20734
Std Err Dif	0.00622	DF	4
Upper CL Dif	-0.00268	Prob > |t|	0.0327
Lower CL Dif	-0.03725	Prob > t	0.9837
Confidence	0.95	Prob < t	0.0163

Oneway Analysis of log[Li ppm] By Heat Treatment Glass #=45



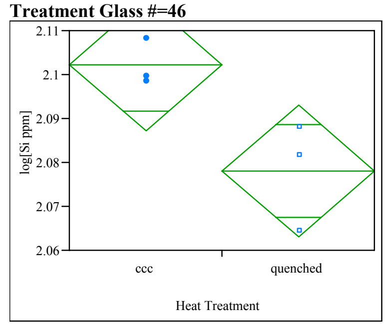
Difference	-0.01642	t Ratio	-4.28648
Std Err Dif	0.00383	DF	4
Upper CL Dif	-0.00578	Prob > |t|	0.0128
Lower CL Dif	-0.02705	Prob > t	0.9936
Confidence	0.95	Prob < t	0.0064

Oneway Analysis of log[B ppm] By Heat Treatment Glass #=46



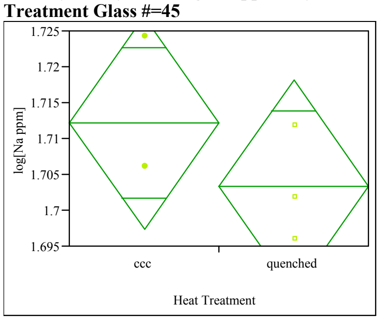
Difference	-0.02762	t Ratio	-2.27002
Std Err Dif	0.01217	DF	4
Upper CL Dif	0.00616	Prob > |t|	0.0857
Lower CL Dif	-0.06140	Prob > t	0.9571
Confidence	0.95	Prob < t	0.0429

Oneway Analysis of log[Si ppm] By Heat Treatment Glass #=46



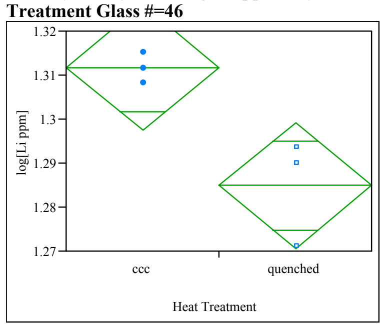
Difference	-0.02420	t Ratio	-3.1456
Std Err Dif	0.00769	DF	4
Upper CL Dif	-0.00284	Prob > |t|	0.0347
Lower CL Dif	-0.04556	Prob > t	0.9827
Confidence	0.95	Prob < t	0.0173

Oneway Analysis of log[Na ppm] By Heat Treatment Glass #=45



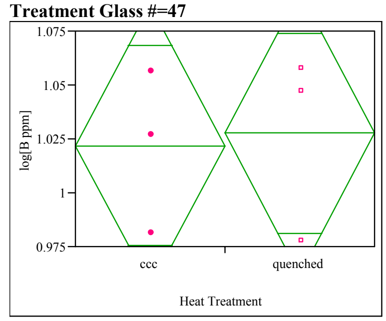
Difference	-0.00895	t Ratio	-1.17861
Std Err Dif	0.00759	DF	4
Upper CL Dif	0.01213	Prob > |t|	0.3039
Lower CL Dif	-0.03003	Prob > t	0.8481
Confidence	0.95	Prob < t	0.1519

Oneway Analysis of log[Li ppm] By Heat Treatment Glass #=46



Difference	-0.02680	t Ratio	-3.66615
Std Err Dif	0.00731	DF	4
Upper CL Dif	-0.00650	Prob > |t|	0.0215
Lower CL Dif	-0.04710	Prob > t	0.9893
Confidence	0.95	Prob < t	0.0107

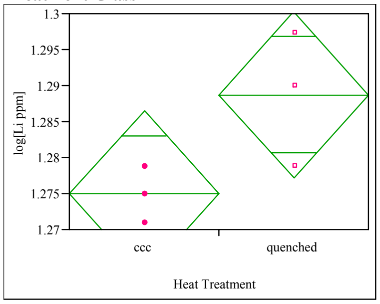
Oneway Analysis of log[B ppm] By Heat Treatment Glass #=47



Difference	0.00559	t Ratio	0.16779
Std Err Dif	0.03331	DF	4
Upper CL Dif	0.09807	Prob > |t|	0.8749
Lower CL Dif	-0.08689	Prob > t	0.4374
Confidence	0.95	Prob < t	0.5626

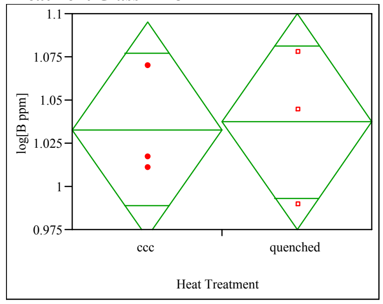
Exhibit D7. Effects of Heat Treatment on PCT log(ppm)-Response of Study Glasses
(continued)

Oneway Analysis of log[Li ppm] By Heat Treatment Glass #=47



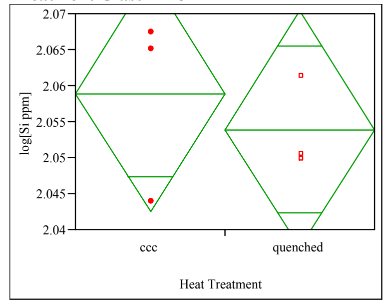
Difference	0.01381	t Ratio	2.357982
Std Err Dif	0.00586	DF	4
Upper CL Dif	0.03008	Prob > |t|	0.0778
Lower CL Dif	-0.00245	Prob > t	0.0389
Confidence	0.95	Prob < t	0.9611

Oneway Analysis of log[B ppm] By Heat Treatment Glass #=48



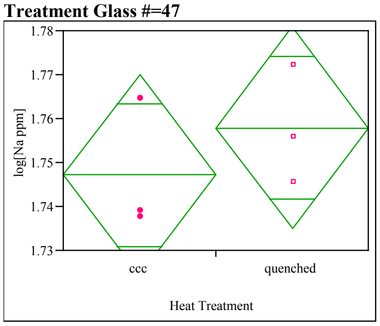
Difference	0.00463	t Ratio	0.145657
Std Err Dif	0.03179	DF	4
Upper CL Dif	0.09288	Prob > |t|	0.8912
Lower CL Dif	-0.08362	Prob > t	0.4456
Confidence	0.95	Prob < t	0.5544

Oneway Analysis of log[Si ppm] By Heat Treatment Glass #=48



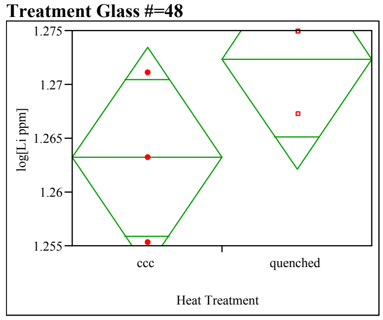
Difference	-0.00499	t Ratio	-0.59784
Std Err Dif	0.00834	DF	4
Upper CL Dif	0.01818	Prob > |t|	0.5822
Lower CL Dif	-0.02816	Prob > t	0.7089
Confidence	0.95	Prob < t	0.2911

Oneway Analysis of log[Na ppm] By Heat Treatment Glass #=47



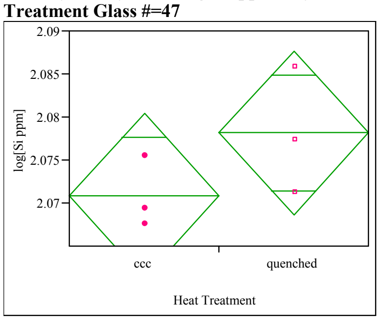
Difference	0.01070	t Ratio	0.916469
Std Err Dif	0.01168	DF	4
Upper CL Dif	0.04312	Prob > |t|	0.4113
Lower CL Dif	-0.02172	Prob > t	0.2056
Confidence	0.95	Prob < t	0.7944

Oneway Analysis of log[Li ppm] By Heat Treatment Glass #=48



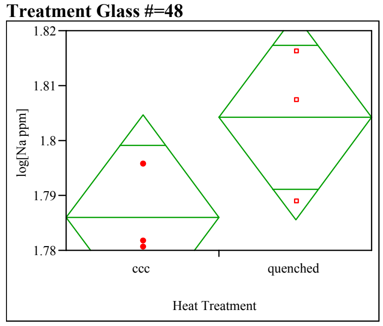
Difference	0.00915	t Ratio	1.745438
Std Err Dif	0.00524	DF	4
Upper CL Dif	0.02370	Prob > |t|	0.1558
Lower CL Dif	-0.00540	Prob > t	0.0779
Confidence	0.95	Prob < t	0.9221

Oneway Analysis of log[Si ppm] By Heat Treatment Glass #=47



Difference	0.00729	t Ratio	1.504368
Std Err Dif	0.00485	DF	4
Upper CL Dif	0.02074	Prob > |t|	0.2069
Lower CL Dif	-0.00616	Prob > t	0.1035
Confidence	0.95	Prob < t	0.8965

Oneway Analysis of log[Na ppm] By Heat Treatment Glass #=48



Difference	0.01808	t Ratio	1.914899
Std Err Dif	0.00944	DF	4
Upper CL Dif	0.04429	Prob > |t|	0.1280
Lower CL Dif	-0.00813	Prob > t	0.0640
Confidence	0.95	Prob < t	0.9360

Exhibit D8. Effects of Heat Treatment for Study Glasses by Compositional View

Composition=measured
Variability Chart for log NL[B (g/L)]

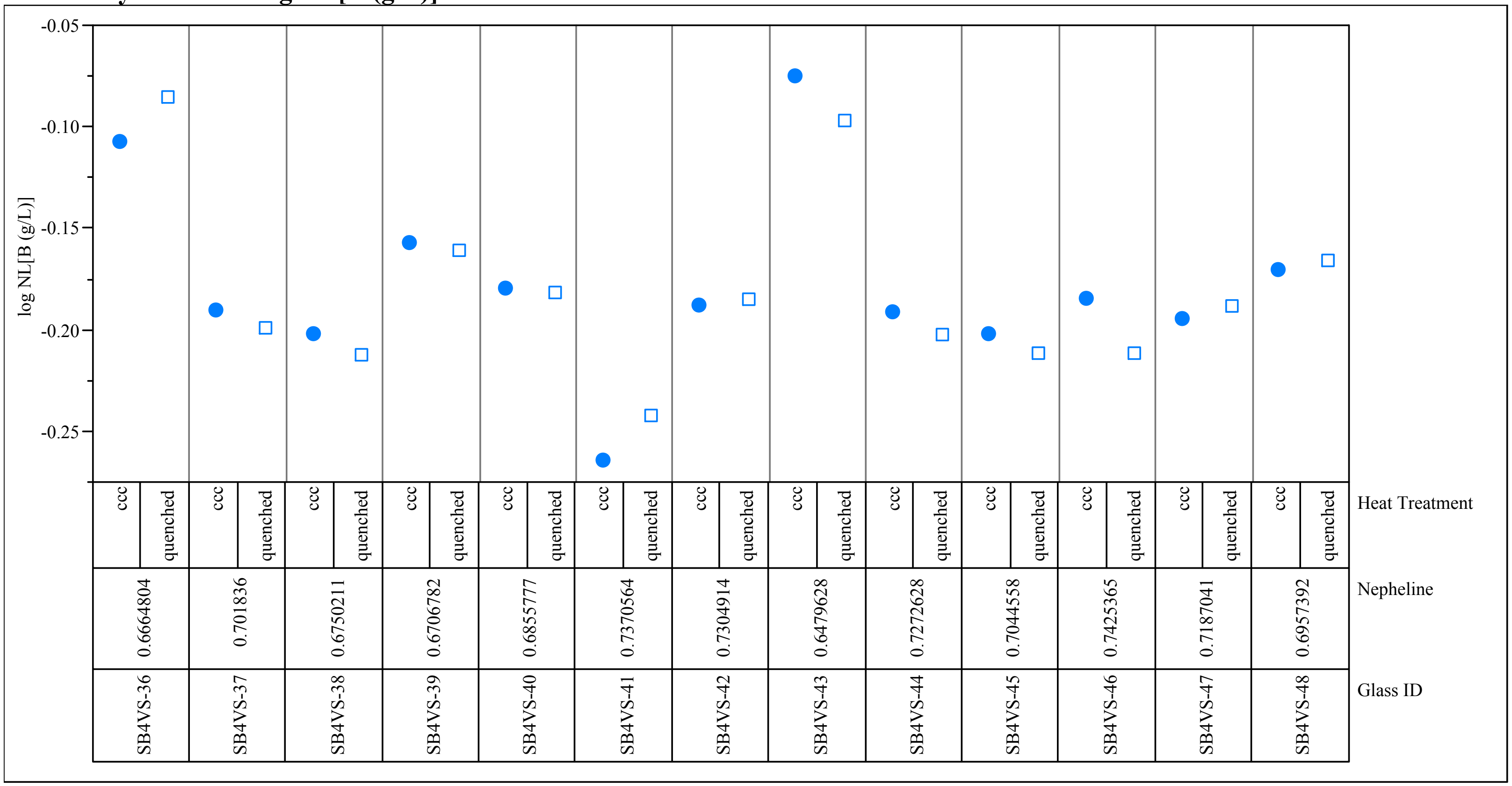


Exhibit D8. Effects of Heat Treatment for Study Glasses by Compositional View (continued)

Composition=measured
Variability Chart for log NL[Li (g/L)]

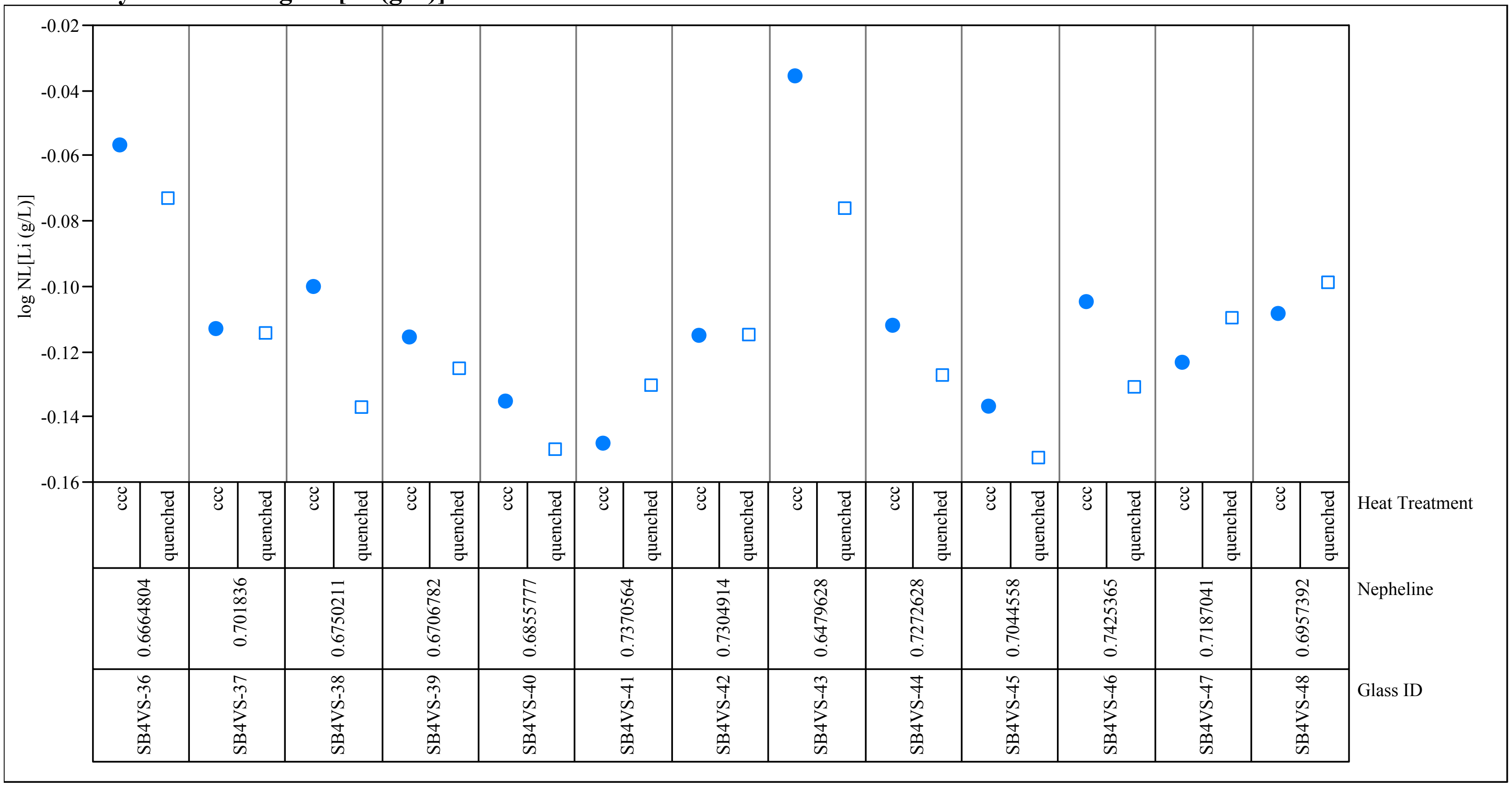


Exhibit D8. Effects of Heat Treatment for Study Glasses by Compositional View (continued)

Composition=measured
Variability Chart for log NL[Na (g/L)]

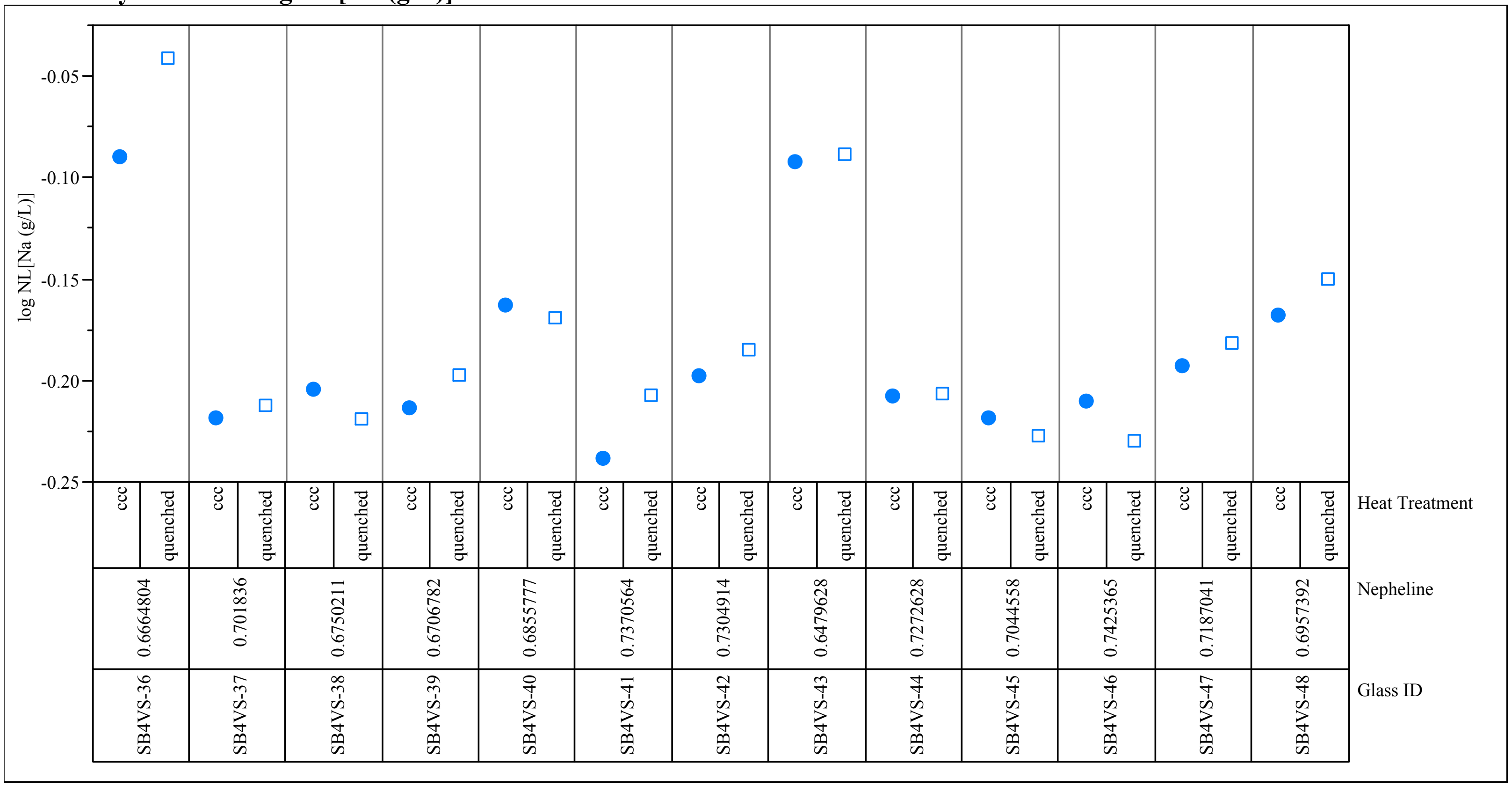


Exhibit D8. Effects of Heat Treatment for Study Glasses by Compositional View (continued)

Composition=measured
Variability Chart for log NL[Si (g/L)]

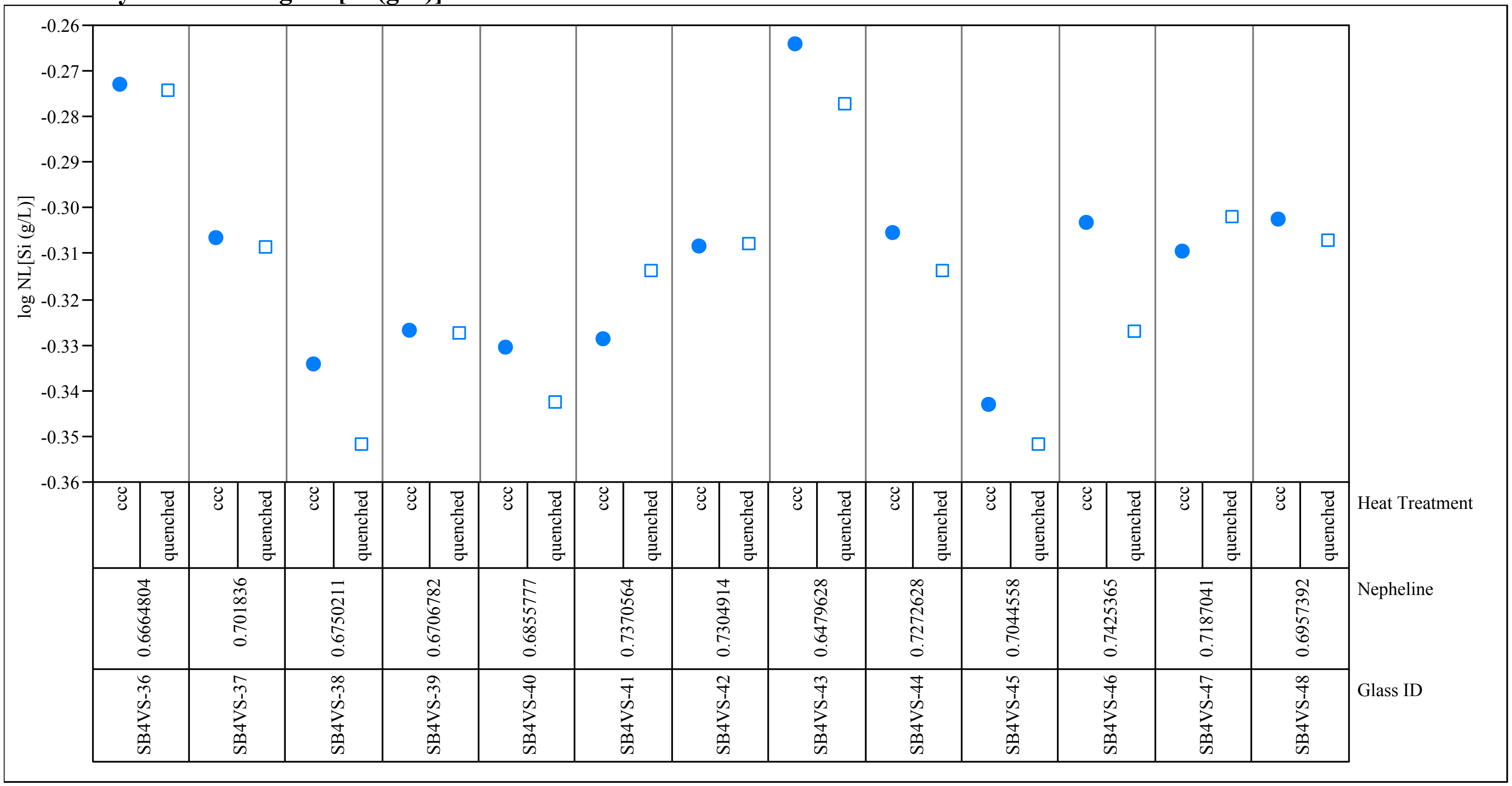


Exhibit D8. Effects of Heat Treatment for Study Glasses by Compositional View (continued)

Composition=measured bc
Variability Chart for log NL[B (g/L)]

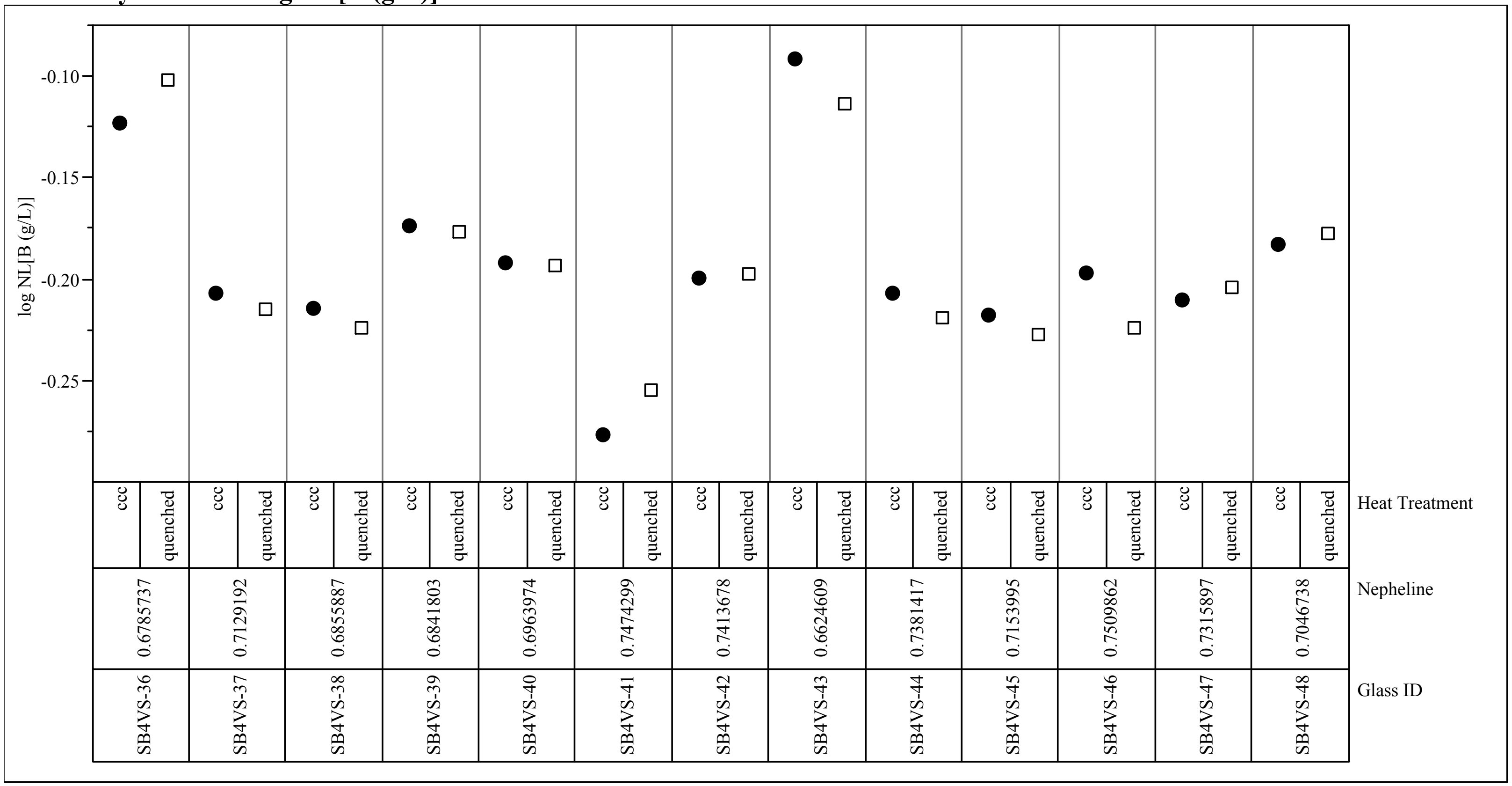


Exhibit D8. Effects of Heat Treatment for Study Glasses by Compositional View (continued)

Composition=measured bc
Variability Chart for log NL[Li (g/L)]

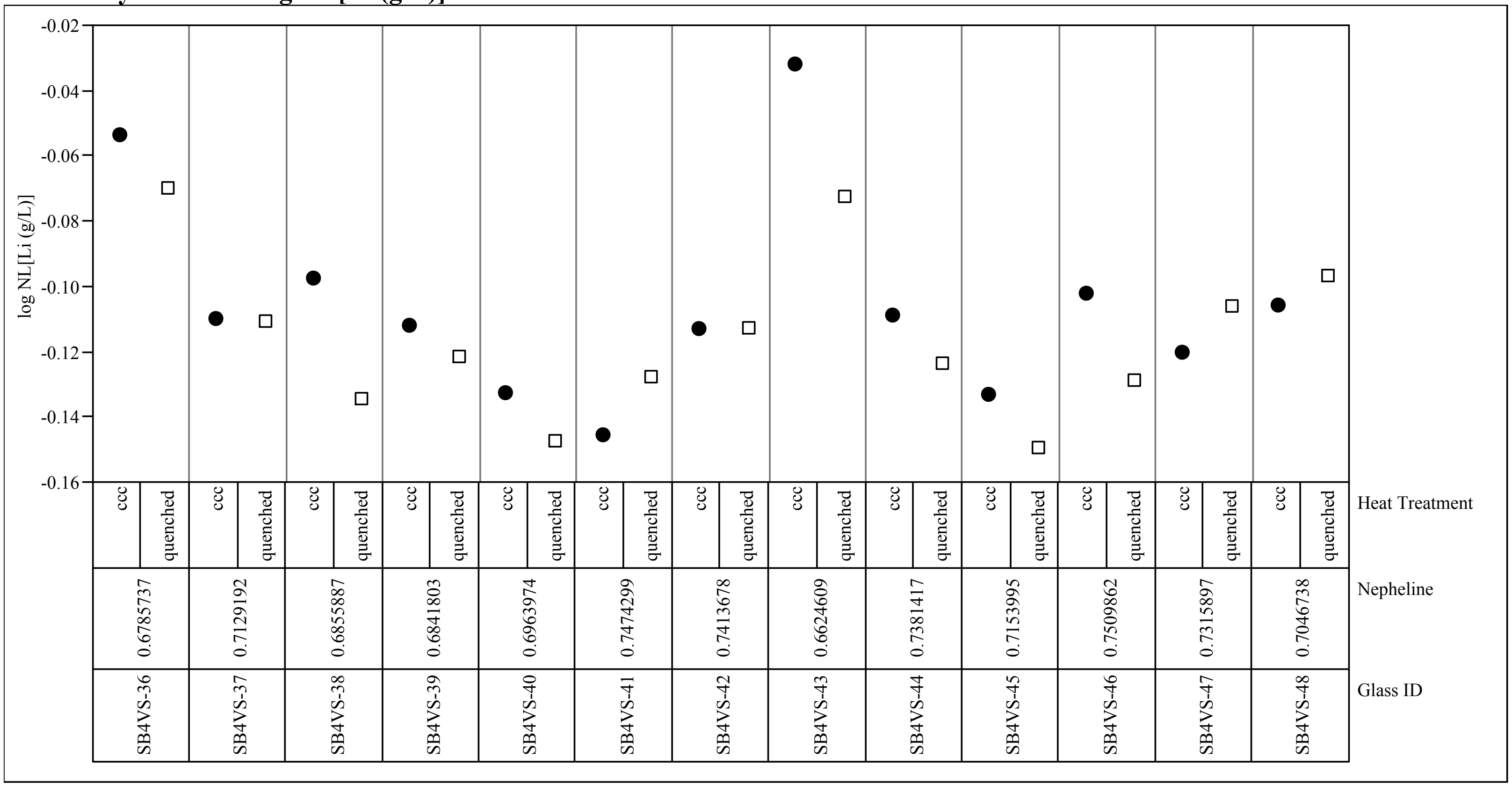


Exhibit D8. Effects of Heat Treatment for Study Glasses by Compositional View (continued)

Composition=measured bc
Variability Chart for log NL[Na (g/L)]

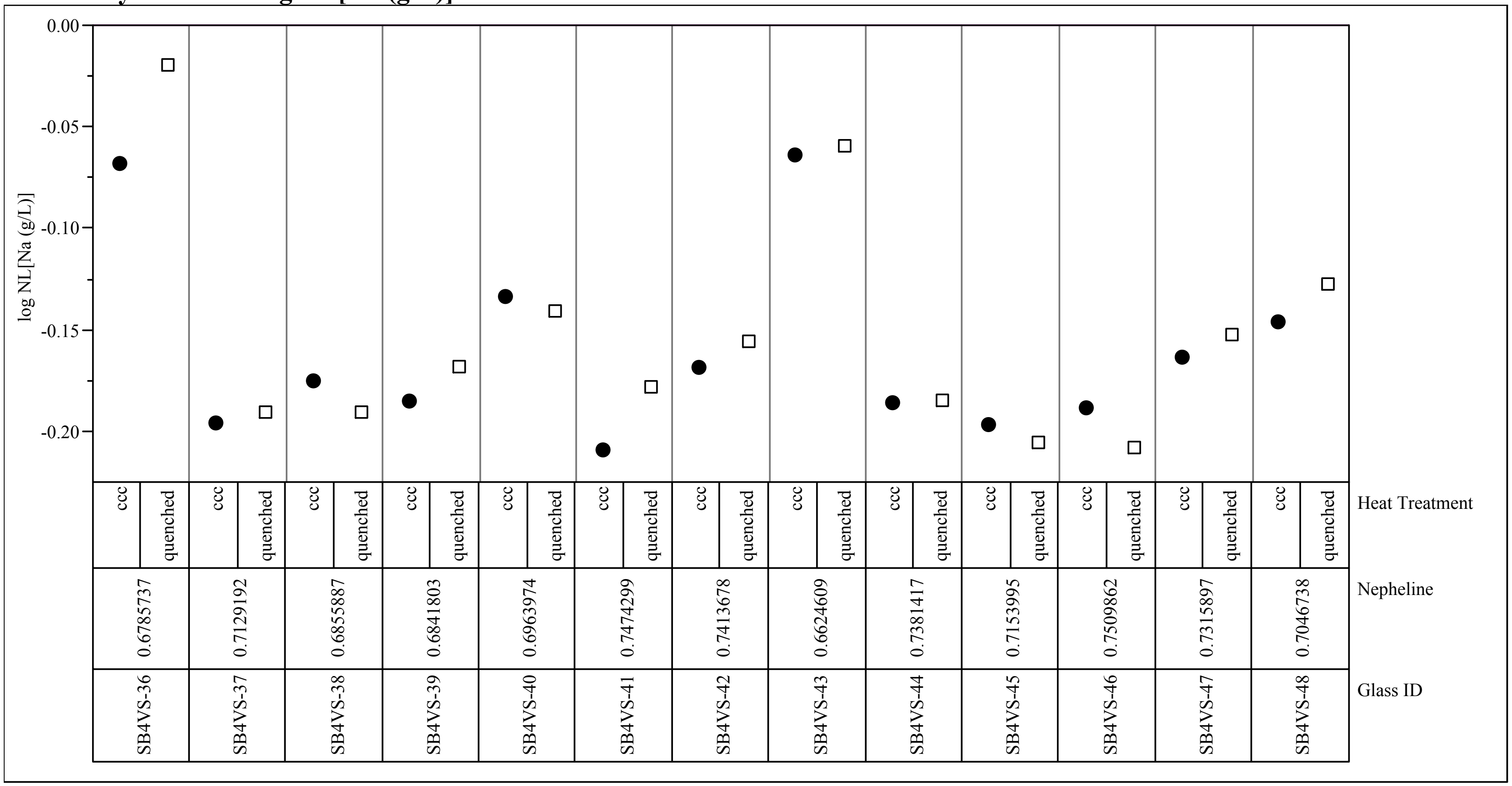


Exhibit D8. Effects of Heat Treatment for Study Glasses by Compositional View (continued)

Composition=measured bc
Variability Chart for log NL[Si (g/L)]

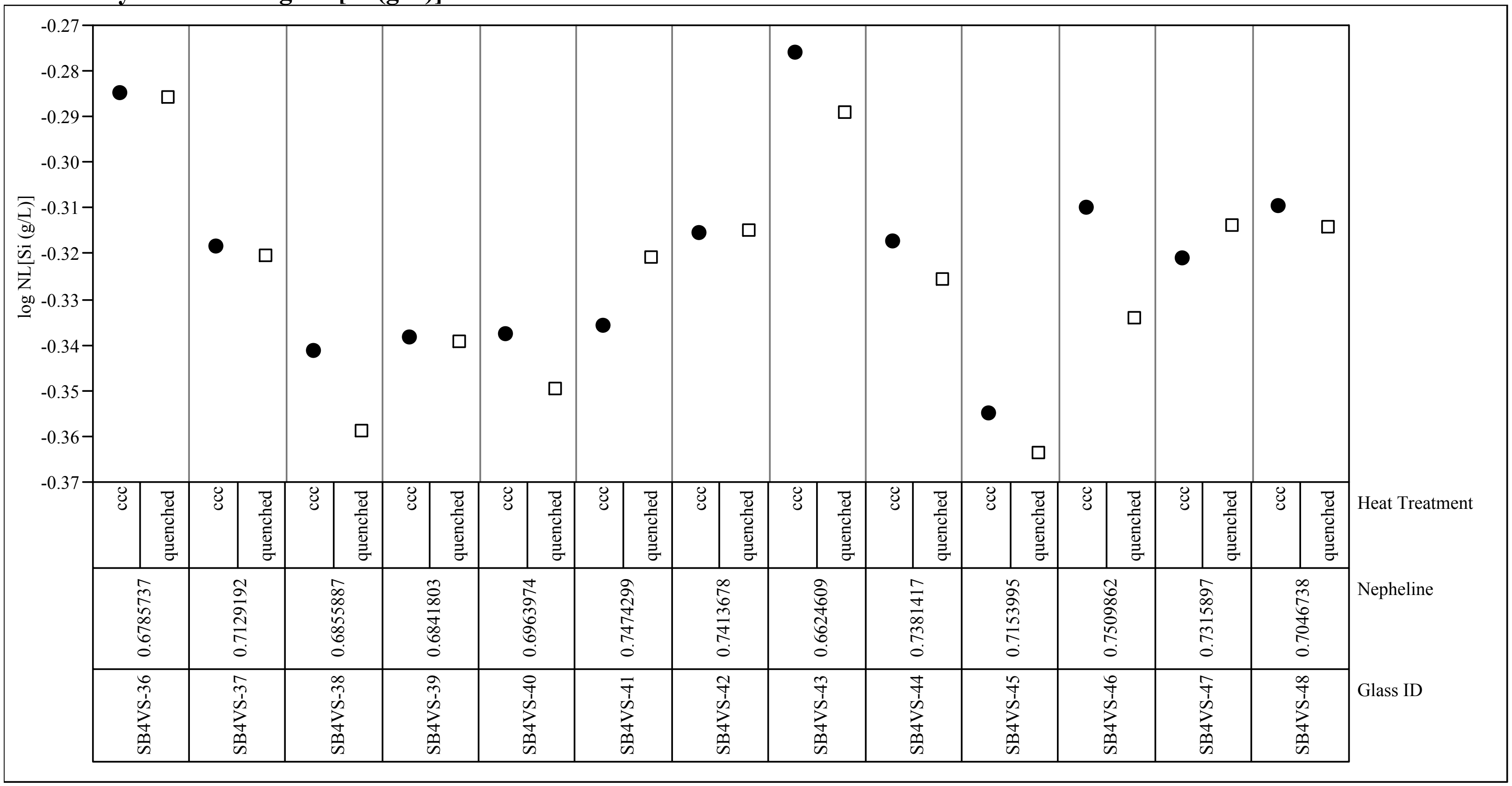


Exhibit D8. Effects of Heat Treatment for Study Glasses by Compositional View (continued)

Composition=targeted
Variability Chart for log NL[B (g/L)]

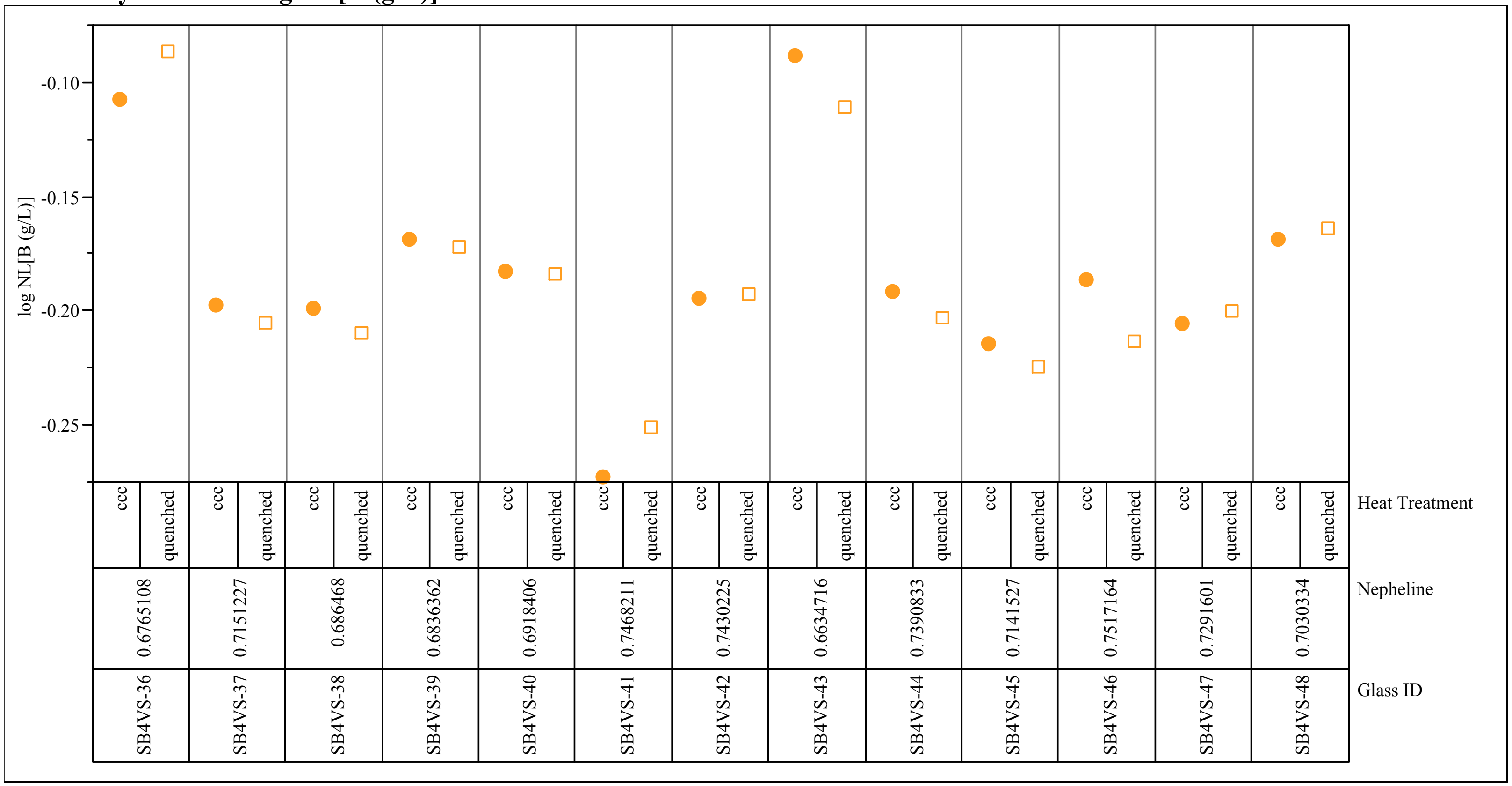


Exhibit D8. Effects of Heat Treatment for Study Glasses by Compositional View (continued)

Composition=targeted
Variability Chart for log NL[Li (g/L)]

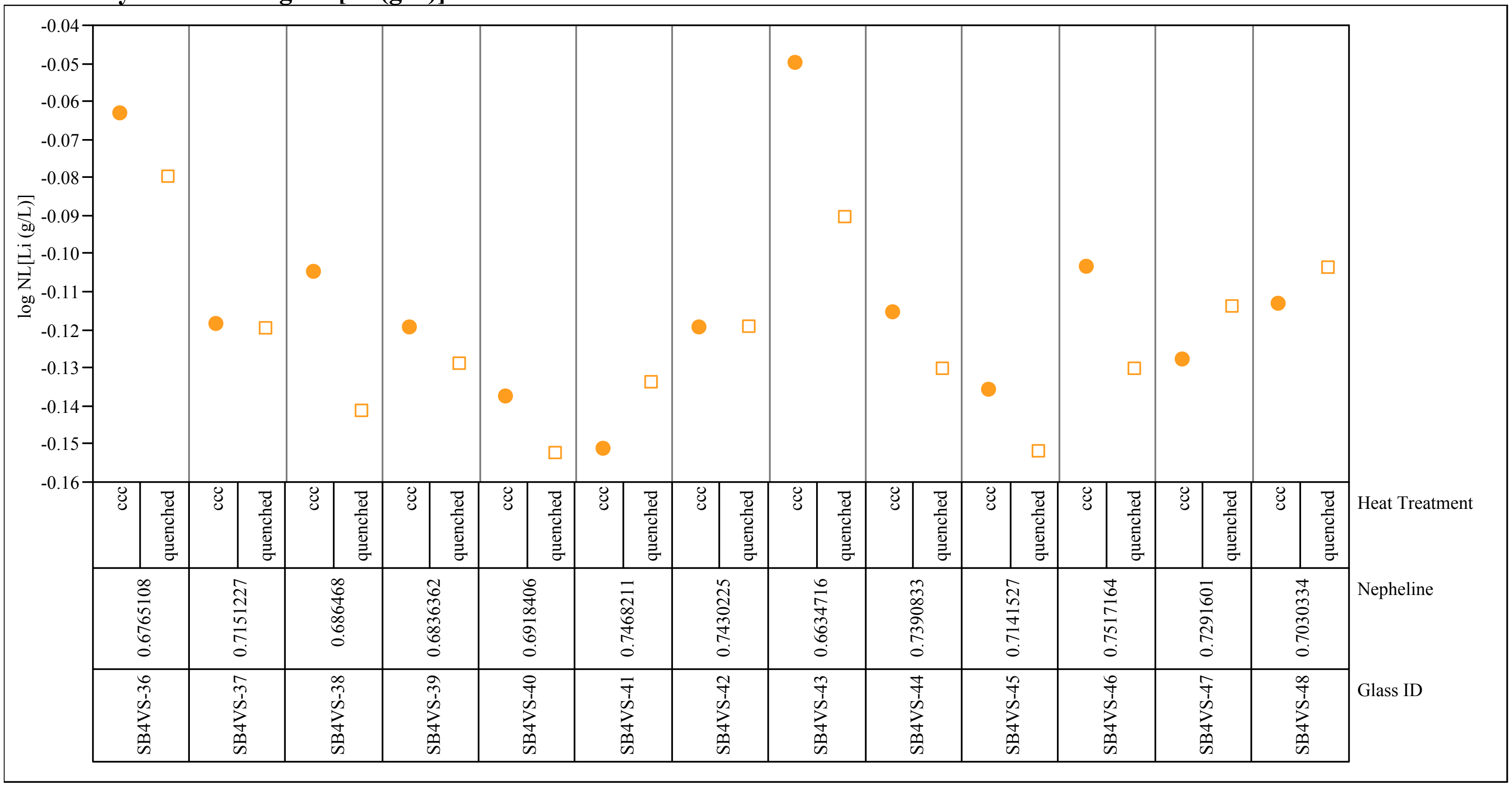


Exhibit D8. Effects of Heat Treatment for Study Glasses by Compositional View (continued)

Composition=targeted
Variability Chart for log NL[Na (g/L)]

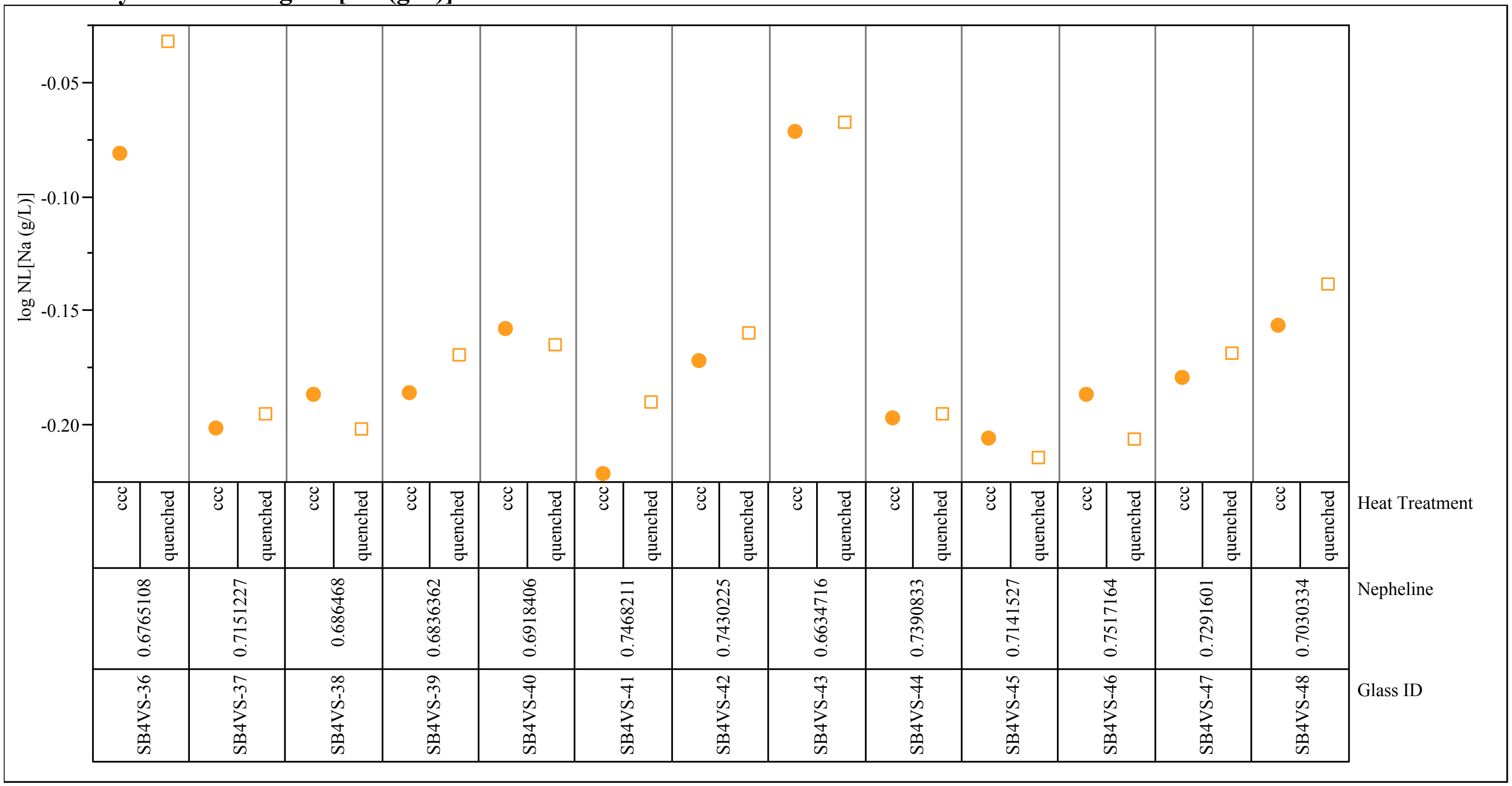


Exhibit D8. Effects of Heat Treatment for Study Glasses by Compositional View (continued)

Composition=targeted
Variability Chart for log NL[Si (g/L)]

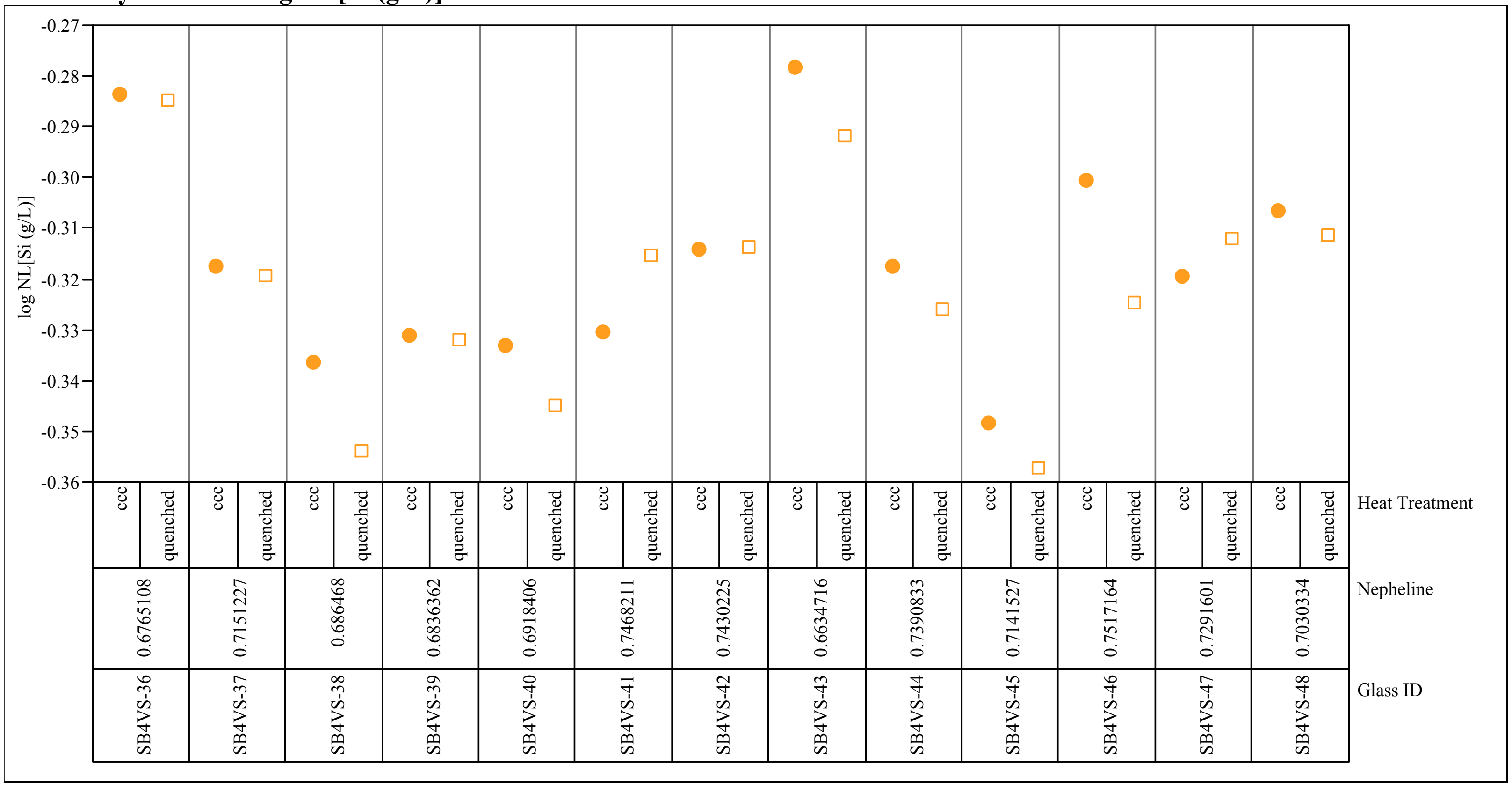
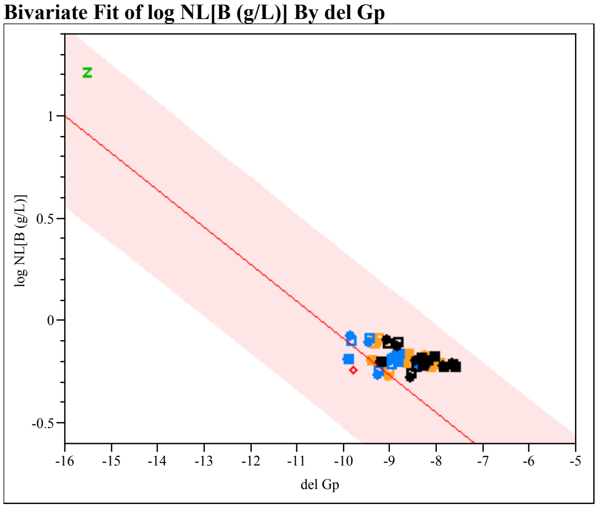


Exhibit D9. del Gp (ΔG_p) Predictions versus Common Logarithm Normalized Leachate (log NL[.]) for B, Li, Na, and Si Over All Compositional Views and Heat Treatments

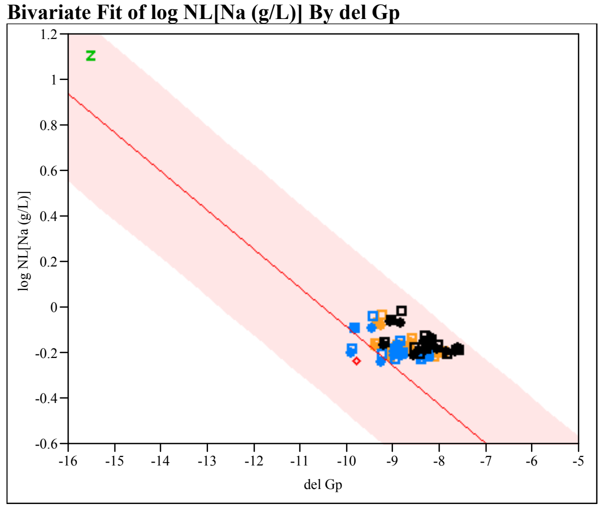
Legend

	Sludge	Heat Treatment	Composition
1	ARM		reference
2	EA		reference
3	SB4 VS	ccc	measured
4	SB4 VS	ccc	measured bc
5	SB4 VS	ccc	targeted
6	SB4 VS	quenched	measured
7	SB4 VS	quenched	measured bc
8	SB4 VS	quenched	targeted

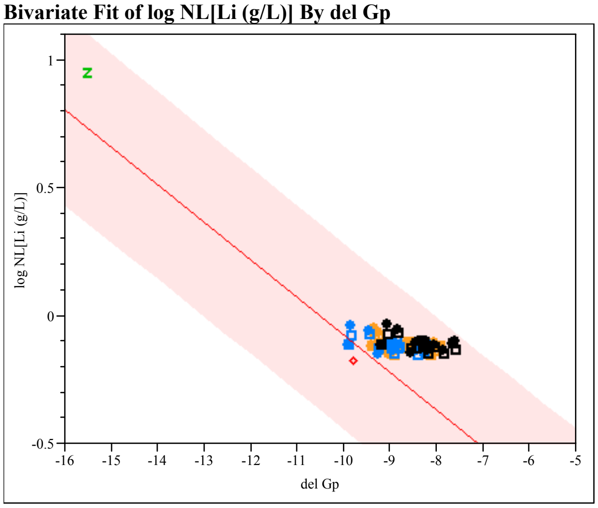
Bivariate Fit of log NL[B (g/L)] By del Gp



Bivariate Fit of log NL[Na (g/L)] By del Gp



Bivariate Fit of log NL[Li (g/L)] By del Gp



Bivariate Fit of log NL[Si (g/L)] By del Gp

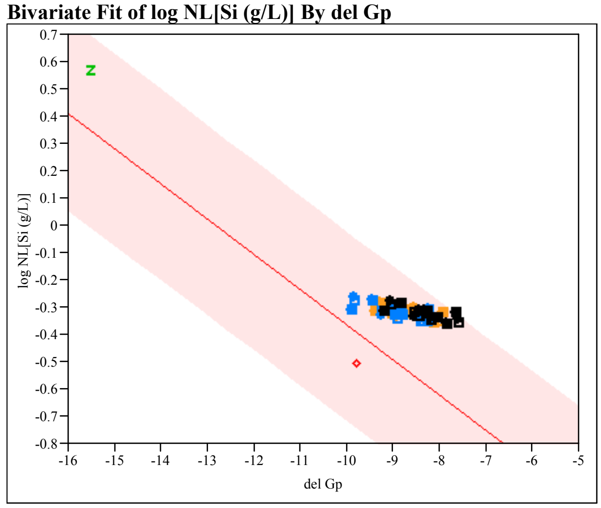
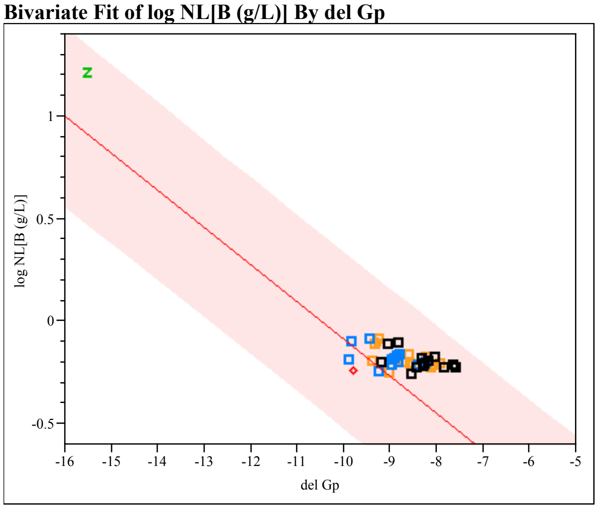


Exhibit D10. del Gp (ΔG_p) Predictions versus Common Logarithm Normalized Leachate (log NL[.]) for B, Li, Na, and Si Over All Compositional Views for Quenched Glasses

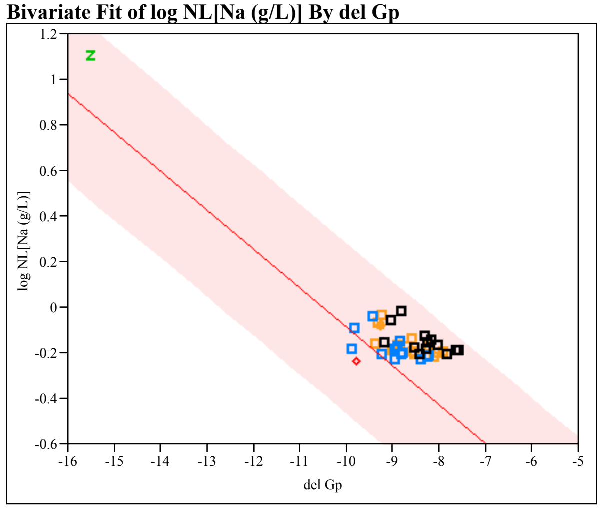
Legend

		Sludge	Heat Treatment	Composition
	1	ARM		reference
	2	EA		reference
	3	SB4VS	ccc	measured
	4	SB4VS	ccc	measured bc
	5	SB4VS	ccc	targeted
	6	SB4VS	quenched	measured
	7	SB4VS	quenched	measured bc
	8	SB4VS	quenched	targeted

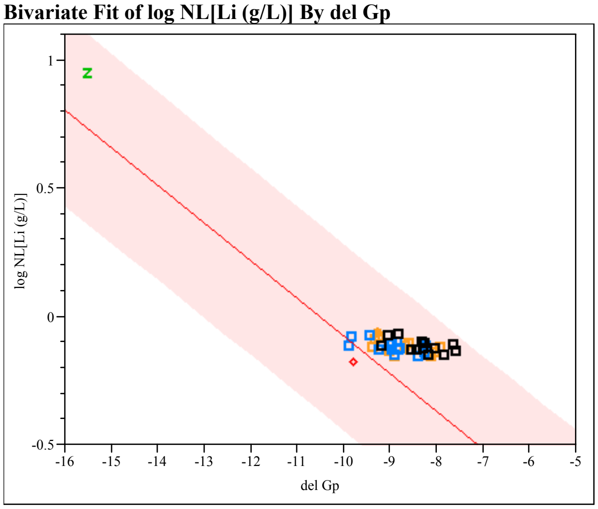
Bivariate Fit of log NL[B (g/L)] By del Gp



Bivariate Fit of log NL[Na (g/L)] By del Gp



Bivariate Fit of log NL[Li (g/L)] By del Gp



Bivariate Fit of log NL[Si (g/L)] By del Gp

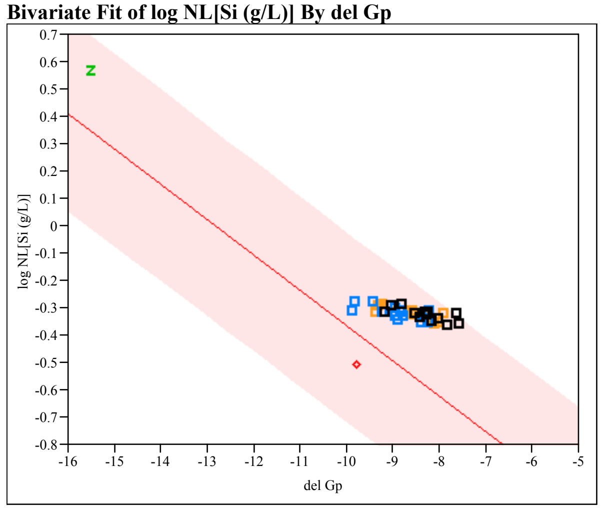
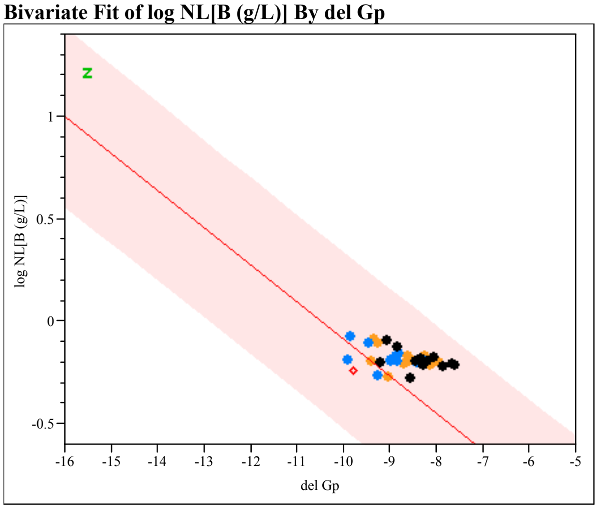


Exhibit D11. del Gp (ΔG_p) Predictions versus Common Logarithm Normalized Leachate (log NL[.]) for B, Li, Na, and Si Over All Compositional Views for ccc Glasses

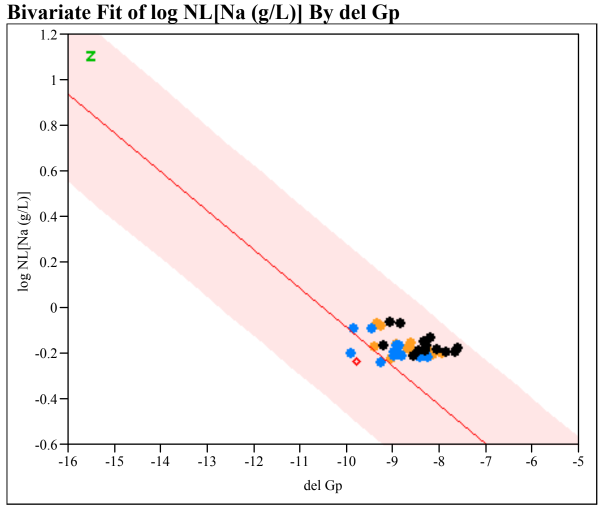
Legend

	Sludge	Heat Treatment	Composition
1	ARM		reference
2	EA		reference
3	SB4VS	ccc	measured
4	SB4VS	ccc	measured bc
5	SB4VS	ccc	targeted
6	SB4VS	quenched	measured
7	SB4VS	quenched	measured bc
8	SB4VS	quenched	targeted

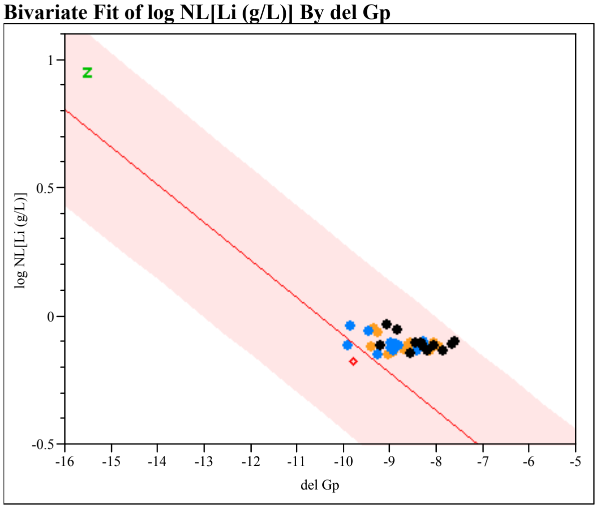
Bivariate Fit of log NL[B (g/L)] By del Gp



Bivariate Fit of log NL[Na (g/L)] By del Gp



Bivariate Fit of log NL[Li (g/L)] By del Gp



Bivariate Fit of log NL[Si (g/L)] By del Gp