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NEPHELINE FORMATION STUDY FOR SLUDGE BATCH 4 (SB4): PHASE 2 EXPERIMENTAL RESULTS

D.K. Peeler
T.B. Edwards
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R.J. Workman

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REVIEWS AND APPROVALS

AUTHORS:

2-15-06
D.K. Peeler, Process Science and Engineering Section — Date

2-15-06
T.B. Edwards, Statistical Consulting Section — Date

2-15-06
D.R. Best, Process Science and Engineering Section — Date

2/15/06
I.A. Reamer, Process Science and Engineering Section — Date

R. J. Workman 2-15-06
R.J. Workman, Process Science and Engineering Section — Date

TECHNICAL REVIEWER:

2/15/06
C.C. Herman, Process Engineering Technology Group — Date

APPROVERS:

3/3/06
R.E. Edwards, Manager, Process Science and Engineering Section — Date

2/15/06
D.A. Crowley, Manager, Stabilization Science Research Group — Date

3-16-06
J.E. Occhipinti, Manager,
Process Cognizant Engineer – Waste Solidification Engineering — Date

EXECUTIVE SUMMARY

The impact of devitrification on durability is complex and depends on several interrelated factors including the change in residual glass composition, the formation of internal stress or microcracks, and the preferential attack at the glass-crystal interface. As noted from previous experimental studies, perhaps the most significant effects are the type and extent (or fraction) of crystallization and the resulting change to the residual glass composition. Conceptually, the formation of crystalline phases within a glass matrix ultimately changes the composition of the host glass phase as specific elements/oxides are extracted from the glass matrix to form the crystals. The formation of nepheline ($NaAlSiO_4$) can have a negative impact on durability as it produces an Al_2O_3 and SiO_2 deficient continuous glass matrix (relative to the same composition which is void of crystals). The primary driver for the reduction in durability is the fact that nepheline removes three moles of glass forming oxides (Al_2O_3 and $2SiO_2$) per each mole of Na_2O from the continuous glass phase. The magnitude of the reduction in durability ultimately depends on the extent (i.e., volume %) of crystallization. The formation of nepheline and/or other aluminum/silicon-containing crystals is a potential problem in the Sludge Batch 4 (SB4) system based on the projected compositional views recently evaluated coupled with the frit development strategy.

Twenty-eight Phase 2 glasses were identified that intentionally challenged the "nepheline discriminator" value for the 1.6M Na, 40" and 1.6M Na, 127" sludge options as defined by the Closure Business Unit (CBU) (Elder 2005a and 2005b). The glasses were fabricated and the durability (as defined by the Product Consistency Test (PCT)) assessed for both quenched and centerline canister cooled (ccc) samples.

All of the Phase 2 quenched glasses have normalized boron releases (NL [B]) less than 1.19 g/L which in terms of acceptability are approximately an order of magnitude better than the Environmental Assessment (EA) benchmark glass which has a reported NL [B] of 16.695 g/L. However, the potential for crystallization was suppressed in the quenched glasses in terms of kinetics. That is, the glasses may be prone to nepheline formation but the rapid cooling limited (or eliminated) the formation of nepheline (or other crystalline phases).

For the ccc glasses, visual observations suggested that in general, as the targeted waste loading (WL) within a specific frit – sludge system was increased, the degree of crystallization or devitrification appeared to be more extensive. This is not unexpected as the slower cooling provides a thermodynamically favorable glass (i.e., a composition within the nepheline primary phase field) the kinetic opportunity to devitrify. X-ray diffraction (XRD) results indicated the presence of nepheline ($NaAlSiO_4$), trevorite ($NiFe_2O_4$), and/or lithium silicate (Li_2SiO_3) in select Phase 2 ccc glasses. In general, as the WL increases within a specific frit – sludge system, the crystalline phase(s) detected transitioned from amorphous or spinels (at the lowest WL), to spinel and nepheline (at the intermediate WL), and ultimately to spinel, nepheline, and lithium silicate (at the highest WL). As a result, the difference between the quenched and ccc PCT response for each specific frit system increased as WL increased. Coupling this trend with the crystallization results, one can easily explain the durability responses as a function of WL. More specifically, as WL increases within a specific frit – sludge system, the durability of the ccc based glasses decreases due to the formation of nepheline and/or lithium silicate. The trends are in agreement with previous observations that the impact on durability is dependent upon the type and extent of crystallization and the resulting change to the residual glass composition. As previously noted, nepheline formation can result in a severe deterioration of the chemical durability of the glass through residual glass compositional changes (i.e., a continuous glass matrix which is Al_2O_3 and/or SiO_2 deficient).

The results of the Phase 1 and Phase 2 studies suggest that the 0.62 value appears to be a reasonable guide to monitor SB4 – frit systems with respect to potential nepheline formation upon ccc.[1] The significance of "ccc" in this sentence is based on the fact that none of the Phase 1 or Phase 2 quenched glasses showed any sign of nepheline formation (based on the PCT response) although some of the Phase 2 glasses had nepheline discriminator values as low as 0.541. The PCT responses for all of the quenched glasses were very acceptable. It is only when the glass is provided the kinetic opportunity to devitrify through the slow ccc schedule that nepheline forms and ultimately has an adverse impact on durability.

In Phase 2, the lower WL glasses showed no significant or practical differences in durability when comparing quenched and ccc glasses – this is consistent with the Phase 1 results. It was only at the higher WLs (in Phase 2) that nepheline formation had a significantly negative impact on durability. The practical implication to DWPF is that higher WL glasses should be avoided for these types of glass systems (i.e., high Al_2O_3 and Na_2O). The primary question becomes how can potential nepheline formation regions be avoided or controlled in DWPF if necessary? Although a formal recommendation of the specific path is not made in this report, a general discussion is provided on options that are available. These include (but are not limited to): (1) use of an administrative control on waste loading, (2) implementation of a nepheline discriminator value in the process control system, or (3) strategic frit development efforts to mitigate nepheline formation. It should be noted that although nepheline formation is a real and potentially significant issue, other constraints or alternatives may arise (e.g., pumping issues in the Chemical Process Cell (CPC) or melt rate) which could result in targeting lower WLs where nepheline is not an issue.

[1] Li et al. (1997 and 2003) indicated that sodium alumino-borosilicate glasses are prone to nepheline crystallization if their compositions projected on the Na_2O-Al_2O_3-SiO_2 ternary fall within or close to the nepheline primary phase field. In particular, glasses with $SiO_2/(SiO_2+Na_2O+Al_2O_3) > 0.62$, where the chemical formula stands for the mass fractions in the glass, do not tend to precipitate nepheline as their primary phase.

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LIST OF ACRONYMS

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
CBU	Closure Business Unit
ccc	centerline canister cooled
CPC	Chemical Process Cell
DWPF	Defense Waste Processing Facility
EA	Environmental Assessment
delGP or ΔG_P	preliminary glass dissolution estimator
g/L	grams per liter
HLW	high-level waste
ICP-AES	Inductively-Coupled Plasma – Atomic Emission Spectroscopy
LM	lithium-metaborate
MAR	Measurement Acceptability Region
NL	normalized leachate (or normalized release)
PCCS	Product Composition Control System
PCT	Product Consistency Test
PF	peroxide fusion
PSAL	Process Science Analytical Laboratory
ppm	parts per million
SB3	Sludge Batch 3
SB4	Sludge Batch 4
SME	Slurry Mix Evaporator
SRL	Savannah River Laboratory
SRNL	Savannah River National Laboratory
T_L	liquidus temperature
U_{std}	uranium standard
WL	waste loading
WQR	Waste Qualification Report
XRD	X-ray diffraction

1.0 INTRODUCTION

Crystallization (or devitrification) in nuclear waste glasses is an important consideration in terms of processing and product performance. With respect to the impact of crystallization on processability, the Defense Waste Processing Facility (DWPF) uses a liquidus temperature (T_L) model (Brown et al., 2001) and an imposed T_L limit for feed acceptability to avoid bulk devitrification within the melter. In terms of product quality or the durability of the waste form, the impact of devitrification depends on the type and extent of crystallization.

Although not summarized here, numerous studies (e.g., Bickford and Jantzen (1984 and 1986), Jantzen et al. (1984), Spilman et al. (1986), Marra and Jantzen (1993), Li et al. (1997), and Riley et al. (2001)) have assessed the devitrification potential of various high level waste (HLW) glasses and the impact on durability. In general, these studies agree that the impact of devitrification on durability is dependent upon the type and extent of crystallization. For example, a strong increase in glass dissolution (or decrease in durability) was observed in previous studies (Jantzen et al. (1984); Cicero et al. (1993); and Kim et al. (1995)) in glasses that formed aluminum-containing crystals, such as $NaAlSiO_4$ (nepheline) and $LiAlSi_2O_6$, or crystalline SiO_2. This is in contrast to the results from Bickford and Jantzen (1984) that indicated that the formation of spinel had little or no effect on the durability of Savannah River Laboratory (SRL) 165- or SRL 131-based glasses, while the formation of acmite produced a small but noticeable increase in the rate of dissolution of the matrix glass. The impact of devitrification on durability is complex and depends on several interrelated factors including the change in residual glass composition, the formation of internal stress or microcracks, and the preferential attack at the glass-crystal interface. As noted from previous experimental studies, perhaps the most significant effects are the type and extent (or fraction) of crystallization and the resulting change to the residual glass composition.

While it is well known that the addition of Al_2O_3 to borosilicate glasses generally enhances the durability of the waste form (through creation of network-forming tetrahedral Na^+-$[AlO_{4/2}]^-$ pairs), nepheline formation, which depends in part on the Al_2O_3 content, can result in a severe deterioration of the chemical durability of the glass through residual glass compositional changes. The primary driver for the reduction in durability is the fact that nepheline removes three moles of glass forming oxides (Al_2O_3 and $2SiO_2$) per each mole of Na_2O from the continuous glass phase. Therefore, nepheline formation produces an Al_2O_3 and SiO_2 deficient continuous glass matrix (relative to the same composition which is void of crystals) which reduces the durability of the final product. The magnitude of the reduction ultimately depends on the extent (e.g., volume %) of crystallization.

Li et al. (1997 and 2003) indicated that sodium alumino-borosilicate glasses are prone to nepheline crystallization if their compositions projected on the Na_2O-Al_2O_3-SiO_2 ternary fall within or close to the nepheline primary phase field. In particular, glasses with $SiO_2/(SiO_2+Na_2O+Al_2O_3) > 0.62$, where the chemical formula stands for the mass fractions in the glass, do not tend to precipitate nepheline as their primary phase. The formation of nepheline and/or other aluminum/silicon-containing crystals is a potential in the Sludge Batch 4 (SB4) system due to the projected compositional views recently evaluated coupled with the frit development strategy. Compositional projections of SB4 by Lilliston (2005) indicate the sludge will be enriched in Al_2O_3 (relative to the Al_2O_3 concentrations of previous sludge batches processed through the DWPF). Peeler and Edwards (2005a) have identified candidate frits (ranging in Na_2O concentration from 8 – 13% by mass) for the SB4 compositional projections. The combination of high Al_2O_3 and Na_2O concentrations, coupled with lower SiO_2 concentrations as waste loadings increase (given the primary source of SiO_2 is from the frit), can lead to the formation of nepheline.

Peeler et al. (2005a and 2005b) provided insight into the potential impact of nepheline formation for SB4 glasses based on the Lilliston (2005) compositional projections. In that study (referred to as Phase 1), twelve SB4-based glasses were fabricated (only two of which were prone to nepheline formation using the 0.62 value developed by Li et al. (2003) as a guide) and their durabilities measured. [2] In terms of "acceptability," the results indicated that all of the study glasses (both quenched and centerline canister cooled (ccc)) were acceptable with respect to durability as defined by the Product Consistency Test (PCT) (ASTM 2002). More specifically, the normalized boron release (NL [B]) values for all the Phase 1 nepheline glasses were much lower than the Environmental Assessment (EA) glass value of 16.695 g/L as defined by Jantzen et al. (1993). The most durable glass was NEPH-04 (quenched) with a NL [B] of 0.61 g/L, while the least durable glass was NEPH-01 (ccc) with an NL [B] of 2.47 g/L (based on the measured composition).

The Phase 1 PCT results suggested that for the two glasses prone to nepheline formation (NEPH-01 and NEPH-02), a statistically significant difference in PCT response was observed between the quenched and ccc versions but the impact on durability was of little or no practical concern. When the PCT responses were coupled with the X-Ray Diffraction (XRD) results and/or visual observations, it was concluded that the formation of nepheline in these glasses did have a negative impact on durability. However, the impact was only a statistical difference – and not of practical significance or concern.

The results of the Phase 1 study not only suggested that the 0.62 value appeared to be a reasonable guide to monitor alumino-borosilicate based glass systems with respect to potential nepheline formation, but also that the presence of nepheline, although statistically significant, has little or no practical impact in the SB4 system on durability as measured by the PCT. This latter statement must be qualified to some extent given that only two glasses were selected which were actually prone to nepheline formation based on the general guide and that the volume % of nepheline formed based on XRD results was relatively low (~ 0.5 vol%). Given the waste loadings (WLs) for the Phase 1 glasses were limited to 40%, if higher WLs were considered, the potential for nepheline formation (and potentially the vol%) could increase and the likelihood of observing a significant and practical difference in PCT response could be realized.

Since the issuance of the Phase 1 report, revised compositional projections from the Closure Business Unit (CBU) for SB4 have been issued (Elder 2005a, Elder 2005b). These revised compositional projections were framed around three decision areas: the sodium molarity of the sludge (at values of 1M Na and 1.6M Na), the Sludge Batch 3 (SB3) heel that will be included in the batch (expressed in inches of SB3 sludge with values of 0, 40, and 127"), and the introduction of an Actinide Removal Process (ARP) stream into the sludge (which is represented by six options: no ARP, ARP-A, ARP-E, ARP-K, ARP-M, and ARP-V). In response to these revised projections, Peeler and Edwards (2005b) have identified candidate frits (via a paper study approach) whose operating windows (i.e., waste loading intervals that meet Product Composition Control System (PCCS) Measurement Acceptability Region (MAR) criteria) are robust to and/or selectively optimal for these sludge options. The results of that paper study indicated that candidate frits are available for the various SB4 options which provide relatively large operating windows. Besides the revised compositional projections, the primary difference between this second assessment (Peeler and Edwards 2005b) and the first (Peeler and Edwards 2005a) was the fact that the 0.62 nepheline value was used as a screening tool to evaluate the potential impact of nepheline formation on the projected operating windows in the most recent assessment. The results of activating the nepheline discriminator (Peeler and Edwards 2005b) indicated that access to higher WLs for almost all frit – sludge options was possible assuming that the nepheline discriminator value was "challenged." That is, a relatively large WL interval was available in which all PCCS MAR criteria were satisfied except for the nepheline discriminator value. This suggested possible issues associated with crystallization and

[2] Both NEPH-01 and NEPH-02 had nepheline discriminator values of approximately 0.61 – just below the 0.62 cut-off value as defined by Li et al. (2003).

ultimately a possible impact on durability. In response to this finding, Edwards and Peeler (2005) identified 28 Phase 2 glasses that intentionally challenged the "nepheline discriminator" value based on the 1.6M Na, 40" and 1.6M Na, 127" sludge options as defined by Elder (2005a and 2005b). The Phase 2 glasses were selected to complement the Phase 1 study (Peeler et al. 2005b) by continuing the investigation into the ability of the nepheline constraint to predict the occurrence of this primary phase for SB4 glasses and the potential for such a crystalline phase to have an impact on durability. In general, the Phase 2 glasses were selected to cover WLs over which nepheline was the only criterion restricting acceptability (see Section 2.0 for more details). It should be noted that the primary difference between the Phase 1 and Phase 2 nepheline studies is that Phase 2 "pushes the envelope" or challenges the nepheline predictor for all glasses – not just a few select glasses as in Phase 1. In order to meet this objective, WLs of ~ 40% or higher were targeted for the Phase 2 glasses where 40% was the maximum WL used during Phase 1. As previously mentioned, as WL increases, the probability of nepheline formation increases given the Al_2O_3 and Na_2O concentrations increase and SiO_2 concentrations decrease.

The Phase 2 glasses were batched and fabricated using standard procedures. Visual observations and other analytical techniques were used, as needed, to assess the presence of crystals and specifically, nepheline. The durability of these glasses (both quenched and ccc versions) were measured using the ASTM PCT (ASTM 2002). This report documents the experimental results of the Phase 2 nepheline study.

An overview of the Phase 2 glass selection process is provided in Section 2.0. The experimental approach is described in Section 3.0. In Section 4.0, the results of the study are presented and discussed. More specifically, an assessment of the target versus measured compositions is provided to ensure the objectives of the task can be met. In addition, the PCT results for both quenched and ccc glasses are presented for each study glass. The PCT results are discussed in terms of acceptability and model predictability. The results of both visual and XRD analyses are also presented and discussed in relation to the objectives of the task. The impacts to DWPF are discussed in Section 5.0. Section 6.0 and Section 7.0 provide a summary and path forward, respectively.

The results of this study will provide valuable input for the frit development efforts and subsequent feedback to the CBU regarding the relative viability of the various SB4 options under consideration. Specifically, if the formation of nepheline for SB4 glasses is found through this study to have an impact on durability that is overly detrimental, then candidate frits, that lessen the likelihood of the formation of nepheline over an interval of waste loadings of interest to the DWPF, would move up the list of preferred frits. On the other hand, if the presence of nepheline has no appreciable, adverse impact on durability, then as decisions regarding the viability of the SB4 options and the down select of candidate frits are pursued, little weight will be given to minimizing the likelihood of nepheline and the decisions will be dominated by waste throughput criteria.

2.0 GLASS SELECTION

Edwards and Peeler (2005) provide a detailed description of the selection process for the twenty-eight Phase 2 glasses. For completeness, a brief overview is provided below. Fourteen of the 28 Phase 2 glasses were based on the nominal 1.6M Na^+ with a 40" SB3 heel option while the other 14 glasses were based on the nominal 1.6M Na^+ with a 127" SB3 heel – both "sludge-only" based flowsheets with no addition of ARP. Each of these nominal sludge options was combined with frits 320, 417, 418, 425, and 426 at WLs from 25 through 60% (in WL increments of 1%) to provide the initial set of glass compositions from which the twenty-eight nepheline glasses were selected. Figure 2-1 summarizes the MAR-based operating windows for these SB4 glass systems. For this plot the interpretation of the colors is as follows**: red indicates WLs that are restricted by PCCS**, **blue indicates WLs that are "restricted" only by the concern for the potential for the formation of a nepheline primary phase field using a 0.62 value**, and **green indicates WLs that are acceptable by PCCS.**

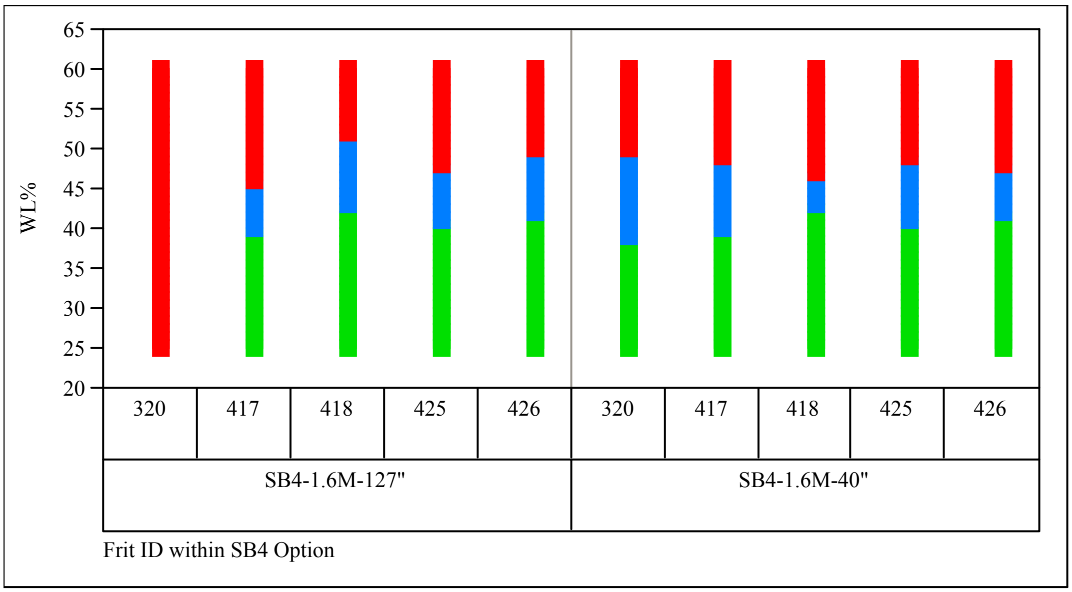

Figure 2-1. Operating Windows for Select SB4 Glass Systems.

With the exception of the Frit 320 - 1.6M-127" option, the plots indicate that the operating window for each system would be expanded if the nepheline constraint were challenged (i.e., the "blue" WL range). The MAR-based assessment was used for selecting the Phase 2 nepheline study glasses – glasses that were prone to nepheline formation without failing any PCCS constraint. In general (and when applicable), three glasses spanning the "blue WL range" were selected for each SB4 – frit system. Within a specific frit – SB4 system, the lowest WL glass selected represents a transition from a non-nepheline prone glass ("green" region) to a glass that is anticipated to form nepheline ("blue" region). These lower WL glasses have nepheline discriminator values falling just below the 0.62 guide. On the opposite end of the WL spectrum, the maximum WL selected for the Phase 2 glasses (within each specific frit – sludge system) targets the transition from "blue" to "red" which suggests that not only is nepheline a concern but a PCCS property (such as T_L, viscosity, or durability) is close to failing its MAR criterion. The maximum WL targeted for the Phase 2 glasses represents the highest WL that is still considered acceptable by all PCCS criteria but does not satisfy the nepheline discriminator value. In fact, the glasses targeting the higher WLs for all frit – sludge systems represent the lowest nepheline discriminator values which could translate into a higher propensity to form nepheline (and/or a higher volume %) and ultimately a more significant impact on durability. A third glass was selected at an intermediate WL within each frit – sludge option (when appropriate).

The glass compositions generated by this process are given in Table 2-1 and Table 2-2. Table 2-1 summarizes the 14 glasses based on the 127" SB3 heel option. Table 2-2 summarizes the 14 glasses based on the 40" SB3 heel option. Unique identifiers for these glasses are provided in the first row of each table, and the value of the nepheline discriminator for each glass is also included in these tables. As previously mentioned, within a specific frit – sludge system, the nepheline discriminator value decreases with increased WLs.

For the Frit 320 – 1.6M, 127" option, the entire WL interval from 25 – 60% is restricted by predictions of durability given the high content of Na_2O in the sludge as well as the frit. For this system, two glasses were selected – NEPH2-13 and NEPH2-14. These glasses target 39 and 42% WL and represent the WL interval which challenges nepheline when one ignores predictions of durability. These two glasses will provide insight into possible conservatism in the durability model even with the proposed durability limits as defined by Edwards, Peeler, and Marra (2003). For the Frit 418 – 1.6M, 40" SB3 heel option, the WL interval over which nepheline was challenged was 43 – 46% WL (i.e., NEPH2-39 and NEPH2-40, respectively). Therefore selecting a third, intermediate WL for this system was not seen to be of much value.

Table 2-1. Target Compositions of the SB4-1.6M-127" Based Phase 2 Glasses.
(as wt%'s)

#	NEPH2-13	NEPH2-14	NEPH2-15	NEPH2-16	NEPH2-17	NEPH2-18	NEPH2-19	NEPH2-20	NEPH2-21	NEPH2-22	NEPH2-23	NEPH2-24	NEPH2-25	NEPH2-26
Frit ID	320	320	417	417	417	425	425	425	426	426	426	418	418	418
%WL	39	42	40	43	45	41	44	47	42	46	49	43	47	51
nepheline	0.617	0.596	0.618	0.596	0.581	0.619	0.597	0.573	0.620	0.589	0.565	0.620	0.588	0.556
Al_2O_3	10.210	10.995	10.472	11.257	11.781	10.734	11.519	12.304	10.995	12.043	12.828	11.257	12.304	13.352
B_2O_3	4.880	4.640	4.800	4.560	4.400	4.720	4.480	4.240	4.640	4.320	4.080	4.560	4.240	3.920
BaO	0.053	0.057	0.054	0.058	0.061	0.055	0.059	0.064	0.057	0.062	0.066	0.058	0.064	0.069
CaO	0.776	0.836	0.796	0.856	0.896	0.816	0.876	0.936	0.836	0.916	0.976	0.856	0.936	1.015
Ce_2O_3	0.073	0.078	0.075	0.080	0.084	0.076	0.082	0.088	0.078	0.086	0.091	0.080	0.088	0.095
Cr_2O_3	0.091	0.098	0.093	0.100	0.105	0.095	0.102	0.109	0.098	0.107	0.114	0.100	0.109	0.119
CuO	0.028	0.031	0.029	0.031	0.033	0.030	0.032	0.034	0.031	0.033	0.036	0.031	0.034	0.037
Fe_2O_3	8.648	9.313	8.870	9.535	9.979	9.092	9.757	10.422	9.313	10.200	10.866	9.535	10.422	11.309
K2O	0.545	0.587	0.559	0.601	0.629	0.573	0.615	0.657	0.587	0.643	0.685	0.601	0.657	0.713
La_2O_3	0.031	0.034	0.032	0.035	0.036	0.033	0.035	0.038	0.034	0.037	0.039	0.035	0.038	0.041
Li_2O	4.880	4.640	4.800	4.560	4.400	4.720	4.480	4.240	4.640	4.320	4.080	4.560	4.240	3.920
MgO	0.548	0.590	0.562	0.604	0.633	0.576	0.618	0.661	0.590	0.647	0.689	0.604	0.661	0.717
MnO	1.901	2.047	1.949	2.095	2.193	1.998	2.144	2.290	2.047	2.242	2.388	2.095	2.290	2.485
Na_2O	17.695	18.133	17.241	17.709	18.021	16.807	17.305	17.804	16.393	17.098	17.626	15.999	16.744	17.488
NiO	1.192	1.284	1.223	1.314	1.375	1.253	1.345	1.437	1.284	1.406	1.498	1.314	1.437	1.559
PbO	0.069	0.074	0.071	0.076	0.080	0.072	0.078	0.083	0.074	0.081	0.087	0.076	0.083	0.090
SO_4	0.417	0.449	0.428	0.460	0.481	0.439	0.471	0.503	0.449	0.492	0.524	0.460	0.503	0.546
SiO_2	44.964	42.884	44.871	42.761	41.355	44.758	42.618	40.478	44.624	41.731	39.562	44.471	41.538	38.605
ThO_2	0.015	0.016	0.015	0.016	0.017	0.016	0.017	0.018	0.016	0.017	0.019	0.016	0.018	0.019
TiO_2	0.007	0.008	0.008	0.008	0.008	0.008	0.008	0.009	0.008	0.009	0.009	0.008	0.009	0.010
U_3O_8	2.836	3.054	2.908	3.126	3.272	2.981	3.199	3.417	3.054	3.345	3.563	3.126	3.417	3.708
ZnO	0.042	0.045	0.043	0.046	0.048	0.044	0.047	0.050	0.045	0.049	0.052	0.046	0.050	0.055
ZrO_2	0.100	0.107	0.102	0.110	0.115	0.105	0.112	0.120	0.107	0.117	0.125	0.110	0.120	0.130

Table 2-2. Target Compositions of the SB4-1.6M-40" Based Phase 2 Glasses.
(as wt%'s)

Glass ID #	NEPH2-27	NEPH2-28	NEPH2-29	NEPH2-30	NEPH2-31	NEPH2-32	NEPH2-33	NEPH2-34	NEPH2-35	NEPH2-36	NEPH2-37	NEPH2-38	NEPH2-39	NEPH2-40
Frit ID	320	320	320	417	417	417	425	425	425	426	426	426	418	418
%WL	39	44	49	40	44	48	41	45	48	42	45	47	43	46
nepheline	0.615	0.579	0.541	0.616	0.587	0.556	0.617	0.587	0.563	0.618	0.594	0.579	0.618	0.594
Al_2O_3	11.641	13.133	14.626	11.939	13.133	14.327	12.238	13.432	14.327	12.536	13.432	14.029	12.835	13.730
B_2O_3	4.880	4.480	4.080	4.800	4.480	4.160	4.720	4.400	4.160	4.640	4.400	4.240	4.560	4.320
BaO	0.056	0.063	0.071	0.058	0.063	0.069	0.059	0.065	0.069	0.060	0.065	0.068	0.062	0.066
CaO	0.749	0.845	0.941	0.769	0.845	0.922	0.788	0.865	0.922	0.807	0.865	0.903	0.826	0.884
Ce_2O_3	0.075	0.085	0.095	0.077	0.085	0.093	0.079	0.087	0.093	0.081	0.087	0.091	0.083	0.089
Cr_2O_3	0.098	0.110	0.123	0.100	0.110	0.120	0.103	0.113	0.120	0.105	0.113	0.118	0.108	0.115
CuO	0.029	0.033	0.037	0.030	0.033	0.036	0.031	0.034	0.036	0.031	0.034	0.035	0.032	0.034
Fe_2O_3	8.330	9.398	10.466	8.544	9.398	10.252	8.757	9.612	10.252	8.971	9.612	10.039	9.184	9.825
K2O	0.669	0.755	0.840	0.686	0.755	0.823	0.703	0.772	0.823	0.720	0.772	0.806	0.737	0.789
La_2O_3	0.032	0.036	0.040	0.033	0.036	0.039	0.033	0.037	0.039	0.034	0.037	0.038	0.035	0.037
Li_2O	4.880	4.480	4.080	4.800	4.480	4.160	4.720	4.400	4.160	4.640	4.400	4.240	4.560	4.320
MgO	0.415	0.468	0.522	0.426	0.468	0.511	0.436	0.479	0.511	0.447	0.479	0.500	0.458	0.490
MnO	1.872	2.112	2.352	1.920	2.112	2.304	1.968	2.160	2.304	2.016	2.160	2.256	2.064	2.208
Na_2O	16.514	17.093	17.671	16.030	16.533	17.036	15.565	16.108	16.516	15.121	15.558	15.850	14.697	15.164
NiO	1.358	1.532	1.706	1.393	1.532	1.672	1.428	1.567	1.672	1.463	1.567	1.637	1.498	1.602
PbO	0.076	0.086	0.096	0.078	0.086	0.094	0.080	0.088	0.094	0.082	0.088	0.092	0.084	0.090
SO_4	0.402	0.453	0.505	0.412	0.453	0.495	0.423	0.464	0.495	0.433	0.464	0.484	0.443	0.474
SiO_2	44.987	41.524	38.061	44.894	42.084	39.273	44.782	41.931	39.793	44.649	42.481	41.036	44.497	42.299
ThO_2	0.016	0.018	0.020	0.017	0.018	0.020	0.017	0.019	0.020	0.017	0.019	0.020	0.018	0.019
TiO_2	0.007	0.008	0.009	0.007	0.008	0.009	0.008	0.008	0.009	0.008	0.008	0.009	0.008	0.009
U_3O_8	2.765	3.120	3.474	2.836	3.120	3.403	2.907	3.190	3.403	2.978	3.190	3.332	3.049	3.261
ZnO	0.042	0.048	0.053	0.043	0.048	0.052	0.044	0.049	0.052	0.045	0.049	0.051	0.046	0.050
ZrO_2	0.107	0.120	0.134	0.109	0.120	0.131	0.112	0.123	0.131	0.115	0.123	0.128	0.117	0.126

3.0 EXPERIMENTAL

3.1 Glass Fabrication

Each Phase 2 glass, NEPH2-13 through NEPH2-40, was prepared from the proper proportions of reagent-grade metal oxides, carbonates, H_3BO_3, and salts in 150-g batches. Once batched (SRNL 2002a), the glasses were melted using Savannah River National Laboratory (SRNL) technical procedure "Glass Melting" (SRNL 2002b). In general, 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. After an isothermal hold at 1150°C for 1.0 h, the crucible was removed, and 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 (i.e., chemical composition and durability).

In order to bound the effects of thermal history on the product performance, approximately 25 g of each glass was heat-treated to simulate cooling along the centerline of a DWPF-type canister (Marra and Jantzen, 1993). This cooling regime is commonly referred to as the centerline canister cooled (ccc) curve.[3] Visual observations on both quenched and ccc glasses were documented.[4]

3.2 Property Measurements

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

3.2.1 Compositional Analysis

To confirm that the "as-fabricated" glasses corresponded to the defined 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 dissolution techniques (i.e., sodium peroxide fusion [PF] and lithium-metaborate [LM]) to be used. The samples prepared by LM were used to measure for 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 for aluminum (Al), boron (B), iron (Fe), lithium (Li), manganese (Mn), nickel (Ni), silicon (Si), and uranium (U). Each glass was prepared in duplicate for each cation dissolution technique (PF and LM). 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 error. Glass standards were also intermittently run to assess the performance of the ICP-AES over the course of these analyses.

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[3] With respect to DWPF processing, there are two extremes in terms of the thermal history the glass being poured into the canister could experience. A certain fraction of the glass would be quenched as it contacts the DWPF canister and cools rapidly. On the other end of the spectrum, a certain fraction of the glass will experience a relatively slow cooling which occurs along the centerline of the canister as described by Marra and Jantzen (1993).

[4] WSRC-NB-2005-00054 contains the visual observations of the quenched and ccc glasses as well as the results of the XRD and PCT analyses for the Phase 2 glasses.

Although not the primary focus of the Phase 2 study, SO_4 solubility is a secondary concern for this SB4 study. The compositional analysis, coupled with the visual observations of the as-fabricated glasses, will serve as primary indicators that the current 0.6 wt% SO_4 limit (established for the Frit 418 – SB3 system by Peeler et al. (2004)) is still applicable for SB4. Previous tests have suggested that the use of reagent grade raw materials is conservative with respect to SO_4 retention and/or volatility.[5] Therefore, the ability of the Phase 2 glasses to retain the targeted SO_4 concentrations (especially at the higher WLs) will provide valuable insight into the applicability of the SO_4 limit for SB4. Although the concentrations in the Phase 2 glasses do not exceed the 0.6 wt% limit, the results when coupled with the preliminary SB4 results presented by Lorier et al. (2005) will provide part of the technical basis for the SO_4 limit for SB4. As previously mentioned, both visual observations (i.e., the formation of a salt layer on the surface of the glass being indicative of exceeding the SO_4 limit) and a comparison of measured versus targeted SO_4 concentrations in glass will be the primary tools to support this assessment. From Table 2-1 and Table 2-2 the targeted SO_4 concentrations in the Phase 2 glasses range from 0.402 (in NEPH2-27) to 0.546 wt% (NEPH2-26).

3.2.2 Product Consistency Test (PCT)

The PCT was performed in triplicate on each quenched and each ccc Phase 2 glass to assess chemical durability using technical procedure "Standard Test Methods for Determining Chemical Durability of Nuclear Waste Glasses: The Product Consistency Test (PCT)" (ASTM 2002). Also included in this experimental test matrix was the EA glass (Jantzen et al., 1993), the Approved Reference Material (ARM) glass, and blanks from the sample cleaning batch. Samples were ground, washed, and prepared according to procedure (ASTM 2002). 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 $90 \pm 2°C$ where the samples were maintained for 7 days. The resulting solutions (once cooled) were sampled (filtered and acidified), labeled (according to the analytical plan), and analyzed under the auspices of two analytical plans (see Appendix B).[6] The overall philosophy of the plans was to provide an opportunity to assess the consistency (repeatability) of the PCT and analytical procedures in an effort to evaluate chemical durability of the Phase 2 glasses. Normalized release rates were calculated based on targeted, measured, and bias-corrected (bc) compositions using the average of the logs of the leachate concentrations.

3.2.3 X-Ray Diffraction (XRD) Analysis

Although visual observations for crystallization were performed and documented, representative samples for all ccc Phase 2 glasses were submitted to the SRNL Analytical Development Section (ADS) for XRD analysis.[7] Samples were run under conditions allowing a detection limit of approximately 0.5 vol%. That is, if crystals (or undissolved solids) are present at 0.5 vol% (or

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[5] Previous results have indicated that the use of raw materials (reagent grade chemicals) to produce the glasses minimizes SO_4 volatilization during the fabrication process. This approach will provide a conservative measure of SO_4 retention in the glass as volatilization is anticipated in slurry-fed melters.

[6] One analytical plan (SRNL-SCS-2005-00041) was developed to assess the PCT solutions resulting from the 127" SB3 heel based glasses (shown in Table 2-1); while a second plan (SRNL-SCS-2005-00044) was developed for the 40" SB3 heel glasses (shown in Table 2-2). Also provided in Appendix B is a third analytical plan (SRNL-SCS-2005-00051) which was developed to support the remeasurement of select Phase 2 glasses as will be discussed in Section 4.2.

[7] Based on visual observations and the PCT responses, the quenched glasses were not submitted for XRD analyses.

greater), the diffractometer will not only be capable of detecting the crystals but will also allow a qualitative measure (i.e., determine the type of crystal[s] present). Otherwise, a characteristically high background devoid of crystalline spectral lines indicates that the glass product is amorphous (suggesting either a completely amorphous product or that the degree of crystallization is below the detection limit).

4.0 RESULTS

In this section, the compositional assessment (targeted versus measured), the durability response (as measured by the PCT), and the XRD results are presented. Initially, the compositional results are presented to determine if the measured compositions are in-line with the targeted compositions (i.e., no significant batching errors were evident). The durability information for both quenched and ccc versions of each Phase 2 glass is then presented and discussed given it is the primary response variable of interest. The PCT results should provide a marker for those systems in which nepheline formation was likely. Significant differences observed between quenched and ccc versions of each glass will be highlighted and compared to the corresponding nepheline discriminator value. In addition, the acceptability of the Phase 2 glasses (measured releases compared to the EA glass benchmark) as well as the predictability of the glasses are also discussed. Finally, visual and XRD results are presented to provide a technical basis from which the impact (or lack thereof) of crystallization on durability can be assessed.

4.1 A Statistical Review

of the Chemical Composition Measurements for the Phase 2 Nepheline Glasses

In this section, the measured versus targeted compositions of the 28 Phase 2 nepheline study glasses (NEPH2-13 through NEPH2-40) are presented and compared. The targeted compositions for these glasses were provided in Table 2-1 and Table 2-2 (also shown 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 as described in Section 3.2.1.

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 plans 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.

4.1.1 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. A 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 obvious outliers in these chemical composition measurements.

4.1.2 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-AES 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 for each oxide of interest. The results include analysis of variance (ANOVA) investigations looking for statistically significant differences among the block means for each of the oxides for each of the standards. The results from the statistical tests for significant differences for the Batch 1 standard may be summarized as follows: BaO, CaO, Cr_2O_3, CuO, K_2O, MgO, TiO_2, and ZrO_2 have measurements that indicate a significant ICP-AES calibration effect on the block averages at the 5% significance level. For the U_{std}, CaO, K_2O, MgO, Na_2O, and TiO_2 have measurements that indicate a significant ICP-AES 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 significant differences for the Batch 1 standard may be summarized as follows: Al_2O_3, Fe_2O_3, Li_2O, NiO, and SiO_2 have measurements that indicate a significant ICP-AES calibration effect on the block averages at the 5% significance level. For the U_{std}, Al_2O_3, Fe_2O_3, Li_2O, NiO, and SiO_2 have measurements that indicate a significant ICP-AES 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.

These results provide incentive for adjusting the measurements by the effect of the ICP-AES calibration. Therefore, the oxide measurements of the study glasses were bias corrected for the effect of the ICP-AES calibration on each of the analytical 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-AES block/sub-block for 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 and the average measurement for U_{std} for each ICP-AES block/sub-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, ThO_2, ZnO, or ZrO_2.

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

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

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). 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 (i.e., once again, no bias correction was performed for this group of oxides).

4.1.3 Composition Measurements by Glass Number

Exhibits C5 and C6 in Appendix C provide plots of the oxide concentration measurements by Glass ID # (including both Batch 1, labeled as glass numbered 100 and U_{std}, labeled as glass numbered 200) 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-AES calibrations. A review of the plots presented in these exhibits reveals the repeatability of the four individual oxide values for each glass. There appears to be a good bit of scatter in the Fe_2O_3 values, in the MnO values, and in the SiO_2 values. In addition, there appears to be inconsistencies between the two dissolutions for the La_2O_3 values for NEPH2-15 and -26 as well as an outlier in the ZnO concentration for one of the NEPH2-30 replicates. No other problems are evident in these plots.

More detailed discussions of the average, measured chemical compositions of the study glasses are provided in the sections that follow.

4.1.4 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: The measured values for NEPH2-21 for many of the oxides are consistently lower than their corresponding targets. NEPH2-27 and NEPH2-28 reveal a disturbing pattern in their measured versus targeted values for several of the oxides. The pattern reflects the potential of a batching issue (i.e., the glasses may have been switched) in that the measured values for NEPH2-27 and NEPH2-28 are close to the targeted values for the other glass. For nearly every nepheline study glass, the measured Fe_2O_3 values, the NiO values, and the Ce_2O_3 values are less than their respective targeted concentrations. As mentioned in Section 4.1.3, the La_2O_3 values for NEPH2-15 and -26 showed significant scatter among the replicates which results in the measured values being higher than targeted. Although no scatter was observed among the replicates for NEPH2-19, the measured La_2O_3 values are also higher than targeted. A review of the ZnO values for NEPH2-21 and NEPH2-30 suggests that the measured values are lower and higher, respectively, as compared to their corresponding targeted values.

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%; the measured sum of oxides for NEPH2-21 was only 95.2%, however. 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 that there were some difficulties in hitting the targeted compositions for some of the oxides for some of the glasses.

Specifically, the issues identified above for NEPH2-21, NEPH2-27, and NEPH2-28 led to the re-submission of samples of these glasses to PSAL for additional measurements. Table C5 in Appendix C provides the results generated by PSAL for these samples. Exhibit C8 in Appendix C provides comparison plots (measured, targeted, and re-measured) for the three glasses by oxide. Table C6 in Appendix C provides the average of these oxide values for each glass. While the re-measured values move more toward the target values for some oxides, it is not clear from these results what may have happened in the batching or measurement of these samples, although such problems are thought to have occurred. As a result, it is recommended that the three glasses (NEPH2-21, NEPH2-27, and NEPH2-28) not be included in any future modeling of durability responses. In the results that follow, the original measurements of these glasses will be used in the assessments of the durability of these three glasses.

4.1.5 SO_4 Retention or Solubility

Although not the primary focus of the Phase 2 study, a secondary concern for SB4 is the potential need to redefine the SO_4 solubility limit for SB4. The compositional analysis, coupled with the visual observations of the as-fabricated glasses (see Section 4.3.1), will serve as primary indicators that the current 0.6 wt% SO_4 limit (established for the Frit 418 – SB3 system by Peeler et al. (2004)) is still applicable for SB4. From Table 2-1 and Table 2-2, the targeted SO_4 concentrations in the Phase 2 glasses range from 0.402 (in NEPH2-27) to 0.546 wt% (NEPH2-26).

Figure 4-1 summarizes the targeted versus measured SO_4 concentrations in glass. The blue line represents the targeted concentrations as noted in Table 2-1 and Table 2-2. The red x's represent the measured SO_4 concentrations in glass, while the green squares are the measured bias-corrected values. Since there is no SO_4 in either standard glass, the measured values could not be bias corrected. The data suggest essentially full retention in glass – i.e., no volatilization during the fabrication process. Although the visual observations are discussed in Section 4.3.1 in more detail, there were no signs of a salt layer on any of the Phase 2 glasses upon fabrication. Coupling the analytical measurements with visual observations of the as-fabricated glasses, the results suggest that the 0.6 wt% SO_4 limit is applicable for the SB4 system. If the SO_4 concentration in the SB4 feed to DWPF contains the projected levels, then expectations are that no issues with SO_4 solubility are anticipated.

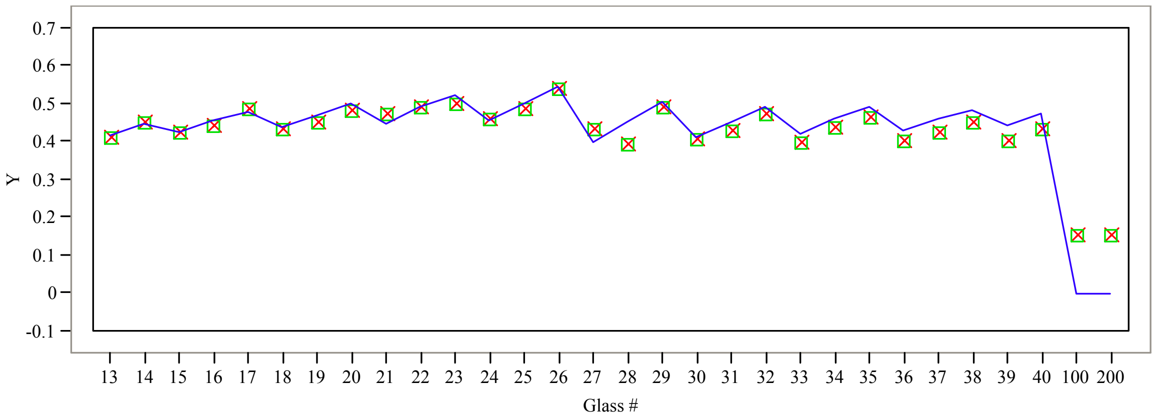

Figure 4-1. Targeted Versus Measured SO4 Values.

4.2 A Statistical Review of the PCT Measurements

The nepheline study glasses, after being batched and fabricated, were subjected to the PCT to assess their durabilities as described in Section 3.2.2. 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. However, one sample (D92) was inadvertently spilled and lost (as indicated by its blank row in Table D1).[8] No measurements were possible for this sample. Any measurement in Table D1 below the detection limit of the analytical procedure (indicated by a "<") was replaced by ½ 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.

Initial screening of the results of Table D2 suggested some problems with the measurements for NEPH2-33, NEPH2-34, and NEPH2-35. Both heat treatments for these glasses were re-submitted for PCT testing and measurement by PSAL. An analytical plan was prepared for the samples and standards for these tests and the measurements generated by PSAL are included in Table D1 and Table D2 as Part 3.[9] For the analyses that follow, the PCTs for NEPH2-33, NEPH2-34, and NEPH2-35 are those provided in Part 3 of these tables.

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[8] D92 was one of the triplicate PCT solutions for the quenched version of NEPH2-34 glass.

[9] The analytical plan supporting this assessment was SRNL-SCS-2005-00051 ("An Analytical Plan for Measuring the PCT Solutions for Select Set of Glasses from the Phase 2 Nepheline Study") – see Appendix B.

One of the important objectives of this study is the investigation of the effects of the heat treatment on the PCTs. 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 (Jantzen et al. 1995).

4.2.1 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 excluding EA, respectively. A different color and symbol is used for each study glass or standard. No problems are seen in these plots.

4.2.2 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-AES analytical (or calibration) block. An ANOVA investigating for statistically significant differences among the part/block averages for these samples for each element of interest is included in these exhibits. These results indicate a statistically significant (at the 5% level) difference among the B, Li, Na, and Si average measurements over these parts/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-AES blocks. Averaging the ppm's for each set of triplicates helps to minimize the impact of the ICP-AES effects.

Table 4-1 summarizes the average measurements and the reference values for the 4 primary elements of interest. The results indicate consistent and accurate measurements from the PSAL processes used to conduct these analyses.

Table 4-1. Results from Samples of the Multi-Element Solution Standard.

Analytical Part/Block	Avg B (ppm)	Avg Li (ppm)	Avg Na (ppm)	Avg Si (ppm)
1/1	20.3	10.2	82.5	49.5
1/2	19.4	10.1	82.8	50.0
1/3	20.0	10.0	85.5	51.3
2/1	21.0	9.8	85.2	51.5
2/2	21.0	9.9	81.6	51.4
2/3	20.3	9.7	81.4	51.5
3/1	18.7	9.7	87.8	49.4
3/2	20.1	9.9	86.0	48.3
3/3	20.2	9.7	85.4	48.3
Grand Average	20.1	9.9	84.2	50.1
Reference Value	20	10	81	50
% difference	0.5%	-1.1%	4.0%	0.3%

4.2.3 Measurements by Glass Number

Exhibit D4 in Appendix D provides plots of the leachate concentrations for each type of submitted sample: the study glasses and the standards (EA, ARM, the multi-element solution standard, and blanks). Exhibit D5 in Appendix D provides plots of the leachate concentrations for the ccc results of the study glasses and for EA. These plots allow for the 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 the results from the two heat treatments are shown for each study glass and that some differences between the two sets of values are evident.

4.2.4 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 D2 of Appendix D),

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 normalizations of the PCTs (i.e., those generated using the targeted, measured, and bias-corrected compositional views) and both heat treatments are represented in these 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. A high degree of correlation is seen for these data. The smallest correlation (93.48%) is for the Li and Na data.

Table 4-2 and Table 4-3 summarize the normalized release values for the 1.6M, 127" SB3 heel and 1.6M, 40" SB3 heel option glasses, respectively. The quenched values for each glass are shaded gray. The PCT results have been normalized based on all three compositional views for both quenched and ccc based glasses.

All of the Phase 2 quenched glasses have normalized boron releases less than 1.19 g/L, which in terms of acceptability are approximately an order of magnitude better than the EA benchmark glass that has a reported NL [B] of 16.695 g/L (Jantzen et al. 1993). The range of normalized boron releases for the quenched Phase 2 glasses is from 0.67 g/L (NEPH2-27 based on the Frit 320 – 40" SB3 heel case at 39% WL) to 1.19 g/L (NEPH2-16 based on the Frit 417 – 127" SB3 heel case at 43% WL). The results suggest that even though the glasses are prone to nepheline formation based on the 0.62 guide value, all 28 Phase 2 quenched glasses are acceptable which may provide some technical basis for "challenging" nepheline formation to gain access to higher WLs for the various SB4 options – independent of frit composition. However, the potential for crystallization was suppressed in the quenched glasses in terms of kinetics. That is, the glasses may be prone to nepheline formation but the rapid cooling limited (or eliminated) the formation of nepheline (or other crystalline phases). As observed in the Phase 1 glasses, it was only in the slow cooled (ccc) NEPH-01 and NEPH-02 glasses where the impact of nepheline on the durability response was observed. Both of these glasses were prone to nepheline formation with a statistical (not practical) difference in PCT response being observed between the quenched and ccc versions.

Table 4-2. Normalized Release Values for the 127" SB3 Heel Based Phase 2 Glasses. (NEPH2-13 through NEPH2-26)

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	-0.269	-0.189	-0.229	-0.506	0.54	0.65	0.59	0.31
EA	-	reference	1.252	0.991	1.142	0.610	17.85	9.80	13.86	4.07
NEPH2-13	quenched	measured	-0.007	0.024	0.176	-0.123	0.98	1.06	1.50	0.75
NEPH2-13	quenched	measured bc	-0.012	0.015	0.195	-0.128	0.97	1.04	1.57	0.74
NEPH2-13	quenched	target	-0.026	0.002	0.166	-0.129	0.94	1.00	1.46	0.74
NEPH2-13	ccc	measured	0.020	0.077	0.151	-0.113	1.05	1.19	1.42	0.77
NEPH2-13	ccc	measured bc	0.015	0.068	0.170	-0.119	1.04	1.17	1.48	0.76
NEPH2-13	ccc	target	0.001	0.055	0.141	-0.120	1.00	1.13	1.38	0.76
NEPH2-14	quenched	measured	0.049	0.035	0.207	-0.116	1.12	1.09	1.61	0.77
NEPH2-14	quenched	measured bc	0.047	0.031	0.222	-0.117	1.11	1.07	1.67	0.76
NEPH2-14	quenched	target	0.022	0.012	0.183	-0.118	1.05	1.03	1.52	0.76
NEPH2-14	ccc	measured	0.322	0.278	0.277	-0.007	2.10	1.90	1.89	0.98
NEPH2-14	ccc	measured bc	0.320	0.274	0.291	-0.008	2.09	1.88	1.96	0.98
NEPH2-14	ccc	target	0.295	0.255	0.252	-0.008	1.97	1.80	1.79	0.98
NEPH2-15	quenched	measured	0.035	0.005	0.137	-0.134	1.08	1.01	1.37	0.73
NEPH2-15	quenched	measured bc	0.031	-0.004	0.157	-0.140	1.07	0.99	1.43	0.72
NEPH2-15	quenched	target	0.008	-0.020	0.133	-0.140	1.02	0.95	1.36	0.72
NEPH2-15	ccc	measured	0.023	0.070	0.111	-0.137	1.05	1.17	1.29	0.73
NEPH2-15	ccc	measured bc	0.018	0.061	0.130	-0.143	1.04	1.15	1.35	0.72
NEPH2-15	ccc	target	-0.004	0.045	0.107	-0.143	0.99	1.11	1.28	0.72
NEPH2-16	quenched	measured	0.077	0.008	0.156	-0.126	1.19	1.02	1.43	0.75
NEPH2-16	quenched	measured bc	0.072	0.000	0.176	-0.131	1.18	1.00	1.50	0.74
NEPH2-16	quenched	target	0.060	-0.004	0.155	-0.137	1.15	0.99	1.43	0.73
NEPH2-16	ccc	measured	0.275	0.236	0.227	-0.027	1.88	1.72	1.69	0.94
NEPH2-16	ccc	measured bc	0.270	0.227	0.246	-0.033	1.86	1.69	1.76	0.93
NEPH2-16	ccc	target	0.258	0.224	0.226	-0.039	1.81	1.67	1.68	0.91
NEPH2-17	quenched	measured	0.029	0.003	0.176	-0.142	1.07	1.01	1.50	0.72
NEPH2-17	quenched	measured bc	0.027	-0.002	0.191	-0.144	1.06	1.00	1.55	0.72
NEPH2-17	quenched	target	0.015	-0.005	0.168	-0.140	1.04	0.99	1.47	0.72
NEPH2-17	ccc	measured	0.546	0.555	0.434	0.103	3.52	3.59	2.72	1.27
NEPH2-17	ccc	measured bc	0.544	0.550	0.449	0.102	3.50	3.55	2.81	1.26
NEPH2-17	ccc	target	0.532	0.547	0.425	0.105	3.40	3.53	2.66	1.27
NEPH2-18	quenched	measured	-0.036	-0.024	0.108	-0.177	0.92	0.95	1.28	0.67
NEPH2-18	quenched	measured bc	-0.039	-0.028	0.122	-0.178	0.91	0.94	1.32	0.66
NEPH2-18	quenched	target	-0.048	-0.042	0.101	-0.179	0.89	0.91	1.26	0.66
NEPH2-18	ccc	measured	-0.023	0.028	0.093	-0.166	0.95	1.07	1.24	0.68
NEPH2-18	ccc	measured bc	-0.026	0.023	0.108	-0.167	0.94	1.05	1.28	0.68
NEPH2-18	ccc	target	-0.035	0.009	0.086	-0.168	0.92	1.02	1.22	0.68
NEPH2-19	quenched	measured	-0.034	-0.028	0.111	-0.182	0.92	0.94	1.29	0.66
NEPH2-19	quenched	measured bc	-0.039	-0.037	0.130	-0.187	0.91	0.92	1.35	0.65
NEPH2-19	quenched	target	-0.028	-0.039	0.118	-0.178	0.94	0.91	1.31	0.66
NEPH2-19	ccc	measured	0.314	0.287	0.238	-0.020	2.06	1.93	1.73	0.95
NEPH2-19	ccc	measured bc	0.309	0.278	0.257	-0.026	2.04	1.90	1.81	0.94
NEPH2-19	ccc	target	0.320	0.275	0.245	-0.016	2.09	1.88	1.76	0.96
NEPH2-20	quenched	measured	0.018	-0.005	0.161	-0.168	1.04	0.99	1.45	0.68
NEPH2-20	quenched	measured bc	0.014	-0.014	0.180	-0.173	1.03	0.97	1.51	0.67
NEPH2-20	quenched	target	0.009	-0.021	0.163	-0.155	1.02	0.95	1.46	0.70
NEPH2-20	ccc	measured	0.960	0.819	0.712	0.230	9.13	6.60	5.16	1.70
NEPH2-20	ccc	measured bc	0.956	0.811	0.732	0.225	9.04	6.47	5.39	1.68
NEPH2-20	ccc	target	0.952	0.804	0.714	0.243	8.94	6.36	5.18	1.75
NEPH2-21	quenched	measured	0.007	-0.014	0.093	-0.204	1.02	0.97	1.24	0.62
NEPH2-21	quenched	measured bc	0.004	-0.018	0.107	-0.205	1.01	0.96	1.28	0.62
NEPH2-21	quenched	target	-0.046	-0.064	0.079	-0.214	0.90	0.86	1.20	0.61
NEPH2-21	ccc	measured	0.014	0.035	0.079	-0.187	1.03	1.09	1.20	0.65
NEPH2-21	ccc	measured bc	0.011	0.031	0.093	-0.188	1.03	1.07	1.24	0.65
NEPH2-21	ccc	target	-0.040	-0.015	0.065	-0.197	0.91	0.97	1.16	0.64
NEPH2-22	quenched	measured	-0.022	-0.045	0.109	-0.198	0.95	0.90	1.29	0.63
NEPH2-22	quenched	measured bc	-0.025	-0.050	0.124	-0.199	0.94	0.89	1.33	0.63
NEPH2-22	quenched	target	-0.038	-0.057	0.095	-0.191	0.92	0.88	1.24	0.64

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)
NEPH2-22	ccc	measured	0.402	0.435	0.281	0.036	2.52	2.72	1.91	1.09
NEPH2-22	ccc	measured bc	0.399	0.430	0.296	0.035	2.51	2.69	1.98	1.08
NEPH2-22	ccc	target	0.386	0.423	0.267	0.043	2.43	2.65	1.85	1.10
NEPH2-23	quenched	measured	0.044	0.001	0.162	-0.152	1.11	1.00	1.45	0.70
NEPH2-23	quenched	measured bc	0.039	-0.007	0.181	-0.157	1.09	0.98	1.52	0.70
NEPH2-23	quenched	target	0.032	-0.024	0.161	-0.153	1.08	0.95	1.45	0.70
NEPH2-23	ccc	measured	1.012	0.867	0.749	0.224	10.29	7.37	5.61	1.68
NEPH2-23	ccc	measured bc	1.008	0.859	0.768	0.219	10.18	7.23	5.86	1.66
NEPH2-23	ccc	target	1.001	0.843	0.748	0.223	10.03	6.96	5.60	1.67
NEPH2-24	quenched	measured	-0.064	-0.044	0.081	-0.202	0.86	0.90	1.21	0.63
NEPH2-24	quenched	measured bc	-0.067	-0.049	0.096	-0.203	0.86	0.89	1.25	0.63
NEPH2-24	quenched	target	-0.083	-0.061	0.072	-0.209	0.83	0.87	1.18	0.62
NEPH2-24	ccc	measured	-0.032	0.001	0.052	-0.204	0.93	1.00	1.13	0.63
NEPH2-24	ccc	measured bc	-0.034	-0.004	0.067	-0.205	0.92	0.99	1.17	0.62
NEPH2-24	ccc	target	-0.051	-0.017	0.043	-0.211	0.89	0.96	1.10	0.62
NEPH2-25	quenched	measured	-0.008	-0.025	0.109	-0.192	0.98	0.94	1.28	0.64
NEPH2-25	quenched	measured bc	-0.012	-0.033	0.128	-0.197	0.97	0.93	1.34	0.63
NEPH2-25	quenched	target	-0.022	-0.040	0.104	-0.195	0.95	0.91	1.27	0.64
NEPH2-25	ccc	measured	0.688	0.654	0.495	0.130	4.87	4.51	3.12	1.35
NEPH2-25	ccc	measured bc	0.683	0.646	0.514	0.125	4.82	4.42	3.27	1.33
NEPH2-25	ccc	target	0.674	0.638	0.491	0.128	4.72	4.35	3.09	1.34
NEPH2-26	quenched	measured	0.020	-0.011	0.179	-0.150	1.05	0.98	1.51	0.71
NEPH2-26	quenched	measured bc	0.017	-0.015	0.193	-0.151	1.04	0.97	1.56	0.71
NEPH2-26	quenched	target	0.007	-0.024	0.162	-0.153	1.02	0.95	1.45	0.70
NEPH2-26	ccc	measured	1.590	1.123	1.245	0.738	38.94	13.28	17.59	5.47
NEPH2-26	ccc	measured bc	1.588	1.119	1.260	0.737	38.73	13.14	18.19	5.46
NEPH2-26	ccc	target	1.578	1.110	1.228	0.735	37.82	12.88	16.91	5.43

Table 4-3. Normalized Release Values for the 40" SB3 Heel Based Phase 2 Glasses. (NEPH2-27 through NEPH2-40)

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	-0.269	-0.189	-0.229	-0.506	0.54	0.65	0.59	0.31
EA	-	reference	1.252	0.991	1.142	0.610	17.85	9.80	13.86	4.07
NEPH2-27	quenched	measured	-0.095	-0.115	0.074	-0.234	0.80	0.77	1.19	0.58
NEPH2-27	quenched	measured bc	-0.110	-0.123	0.084	-0.237	0.78	0.75	1.21	0.58
NEPH2-27	quenched	target	-0.175	-0.131	0.062	-0.240	0.67	0.74	1.15	0.58
NEPH2-27	ccc	measured	0.385	0.380	0.224	-0.002	2.42	2.40	1.68	0.99
NEPH2-27	ccc	measured bc	0.370	0.373	0.233	-0.005	2.35	2.36	1.71	0.99
NEPH2-27	ccc	target	0.304	0.365	0.212	-0.008	2.02	2.32	1.63	0.98
NEPH2-28	quenched	measured	0.047	-0.066	0.103	-0.188	1.11	0.86	1.27	0.65
NEPH2-28	quenched	measured bc	0.033	-0.074	0.112	-0.191	1.08	0.84	1.29	0.64
NEPH2-28	quenched	target	0.047	-0.079	0.073	-0.191	1.12	0.83	1.18	0.64
NEPH2-28	ccc	measured	0.379	0.319	0.249	-0.010	2.40	2.08	1.78	0.98
NEPH2-28	ccc	measured bc	0.365	0.311	0.258	-0.013	2.32	2.05	1.81	0.97
NEPH2-28	ccc	target	0.380	0.306	0.219	-0.013	2.40	2.02	1.66	0.97
NEPH2-29	quenched	measured	0.020	-0.066	0.129	-0.165	1.05	0.86	1.35	0.68
NEPH2-29	quenched	measured bc	0.012	-0.070	0.152	-0.168	1.03	0.85	1.42	0.68
NEPH2-29	quenched	target	-0.016	-0.080	0.125	-0.170	0.96	0.83	1.33	0.68
NEPH2-29	ccc	measured	1.640	1.046	1.249	0.662	43.63	11.13	17.73	4.59
NEPH2-29	ccc	measured bc	1.632	1.042	1.272	0.659	42.84	11.02	18.70	4.56
NEPH2-29	ccc	target	1.603	1.033	1.245	0.658	40.11	10.79	17.59	4.55
NEPH2-30	quenched	measured	-0.090	-0.092	0.037	-0.226	0.81	0.81	1.09	0.59
NEPH2-30	quenched	measured bc	-0.104	-0.099	0.047	-0.229	0.79	0.80	1.11	0.59
NEPH2-30	quenched	target	-0.122	-0.108	0.034	-0.228	0.76	0.78	1.08	0.59
NEPH2-30	ccc	measured	0.050	-0.031	0.021	-0.218	1.12	0.93	1.05	0.61
NEPH2-30	ccc	measured bc	0.036	-0.039	0.030	-0.221	1.09	0.91	1.07	0.60
NEPH2-30	ccc	target	0.018	-0.047	0.018	-0.220	1.04	0.90	1.04	0.60
NEPH2-31	quenched	measured	-0.066	-0.095	0.066	-0.218	0.86	0.80	1.16	0.60
NEPH2-31	quenched	measured bc	-0.074	-0.099	0.089	-0.221	0.84	0.80	1.23	0.60
NEPH2-31	quenched	target	-0.086	-0.106	0.058	-0.224	0.82	0.78	1.14	0.60
NEPH2-31	ccc	measured	0.763	0.658	0.423	0.149	5.80	4.55	2.65	1.41
NEPH2-31	ccc	measured bc	0.755	0.654	0.446	0.147	5.69	4.50	2.79	1.40
NEPH2-31	ccc	target	0.743	0.647	0.415	0.144	5.53	4.43	2.60	1.39
NEPH2-32	quenched	measured	0.054	-0.061	0.102	-0.186	1.13	0.87	1.26	0.65
NEPH2-32	quenched	measured bc	0.040	-0.069	0.111	-0.189	1.10	0.85	1.29	0.65
NEPH2-32	quenched	target	0.003	-0.096	0.092	-0.200	1.01	0.80	1.24	0.63
NEPH2-32	ccc	measured	1.572	1.079	1.176	0.657	37.34	11.98	14.99	4.54
NEPH2-32	ccc	measured bc	1.558	1.071	1.185	0.654	36.15	11.77	15.31	4.51
NEPH2-32	ccc	target	1.522	1.044	1.167	0.643	33.24	11.07	14.68	4.39
NEPH2-33	quenched	measured	-0.137	-0.097	0.056	-0.260	0.73	0.80	1.14	0.55
NEPH2-33	quenched	measured bc	-0.151	-0.105	0.065	-0.262	0.71	0.79	1.16	0.55
NEPH2-33	quenched	target	-0.169	-0.115	0.046	-0.265	0.68	0.77	1.11	0.54
NEPH2-33	ccc	measured	0.149	0.127	0.098	-0.226	1.41	1.34	1.25	0.59
NEPH2-33	ccc	measured bc	0.135	0.119	0.107	-0.228	1.36	1.32	1.28	0.59
NEPH2-33	ccc	target	0.117	0.109	0.087	-0.231	1.31	1.29	1.22	0.59
NEPH2-34	quenched	measured	-0.094	-0.108	0.071	-0.264	0.81	0.78	1.18	0.54
NEPH2-34	quenched	measured bc	-0.102	-0.112	0.094	-0.267	0.79	0.77	1.24	0.54
NEPH2-34	quenched	target	-0.126	-0.116	0.076	-0.262	0.75	0.76	1.19	0.55
NEPH2-34	ccc	measured	0.924	0.807	0.612	0.176	8.40	6.41	4.09	1.50
NEPH2-34	ccc	measured bc	0.917	0.802	0.635	0.173	8.25	6.34	4.32	1.49
NEPH2-34	ccc	target	0.893	0.798	0.617	0.177	7.81	6.29	4.14	1.50
NEPH2-35	quenched	measured	-0.065	-0.084	0.109	-0.222	0.86	0.82	1.29	0.60
NEPH2-35	quenched	measured bc	-0.073	-0.089	0.132	-0.225	0.85	0.82	1.36	0.60
NEPH2-35	quenched	target	-0.111	-0.098	0.108	-0.229	0.77	0.80	1.28	0.59
NEPH2-35	ccc	measured	1.583	1.073	1.188	0.669	38.32	11.84	15.41	4.67
NEPH2-35	ccc	measured bc	1.576	1.069	1.211	0.667	37.63	11.72	16.25	4.64
NEPH2-35	ccc	target	1.538	1.060	1.186	0.663	34.48	11.47	15.35	4.60

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)
NEPH2-36	quenched	measured	-0.070	-0.124	-0.042	-0.267	0.85	0.75	0.91	0.54
NEPH2-36	quenched	measured bc	-0.084	-0.131	-0.033	-0.270	0.82	0.74	0.93	0.54
NEPH2-36	quenched	target	-0.113	-0.145	-0.037	-0.269	0.77	0.72	0.92	0.54
NEPH2-36	ccc	measured	0.064	0.033	0.004	-0.209	1.16	1.08	1.01	0.62
NEPH2-36	ccc	measured bc	0.050	0.026	0.013	-0.212	1.12	1.06	1.03	0.61
NEPH2-36	ccc	target	0.021	0.012	0.009	-0.211	1.05	1.03	1.02	0.62
NEPH2-37	quenched	measured	-0.067	-0.122	-0.008	-0.266	0.86	0.76	0.98	0.54
NEPH2-37	quenched	measured bc	-0.075	-0.126	0.015	-0.269	0.84	0.75	1.03	0.54
NEPH2-37	quenched	target	-0.105	-0.146	-0.003	-0.269	0.79	0.72	0.99	0.54
NEPH2-37	ccc	measured	0.600	0.576	0.290	0.050	3.98	3.77	1.95	1.12
NEPH2-37	ccc	measured bc	0.592	0.572	0.313	0.047	3.91	3.73	2.05	1.12
NEPH2-37	ccc	target	0.562	0.553	0.295	0.048	3.65	3.57	1.97	1.12
NEPH2-38	quenched	measured	-0.056	-0.120	0.029	-0.252	0.88	0.76	1.07	0.56
NEPH2-38	quenched	measured bc	-0.064	-0.124	0.052	-0.254	0.86	0.75	1.13	0.56
NEPH2-38	quenched	target	-0.080	-0.126	0.036	-0.244	0.83	0.75	1.09	0.57
NEPH2-38	ccc	measured	0.994	0.804	0.531	0.162	9.86	6.37	3.39	1.45
NEPH2-38	ccc	measured bc	0.986	0.800	0.554	0.160	9.68	6.31	3.58	1.44
NEPH2-38	ccc	target	0.969	0.798	0.538	0.169	9.32	6.28	3.45	1.48
NEPH2-39	quenched	measured	-0.133	-0.142	-0.043	-0.287	0.74	0.72	0.91	0.52
NEPH2-39	quenched	measured bc	-0.147	-0.150	-0.034	-0.289	0.71	0.71	0.92	0.51
NEPH2-39	quenched	target	-0.155	-0.149	-0.050	-0.284	0.70	0.71	0.89	0.52
NEPH2-39	ccc	measured	0.075	0.024	-0.006	-0.216	1.19	1.06	0.99	0.61
NEPH2-39	ccc	measured bc	0.061	0.017	0.003	-0.219	1.15	1.04	1.01	0.60
NEPH2-39	ccc	target	0.053	0.018	-0.013	-0.214	1.13	1.04	0.97	0.61
NEPH2-40	quenched	measured	0.062	-0.132	-0.038	-0.276	1.15	0.74	0.92	0.53
NEPH2-40	quenched	measured bc	0.055	-0.137	-0.015	-0.278	1.13	0.73	0.97	0.53
NEPH2-40	quenched	target	0.028	-0.149	-0.029	-0.277	1.07	0.71	0.93	0.53
NEPH2-40	ccc	measured	0.374	0.378	0.159	-0.052	2.37	2.39	1.44	0.89
NEPH2-40	ccc	measured bc	0.366	0.373	0.182	-0.055	2.33	2.36	1.52	0.88
NEPH2-40	ccc	target	0.340	0.361	0.167	-0.053	2.19	2.30	1.47	0.88

Prior to evaluating the ccc glasses, it should be noted that the two quenched glasses within the Frit 320 – 1.6M, 127" SB3 heel option (NEPH2-13 and NEPH2-14) were acceptable with NL [B]'s of 0.94 and 1.05 g/L (based on the target composition), respectively. These results suggest that although the new proposed durability limits allow access to higher alkali compositional regions, there is still conservatism in the limits and/or model (i.e., the model predictions and limits suggested that the glasses would be unacceptable (see Figure 2-1) but the measured durability response shows otherwise).

Also shown in Table 4-2 and Table 4-3 are the normalized releases based on the ccc versions of each Phase 2 glass for each compositional view. As will be discussed in Section 4.3.1 (visual observations) and Section 4.3.2 (XRD results), the slow cooling of the Phase 2 glasses typically resulted in devitrification (partial or complete) with the severity (or degree) of crystallization being generally correlated to the targeted WL. In general, as the targeted WL within a specific frit – sludge system was increased, the degree of crystallization or devitrification appeared to be more extensive. This is not unexpected as the slower cooling provides a thermodynamically favorable (compositional-wise) glass the kinetic opportunity to devitrify. With the knowledge of devitrification in the Phase 2 ccc glasses, the questions of interest to this study are: "What is the impact on the PCT response?", "What are the crystalline phase(s) that formed?", and "Does the type and/or extent of crystallization agree with glass science theory in terms of their anticipated impact on the durability response?" These are the questions to be addressed in this section and the following subsections which will ultimately lead to potential decisions to be made in terms of the frit selection process for SB4.

Based on target compositions, the normalized boron releases for the 1.6M, 127" SB3 heel based ccc glasses range from 0.89 g/L (NEPH2-24) to 37.82 g/L (NEPH2-26). For the 1.6M, 40" ccc glasses the NL [B]'s (based on target compositions) range from 1.04 g/L (NEPH2-30) to 40.11 g/L (NEPH2-29). These values obviously span a much wider PCT response as compared to the quenched versions. In addition, and more importantly, the PCT results suggest that select Phase 2 glasses exceed the benchmark EA glass NL [B] of 16.695 g/L. An obvious question to ask is: "Which frit – sludge combinations and/or WLs result in these unacceptable durabilities?"

Figure 4-2 shows the PCT response (normalized based on targeted compositions) for both quenched and ccc glasses based on the 127" SB3 heel option. The "+"'s represent the quenched glasses while the solid circles represent the ccc versions. The PCT response (in log NL [B] g/L) is plotted on the y-axis with the fourteen 127" based glasses (NEPH2-13 through NEPH2-26) shown on the x-axis. In addition to the glass identifications, the targeted WL, the frit, and the % Na_2O in the frit are shown below the glass IDs.

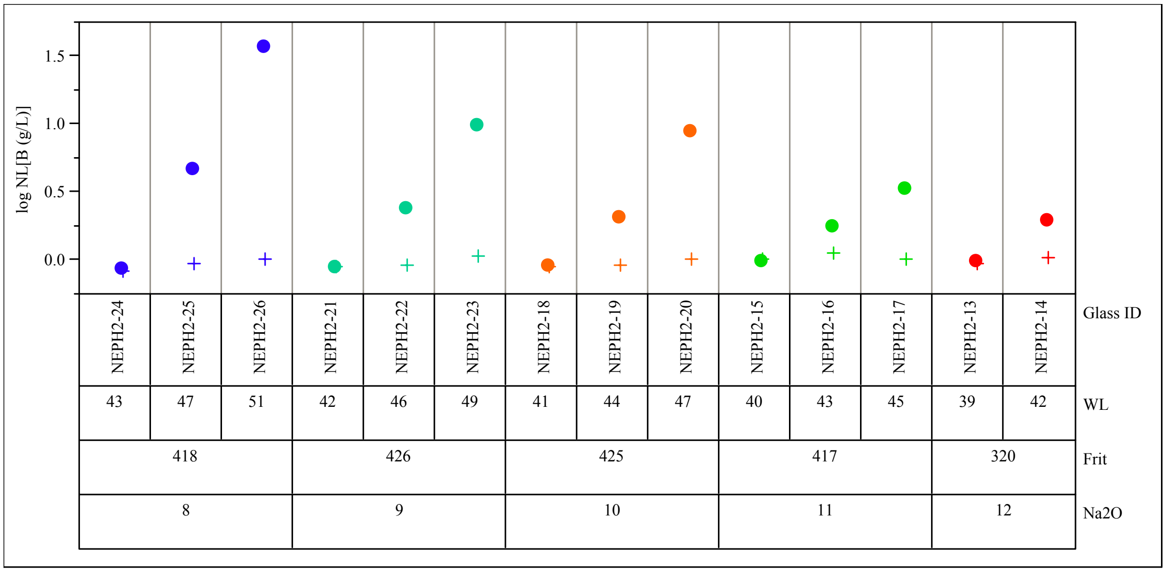

Figure 4-2. Normalized Boron Release for the 127" Phase 2 Glasses (quenched (+) and ccc (●)).

The general trend within each specific frit system is that as WL increases, the difference between the quenched and ccc PCT response increases. For example, consider the Frit 418 – 1.6M, 127" SB3 heel glasses at 43, 47, and 51% WL (represented by the blue "+"s and "●"s). At 43% WL, the difference between the quenched and ccc versions is minimal and of no practical concern. More specifically, the NL [B] for the quenched and ccc versions of NEPH2-24 are 0.83 g/L and 0.89 g/L, respectively. Although potentially of statistical significance, the practical impact is of no concern – similar to the Phase 1 results. As WL is increased in this system to 47% WL, the difference in the quenched and ccc glasses for NEPH2-25 shows a significant difference in PCT response – 0.95 g/L versus 4.72 g/L, respectively. Although the ccc version of NEPH2-25 is still less than the EA benchmark of 16.695 g/L, the response is approaching a level that DWPF may wish to avoid. Further increases in WL within this system result in a continued decrease in durability. More specifically, the quenched and ccc responses for NEPH2-26 (targeting 51% WL) are 1.02 g/L and 37.82 g/L, respectively. Although the quenched version of NEPH2-26 is very acceptable (1.02 g/L), its ccc counterpart should be avoided in DWPF as the measured durability response exceeds the acceptable limit of the EA benchmark glass by a factor of 2 (37.82 g/L versus 16.695 g/L). Although not specifically discussed, this general trend (i.e., as WL increases the differences in PCT response between the quenched and ccc versions of the glass increase) holds for all other frit – sludge combinations (for both the 40" and 127" SB3 heel options as well). Figure 4-3 summarizes the PCT responses for the 40" SB3 heel options.

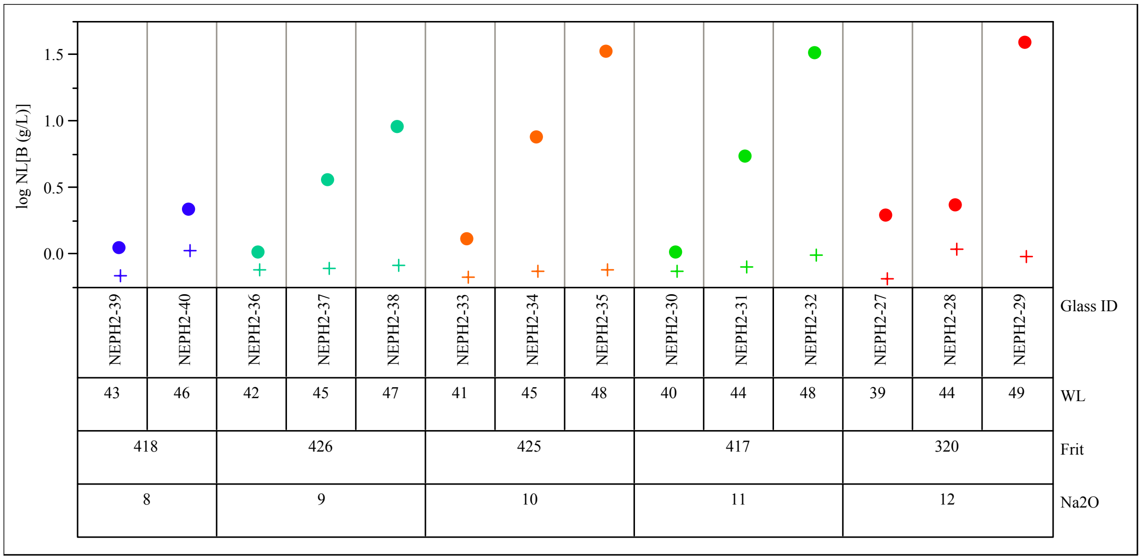

Figure 4-3. Normalized Boron Release for the 40" Phase 2 Glasses (quenched (+) and ccc (●)).

One notable difference between the 127" SB3 heel and 40" SB3 heel glasses is the delta in PCT response for the quenched and ccc glass at the lowest WL (for each specific frit – sludge system). For the 127" cases (see Figure 4-2), the difference between the quenched and ccc versions of each glass is minimal (and of no practical concern) at the lowest WLs. For the 40" SB3 heel cases, there is a measurable difference in the PCT responses for the lowest WL glass between the quenched and ccc versions. Consider the Frit 418 – 1.6M, 40" option at 43% WL (NEPH2-39). From Table 4-3, the quenched version of this glass has a measured NL [B] of 0.70 g/L (based on target composition), while the ccc version has a NL [B] of 1.13 g/L (again based on target composition). It should be noted that the difference in PCT response for these "lowest" WL glasses seems to generally increase as one transitions from left to right in Figure 4-3 (or as the % Na_2O in frit increases). Another important point when making these comparisons is to realize that the "lowest WL" glasses do not target the same WL as a function of frit composition. That is, as the Na_2O concentration in frit increases (by 1% in moving from left to right) the "lowest WL" (i.e., the WL at which nepheline first becomes a prediction issue based on the 0.62 value) decreases by 1%. The lowest WL for the Frit 418 system is 43% (NEPH2-39), while the "lowest" WL for the Frit 320 based glasses is 39% (NEPH2-27). Although all the lower WL glasses (both quenched and ccc versions) are acceptable, there is some critical WL at which the Phase 2 glasses transition from acceptable to unacceptable when slow cooled. However, the specific WL transition depends upon the definition of "acceptable." In Section 4.4, an assessment of the importance of selecting the "acceptance value" (in terms of a maximum g/L value to be produced) is discussed with respect to the possible impacts on DWPF processing.

Note the general trend for the Frit 320 – 127" SB3 heel glasses (NEPH2-27, -28, and -29) shown in Figure 4-3. Although there is a gradual decrease in durability for the ccc glasses, the difference between the PCT response of the 39% (NEPH2-27) and 44% (NEPH2-28) WL glasses is not that dramatic – not the "step-wise" function observed in other frit – sludge systems of this study. In fact, the NL [B]'s for these two ccc glasses are 2.02 and 2.40 g/L, respectively. The minimal difference in the PCT response can be related to (and triggered the review of) potential batching issues as discussed in Section 4.1.4. As noted in that section, these data points should not be used to support subsequent modeling activities.

Exhibit D7 in Appendix D provides a closer look at the effects of heat treatment on the PCT response based on target compositions. Exhibit D8 in Appendix D provides a look at the effects of heat treatment on the PCT response based on measured compositions. Exhibit D9 in Appendix D provides a look at the effects of heat treatment on the PCT response based on measured bias-corrected compositions. The behaviors of the differences between the PCTs for the quenched and ccc versions of the glasses are similar to those discussed above.

4.2.5 Predicted versus Measured PCTs

As seen in Table 4-2 and Table 4-3, the durabilities for select Phase 2 glasses fall into three distinct categories or classifications. The first category would envelope all of the quenched glasses which were classified as having acceptable PCT responses (i.e., NL [B]'s < 1.19 g/L which in terms of acceptability are approximately an order of magnitude better than the EA benchmark glass). The second classification would be those ccc glasses that resulted in no detectable crystallization or which precipitated crystals that are known not to have an adverse impact on the PCT response. The final category would be those ccc glasses whose crystallization resulted in an extremely negative impact on PCT response. The primary difference between a glass falling into the second classification versus the latter was waste loading. As the WL increased, the probability that crystallization had a negative impact on durability increased. With respect to predictability, the current durability model is only applicable to homogeneous glasses. Therefore, applicability of the model to those ccc glasses which resulted in devitrification (especially the formation of nepheline) is not expected.

Exhibit D10 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 (Jantzen et al. 1995). Prediction limits (at a 95% confidence) for an individual PCT result are also plotted along with the linear fit. The EA and ARM results are also indicated on these plots. Exhibit D11 in Appendix D provides a version of these plots for the quenched glasses only while Exhibit D12 provides a version for ccc glasses only. Figure 4-4 and Figure 4-5 show the log NL [B] versus ΔG_P for the quenched and ccc glasses, respectively.

In Figure 4-4, the open blocks are those Phase 2 glasses based on the 127" SB3 heel sludge; while the open circles are those based on the 40" SB3 heel nominal sludge composition. As shown in Figure 4-4, most of the study glasses are predictable by the ΔG_p model. Those that are not predictable (i.e., outside of the prediction limits) actually fall below the prediction interval (i.e., they are over predicted by the model) suggesting the model is conservative.

Although the model should not be applied to inhomogeneous glasses, Figure 4-5 shows the predictability (or lack thereof) for the ccc-based Phase 2 glasses. Over ½ of the Phase 2 ccc glasses are predicted by the current durability model. These glasses are presumably those resulting in spinel formation upon slow cooling which has been shown not to have an impact on the PCT response (see Section 4.3 for a more detailed discussion of the crystalline phases). Therefore, the model should be applicable. Also shown in Figure 4-5 are several glasses that are not only unpredictable but, more importantly, fall above the prediction interval suggesting that the model is not conservative. Although not discussed as of yet, these glasses are presumably those in which nepheline formation occurred resulting in a dramatic reduction in durability leading to the inability of the durability model to adequately predict their response. The practical implication to DWPF is to eliminate the possibility of producing an unacceptable glass through the implementation of a nepheline discriminator function, limiting WL through an administrative control, or eliminating nepheline formation through strategic frit development efforts. The practical implications to DWPF are discussed in detail in Section 4.4.

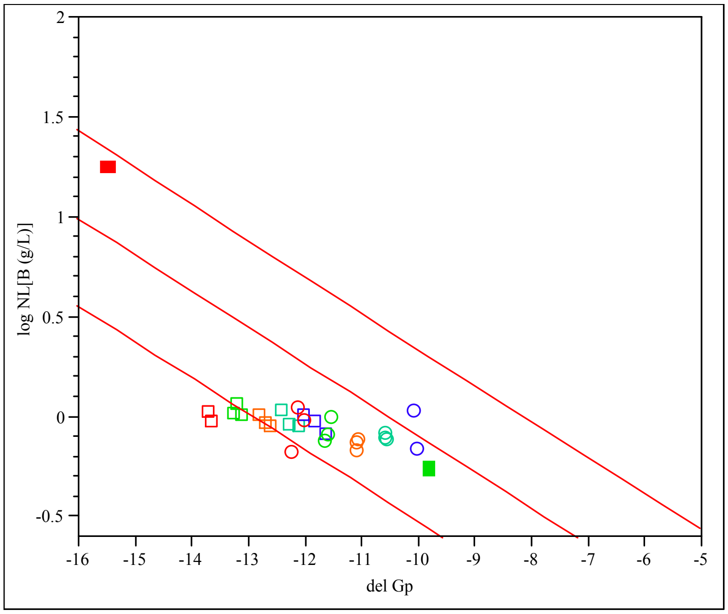

Figure 4-4. log NL [B] Versus ΔG_P for the Quenched Phase 2 Glasses.

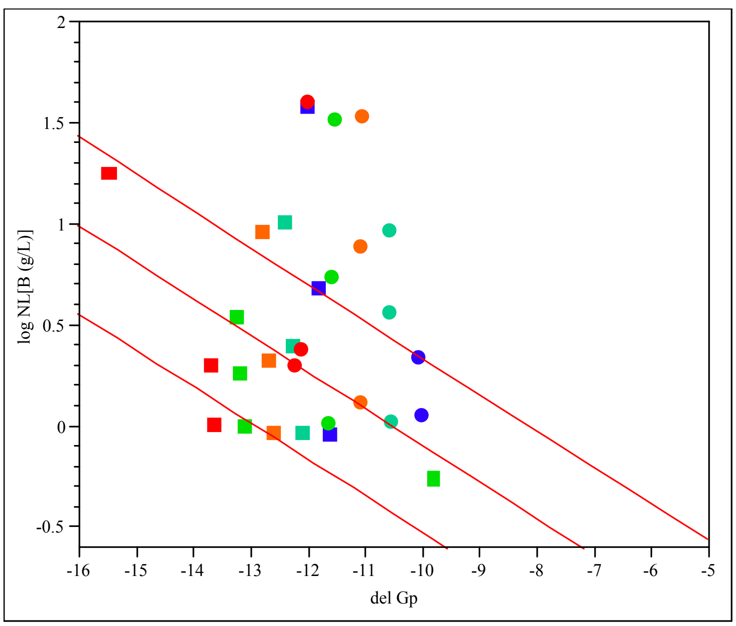

Figure 4-5. log NL [B] Versus ΔG_P for the ccc Phase 2 Glasses.

4.3 Homogeneity

In this section, the primary interest is the possible formation of nepheline (and/or other crystalline phases) in the ccc glasses which could be responsible for the measurable and significant difference in PCT response for the higher WL Phase 2 glasses as compared to their quenched counterparts. Table 4-4 (glasses based on the 127" SB3 heel option) and Table 4-5 (glasses based on the 40" SB3 heel option) summarize the visual and XRD results for the quenched and ccc Phase 2 nepheline study glasses, respectively. It should be noted that only the ccc versions of the Phase 2 glasses were submitted for XRD analysis given the durability response suggested no significant differences among all 28 quenched glasses. With NL [B]'s ranging from 0.67 g/L to 1.19 g/L, there is no evidence of nepheline formation in the quenched glasses – even if present, the impact is of no practical concern.

In Table 4-4 and Table 4-5, glasses within a specific frit – sludge system are grouped (shaded or not) to aid in the discussions. Tracking the results of visual observations and/or XRD results as a function of WL will be of utmost interest given the differences in PCT response between the quenched and ccc as a function of WL.

Prior to discussing the results, a few words regarding the terminology used in the tables are warranted. The use of "homogeneous" for visual observations indicates that the sample was classified as a single-phase system (i.e., no evidence of crystallization). The term "surface crystals" (used as a descriptor for visual observations) implies that the surface of the glass was characterized by the presence of crystallization while the cross-section of bulk glass appeared homogeneous (i.e., single-phased, black and shiny). Surface crystallization in the Phase 2 glasses was apparent through the presence of a "textured" surface that ranged in appearance from a "dull or matte" surface to a "highly metallic-like" surface.

The XRD results are more qualitative in nature. As previously mentioned, only the ccc glasses were submitted for XRD analysis based on both the PCT responses as well as visual observations of the quenched glasses. The PCT responses of the quenched glasses were "acceptable and predictable" and visual observations suggested only the presence of surface devitrification on select glasses. Historically, surface devitrification occurs as WLs increase and for DWPF type glasses is typically the result of spinel formation. The Phase 2 PCT responses suggested that for those quenched glasses that were classified as having "surface crystallization" or a "metallic haze on the surface", spinel formation was highly probable – which is consistent with recent observations and the inert effect on the PCT response. For the ccc glasses, the XRD results suggested that the glass was either amorphous or contained some degree of crystallization. The presence of a characteristically high background devoid of crystalline spectral lines indicates that the glass product is amorphous (suggesting either a completely amorphous product or that the degree of crystallization is below the detection limit – approximately 0.5 vol% in glass). In terms of crystallization, the XRD results indicated the presence of spinel (Trevorite, $NiFe_2O_4$), nepheline ($NaAlSiO_4$), and/or lithium silicate (Li_2SiO_3). For a more detailed description of the visual observations and XRD results of both the quenched and ccc glasses, see WSRC-NB-2005-00054.

Table 4-4. Visual and XRD Results for the SB4 Nepheline Phase 2 Glasses Based on the 1.6M, 127" SB3 Heel Options.

Glass	Frit ID	Target WL	Heat Treatment	Visual	XRD
NEPH-13	320	39	quenched	Homogeneous	-
NEPH-13	320	39	ccc	Surface dull matte color with crystals, bulk homogeneous	Amorphous
NEPH-14	320	42	quenched	Slight metallic haze on surface, bulk homogeneous	-
NEPH-14	320	42	ccc	Surface dull matte color with crystals, bulk homogeneous	$NiFe_2O_4$, $NaAlSiO_4$
NEPH-15	417	40	quenched	Homogeneous	-
NEPH-15	417	40	ccc	Surface dull matte color with crystals, bulk homogeneous	Amorphous
NEPH-16	417	43	quenched	Slight metallic haze on surface, bulk was homogeneous	-
NEPH-16	417	43	ccc	Surface dull matte color with crystals, bulk homogeneous	$NiFe_2O_4$, $NaAlSiO_4$
NEPH-17	417	45	quenched	Slight metallic haze on surface, bulk was homogeneous	-
NEPH-17	417	45	ccc	Surface dull matte color with crystals, bulk homogeneous	$NiFe_2O_4$, $NaAlSiO_4$, Li_2SiO_3
NEPH-18	425	41	quenched	Homogeneous	-
NEPH-18	425	41	ccc	Surface dull matte color with crystals, bulk homogeneous	$NiFe_2O_4$
NEPH-19	425	44	quenched	Metallic haze on surface, bulk was homogeneous	-
NEPH-19	425	44	ccc	Surface dull matte color with crystals, bulk homogeneous	$NiFe_2O_4$, $NaAlSiO_4$
NEPH-20	425	47	quenched	Metallic haze on surface, bulk was homogeneous	-
NEPH-20	425	47	ccc	Surface dull matte color with crystals, bulk devitrified	$NiFe_2O_4$, $NaAlSiO_4$, Li_2SiO_3
NEPH-21	426	42	quenched	Homogeneous	-
NEPH-21	426	42	ccc	Surface dull matte color with crystals, bulk homogeneous	Amorphous
NEPH-22	426	46	quenched	Metallic haze on surface, bulk was homogeneous	-
NEPH-22	426	46	ccc	Surface dull matte color with crystals, bulk partially devitrified	$NiFe_2O_4$, $NaAlSiO_4$
NEPH-23	426	49	quenched	Metallic haze on surface, bulk was homogeneous	-
NEPH-23	426	49	ccc	Surface dull matte color with crystals, bulk completely devitrified	$NiFe_2O_4$, $NaAlSiO_4$, Li_2SiO_3
NEPH-24	418	43	quenched	Metallic haze on surface, bulk was homogeneous	-
NEPH-24	418	43	ccc	Surface dull matte color with crystals, bulk homogeneous	Amorphous
NEPH-25	418	47	quenched	Metallic haze on surface, bulk was homogeneous	-
NEPH-25	418	47	ccc	Surface dull matte color with crystals, bulk devitrified	$NiFe_2O_4$, $NaAlSiO_4$
NEPH-26	418	51	quenched	Metallic haze on surface, bulk was homogeneous	-
NEPH-26	418	51	ccc	Surface dull matte color with crystals, bulk completely devitrified	$NiFe_2O_4$, $NaAlSiO_4$, Li_2SiO_3

Table 4-5. Visual and XRD Results for the SB4 Nepheline Phase 2 Glasses Based on the 1.6M, 40" SB3 Heel Options.

Glass	Frit ID	Target WL	Heat Treatment	Visual	XRD
NEPH-27	320	39	quenched	Partial metallic haze on surface, bulk was homogeneous	-
NEPH-27	320	39	ccc	Surface dull matte color with crystals, bulk homogeneous	Amorphous
NEPH-28	320	44	quenched	Metallic haze on surface, bulk was homogeneous	-
NEPH-28	320	44	ccc	Surface dull matte color with crystals, questionable crystallization within bulk	$NiFe_2O_4$
NEPH-29	320	49	quenched	Metallic haze on surface, bulk was homogeneous	-
NEPH-29	320	49	ccc	Surface dull matte color with crystals, bulk completely devitrified	$NiFe_2O_4$, $NaAlSiO_4$, Li_2SiO_3
NEPH-30	417	40	quenched	Minor metallic haze on surface, bulk was homogeneous	-
NEPH-30	417	40	ccc	Isolated crystals on surface, bulk homogeneous	Amorphous
NEPH-31	417	44	quenched	Metallic haze on surface, bulk was homogeneous	-
NEPH-31	417	44	ccc	Surface dull matte color with crystals, bulk partially devitrified	$NiFe_2O_4$, $NaAlSiO_4$, Li_2SiO_3
NEPH-32	417	48	quenched	Metallic haze on surface, bulk was homogeneous	-
NEPH-32	417	48	ccc	Surface dull matte color with crystals, bulk completely devitrified	$NiFe_2O_4$, $NaAlSiO_4$, Li_2SiO_3
NEPH-33	425	41	quenched	Metallic haze on surface, bulk was homogeneous	-
NEPH-33	425	41	ccc	Surface dull matte color with crystals, bulk homogeneous	$NiFe_2O_4$
NEPH-34	425	45	quenched	Metallic haze on surface, bulk was homogeneous	-
NEPH-34	425	45	ccc	Surface dull matte color with crystals, bulk completely devitrified	$NiFe_2O_4$, $NaAlSiO_4$, Li_2SiO_3
NEPH-35	425	48	quenched	Metallic haze on surface, bulk partially devitrified	-
NEPH-35	425	48	ccc	Surface dull matte color with crystals, bulk completely devitrified	$NiFe_2O_4$, $NaAlSiO_4$, Li_2SiO_3
NEPH-36	426	42	quenched	Minor metallic haze on surface, bulk was homogeneous	-
NEPH-36	426	42	ccc	Surface dull matte color with crystals, bulk homogeneous	$NiFe_2O_4$
NEPH-37	426	45	quenched	Metallic haze on surface, bulk was homogeneous	-
NEPH-37	426	45	ccc	Surface dull matte color with crystals, bulk partially devitrified	$NiFe_2O_4$, $NaAlSiO_4$
NEPH-38	426	47	quenched	Metallic haze on surface, bulk was homogeneous	-
NEPH-38	426	47	ccc	Surface dull matte color with crystals, bulk partially devitrified	$NiFe_2O_4$, $NaAlSiO_4$, Li_2SiO_3
NEPH-39	418	43	quenched	Metallic haze on surface, bulk was homogeneous	-
NEPH-39	418	43	ccc	Surface dull matte color with crystals, bulk partially devitrified	$NiFe_2O_4$
NEPH-40	418	46	quenched	Metallic haze on surface, bulk was homogeneous	-
NEPH-40	418	46	ccc	Surface dull matte color with crystals, bulk partially devitrified	$NiFe_2O_4$

4.3.1 Visual Observations

Visual observations on the quenched Phase 2 glasses indicated that four glasses were homogeneous, while the remaining 24 glasses were characterized by a metallic haze on the surface with the bulk (cross-section) being homogeneous. The four quenched glasses classified as visually homogeneous were NEPH2-13, NEPH2-15, NEPH2-18, and NEPH2-21 – all low WL glasses within their respective frit series and all based on the 127" option. No 40" SB3 heel option based glasses were visually characterized as homogeneous.

The noted surface crystallization on the remaining 24 glasses is consistent with historical visual observations of DWPF-based glasses especially those targeting higher waste loadings. More specifically, use of descriptions such as a dull or matte texture and/or metallic-like surface is common for DWPF-type glasses targeting higher WLs and/or having undergone a slow cooling schedule. Previous XRD analyses have typically indicated that the textured or metallic-like surfaces are a result of spinels that precipitate during the cooling process. This is in-line with glass theory that suggests that as WL increases, the concentrations of Fe_2O_3, NiO, Cr_2O_3, and/or MnO also increase; thus enhancing the likelihood of spinel devitrification. Based on the PCT responses for the quenched Phase 2 glasses, spinel formation resulting in the metallic haze is reasonable as spinels have been shown to have no impact on the durability response.

A dull matte surface texture characterized the surface of all 28 ccc glasses. The primary difference among the ccc glasses is the degree of devitrification visually observed within the bulk glass. That is, when examining the cross-sections of the heat treated samples, visual observations ranged from "homogeneous" to "completely devitrified". In general, the transition from homogeneous to partially devitrified and ultimately to completely devitrified resulted as WL increased within a specific frit – sludge system. For example, consider NEPH2-21ccc through NEPH2-23ccc (from Table 4-4). The visual observations suggest that the bulk of the heat treated samples were homogeneous at 42% WL (NEPH2-21ccc), partially devitrified at 46% WL (NEPH2-22ccc), and completely devitrified at 49% WL (NEPH2-23ccc).

In general, visual observations indicate that devitrification was more prevalent in the ccc glasses than in the quenched glasses, as expected, given kinetics are more favorable during the slower cooling cycle.

4.3.2 XRD Results

The XRD results shown in Table 4-4 and Table 4-5 provide a technical basis for making decisions regarding the impact of nepheline formation on durability. The PCT data (as shown in Figure 4-2 and Figure 4-3) indicated that as WL increased within a frit – sludge system, the difference in NL [B] between quenched and ccc glasses increased. Visual observations suggested that the ccc glasses became progressively more devitrified as WL increased, which is in agreement with the PCT response assuming precipitation of a phase such as nepheline. With all of the Phase 2 glasses being prone to nepheline formation based on the 0.62 value, expectations were that nepheline would form in these glasses, resulting in a decrease in durability, with only the magnitude being unknown. The XRD results confirm these expectations.

XRD results for all of the lower WL ccc glasses within each frit – sludge system indicate that the glasses were either amorphous or contained spinel (trevorite). For the 127"-based glasses, the PCT results suggested no measurable difference between the quenched and ccc glasses at the lower WLs. XRD results indicated that 4 of the 5 lower WL ccc glasses were amorphous with only one (NEPH2-18ccc) being characterized by spinel. The XRD results agree with the PCT responses given there was no significant or measurable difference in PCT response between the quenched and ccc glasses. When considering the 40"-based, lower WL ccc glasses, XRD results indicate that two of the five glasses were amorphous; while spinels characterized the remaining three. Expectations in terms of PCT response could be in-line with the 127"-based systems – no measurable difference in durability between quenched and ccc glasses. However, based on the measured PCT responses, this is not the case. That is (and as previously discussed), there appears to be a more significant and measurable difference in PCT response for these five lower WL glasses as compared to the 127" based glasses. This suggests that nepheline may be present (but below the XRD detection limit) in these 40" SB3 heel based ccc glasses but the impact on durability is minimal and of no practical concern – consistent with the Phase 1 results. The practical implication for DWPF is that blending the higher Al_2O_3 sludge with less of a SB3 heel would increase the probability of nepheline formation. More specifically, blending SB4 with a larger heel of SB3 would "dilute" the Al_2O_3 concentration, which would lessen the likelihood of nepheline formation.

The most significant change in PCT response between the quenched and ccc 40"-based, lower WL glasses was for NEPH2-27 with a 0.67 g/L NL [B] to 2.02 g/L shift upon ccc. As with the Phase 1 glasses, this shift is a measurable difference but is not of practical concern (i.e., avoiding this glass system at WLs up to 39% is not warranted). The bottom line is that all the quenched glasses and low WL ccc based glasses are very acceptable based on the measured PCT responses. This is not the case at higher WLs for the ccc glasses.

XRD results indicated the presence of nepheline ($NaAlSiO_4$), trevorite (($NiFe_2O_4$), and/or lithium silicate (Li_2SiO_3) in the Phase 2 glasses at higher WLs. In general, as the WL increases within a specific frit – sludge system, the crystalline phase(s) detected transition from amorphous or spinels (at the lowest WL), to spinel and nepheline (at the intermediate WL), and ultimately to spinel, nepheline, and lithium silicate (at the highest WL). Although numerous comparisons can be made, consider the series of NEPH2-24, -25, and -26 based on Frit 418 and the 127" SB3 heel option at 43, 47, and 51% WLs, respectively. XRD results indicate that NEPH2-24 ccc is amorphous (i.e., no crystallization identified at the detection limits of the X-ray diffractometer). Assuming the quenched version is amorphous as well, one would expect the PCT response between the quenched and ccc glasses to be essentially the same. Based on Table 4-2, the NL [B]'s for the quenched and ccc NEPH2-24 glasses were 0.83 g/L and 0.89 g/L, respectively. As the WL is increased from 43 to 47%, XRD results indicate the formation of spinel ($NiFe_2O_4$) and nepheline ($NaAlSiO_4$). With the formation of spinels having no impact on the PCT response, the main question is what impact (if any) did the formation of nepheline have and to what extent? The NL [B]'s for the quenched and ccc glasses of NEPH2-25 (targeting the intermediate WL of 47%) were 0.95 g/L and 4.72 g/L, respectively. The impact of nepheline formation is not only a statistically significant difference but may be of practical significance as well (as discussed in Section 4.2.4). Prior to evaluating the highest WL glass in this series, a comparison among the quenched and ccc glasses at the two "lower" WLs is warranted. First, consider the quenched versions of NEPH2-24 and NEPH2-25. The NL [B] releases for these two glasses are 0.83 g/L and 0.95 g/L, respectively. The decrease in durability between these two glasses is likely due to a change in glass composition – not a result of devitrification. That is, at the higher WL, the SiO_2 content in the glass decreases and the Na_2O content increases which typically results in a lower durability product – although the Al_2O_3 content in the glass increases. This gradual decrease in durability with increased WL is not only expected by glass science but predicted by the durability model. As previously noted, the NL [B]'s for the NEPH2-24ccc and NEPH2-25ccc are 0.89 g/L and 4.72 g/L, respectively. This decrease in durability is primarily related to the formation of nepheline in the NEPH2-25ccc glass – given spinels have no impact on the PCT response in

DWPF type glasses, but the increase in WL should have minimal impact on the durability response in the absence of any significant microstrutural changes.

As WL increases from 47% to 51%, one would expect to observe a continual decrease in the durability of the quenched glasses (based on model predictions). Indeed this is the case as the NL [B] for NEPH2-26 quenched is 1.02 g/L – up from the 0.95 g/L for NEPH2-25 quenched at 47% WL. Although a slight decrease in durability, the glass is very acceptable, which agrees with model predictions. The same can not be said for the NEPH2-26ccc glass as the NL [B] release was 37.82 g/L – compared to the 4.72 g/L release of intermediate WL NEPH2-25ccc glass. The XRD results indicate the presence of spinel, nepheline, and lithium silicate in NEPH2-26ccc. Although quantitative XRD results (i.e., vol% of each phase) were not obtained, given the significant shift in PCT response between the two higher WL glasses upon ccc, one of two possibilities exists. The first is to consider or assume that the formation of Li_2SiO_3 has no impact on durability. If true, then the results suggests that the vol% of nepheline increases with increased WL, removing more and more SiO_2 and Al_2O_3 from the continuous glass matrix, which continually reduces the durability of the final product. The other option is that both Li_2SiO_3 and nepheline have a negative impact on durability. In either case, the end result is a final product that is unacceptable in terms of durability.

The PCT results not only indicate an 8x decrease in durability when transitioning from 47 to 51% WL for the Frit 418 – 127" SB3 heel based glasses but, perhaps more importantly, classification as an "unacceptable" glass when compared to the EA benchmark glass. That is, regardless of where one may ultimately draw the "line of demarcation" between acceptable and unacceptable glasses (in terms of a NL [B] release), NEPH2-26ccc is "unacceptable" – with the practical implications to DWPF being that at some critical WL, unacceptable glasses (based on the ccc thermal history) could be produced. It should be noted that the quenched version of NEPH2-26 (51% WL) is very acceptable with a 1.02 g/L NL [B]. It is only when the higher WL glasses are subjected to the ccc schedule leading to the formation of nepheline and/or Li_2SiO_3 that results in the potential for an "unacceptable" glass.

As previously noted, in general, as WL increases within a specific frit – sludge system, the crystalline phase(s) detected transition from amorphous or spinels (at the lowest WL), to spinel and nepheline (at the intermediate WL), and ultimately to spinel, nepheline, and lithium silicate (at the highest WL). The formation of nepheline can have a detrimental impact on the PCT response. The magnitude of the impact is likely related to the vol% of nepheline formed (although not formally measured), which should be directly related to the targeted WL and the value of the nepheline discriminator. Although the formation of Li_2SiO_3 could potentially reduce durability as well, as WLs increase the nepheline discriminator values decrease which could reflect a higher propensity for nepheline formation. Coupling this trend with the known impact on PCT response, one can easily explain the general trends observed in Figure 4-2 and Figure 4-3. More specifically, as WL increases within a specific frit – sludge system, the durability of the ccc based glasses decreases.

Figure 4-6 summarizes the PCT response for the ccc Phase 2 glasses as a function of the type of crystallization (amorphous, spinel ($NiFe_2O_4$), nepheline ($NaAlSiO_4$), and lithium silicate (Li_2SiO_3)) and WL. The trends are in agreement with previous observations that the impact on durability is dependent upon the type and extent of crystallization and the resulting change to the residual glass composition. As previously noted, nepheline formation can result in a severe deterioration of the chemical durability of the glass through residual glass compositional changes (i.e., a continuous glass matrix which is Al_2O_3 and/or SiO_2 deficient). The primary driver for the reduction in durability is the fact that nepheline removes three moles of glass forming oxides

(Al_2O_3 and $2SiO_2$) per each mole of Na_2O from the continuous glass phase. Therefore, nepheline formation produces an Al_2O_3 and SiO_2 deficient continuous glass matrix (relative to the same composition which is void of crystals), which reduces the durability of the final product. The magnitude of the reduction ultimately depends on the extent (e.g., vol%) of crystallization.

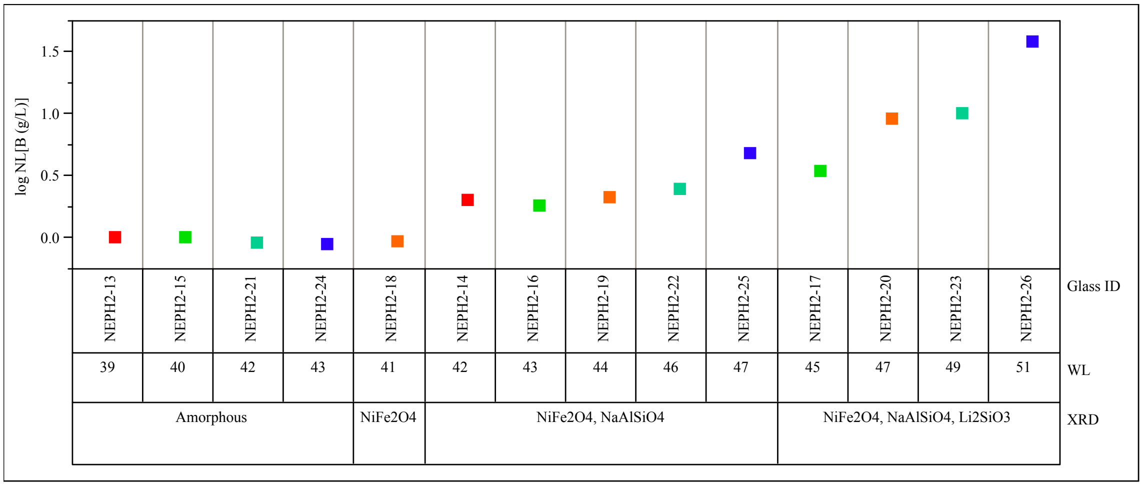

Figure 4-6. PCT Response of the ccc Phase 2 Glasses as a Function of Crystalline Type and WL.

5.0 PRACTICAL IMPACTS TO DWPF

Edwards and Peeler (2005) selected the Phase 2 glasses in an effort to "challenge" the nepheline discriminator value of 0.62. That is, all 28 Phase 2 glasses were prone to nepheline formation based on the nominal targeted compositions. The results suggest that the 0.62 value appears to be a reasonable guide to monitor SB4 – frit systems with respect to potential nepheline formation upon ccc. The significance of "ccc" in the latter sentence is based on the fact that none of the Phase 2 quenched glasses show any sign of nepheline formation (based on the PCT response) although some had nepheline discriminator values as low as 0.541. The PCT responses for all of the quenched glasses were very acceptable with NL [B] values of 1.19 g/L or less. It is only when the glass is provided a kinetic opportunity to devitrify through the slow ccc schedule does nepheline form and ultimately have an adverse impact on durability.

When comparing the Phase 2 results to Phase 1 (Peeler et al. 2005b), one may want to conclude that differences exist in their respective conclusions. That is, in Phase 1 it was concluded that the PCT responses for the two glasses prone to nepheline formation were statistically different but of no practical concern. The Phase 2 glasses show not only a statistical difference but a practical difference as well. Before making further comparisons between the two phases, one must review the targeted WLs. The WLs of Phase 1 were limited to a high of 40%. The Phase 2 glasses were primarily based on glasses targeting 40% or higher. In Phase 2, the lower WL glasses showed no significant or practical differences in durability when comparing quenched and ccc glasses – this is consistent with the Phase 1 results. It was only at the higher WLs (in Phase 2) that nepheline formation had a significantly negative impact on durability. The practical implication to DWPF is that higher WL glasses should be avoided for these types of glass systems (i.e., high Al_2O_3). The primary question becomes how should DWPF control or eliminate nepheline formation? Should the control be WL driven or strictly mitigated through the implementation of a nepheline discriminator value or administrative limit? If the former (WL), then how does one define the critical WL at which nepheline becomes an issue (given the Phase 2 data suggest that the critical WL may be frit and sludge dependent)? If the latter (nepheline discriminator or administrative limit), then what value should one use as a guide (0.62 or 0.60)? Or can strategic frit development efforts identify candidate frits that lessen the likelihood of nepheline formation, while meeting other critical process related goals (such as melt rate)? Although a formal recommendation of the specific path is not made in this report, a general discussion is provided on options that are available. It should be noted that although nepheline formation is a real and potentially significant issue, other constraints or alternatives may arise that would mitigate the impact as will be discussed.

Thus, the results of the Phase 2 study suggest that there is a real need to minimize and/or control the potential for nepheline formation during the processing of SB4 (based on the options currently being considered for this sludge). One strategy being pursued to support this effort is in the area of frit development.[10] Specifically, as candidate frits are identified and evaluated, the nepheline discriminator will be used along with the more traditional PCCS MAR assessments. This will allow the frit development team to downselect the frits to those that offer attractive operating windows, provide the potential for acceptable melt rates, and lessen the likelihood (based on their evaluation using the nepheline discriminator) that the corresponding glass systems would form nepheline when kinetic conditions are favorable. This strategy alone may be sufficiently

[10] Based strictly on mathematics, frit development efforts to lower the Na_2O and/or increase the SiO_2 content (in the frit) should be evaluated to minimize the impacts of nepheline formation. Although this strategy may be advantageous with respect to nepheline formation, other processing properties (e.g., T_L, viscosity, or melt rate) may be negatively impacted.

successful to provide DWPF adequate and defensible assurance for the "nepheline-free" processing of SB4. If not, then other options such as the implementation of administrative controls on WL or incorporation of a nepheline discriminator in DWPF's PCCS may have to be pursued.

Assuming strategic frit development efforts are not successful, DWPF could elect to use an administrative control on WL to avoid nepheline formation. However, selecting a single WL as a control based on the Phase 2 data may be ill-advised given the dependence upon the specific frit – sludge system (until the specific SB4 sludge and frit is known) and the lack of a defined "acceptability bar". The "acceptability bar" referring to a g/L value that one could use to differentiate acceptable versus unacceptable glasses relative to EA. For example, one could use a normalized boron release limit of 10 g/L (consistent with Edwards and Brown (1998)) or a more conservative value of 4 g/L. Even if an "acceptability bar" is defined, establishing a WL limit to meet such a criterion would be dependent upon the specific frit – sludge system of interest. Given this dependence, DWPF may elect to use a nepheline "administrative control" limit value to avoid producing an unacceptable glass upon ccc. More specifically, a nepheline discriminator value (such as the 0.62 value proposed by Li et al. (2003)) may be determined for each Slurry Mix Evaporator (SME) batch to ensure that there are no negative impacts on durability. Regardless of the control method (i.e., a nepheline value or a WL constraint), the "acceptance bar" must be defined. For example, consider the use of a 0.62 nepheline "administrative control" limit and an "acceptance bar" value 4 g/L (or 0.5 log NL [B]).

Figure 5-1 shows the ccc PCT responses for Phase 2 glasses as a function of their nepheline discriminator values (computed based on targeted compositions). Using the 4.0 g/L acceptance criteria (horizontal green line located at 0.6 log NL [B] release), a nepheline discriminator value of ~0.608 would be required to ensure that the ccc versions of the SB4 based glasses do not exceed a 4 g/L NL [B] limit (based solely on the Phase 2 data). In terms of DWPF processing, one could implement SME acceptability control based on either a 0.608 limit or a WL limit. Due to the added uncertainties associated with a potential WL assessment, if needed or required, it is recommended that the nepheline discriminator be used to control the possibility of making a glass (or a certain fraction of the glass which has undergone the ccc profile), which exceeds the 4 g/L criteria – albeit arbitrary and well below the EA glass response of 16.695 g/L. Edwards and Brown (1998) used an acceptance criterion of 10 g/L to assess the potential elimination of the homogeneity constraint through the use of an Al_2O_3 and/or sum of alkali criteria. If the 10 g/L limit is used as the "acceptance criterion" (red horizontal line) then nepheline discriminator values of approximately 0.59 (or higher) would be acceptable to avoid making a DWPF glass that exceeds the 10 g/L limit. On the other hand, lowering the acceptance limit to 2 g/L (blue horizontal line), forces one to implement a nepheline discriminator value of approximately 0.62 (or greater).

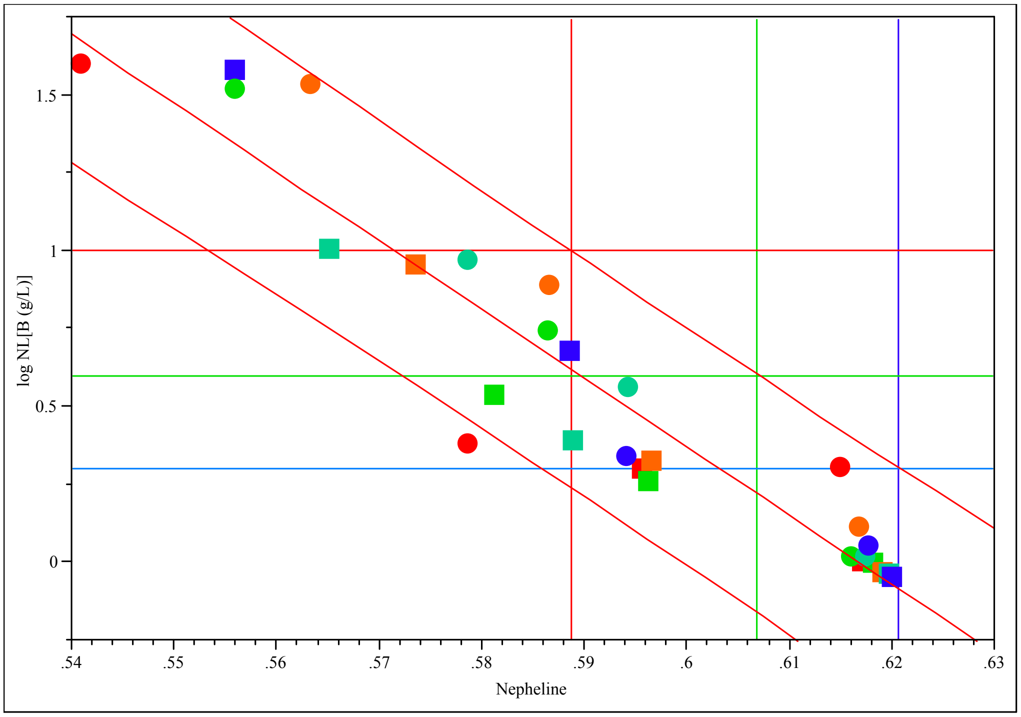

Figure 5-1. log NL [B] (g/L) Versus Computed Nepheline Discriminator Value for the Phase 2 ccc glasses.

Although perhaps initially conceived as a trivial matter, the practical implications of setting an "acceptance bar" are two-fold: First, one has to consider how far to push or challenge the Waste Qualification Report (WQR) acceptance criteria as they relate to the EA glass. In doing so, one also needs to balance the fact that allowing or setting a lower nepheline discriminator value allows access to higher WLs for all the SB4 – frit options that have been assessed. Obviously the higher WLs are attractive as there is potential to improve waste throughputs in DWPF assuming melt rate can be sustained at the higher WLs. Other processing criteria could also impact the targeted WL in DWPF. As an example, the ability to pump the sludge effectively may be inhibited as WL increases. If so, then WLs may be limited based on a processing issue that effectively pulls or removes the issue of nepheline formation and its ultimate impact on durability. Therefore, one may not need to implement such an administrative constraint in DWPF to control nepheline formation. As previously mentioned, historical melt rate trends suggest that as WL is increased, melt rate decreases. Although this potentially establishes a precedent to target lower WLs, it has also been shown that waste throughput (the amount of waste processed per unit time – the ultimate measure of success) is a compromise between melt rate and waste loading. Historically, maximum waste throughput has been achieved at some "intermediate" WL. If this trend holds for SB4, then not only could "processing" issues (such as pumpability as related to rheology) limit targeting higher WLs but melt rate and/or waste throughput issues could also limit WLs to the point where nepheline is not a concern. Therefore, as the SB4 flowsheet is refined, one must continue to assess which parameter may ultimately influence the targeted WLs. If nepheline becomes the limiting factor, then decisions regarding the "acceptance bar" should be defined and ultimately implemented into the DWPF process control scheme – potentially as an administrative control outside the realm of the SME acceptability decision.

The frit selection process for SB4 will ultimately be dependent on the strategy (or risks) one elects to take. More specifically, a conservative (and potentially bounding) strategy would be to avoid nepheline formation altogether through strategic frit development efforts or at least suppress it to WLs of 50% of higher. At these higher WLs, the probability of another property limiting acceptability is extremely high – thus taking nepheline and its potential negative impact out of the picture. To do this one may need to reduce the Na_2O content and/or increase the SiO_2 content of the frit, both of which may lead to relatively slow melt rates. The other extreme would be to push the Na_2O concentration in glass to the point at which WL and/or melt rate may be optimized but could put DWPF on the edge of compromising product quality – a condition to be avoided. The answer may lie somewhere between these two extremes. That is, one needs to balance the probability (or possibility) to mitigate nepheline formation while gaining as much advantage in melt rate and/or WL space as possible. To perform such a balancing act, more information than presented in this report is required. The concept of frit selection to meet processing goals will be explored more thoroughly in the baseline report.

6.0 SUMMARY

The impact of devitrification on durability is complex and depends on several interrelated factors including the change in residual glass composition, the formation of internal stress or microcracks, and the preferential attack at the glass-crystal interface. As noted from previous experimental studies, perhaps the most significant effects are the type and extent (or fraction) of crystallization and the resulting change to the residual glass composition. The formation of nepheline ($NaAlSiO_4$) can have a negative impact on durability as it produces an Al_2O_3 and SiO_2 deficient continuous glass matrix (relative to the same composition which is void of crystals). The magnitude of the reduction ultimately depends on the extent (e.g., volume %) of crystallization.

To assess the propensity of alumino-borosilicate glasses to precipitate nepheline, Li et al. (1997 and 2003) indicated that if the compositional projection falls within or close to the nepheline primary phase field (within the Na_2O-Al_2O_3-SiO_2 ternary) the glass is prone to nepheline formation. Specifically, glasses with $SiO_2/(SiO_2+Na_2O+Al_2O_3) > 0.62$, where the chemical formula stands for the mass fractions in the glass, do not tend to precipitate nepheline as their primary phase. The formation of nepheline and/or other aluminum/silicon-containing crystals is a potential in the SB4 system due to the projected compositional views recently evaluated coupled with the frit development strategy.

Peeler et al. (2005b) initially addressed this concern through a Phase 1 study. The results not only suggested that the 0.62 value appeared to be a reasonable guide to monitor alumino-borosilicate based glass systems with respect to potential nepheline formation, but also that the presence of nepheline, although statistically significant, had little or no practical impact in the SB4 system on durability as measured by the PCT. This latter statement was qualified to some extent given that only two glasses were selected that were actually prone to nepheline formation based on the general guide and that the volume % of nepheline formed based on XRD results was relatively low (~ 0.5 vol%). Given access to higher WLs may be anticipated, a subsequent study (referred to as Phase 2) was undertaken. The assumption was that targeting higher WLs may increase the potential for nepheline formation (and potentially the vol%), which could ultimately lead to a significant and practical difference in PCT response – when considering differences in PCT response between the quenched and slow cooled version of the same glass.

Twenty-eight glasses were identified for the Phase 2 scope. The glasses were fabricated and the durability assessed for both quenched and centerline canister cooled samples. Fourteen of the 28 Phase 2 glasses were based on the nominal 1.6M Na^+ with a 40" SB3 heel option, while the other 14 glasses were based on the nominal 1.6M Na^+ with a 127" SB3 heel – both "sludge-only" based flowsheets with no addition of ARP. Although high in Al_2O_3, these compositions are not considered the baseline or final projections.

All of the Phase 2 quenched glasses have normalized boron releases less than 1.19 g/L, which in terms of acceptability are approximately an order of magnitude better than the EA benchmark glass which has a reported NL [B] of 16.695 g/L (Jantzen et al. 1993). The range of normalized releases for the quenched Phase 2 glasses is from 0.67 g/L (NEPH2-27 based on the Frit 320 – 40" SB3 heel case at 39% WL) to 1.15 g/L (NEPH2-16 based on the Frit 417 – 127" SB3 heel case at 43% WL). The results suggest that even though the glasses are prone to nepheline formation based on the 0.62 guide value, all 28 Phase 2 quenched glasses are acceptable (as well as predictable by the model), which may provide some technical basis for "challenging" nepheline formation to gain access to higher WLs for the various SB4 options – independent of frit composition. However, the potential for crystallization was suppressed in the quenched glasses in terms of kinetics. That is, the glasses may be prone to nepheline formation but the rapid cooling limited (or eliminated) the formation of nepheline (or other crystalline phases).

For the ccc glasses, visual observations suggested that in general, as the targeted WL within a specific frit – sludge system was increased, the degree of crystallization or devitrification appeared to be more extensive. This is not unexpected as the slower cooling provides a thermodynamically favorable (compositional-wise) glass the kinetic opportunity to devitrify. With the knowledge of devitrification, the questions of interest to this study were: "What is the impact on the PCT response?", "What are the crystalline phase(s) that formed?", and "Does the type and/or extent of crystallization agree with glass science theory in terms of their anticipated impact on the durability response?"

XRD results indicated the presence of nepheline ($NaAlSiO_4$), trevorite (($NiFe_2O_4$), and/or lithium silicate (Li_2SiO_3) in select Phase 2 ccc glasses. In general, as the WL increases within a specific frit – sludge system, the crystalline phase(s) detected transitioned from amorphous or spinels (at the lowest WL), to spinel and nepheline (at the intermediate WL), and ultimately to spinel, nepheline, and lithium silicate (at the highest WL). With the type of crystalline known, the focus shifted to the possible impact on durability.

The normalized boron releases for the 1.6M, 127" SB3 heel based ccc glasses ranged from 0.89 g/L to 37.82 g/L. For the 1.6M, 40" ccc glasses the NL [B]'s ranged from 1.04 g/L to 40.11 g/L. These values obviously span a much wider PCT response as compared to the quenched versions. In addition, and more importantly, the PCT results suggest that select Phase 2 glasses exceed the benchmark EA glass response of 16.695 g/L. The obvious question to ask is: "Which frit – sludge combinations and/or WLs result in these unacceptable durabilities?" The general trend within each specific frit system is that as WL increases, the difference between the quenched and ccc PCT response increases. Coupling this trend with the crystallization results, one can easily explain the durability responses as a function of WL. More specifically, as WL increases within a specific frit – sludge system, the durability of the ccc based glasses decreases due to the formation of nepheline and/or lithium silicate. The trends are in agreement with previous observations that the impact on durability is dependent upon the type and extent of crystallization and the resulting change to the residual glass composition. As previously noted, nepheline formation can result in a severe deterioration of the chemical durability of the glass through residual glass compositional changes (i.e., a continuous glass matrix which is Al_2O_3 and/or SiO_2 deficient).

The results of the Phase 1 and Phase 2 studies suggest that the 0.62 value appears to be a reasonable guide to monitor SB4 – frit systems with respect to potential nepheline formation upon ccc. The significance of "ccc" in the latter sentence is based on the fact that none of the Phase 1 or Phase 2 quenched glasses show any sign of nepheline formation (based on the PCT response) although some of the Phase 2 glasses had nepheline discriminator values as low as 0.541. The PCT responses for all of the quenched glasses were very acceptable. It is only when the glass is provided the kinetic opportunity to devitrify through the slow ccc schedule that nepheline forms and ultimately has an adverse impact on durability.

In Phase 2, the lower WL glasses showed no significant or practical differences in durability when comparing quenched and ccc glasses – this is consistent with the Phase 1 results. It was only at the higher WLs (in Phase 2) that nepheline formation had a significantly negative impact on durability. The practical implication to DWPF is that higher WL glasses should be avoided for these types of glass systems (i.e., high Al_2O_3 and Na_2O). The primary question becomes how should DWPF control or eliminate nepheline formation? Should the control be WL driven or strictly mitigated through the implementation of a nepheline discriminator value or administrative limit? If the former (WL), then how does one define the critical WL at which nepheline becomes an issue (given the Phase 2 data suggest that the critical WL may be frit and sludge dependent)? If the latter (nepheline discriminator or administrative limit), then what value should one use as a guide (0.62 or 0.60)? Or can strategic frit development efforts identify candidate frits that lessen the likelihood of nepheline formation while meeting other critical process related goals (such as melt rate)? Although a formal recommendation of the specific path is not made in this report, a general discussion is provided on options that are available. It should be noted that although nepheline formation is a real and potentially significant issue, other constraints or alternatives may arise (e.g., pumping issues in the CPC) that would mitigate the impact as was discussed.

7.0 PATH FORWARD

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

- Develop strategy to avoid nepheline formation in SB4 type glasses. Options include:
  - Strategic frit development efforts
    - Frit compositions targeting lower Na_2O values and higher SiO_2 values should (mathematically) minimize the possibility of nepheline formation for a given sludge composition. Although potentially effective for minimizing nepheline formation in SB4 glasses, the impact of these frit compositional changes on melt rate or waste throughput are unknown at this time and should be evaluated.
  - Administrative control on WL
    - In order to effectively identify or set an administrative control on WL, specific information regarding the sludge composition and frit should be known. This is due to the dependence of the "critical" WL at which nepheline is predicted to be active (using the 0.62 value) for the sludge and frit combinations used.
  - Implementation of nepheline discriminator (with uncertainties applied)
    - Although the 0.62 value appears to be a reasonable value to guide assessments of nepheline formation (and its potential impact on durability), there appears to be some "uncertainty" in the exact value to use (e.g., 0.62 or 0.60 given the lower WL Phase 1 and Phase 2 glasses showed no significant or practical impact). Or, if implemented in PCCS, should uncertainties be added to this value similar to those for other properties which would increase the discriminator value to potentially > 0.62?
- Future frit development efforts for SB4 (or other higher Al_2O_3-based waste streams) should continue to use the nepheline discriminator value of 0.62 to assess nepheline formation potential.
- Ultimately, the Phase 1 and Phase 2 nepheline study data will play a major role in assessing the need for a variability study. The Phase 1 and Phase 2 data (along with other information that could support this assessment) should be integrated into the compiled composition – property database (ComPro™) and validated per procedures or guidelines recommended by Taylor et al. (2004).
  - It is recommended that the three Phase 2 glasses (NEPH2-21, NEPH2-27, and NEPH2-28) not be included in any future modeling of durability responses but classified as non-model data in ComPro™ due to the compositional uncertainties observed in this study.

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APPENDIX A

Analytical Plan Supporting the Chemical Composition Measurements

(SRNL-SCS-2005-00042)

SRNL-SCS-2005-00042

August 26, 2005

To: D. K. Peeler, 999-W

cc: R. A. Baker, 773-42A
D. R. Best, 786-1A (wo)
S. L. Marra, 999-W (es)
I. A. Reamer, 999-1W
P. A. Toole, 786-1A (wo)
R. C. Tuckfield, 773-42A
R. J. Workman, 999-1W

TBE

From: T. B. Edwards, 773-42A (5-5148)
Statistical Consulting Section

wo – without glass identifiers
es – executive summary only

Rae A. Baker
R. A. Baker, Technical Reviewer

9/6/2005
Date

for RCT
R. C. Tuckfield, Manager
Statistical Consulting Section

9/6/05
Date

AN ANALYTICAL PLAN FOR MEASURING THE CHEMICAL COMPOSITIONS OF THE NEPHELINE PHASE 2 STUDY GLASSES (U)

1.0 EXECUTIVE SUMMARY

A study is being conducted by the Savannah River National Laboratory (SRNL) for the Defense Waste Processing Facility (DWPF) that involves investigating the potential impact of nepheline formation on the durability of high level waste glasses. To address this issue, twenty-eight glass compositions were identified for their potential for the formation of nepheline as part of the frit development activities for Sludge Batch 4 (SB4) and were selected to complement an earlier nepheline study. In general, the glasses cover waste loadings (WLs) over which nepheline was the only criterion restricting access to higher WLs, and they are to be investigated as Phase 2 of the study of the potential impact of nepheline for SB4.

The chemical compositions of these 28 Phase 2 glasses are to be determined by the Savannah River National Laboratory – Mobile Laboratory (SRNL-ML). This memorandum provides an analytical plan to direct and support these measurements at the SRNL-ML.

2.0 INTRODUCTION

A study is being conducted by the Savannah River National Laboratory (SRNL) for the Defense Waste Processing Facility (DWPF) that involves investigating the potential impact of nepheline formation on the durability of high level waste glasses [1]. To address this issue, twenty-eight glass compositions were identified for their potential for the formation of nepheline as part of the frit development activities for Sludge Batch 4 (SB4) and were selected to complement an earlier nepheline study. In general, the glasses cover waste loadings (WLs) over which nepheline was the only criterion restricting access to higher WLs, and they are to be investigated as Phase 2 of the study of the potential impact of nepheline for SB4.

The chemical compositions of the 28 Phase 2 glasses are to be determined by the Savannah River National Laboratory – Mobile Laboratory (SRNL-ML). This memorandum provides an analytical plan to direct and support these measurements at the SRNL-ML.

3.0 ANALYTICAL PLAN

The analytical procedures used by the SRNL-ML 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), 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), manganese (Mn), nickel (Ni), silicon (Si), and uranium (U). 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 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 the SRNL-ML 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) [2] 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) (wt%)

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
SiO_2	50.22	45.353
SO_3	0	0
TiO_2	0.677	1.049
U_3O_8	0	2.406
ZrO_2	0.098	0

Each glass sample submitted to the SRNL-ML 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 B28, for the 28 glasses fabricated for this nepheline study. The table provides a naming convention that is to be used in analyzing the glasses and reporting the measurements of their compositions.[11]

[11] Renaming these samples helps to ensure that they will be processed as blind samples within the SRNL-ML. Table 2 is not shown in its entirety in the copy going to the SRNL-ML.

Table 2: Glass Identifiers[12] to Establish Blind Samples for the SRNL-ML

Glass ID	Sample ID	Glass ID	Sample ID
NEPH2-13	B23	NEPH2-27	B18
NEPH2-14	B13	NEPH2-28	B20
NEPH2-15	B25	NEPH2-29	B07
NEPH2-16	B21	NEPH2-30	B14
NEPH2-17	B12	NEPH2-31	B08
NEPH2-18	B04	NEPH2-32	B28
NEPH2-19	B26	NEPH2-33	B15
NEPH2-20	B27	NEPH2-34	B01
NEPH2-21	B02	NEPH2-35	B09
NEPH2-22	B10	NEPH2-36	B22
NEPH2-23	B24	NEPH2-37	B05
NEPH2-24	B17	NEPH2-38	B11
NEPH2-25	B19	NEPH2-39	B16
NEPH2-26	B03	NEPH2-40	B06

3.1 PREPARATION OF THE SAMPLES

Each of the 28 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 $28 \cdot 2 \cdot 2 = 112$, not including the samples of the BCH and Ustd glass standards that are to be prepared.

Tables 3a and 3b provide blocking and (random) sequencing schema for conducting the preparation steps of the analytical procedures. One block of preparation work is 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.

12 The nomenclature NEPH2-13 stands for a nepheline glass (“NEPH”), Phase 2 (“2”), with the identifying number 13 (“-13”). The Phase 1 study contained twelve glasses, which leads to the use of the numbers 13-40 for this phase.

Tables 3a and 3b: Preparation Blocks by Method

Table 3a: LM (Lithium Metaborate) Preparation Blocks

Block 1	Block 2
B25LM1	B15LM1
B24LM1	B14LM1
B19LM1	B06LM1
B25LM2	B05LM1
B13LM1	B22LM1
B04LM1	B07LM1
B21LM1	B01LM1
B17LM1	B06LM2
B23LM1	B18LM1
B19LM2	B08LM1
B02LM1	B05LM2
B10LM1	B09LM1
B13LM2	B01LM2
B21LM2	B28LM1
B27LM1	B11LM1
B03LM1	B28LM2
B12LM1	B20LM1
B17LM2	B16LM1
B24LM2	B15LM2
B26LM1	B14LM2
B23LM2	B08LM2
B02LM2	B16LM2
B04LM2	B22LM2
B03LM2	B11LM2
B27LM2	B09LM2
B26LM2	B07LM2
B10LM2	B20LM2
B12LM2	B18LM2

Table 3b: PF (Peroxide Fusion) Preparation Blocks

Block 1	Block 2
B02PF1	B22PF1
B21PF1	B15PF1
B23PF1	B20PF1
B02PF2	B20PF2
B04PF1	B05PF1
B24PF1	B07PF1
B27PF1	B15PF2
B13PF1	B09PF1
B03PF1	B05PF2
B24PF2	B14PF1
B03PF2	B11PF1
B23PF2	B28PF1
B27PF2	B06PF1
B12PF1	B16PF1
B19PF1	B18PF1
B25PF1	B18PF2
B19PF2	B16PF2
B21PF2	B01PF1
B10PF1	B11PF2
B04PF2	B08PF1
B17PF1	B22PF2
B26PF1	B09PF2
B13PF2	B28PF2
B12PF2	B07PF2
B25PF2	B01PF2
B26PF2	B14PF2
B10PF2	B06PF2
B17PF2	B08PF2

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 Tables 4 and 5, respectively. The cations to be measured are specified in the header of each table. In the tables, the sample identifiers for the 28 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 within each of the four ICP-AES blocks. The identifiers for the BCH and Ustd samples have been modified to indicate the ICP-AES block, the calibration, and that each of these prepared samples is to be read 3 times (mirrored in the corresponding suffix of 1, 2, or 3) per block and calibration.

Tables 4: ICP-AES Blocks & Calibration Groups for the LM Glass Samples

(Used to Measure Elemental Ba, Ca, Ce, Cr, Cu, K, La, Mg, Na, Pb, S, Th, Ti, Zn, & Zr)

Block 1		**Block 2**		**Block 3**		**Block 4**	
Calibration 1	**Calibration 2**	**Calibration 1**	**Calibration 2**	**Calibration 1**	**Calibration 2**	**Calibration 1**	**Calibration 2**
BCHLM111	BCHLM121	BCHLM211	BCHLM221	BCHLM311	BCHLM321	BCHLM411	BCHLM421
UstdLM111	UstdLM121	UstdLM211	UstdLM221	UstdLM311	UstdLM321	UstdLM411	UstdLM421
B13LM11	B02LM22	B08LM21	B11LM22	B23LM21	B23LM12	B15LM11	B20LM22
B03LM11	B04LM22	B06LM11	B11LM12	B21LM11	B19LM12	B18LM11	B16LM12
B10LM21	B10LM22	B11LM11	B01LM22	B27LM11	B21LM12	B16LM11	B14LM12
B03LM21	B02LM12	B09LM21	B06LM22	B25LM21	B23LM22	B20LM11	B15LM12
B12LM11	B12LM12	B05LM21	B09LM22	B21LM21	B27LM22	B16LM21	B22LM12
B12LM21	B04LM12	B01LM21	B08LM12	B19LM11	B21LM22	B14LM21	B14LM22
B02LM11	B12LM22	B07LM21	B09LM12	B26LM11	B26LM12	B22LM21	B16LM22
BCHLM112	BCHLM122	BCHLM212	BCHLM222	BCHLM312	BCHLM322	BCHLM412	BCHLM422
UstdLM112	UstdLM122	UstdLM212	UstdLM222	UstdLM312	UstdLM322	UstdLM412	UstdLM422
B10LM11	B13LM12	B06LM21	B06LM12	B23LM11	B27LM12	B28LM11	B18LM12
B02LM21	B03LM22	B11LM21	B08LM22	B26LM21	B24LM12	B15LM21	B18LM22
B17LM21	B10LM12	B01LM11	B05LM12	B24LM11	B25LM22	B20LM21	B20LM12
B04LM11	B17LM12	B09LM11	B07LM22	B24LM21	B25LM12	B28LM21	B15LM22
B13LM21	B13LM22	B08LM11	B05LM22	B27LM21	B24LM22	B14LM11	B28LM12
B04LM21	B03LM12	B05LM11	B07LM12	B25LM11	B26LM22	B18LM21	B28LM22
B17LM11	B17LM22	B07LM11	B01LM12	B19LM21	B19LM22	B22LM11	B22LM22
UstdLM113	UstdLM123	UstdLM213	UstdLM223	UstdLM313	UstdLM323	UstdLM413	UstdLM423
BCHLM113	BCHLM123	BCHLM213	BCHLM223	BCHLM313	BCHLM323	BCHLM413	BCHLM423

Tables 5: ICP-AES Blocks & Calibration Groups for the PF Glass Samples
(Used to Measure Elemental Al, B, Fe, Li, Mn, Ni, Si, & U)

Block 1		Block 2		Block 3		Block 4	
Calibration 1	Calibration 2	Calibration 1	Calibration 2	Calibration 1	Calibration 2	Calibration 1	Calibration 2
BCHPF111	BCHPF121	BCHPF211	BCHPF221	BCHPF311	BCHPF321	BCHPF411	BCHPF421
UstdPF111	UstdPF121	UstdPF211	UstdPF221	UstdPF311	UstdPF321	UstdPF411	UstdPF421
B12PF11	B03PF12	B05PF21	B09PF22	B24PF11	B19PF22	B16PF11	B18PF12
B13PF21	B17PF22	B06PF21	B08PF12	B26PF11	B25PF12	B22PF11	B15PF12
B04PF21	B12PF12	B07PF11	B07PF22	B27PF21	B23PF22	B20PF21	B18PF22
B10PF11	B13PF12	B11PF11	B07PF12	B21PF11	B26PF22	B28PF21	B14PF12
B17PF21	B02PF22	B05PF11	B11PF22	B25PF11	B19PF12	B14PF11	B28PF22
B04PF11	B02PF12	B08PF11	B09PF12	B25PF21	B24PF12	B22PF21	B14PF22
B02PF21	B03PF22	B01PF11	B06PF22	B19PF21	B23PF12	B15PF21	B22PF12
BCHPF112	BCHPF122	BCHPF212	BCHPF222	BCHPF312	BCHPF322	BCHPF412	BCHPF422
UstdPF112	UstdPF122	UstdPF212	UstdPF222	UstdPF312	UstdPF322	UstdPF412	UstdPF422
B03PF21	B17PF12	B08PF21	B08PF22	B24PF21	B26PF12	B15PF11	B16PF12
B03PF11	B04PF12	B11PF21	B01PF22	B23PF21	B27PF12	B14PF21	B28PF12
B02PF11	B10PF22	B07PF21	B05PF12	B23PF11	B21PF22	B18PF21	B22PF22
B17PF11	B13PF22	B09PF11	B01PF12	B27PF11	B25PF22	B18PF11	B20PF22
B13PF11	B04PF22	B06PF11	B06PF12	B21PF21	B24PF22	B28PF11	B20PF12
B10PF21	B12PF22	B01PF21	B05PF22	B19PF11	B27PF22	B16PF21	B15PF22
B12PF21	B10PF12	B09PF21	B11PF12	B26PF21	B21PF12	B20PF11	B16PF22
UstdPF113	UstdPF123	UstdPF213	UstdPF223	UstdPF313	UstdPF323	UstdPF413	UstdPF423
BCHPF113	BCHPF123	BCHPF213	BCHPF223	BCHPF313	BCHPF323	BCHPF413	BCHPF423

4.0 CONCLUDING COMMENTS

In summary, this analytical plan identifies four preparation blocks in Tables 3a and 3b and eight ICP-AES calibration blocks in Tables 4 and 5 for use by the SRNL-ML. 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 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 SRNL-ML 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 REFERENCES

[1] Edwards, T.B. and D.K. Peeler, "Nepheline Formation Potential in Sludge Batch 4 (SB4) and Its Impact on Durability: Selecting Glasses for a Phase 2 Study," WSRC-TR-2005-00370, Revision 0, 2005.

[2] 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™) (U)," WSRC-TR-93-673, Revision 1, Volume 2, Table B.1,
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APPENDIX B

An Analytical Plan for Measuring PCT Solutions for Glasses from the Phase 2 Nepheline Study – Part 1: 1.6M, 127" Heel Glasses

(SRNL-SCS-2005-00041)

SRNL-SCS-2005-00041

August 23, 2005

To: D. K. Peeler, 999-W

cc: R. A. Baker, 773-42A
D. R. Best, 786-1A (wo)
S. L. Marra, 999-W (es)
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, 773-42A (5-5148)
Statistical Consulting Section

wo – without glass identifiers
es – executive summary only

8/26/2005
R. A. Baker, Technical Reviewer — Date

8/26/05
R. C. Tuckfield, Manager — Date
Statistical Consulting Section

AN ANALYTICAL PLAN FOR MEASURING PCT SOLUTIONS FOR GLASSES FROM THE PHASE 2 NEPHELINE STUDY – PART 1: 1.6M, 127" HEEL GLASSES (U)

1.0 EXECUTIVE SUMMARY

A study is being conducted by the Savannah River National Laboratory (SRNL) for the Defense Waste Processing Facility (DWPF) that involves investigating the potential impact of nepheline formation on the durability of high level waste glasses. To address this issue, several glass compositions were identified for their potential for the formation of nepheline as part of the frit development activities for Sludge Batch 4 (SB4). Twenty-eight glasses were selected to be batched and fabricated as Phase 2 of the nepheline study; the durability of the glasses is to be measured using the Product Consistency Test (PCT) as defined in ASTM C-1285-2002. Two heat treatments were utilized during the fabrication of each of these glasses. Specifically, each of the 28 glasses was 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 28 glasses have been grouped into two sets (or parts) based on the Sludge Batch 3 (SB3) heel volume option. The first set (which is covered in this memorandum) is based on the 1.6M, 127" SB3 heel volume while the second set is based on the 1.6M, 40" SB3 heel volume.

The Savannah River National Laboratory-Mobile Laboratory (SRNL-ML) is to be used to measure elemental concentrations of the resulting leachate solutions from the PCTs. This memorandum provides an analytical plan for the SRNL-ML to follow in measuring the compositions of the leachate solutions resulting from the first part of the PCT procedures, covering 14 of the Phase 2 nepheline study glasses (based on the 1.6M, 127" SB3 heel volume option). The analytical plan for the second part of the PCTs of the Phase 2 study glasses (based on the 1.6M, 40" SB3 heel volume option) will be addressed in a separate memorandum.

2.0 INTRODUCTION

A study is being conducted by the Savannah River National Laboratory (SRNL) for the Defense Waste Processing Facility (DWPF) that involves investigating the potential impact of nepheline formation on the durability of high level waste glasses [1]. To address this issue, 28 glass compositions were selected for their potential for the formation of nepheline as part of the frit development activities for Sludge Batch 4 (SB4). These glasses were selected to be batched and fabricated as Phase 2 of the nepheline study; the durability of the glasses is to be measured using the Product Consistency Test (PCT) as defined in ASTM C-1285-2002 [2]. Specifically, each of the 28 glasses was 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 28 glasses have been grouped into two sets (or parts) based on the Sludge Batch 3 (SB3) heel volume option. The first set (which is covered in this memorandum) is based on the 1.6M, 127" SB3 heel volume while the second set is based on the 1.6M, 40" SB3 heel volume.

The Savannah River National Laboratory-Mobile Laboratory (SRNL-ML) is to be used to measure elemental concentrations of the resulting leachate solutions from the PCTs. This memorandum provides an analytical plan for the SRNL-ML to follow in measuring the compositions of the leachate solutions resulting from the first part of the PCT procedures, covering the glasses based on the 1.6M, 127" SB3 heel volume option as indicated in Table 1. The analytical plan for the second part of the PCTs of the Phase 2 study glasses (based on the 1.6M, 40" SB3 heel volume option) will be addressed in a separate memorandum.

Table 1: Identifiers for the Nepheline Study Glasses – Part 1[13]

NEPH2-13	NEPH2-20
NEPH2-13ccc	NEPH2-20ccc
NEPH2-14	NEPH2-21
NEPH2-14ccc	NEPH2-21ccc
NEPH2-15	NEPH2-22
NEPH2-15ccc	NEPH2-22ccc
NEPH2-16	NEPH2-23
NEPH2-16ccc	NEPH2-23ccc
NEPH2-17	NEPH2-24
NEPH2-17ccc	NEPH2-24ccc
NEPH2-18	NEPH2-25
NEPH2-18ccc	NEPH2-25ccc
NEPH2-19	NEPH2-26
NEPH2-19ccc	NEPH2-26ccc

3.0 DISCUSSION

Each of the study glasses of Table 1 is to be subjected to the PCT in triplicate. In addition to those for the 14 study glasses, triplicate PCTs are to be conducted on a sample of the Approved Reference Material (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 92 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 the SRNL-ML. The EA leachates will be further diluted (1:10 v:v) with deionized water prior to submission to the SRNL-ML in order to prevent problems with the nebulizer.

Table 2 presents identifying codes, C01 through C92, for the individual solutions required for the PCTs of the study glasses and of the standards (EA, ARM-1, and blanks). This provides a naming convention that is to be used by the SRNL-ML in analyzing the solutions and reporting the relevant concentration measurements.[14]

[13] The nomenclature NEPH2-13 stands for a nepheline glass ("NEPH"), Phase 2 ("2"), with the identifying number 13 ("-13"). The Phase 1 study contained twelve glasses, which leads to the use of the numbers 13 – 26 for the first part of Phase 2.

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

Table 2: Identifiers for the PCT Solutions – Part 1

Original Sample	Solution Identifier	Original Sample	Solution Identifier	Original Sample	Solution Identifier
NEPH2-13	C89	NEPH2-18ccc	C15	NEPH2-24	C34
NEPH2-13	C64	NEPH2-18ccc	C16	NEPH2-24	C73
NEPH2-13	C50	NEPH2-18ccc	C05	NEPH2-24	C74
NEPH2-13ccc	C83	NEPH2-19	C71	NEPH2-24ccc	C49
NEPH2-13ccc	C62	NEPH2-19	C07	NEPH2-24ccc	C27
NEPH2-13ccc	C87	NEPH2-19	C65	NEPH2-24ccc	C90
NEPH2-14	C82	NEPH2-19ccc	C68	NEPH2-25	C66
NEPH2-14	C36	NEPH2-19ccc	C33	NEPH2-25	C88
NEPH2-14	C28	NEPH2-19ccc	C78	NEPH2-25	C79
NEPH2-14ccc	C42	NEPH2-20	C06	NEPH2-25ccc	C20
NEPH2-14ccc	C18	NEPH2-20	C40	NEPH2-25ccc	C55
NEPH2-14ccc	C26	NEPH2-20	C39	NEPH2-25ccc	C23
NEPH2-15	C52	NEPH2-20ccc	C14	NEPH2-26	C59
NEPH2-15	C47	NEPH2-20ccc	C08	NEPH2-26	C63
NEPH2-15	C30	NEPH2-20ccc	C13	NEPH2-26	C48
NEPH2-15ccc	C76	NEPH2-21	C03	NEPH2-26ccc	C29
NEPH2-15ccc	C01	NEPH2-21	C43	NEPH2-26ccc	C10
NEPH2-15ccc	C37	NEPH2-21	C57	NEPH2-26ccc	C77
NEPH2-16	C72	NEPH2-21ccc	C51	EA	C44
NEPH2-16	C19	NEPH2-21ccc	C02	EA	C53
NEPH2-16	C24	NEPH2-21ccc	C60	EA	C61
NEPH2-16ccc	C32	NEPH2-22	C67	ARM-1	C84
NEPH2-16ccc	C25	NEPH2-22	C17	ARM-1	C38
NEPH2-16ccc	C41	NEPH2-22	C91	ARM-1	C46
NEPH2-17	C92	NEPH2-22ccc	C81	blank	C85
NEPH2-17	C58	NEPH2-22ccc	C35	blank	C21
NEPH2-17	C04	NEPH2-22ccc	C45		
NEPH2-17ccc	C09	NEPH2-23	C70		
NEPH2-17ccc	C22	NEPH2-23	C11		
NEPH2-17ccc	C80	NEPH2-23	C31		
NEPH2-18	C69	NEPH2-23ccc	C56		
NEPH2-18	C75	NEPH2-23ccc	C86		
NEPH2-18	C12	NEPH2-23ccc	C54		

4.0 ANALYTICAL PLAN

The analytical plan for the SRNL-ML is provided in this section. Each of the solution samples submitted to the SRNL-ML is to be analyzed only once for each of the following: boron (B), barium (Ba), cadmium (Cd), chromium (Cr), iron (Fe), lithium (Li) , sodium (Na), lead (Pb), silicon (Si), thorium (Th), and uranium (U). B, Li, Na, and Si are the elements that are to be used in the assessment of glass durability; the other elements are being monitored to address solution disposal issues in 773-A upon termination of the PCTs. The measurements are to be made in parts per million (ppm). The analytical procedure used by the SRNL-ML 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 three ICP-AES blocks for processing by the SRNL-ML in Table 3. Each block requires a different calibration of the ICP-AES.

Table 3: ICP-AES Calibration Blocks for Leachate Measurements – Part 1

Block 1	Block 2	Block 3
std-b1-1	std-b2-1	std-b3-1
C51	C10	C91
C92	C47	C41
C67	C33	C23
C59	C18	C26
C69	C11	C30
C83	C58	C65
C34	C02	C74
C15	C62	C37
C52	C38	C87
C70	C63	C04
C89	C40	C50
C84	C19	C39
C44	C16	C90
C76	C88	C78
C03	C07	C80
std-b1-2	std-b2-2	std-b3-2
C32	C36	C12
C14	C22	C77
C71	C75	C57
C49	C73	C28
C82	C17	C61
C06	C01	C79
C68	C43	C21
C56	C86	C05
C85	C25	C48
C81	C08	C60
C66	C55	C54
C29	C53	C31
C42	C35	C46
C09	C64	C24
C72	C27	C13
C20	std-b2-3	C45
std-b1-3		std-b3-3

A multi-element solution standard (denoted by "std-bi-j" where i=1 to 3 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 three 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 three ICP-AES calibration blocks in Table 3 for the SRNL-ML to use in conducting the boron (B), barium (Ba), cadmium (Cd), chromium (Cr), iron (Fe), lithium (Li), sodium (Na), lead (Pb), silicon (Si), thorium (Th), and uranium (U) concentration measurements for the first part of the PCT study for the Phase 2 nepheline glasses. 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 the 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 the SRNL-ML to include any calibration check standards and/or other standards that are part of their standard operating procedures.

6.0 REFERENCES

[1] Edwards, T.B. and D.K. Peeler, "Nepheline Formation Potential in Sludge Batch 4 (SB4) and Its Impact on Durability: Selecting Glasses for a Phase 2 Study," WSRC-TR-2005-00370, Revision 0, 2005.

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

An Analytical Plan for Measuring PCT Solutions for Glasses from the Phase 2 Nepheline Study – Part 2: 1.6M, 40" Heel Glasses

(SRNL-SCS-2005-00044)

SRNL-SCS-2005-00044

August 31, 2005

To: D. K. Peeler, 999-W

cc: R. A. Baker, 773-42A
D. R. Best, 786-1A (wo)
S. L. Marra, 999-W (es)
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, 773-42A (5-5148)
Statistical Consulting Section

wo – without glass identifiers
es – executive summary only

R. A. Baker, Technical Reviewer — Date: 9/6/2005

for RCT

R. C. Tuckfield, Manager
Statistical Consulting Section — Date: 9/6/05

AN ANALYTICAL PLAN FOR MEASURING PCT SOLUTIONS FOR GLASSES FROM THE PHASE 2 NEPHELINE STUDY – PART 2: 1.6M, 40" HEEL GLASSES (U)

1.0 EXECUTIVE SUMMARY

A study is being conducted by the Savannah River National Laboratory (SRNL) for the Defense Waste Processing Facility (DWPF) that involves investigating the potential impact of nepheline formation on the durability of high level waste glasses. To address this issue, several glass compositions were identified for their potential for the formation of nepheline as part of the frit development activities for Sludge Batch 4 (SB4). Twenty-eight of these glasses were selected to be batched and fabricated as Phase 2 of the nepheline study; the durability of the glasses is to be measured using the Product Consistency Test (PCT) as defined in ASTM C-1285-2002. Two heat treatments were utilized during the fabrication of each of these glasses. Specifically, each of the 28 glasses was 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 28 glasses have been grouped into two sets (or parts) based on the Sludge Batch 3 (SB3) heel volume option. This memorandum covers the second part, the PCT study of the glasses based on the 1.6M, 40” SB3 heel volume.

The Savannah River National Laboratory-Mobile Laboratory (SRNL-ML) is to be used to measure elemental concentrations of the resulting leachate solutions from the PCTs. This memorandum provides an analytical plan for the SRNL-ML to follow in measuring the compositions of the leachate solutions resulting from the second part of the PCT procedures, covering 14 of the Phase 2 nepheline study glasses (based on the 1.6M, 40” SB3 heel volume). The analytical plan for the first part of the PCTs of the Phase 2 study glasses was addressed in a separate memorandum.

2.0 INTRODUCTION

A study is being conducted by the Savannah River National Laboratory (SRNL) for the Defense Waste Processing Facility (DWPF) that involves investigating the potential impact of nepheline formation on the durability of high level waste glasses [1]. To address this issue, 28 glass compositions were selected for their potential for the formation of nepheline as part of the frit development activities for Sludge Batch 4 (SB4). These glasses were selected to be batched and fabricated as Phase 2 of the nepheline study; the durability of the glasses is to be measured using the Product Consistency Test (PCT) as defined in ASTM C-1285-2002 [2]. Two heat treatments were utilized during the fabrication of each of these glasses. Specifically, each of the 28 glasses was 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 28 glasses have been grouped into two sets (or parts) based on the Sludge Batch 3 (SB3) heel volume option. This memorandum covers the second part, the PCT study of the glasses based on the 1.6M, 40” SB3 heel volume.

The Savannah River National Laboratory-Mobile Laboratory (SRNL-ML) is to be used to measure elemental concentrations of the resulting leachate solutions from the PCTs. This memorandum provides an analytical plan for the SRNL-ML to follow in measuring the compositions of the leachate solutions resulting from the second part of the PCT procedures, covering 14 of the Phase 2 nepheline study glasses as indicated in Table 1. The analytical plan for the first part (based on the 1.6M, 127” SB3 heel volume) of the PCTs of the Phase 2 study glasses was addressed in a separate memorandum.

Table 1: Identifiers for the Nepheline Study Glasses – Part 2[15]

NEPH2-27	NEPH2-34
NEPH2-27ccc	NEPH2-34ccc
NEPH2-28	NEPH2-35
NEPH2-28ccc	NEPH2-35ccc
NEPH2-29	NEPH2-36
NEPH2-29ccc	NEPH2-36ccc
NEPH2-30	NEPH2-37
NEPH2-30ccc	NEPH2-37ccc
NEPH2-31	NEPH2-38
NEPH2-31ccc	NEPH2-38ccc
NEPH2-32	NEPH2-39
NEPH2-32ccc	NEPH2-39ccc
NEPH2-33	NEPH2-40
NEPH2-33ccc	NEPH2-40ccc

3.0 DISCUSSION

Each of the study glasses of Table 1 is to be subjected to the PCT in triplicate. In addition to those for the 14 study glasses, triplicate PCTs are to be conducted on a sample of the Approved Reference Material (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 92 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 the SRNL-ML. The EA leachates will be further diluted (1:10 v:v) with deionized water prior to submission to the SRNL-ML in order to prevent problems with the nebulizer.

Table 2 presents identifying codes, D01 through D92, for the individual solutions required for the PCTs of the study glasses and of the standards (EA, ARM-1, and blanks). This provides a naming convention that is to be used by the SRNL-ML in analyzing the solutions and reporting the relevant concentration measurements.[16]

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15 The nomenclature NEPH2-27 stands for a nepheline glass ("NEPH"), Phase 2 ("2"), with the identifying number 27 ("27"). The Phase 1 study contained twelve glasses and the first part of Phase 2 covered glasses 13 through 26, which leads to the use of the numbers 27 – 40 for the second part of Phase 2.

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

Table 2: Identifiers for the PCT Solutions – Part 2

Original Sample	Solution Identifier	Original Sample	Solution Identifier	Original Sample	Solution Identifier
NEPH2-27	D19	NEPH2-32ccc	D53	NEPH2-38	D01
NEPH2-27	D24	NEPH2-32ccc	D21	NEPH2-38	D84
NEPH2-27	D80	NEPH2-32ccc	D61	NEPH2-38	D66
NEPH2-27ccc	D49	NEPH2-33	D59	NEPH2-38ccc	D20
NEPH2-27ccc	D71	NEPH2-33	D73	NEPH2-38ccc	D89
NEPH2-27ccc	D26	NEPH2-33	D12	NEPH2-38ccc	D28
NEPH2-28	D44	NEPH2-33ccc	D78	NEPH2-39	D58
NEPH2-28	D22	NEPH2-33ccc	D50	NEPH2-39	D55
NEPH2-28	D29	NEPH2-33ccc	D64	NEPH2-39	D11
NEPH2-28ccc	D37	NEPH2-34	D92	NEPH2-39ccc	D56
NEPH2-28ccc	D15	NEPH2-34	D25	NEPH2-39ccc	D57
NEPH2-28ccc	D23	NEPH2-34	D13	NEPH2-39ccc	D46
NEPH2-29	D05	NEPH2-34ccc	D54	NEPH2-40	D03
NEPH2-29	D67	NEPH2-34ccc	D17	NEPH2-40	D86
NEPH2-29	D82	NEPH2-34ccc	D77	NEPH2-40	D33
NEPH2-29ccc	D02	NEPH2-35	D40	NEPH2-40ccc	D10
NEPH2-29ccc	D04	NEPH2-35	D83	NEPH2-40ccc	D38
NEPH2-29ccc	D48	NEPH2-35	D39	NEPH2-40ccc	D60
NEPH2-30	D32	NEPH2-35ccc	D36	EA	D07
NEPH2-30	D69	NEPH2-35ccc	D31	EA	D27
NEPH2-30	D88	NEPH2-35ccc	D18	EA	D65
NEPH2-30ccc	D06	NEPH2-36	D63	ARM-1	D81
NEPH2-30ccc	D68	NEPH2-36	D34	ARM-1	D75
NEPH2-30ccc	D47	NEPH2-36	D91	ARM-1	D90
NEPH2-31	D45	NEPH2-36ccc	D52	blank	D76
NEPH2-31	D51	NEPH2-36ccc	D74	blank	D72
NEPH2-31	D62	NEPH2-36ccc	D30		
NEPH2-31ccc	D09	NEPH2-37	D16		
NEPH2-31ccc	D08	NEPH2-37	D70		
NEPH2-31ccc	D43	NEPH2-37	D42		
NEPH2-32	D87	NEPH2-37ccc	D14		
NEPH2-32	D79	NEPH2-37ccc	D35		
NEPH2-32	D85	NEPH2-37ccc	D41		

4.0 ANALYTICAL PLAN

The analytical plan for the SRNL-ML is provided in this section. Each of the solution samples submitted to the SRNL-ML is to be analyzed only once for each of the following: boron (B), barium (Ba), cadmium (Cd), chromium (Cr), iron (Fe), lithium (Li), sodium (Na), lead (Pb), silicon (Si), thorium (Th), and uranium (U). B, Li, Na, and Si are the elements that are to be used in the assessment of glass durability; the other elements are being monitored to address solution disposal issues in 773-A upon termination of the PCTs. The measurements are to be made in parts per million (ppm). The analytical procedure used by the SRNL-ML 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 three ICP-AES blocks for processing by the SRNL-ML in Table 3. Each block requires a different calibration of the ICP-AES.

Table 3: ICP-AES Calibration Blocks for Leachate Measurements – Part 2

Block 1	Block 2	Block 3
std-b1-1	std-b2-1	std-b3-1
D49	D74	D91
D63	D38	D42
D78	D69	D48
D56	D51	D33
D05	D31	D72
D53	D04	D85
D87	D68	D11
D09	D50	D66
D02	D57	D61
D44	D67	D77
D36	D84	D43
D37	D71	D46
D54	D22	D64
D07	D89	D90
D20	D08	D30
std-b1-2	std-b2-2	std-b3-2
D01	D83	D28
D03	D75	D47
D32	D35	D12
D45	D73	D60
D52	D79	D18
D10	D24	D26
D92	D15	D41
D16	D17	D13
D14	D21	D82
D06	D86	D65
D58	D34	D39
D40	D25	D62
D81	D27	D23
D76	D70	D80
D19	D55	D29
D59	std-b2-3	D88
std-b1-3		std-b3-3

A multi-element solution standard (denoted by "std-bi-j" where i=1 to 3 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 three 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 three ICP-AES calibration blocks in Table 3 for the SRNL-ML to use in conducting the boron (B), barium (Ba), cadmium (Cd), chromium (Cr), iron (Fe), lithium (Li), sodium (Na), lead (Pb), silicon (Si), thorium (Th), and uranium (U) concentration measurements for the second part of the

PCT study for the Phase 2 nepheline glasses. 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 the 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 the SRNL-ML to include any calibration check standards and/or other standards that are part of their standard operating procedures.

6.0 REFERENCES

[1] Edwards, T.B. and D.K. Peeler, "Nepheline Formation Potential in Sludge Batch 4 (SB4) and Its Impact on Durability: Selecting Glasses for a Phase 2 Study," WSRC-TR-2005-00370, Revision 0, 2005.

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

SRNL-SCS-2005-00051

October 17, 2005

To: D. K. Peeler, 999-W

cc: R. A. Baker, 773-42A
D. R. Best, 786-1A (wo)
S. L. Marra, 999-W (es)
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, 773-42A (5-5148)
Statistical Consulting Section

wo – without glass identifiers
es – executive summary only

R. A. Baker, Technical Reviewer — 10/19/2005 Date

R. C. Tuckfield, Manager
Statistical Consulting Section — 10/20/05 Date

AN ANALYTICAL PLAN FOR MEASURING PCT SOLUTIONS FOR SELECT SET OF GLASSES FROM THE PHASE 2 NEPHELINE STUDY (U)

1.0 EXECUTIVE SUMMARY

A study is being conducted by the Savannah River National Laboratory (SRNL) for the Defense Waste Processing Facility (DWPF) that involves investigating the potential impact of nepheline formation on the durability of high level waste glasses. To address this issue, several glass compositions were identified for their potential for the formation of nepheline as part of the frit development activities for Sludge Batch 4 (SB4). Twenty-eight of these glasses were selected to be batched and fabricated as Phase 2 of the nepheline study; the durability of the glasses is to be measured using the Product Consistency Test (PCT) as defined in ASTM C-1285-2002. Two heat treatments were utilized during the fabrication of each of these glasses. Specifically, each of the 28 glasses was quenched (i.e., rapidly cooled) and cooled in accordance with the centerline-canister-cooling (ccc) regime. Both heat treatments of each glass were subjected to the PCT. The 28 glasses were grouped into two sets (or parts) based on the Sludge Batch 3 (SB3) heel volume option. Both sets of PCTs (the 1.6M, 40" SB3 heel volume set and the 1.6M, 127" SB3 heel volume set) were submitted to the Savannah River National Laboratory-Mobile Laboratory (SRNL-ML) for measurement.

A review of the measurements generated by the SRNL-ML for these PCTs led to the identification of three glasses that are to be re-batched. The three glasses are to be fabricated using both heat treatments (i.e., they are to be quenched and centerline-canister-cooled), and both heat treatments of each glass are to be subjected to the PCT. This memorandum provides an analytical plan for the measurement of these PCTs by the SRNL-ML.

2.0 INTRODUCTION

A study is being conducted by the Savannah River National Laboratory (SRNL) for the Defense Waste Processing Facility (DWPF) that involves investigating the potential impact of nepheline formation on the durability of high level waste glasses [1]. To address this issue, 28 glass compositions were selected for their potential for the formation of nepheline as part of the frit development activities for Sludge Batch 4 (SB4). These glasses were selected to be batched and fabricated as Phase 2 of the nepheline study; the durability of the glasses is to be measured using the Product Consistency Test (PCT) as defined in ASTM C-1285-2002 [2]. Two heat treatments were utilized during the fabrication of each of these glasses. Specifically, each of the 28 glasses was quenched (i.e., rapidly cooled) and cooled in accordance with the centerline-canister-cooling (ccc) regime. Both heat treatments of each glass were subjected to the PCT. The 28 glasses were grouped into two sets (or parts) based on the Sludge Batch 3 (SB3) heel volume option. Both sets of PCTs (the 1.6M, 40" SB3 heel volume set and the 1.6M, 127" SB3 heel volume set) were submitted to the Savannah River National Laboratory-Mobile Laboratory (SRNL-ML) for measurement.

A review of the measurements generated by the SRNL-ML for these PCTs led to the identification of three glasses that are to be re-batched. The three glasses are based on the 1.6M, 40" SB3 heel volume option coupled with Frit 425 at waste loadings of 41, 45, and 48%. The PCT results for the three glasses suggested that there may have been an inadvertent mislabeling of the glasses. More specifically, the PCT responses for all other Phase 2 glasses suggested a decrease in durability as waste loadings increased for a specific frit – sludge combination. The three Frit 425 – 1.6M, 40" SB3 heel glasses did not show this trend. The glass at the highest waste loading was the most durable of the three. The three glasses are to be fabricated using both heat treatments (i.e., they are to be quenched and centerline-canister-cooled), and both heat treatments of each glass are to be subjected to the PCT. See Table 1 for a listing of the glasses. This memorandum provides an analytical plan for the measurement of these PCTs by the SRNL-ML.

Table 1: Identifiers for Glasses Covered by this Plan[17]

NEPH2-33
NEPH2-33ccc
NEPH2-34
NEPH2-34ccc
NEPH2-35
NEPH2-35ccc

3.0 DISCUSSION

Each of the study glasses of Table 1 is to be subjected to the PCT in triplicate. In addition to those for the 6 study glasses, triplicate PCTs are to be conducted on a sample of the Approved Reference Material (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 26 sample solutions being required to complete these PCTs.

17 The nomenclature NEPH2-33 stands for a nepheline glass ("NEPH"), Phase 2 ("2"), with the identifying number 33 ("33"). The Phase 1 study contained twelve glasses and Phase 2 covered glasses 13 through 40.

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 the SRNL-ML. The leachates of EA will be further diluted (1:10 v:v) with deionized water prior to submission to the SRNL-ML 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 the anticipated low durability of at least two of the three glasses. Upon termination of the PCT, a decision is to be made (by the ITS technicians and an SRNL-ML representative) as to whether any other dilution is 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, the SRNL-ML 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, E01 through E26, 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 the SRNL-ML in analyzing the solutions and reporting the relevant concentration measurements.[18]

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

Original Sample	Solution Identifier
NEPH2-33	E12
NEPH2-33	E04
NEPH2-33	E16
NEPH2-33ccc	E24
NEPH2-33ccc	E19
NEPH2-33ccc	E17
NEPH2-34	E25
NEPH2-34	E13
NEPH2-34	E15
NEPH2-34ccc	E21
NEPH2-34ccc	E23
NEPH2-34ccc	E26
NEPH2-35	E01
NEPH2-35	E14
NEPH2-35	E07
NEPH2-35ccc	E05
NEPH2-35ccc	E20
NEPH2-35ccc	E08
EA	E03
EA	E02
EA	E18
ARM-1	E06
ARM-1	E11
ARM-1	E09
blank	E22
blank	E10

18 Renaming these samples ensures that they will be processed as blind samples by the SRNL-ML. 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 the SRNL-ML is provided in this section. Each of the solution samples submitted to the SRNL-ML is to be analyzed only once for each of the following: boron (B), barium (Ba), cadmium (Cd), chromium (Cr), iron (Fe), lithium (Li), sodium (Na), lead (Pb), silicon (Si), thorium (Th), and uranium (U). B, Li, Na, and Si are the elements that are to be used in the assessment of glass durability; the other elements are being monitored to address solution disposal issues in 773-A upon termination of the PCTs. The measurements are to be made in parts per million (ppm). The analytical procedure used by the SRNL-ML 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 three ICP-AES blocks for processing by the SRNL-ML 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
std-b1-1	std-b2-1	std-b3-1
E06	E19	E18
E03	E13	E09
E01	E02	E10
E12	E11	E08
std-b1-2	std-b2-2	std-b3-2
E25	E14	E17
E24	E20	E26
E05	E04	E15
E21	E23	E07
E22	std-b2-3	E16
std-b1-3		std-b3-3

A multi-element solution standard (denoted by "std-bi-j" where i=1 to 3 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 three 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 three ICP-AES calibration blocks in Table 3 for the SRNL-ML to use in conducting the boron (B), barium (Ba), cadmium (Cd), chromium (Cr), iron (Fe), lithium (Li), sodium (Na), lead (Pb), silicon (Si), thorium (Th), and uranium (U) concentration measurements for the PCT study of this select subset of the Phase 2 nepheline glasses. 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 the 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 the SRNL-ML to include any calibration check standards and/or other standards that are part of their standard operating procedures.

6.0 REFERENCES

[1] Edwards, T.B. and D.K. Peeler, "Nepheline Formation Potential in Sludge Batch 4 (SB4) and Its Impact on Durability: Selecting Glasses for a Phase 2 Study," WSRC-TR-2005-00370, Revision 0, 2005.

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

APPENDIX C

Tables and Exhibits Supporting the Analysis of the Chemical Composition Measurements of the Nepheline Phase 2 Study Glasses

Table C1. Targeted Oxide Concentrations (as wt%'s) for the Phase 2 Nepheline Study Glasses

Glass #	Al2O3	B2O3	BaO	CaO	Ce2O3	Cr2O3	CuO	Fe2O3	K2O	La2O3	Li2O	MgO	MnO	Na2O	NiO	PbO	SO4	SiO2	ThO2	TiO2	U3O8	ZnO	ZrO2	Sum
NEPH2-13	10.21	4.88	0.053	0.776	0.073	0.091	0.028	8.648	0.545	0.031	4.88	0.548	1.901	17.695	1.192	0.069	0.417	44.964	0.015	0.007	2.836	0.042	0.1	100.00
NEPH2-14	10.995	4.64	0.057	0.836	0.078	0.098	0.031	9.313	0.587	0.034	4.64	0.59	2.047	18.133	1.284	0.074	0.449	42.884	0.016	0.008	3.054	0.045	0.107	100.00
NEPH2-15	10.472	4.8	0.054	0.796	0.075	0.093	0.029	8.87	0.559	0.032	4.8	0.562	1.949	17.241	1.223	0.071	0.428	44.871	0.015	0.008	2.908	0.043	0.102	100.00
NEPH2-16	11.257	4.56	0.058	0.856	0.08	0.1	0.031	9.535	0.601	0.035	4.56	0.604	2.095	17.709	1.314	0.076	0.46	42.761	0.016	0.008	3.126	0.046	0.11	100.00
NEPH2-17	11.781	4.4	0.061	0.896	0.084	0.105	0.033	9.979	0.629	0.036	4.4	0.633	2.193	18.021	1.375	0.08	0.481	41.355	0.017	0.008	3.272	0.048	0.115	100.00
NEPH2-18	10.734	4.72	0.055	0.816	0.076	0.095	0.03	9.092	0.573	0.033	4.72	0.576	1.998	16.807	1.253	0.072	0.439	44.758	0.016	0.008	2.981	0.044	0.105	100.00
NEPH2-19	11.519	4.48	0.059	0.876	0.082	0.102	0.032	9.757	0.615	0.035	4.48	0.618	2.144	17.305	1.345	0.078	0.471	42.618	0.017	0.008	3.199	0.047	0.112	100.00
NEPH2-20	12.304	4.24	0.064	0.936	0.088	0.109	0.034	10.422	0.657	0.038	4.24	0.661	2.29	17.804	1.437	0.083	0.503	40.478	0.018	0.009	3.417	0.05	0.12	100.00
NEPH2-21	10.995	4.64	0.057	0.836	0.078	0.098	0.031	9.313	0.587	0.034	4.64	0.59	2.047	16.393	1.284	0.074	0.449	44.624	0.016	0.008	3.054	0.045	0.107	100.00
NEPH2-22	12.043	4.32	0.062	0.916	0.086	0.107	0.033	10.2	0.643	0.037	4.32	0.647	2.242	17.098	1.406	0.081	0.492	41.731	0.017	0.009	3.345	0.049	0.117	100.00
NEPH2-23	12.828	4.08	0.066	0.976	0.091	0.114	0.036	10.866	0.685	0.039	4.08	0.689	2.388	17.626	1.498	0.087	0.524	39.562	0.019	0.009	3.563	0.052	0.125	100.00
NEPH2-24	11.257	4.56	0.058	0.856	0.08	0.1	0.031	9.535	0.601	0.035	4.56	0.604	2.095	15.999	1.314	0.076	0.46	44.471	0.016	0.008	3.126	0.046	0.11	100.00
NEPH2-25	12.304	4.24	0.064	0.936	0.088	0.109	0.034	10.422	0.657	0.038	4.24	0.661	2.29	16.744	1.437	0.083	0.503	41.538	0.018	0.009	3.417	0.05	0.12	100.00
NEPH2-26	13.352	3.92	0.069	1.015	0.095	0.119	0.037	11.309	0.713	0.041	3.92	0.717	2.485	17.488	1.559	0.09	0.546	38.605	0.019	0.01	3.708	0.055	0.13	100.00
NEPH2-27	11.641	4.88	0.056	0.749	0.075	0.098	0.029	8.33	0.669	0.032	4.88	0.415	1.872	16.514	1.358	0.076	0.402	44.987	0.016	0.007	2.765	0.042	0.107	100.00
NEPH2-28	13.133	4.48	0.063	0.845	0.085	0.11	0.033	9.398	0.755	0.036	4.48	0.468	2.112	17.093	1.532	0.086	0.453	41.524	0.018	0.008	3.12	0.048	0.12	100.00
NEPH2-29	14.626	4.08	0.071	0.941	0.095	0.123	0.037	10.466	0.84	0.04	4.08	0.522	2.352	17.671	1.706	0.096	0.505	38.061	0.02	0.009	3.474	0.053	0.134	100.00
NEPH2-30	11.939	4.8	0.058	0.769	0.077	0.1	0.03	8.544	0.686	0.033	4.8	0.426	1.92	16.03	1.393	0.078	0.412	44.894	0.017	0.007	2.836	0.043	0.109	100.00
NEPH2-31	13.133	4.48	0.063	0.845	0.085	0.11	0.033	9.398	0.755	0.036	4.48	0.468	2.112	16.533	1.532	0.086	0.453	42.084	0.018	0.008	3.12	0.048	0.12	100.00
NEPH2-32	14.327	4.16	0.069	0.922	0.093	0.12	0.036	10.252	0.823	0.039	4.16	0.511	2.304	17.036	1.672	0.094	0.495	39.273	0.02	0.009	3.403	0.052	0.131	100.00
NEPH2-33	12.238	4.72	0.059	0.788	0.079	0.103	0.031	8.757	0.703	0.033	4.72	0.436	1.968	15.565	1.428	0.08	0.423	44.782	0.017	0.008	2.907	0.044	0.112	100.00
NEPH2-34	13.432	4.4	0.065	0.865	0.087	0.113	0.034	9.612	0.772	0.037	4.4	0.479	2.16	16.108	1.567	0.088	0.464	41.931	0.019	0.008	3.19	0.049	0.123	100.00
NEPH2-35	14.327	4.16	0.069	0.922	0.093	0.12	0.036	10.252	0.823	0.039	4.16	0.511	2.304	16.516	1.672	0.094	0.495	39.793	0.02	0.009	3.403	0.052	0.131	100.00
NEPH2-36	12.536	4.64	0.06	0.807	0.081	0.105	0.031	8.971	0.72	0.034	4.64	0.447	2.016	15.121	1.463	0.082	0.433	44.649	0.017	0.008	2.978	0.045	0.115	100.00
NEPH2-37	13.432	4.4	0.065	0.865	0.087	0.113	0.034	9.612	0.772	0.037	4.4	0.479	2.16	15.558	1.567	0.088	0.464	42.481	0.019	0.008	3.19	0.049	0.123	100.00
NEPH2-38	14.029	4.24	0.068	0.903	0.091	0.118	0.035	10.039	0.806	0.038	4.24	0.5	2.256	15.85	1.637	0.092	0.484	41.036	0.02	0.009	3.332	0.051	0.128	100.00
NEPH2-39	12.835	4.56	0.062	0.826	0.083	0.108	0.032	9.184	0.737	0.035	4.56	0.458	2.064	14.697	1.498	0.084	0.443	44.497	0.018	0.008	3.049	0.046	0.117	100.00
NEPH2-40	13.73	4.32	0.066	0.884	0.089	0.115	0.034	9.825	0.789	0.037	4.32	0.49	2.208	15.164	1.602	0.09	0.474	42.299	0.019	0.009	3.261	0.05	0.126	100.00

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	K	La	Mg	Mn	Na	Pb	S	Th	Ti	Zn	Zr
Batch 1	BCHLM111	1	1	1	0.123	0.83	<0.010	0.078	0.303	2.478	<0.010	0.813	1.31	6.92	<0.010	<0.100	<0.100	0.384	<0.010	0.062
Ustd	UstdLM11	1	1	2	<0.010	0.87	<0.010	0.16	<0.010	2.4	<0.010	0.66	2.05	8.51	<0.010	<0.100	<0.100	0.525	<0.010	<0.010
NEPH2-14	B13LM11	1	1	3	0.039	0.557	0.049	0.068	0.031	0.526	0.027	0.345	1.42	12.3	0.065	0.151	<0.100	<0.010	0.04	0.071
NEPH2-26	B03LM11	1	1	4	0.053	0.672	0.062	0.073	0.042	0.636	0.079	0.411	1.71	12	0.075	0.18	<0.100	<0.010	0.049	0.086
NEPH2-22	B10LM21	1	1	5	0.044	0.595	0.051	0.071	0.032	0.599	0.034	0.363	1.62	12	0.071	0.175	<0.100	<0.010	0.043	0.075
NEPH2-26	B03LM21	1	1	6	0.054	0.688	0.063	0.068	0.042	0.662	0.061	0.414	1.67	12.7	0.076	0.193	<0.100	<0.010	0.049	0.089
NEPH2-17	B12LM11	1	1	7	0.045	0.59	0.048	0.069	0.033	0.543	0.029	0.369	1.66	13	0.07	0.167	<0.100	<0.010	0.044	0.08
NEPH2-17	B12LM21	1	1	8	0.046	0.595	0.048	0.069	0.032	0.557	0.029	0.367	1.6	13	0.07	0.164	<0.100	<0.010	0.043	0.078
NEPH2-21	B02LM11	1	1	9	0.042	0.546	0.051	0.071	0.029	0.516	0.029	0.348	1.48	11.6	0.064	0.159	<0.100	<0.010	0.012	0.073
Batch 1	BCHLM112	1	1	10	0.122	0.812	<0.010	0.078	0.299	2.446	<0.010	0.808	1.27	6.74	<0.010	<0.100	<0.100	0.377	<0.010	0.061
Ustd	USTDLM112	1	1	11	<0.010	0.857	<0.010	0.159	<0.010	2.356	<0.010	0.653	2.1	8.53	<0.010	<0.100	<0.100	0.515	<0.010	<0.010
NEPH2-22	B10LM11	1	1	12	0.046	0.599	0.051	0.072	0.031	0.558	0.034	0.373	1.68	12.1	0.073	0.166	<0.100	<0.010	0.043	0.077
NEPH2-21	B02LM21	1	1	13	0.039	0.535	0.049	0.068	0.029	0.567	0.028	0.327	1.51	11.5	0.058	0.168	<0.100	<0.010	0.012	0.068
NEPH2-24	B17LM21	1	1	14	0.041	0.558	0.051	0.065	0.03	0.539	0.028	0.349	1.58	11.6	0.062	0.16	<0.100	<0.010	0.04	0.073
NEPH2-18	B04LM11	1	1	15	0.041	0.546	0.046	0.065	0.032	0.522	0.027	0.33	1.48	12	0.057	0.152	<0.100	<0.010	0.039	0.067
NEPH2-14	B13LM21	1	1	16	0.039	0.563	0.047	0.068	0.031	0.541	0.026	0.337	1.55	12.8	0.064	0.159	<0.100	<0.010	0.042	0.064
NEPH2-18	B04LM21	1	1	17	0.04	0.549	0.045	0.066	0.03	0.535	0.027	0.324	1.52	12.3	0.055	0.154	<0.100	<0.010	0.04	0.068
NEPH2-24	B17LM11	1	1	18	0.042	0.565	0.051	0.067	0.031	0.527	0.029	0.357	1.61	11.6	0.066	0.159	<0.100	<0.010	0.043	0.074
Ustd	USTDLM113	1	1	19	<0.010	0.85	<0.010	0.159	<0.010	2.35	<0.010	0.652	2.07	8.49	<0.010	<0.100	<0.100	0.513	<0.010	<0.010
Batch 1	BCHLM113	1	1	20	0.121	0.804	<0.010	0.078	0.297	2.439	<0.010	0.802	1.31	6.95	<0.010	<0.100	<0.100	0.373	<0.010	0.06
Batch 1	BCHLM121	1	2	1	0.122	0.82	<0.010	0.078	0.302	2.42	<0.010	0.807	1.35	6.94	<0.010	<0.100	<0.100	0.382	<0.010	0.061
Ustd	USTDLM121	1	2	2	<0.010	0.862	<0.010	0.158	<0.010	2.329	<0.010	0.658	2.16	8.68	<0.010	<0.100	<0.100	0.529	<0.010	<0.010
NEPH2-21	B02LM22	1	2	3	0.039	0.554	0.052	0.068	0.03	0.559	0.028	0.328	1.6	12	0.058	0.156	<0.100	<0.010	0.011	0.069
NEPH2-18	B04LM22	1	2	4	0.04	0.548	0.048	0.065	0.031	0.529	0.027	0.326	1.54	12.5	0.055	0.135	<0.100	<0.010	0.038	0.068
NEPH2-22	B10LM22	1	2	5	0.043	0.588	0.052	0.069	0.032	0.587	0.033	0.36	1.72	12.7	0.067	0.156	<0.100	<0.010	0.041	0.074
NEPH2-21	B02LM12	1	2	6	0.042	0.559	0.054	0.07	0.03	0.52	0.03	0.349	1.58	12	0.063	0.146	<0.100	<0.010	0.011	0.073
NEPH2-17	B12LM12	1	2	7	0.045	0.599	0.05	0.068	0.034	0.542	0.029	0.368	1.68	13.2	0.067	0.161	<0.100	<0.010	0.044	0.089
NEPH2-18	B04LM12	1	2	8	0.04	0.542	0.049	0.065	0.033	0.517	0.027	0.328	1.48	12.3	0.055	0.136	<0.100	<0.010	0.037	0.068
NEPH2-17	B12LM22	1	2	9	0.045	0.596	0.05	0.068	0.032	0.553	0.029	0.367	1.65	13.2	0.067	0.156	<0.100	<0.010	0.041	0.077
Batch 1	BCHLM122	1	2	10	0.121	0.819	<0.010	0.078	0.301	2.418	<0.010	0.804	1.27	6.89	<0.010	<0.100	<0.100	0.382	<0.010	0.061
Ustd	USTDLM122	1	2	11	<0.010	0.853	<0.010	0.157	<0.010	2.317	<0.010	0.648	2.03	8.57	<0.010	<0.100	<0.100	0.52	<0.010	<0.010
NEPH2-14	B13LM12	1	2	12	0.038	0.558	0.051	0.066	0.031	0.517	0.027	0.34	1.51	13	0.063	0.143	<0.100	<0.010	0.038	0.067
NEPH2-26	B03LM22	1	2	13	0.051	0.658	0.063	0.065	0.04	0.625	0.06	0.4	1.66	12.8	0.071	0.172	<0.100	<0.010	0.045	0.086
NEPH2-22	B10LM12	1	2	14	0.045	0.585	0.054	0.071	0.032	0.551	0.034	0.374	1.64	12.3	0.072	0.155	<0.100	<0.010	0.041	0.078
NEPH2-24	B17LM12	1	2	15	0.042	0.58	0.054	0.066	0.032	0.531	0.029	0.357	1.56	11.7	0.063	0.15	<0.100	<0.010	0.041	0.076
NEPH2-14	B13LM22	1	2	16	0.038	0.565	0.05	0.067	0.032	0.544	0.026	0.336	1.47	12.8	0.063	0.149	<0.100	<0.010	0.04	0.065
NEPH2-26	B03LM12	1	2	17	0.051	0.66	0.063	0.071	0.042	0.621	0.078	0.405	1.78	12.4	0.072	0.173	<0.100	<0.010	0.048	0.085
NEPH2-24	B17LM22	1	2	18	0.04	0.568	0.053	0.064	0.031	0.538	0.028	0.347	1.57	11.6	0.06	0.141	<0.100	<0.010	0.038	0.073
Ustd	USTDLM123	1	2	19	<0.010	0.854	<0.010	0.157	<0.010	2.33	<0.010	0.65	2.06	8.63	<0.010	<0.100	<0.100	0.522	<0.010	<0.010
Batch 1	BCHLM123	1	2	20	0.121	0.81	<0.010	0.077	0.301	2.423	<0.010	0.803	1.27	7	<0.010	<0.100	<0.100	0.379	<0.010	0.061

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	K	La	Mg	Mn	Na	Pb	S	Th	Ti	Zn	Zr
Batch 1	BCHLM211	2	1	1	0.124	0.824	<0.010	0.079	0.305	2.441	<0.010	0.82	1.31	7.06	<0.010	<0.100	<0.100	0.387	<0.010	0.063
Ustd	USTDLM211	2	1	2	<0.010	0.875	<0.010	0.159	<0.010	2.353	<0.010	0.661	2.09	8.67	<0.010	<0.100	<0.100	0.534	<0.010	<0.010
NEPH2-31	B08LM21	2	1	3	0.053	0.569	0.059	0.068	0.034	0.617	0.028	0.288	1.59	11.9	0.078	0.144	<0.100	<0.010	0.042	0.085
NEPH2-40	B06LM11	2	1	4	0.05	0.589	0.057	0.068	0.031	0.704	0.03	0.29	1.64	11.4	0.076	0.143	<0.100	<0.010	0.043	0.087
NEPH2-38	B11LM11	2	1	5	0.058	0.604	0.055	0.082	0.036	0.695	0.028	0.304	1.69	11.9	0.082	0.152	<0.100	<0.010	0.044	0.09
NEPH2-35	B09LM21	2	1	6	0.052	0.619	0.059	0.068	0.035	0.731	0.031	0.302	1.71	12.2	0.082	0.155	<0.100	<0.010	0.046	0.085
NEPH2-37	B05LM21	2	1	7	0.049	0.574	0.058	0.071	0.031	0.695	0.028	0.282	1.63	11.9	0.069	0.144	<0.100	<0.010	0.041	0.083
NEPH2-34	B01LM21	2	1	8	0.051	0.572	0.053	0.072	0.033	0.678	0.029	0.282	1.62	11.9	0.074	0.146	<0.100	<0.010	0.043	0.08
NEPH2-29	B07LM21	2	1	9	0.053	0.63	0.069	0.073	0.033	0.718	0.034	0.314	1.73	12.8	0.082	0.16	<0.100	<0.010	0.047	0.091
Batch 1	BCHLML212	2	1	10	0.125	0.835	<0.010	0.078	0.307	2.456	<0.010	0.82	1.26	6.96	<0.010	<0.100	<0.100	0.391	<0.010	0.063
Ustd	USTDLM212	2	1	11	<0.010	0.876	<0.010	0.16	<0.010	2.362	<0.010	0.66	2.07	8.75	<0.010	<0.100	<0.100	0.533	<0.010	<0.010
NEPH2-40	B06LM21	2	1	12	0.049	0.591	0.057	0.067	0.031	0.708	0.029	0.288	1.59	11.6	0.076	0.143	<0.100	<0.010	0.044	0.086
NEPH2-38	B11LM21	2	1	13	0.057	0.596	0.054	0.08	0.033	0.73	0.027	0.299	1.68	11.9	0.08	0.152	<0.100	<0.010	0.042	0.089
NEPH2-34	B01LM11	2	1	14	0.05	0.572	0.053	0.071	0.04	0.706	0.029	0.278	1.59	12.2	0.073	0.151	<0.100	<0.010	0.042	0.079
NEPH2-35	B09LM11	2	1	15	0.053	0.611	0.061	0.068	0.034	0.684	0.032	0.307	1.7	12.2	0.083	0.156	<0.100	<0.010	0.045	0.087
NEPH2-31	B08LM11	2	1	16	0.051	0.572	0.057	0.065	0.037	0.659	0.028	0.282	1.58	12.2	0.074	0.144	<0.100	<0.010	0.043	0.084
NEPH2-37	B05LM11	2	1	17	0.05	0.575	0.059	0.071	0.031	0.662	0.028	0.288	1.61	11.5	0.071	0.139	<0.100	<0.010	0.043	0.085
NEPH2-29	B07LM11	2	1	18	0.055	0.638	0.068	0.076	0.034	0.708	0.036	0.322	1.74	13.3	0.084	0.167	<0.100	<0.010	0.049	0.094
Ustd	USTDLM213	2	1	19	<0.010	0.86	<0.010	0.16	<0.010	2.358	<0.010	0.664	2.03	8.76	<0.010	<0.100	<0.100	0.533	<0.010	<0.010
Batch 1	BCHLM213	2	1	20	0.125	0.826	<0.010	0.079	0.308	2.463	<0.010	0.828	1.26	7.16	<0.010	<0.100	<0.100	0.393	<0.010	0.063
Batch 1	BCHLM221	2	2	1	0.121	0.824	<0.010	0.077	0.304	2.44	<0.010	0.806	1.41	7	<0.010	<0.100	<0.100	0.385	<0.010	0.061
Ustd	USTDLM221	2	2	2	<0.010	0.881	<0.010	0.158	<0.010	2.372	<0.010	0.655	2.21	8.69	<0.010	<0.100	<0.100	0.526	<0.010	<0.010
NEPH2-38	B11LM22	2	2	3	0.055	0.591	0.053	0.078	0.033	0.721	0.027	0.291	1.82	11.8	0.078	0.147	<0.100	<0.010	0.041	0.086
NEPH2-38	B11LM12	2	2	4	0.056	0.591	0.054	0.081	0.036	0.688	0.027	0.296	1.88	12.2	0.08	0.147	<0.100	<0.010	0.042	0.088
NEPH2-34	B01LM22	2	2	5	0.049	0.566	0.051	0.07	0.033	0.674	0.029	0.276	1.76	12.1	0.072	0.144	<0.100	<0.010	0.042	0.078
NEPH2-40	B06LM22	2	2	6	0.047	0.588	0.056	0.065	0.031	0.7	0.029	0.281	1.71	11.6	0.072	0.145	<0.100	<0.010	0.043	0.084
NEPH2-35	B09LM22	2	2	7	0.05	0.607	0.058	0.066	0.035	0.726	0.031	0.293	1.79	12.3	0.079	0.148	<0.100	<0.010	0.045	0.082
NEPH2-31	B08LM12	2	2	8	0.05	0.572	0.055	0.064	0.037	0.653	0.027	0.277	1.66	12.2	0.073	0.138	<0.100	<0.010	0.041	0.082
NEPH2-35	B09LM12	2	2	9	0.051	0.606	0.059	0.066	0.034	0.68	0.031	0.3	1.78	12.1	0.082	0.157	<0.100	<0.010	0.044	0.085
Batch 1	BCHLM222	2	2	10	0.12	0.823	<0.010	0.076	0.305	2.447	<0.010	0.799	1.31	6.98	<0.010	<0.100	<0.100	0.38	<0.010	0.062
Ustd	USTDLM222	2	2	11	<0.010	0.878	<0.010	0.156	<0.010	2.361	<0.010	0.643	2.2	8.69	<0.010	<0.100	<0.100	0.522	<0.010	<0.010
NEPH2-40	B06LM12	2	2	12	0.047	0.587	0.056	0.066	0.031	0.697	0.029	0.28	1.71	11.3	0.074	0.142	<0.100	<0.010	0.041	0.084
NEPH2-31	B08LM22	2	2	13	0.051	0.57	0.059	0.066	0.035	0.622	0.028	0.28	1.64	11.9	0.076	0.143	<0.100	<0.010	0.04	0.084
NEPH2-37	B05LM12	2	2	14	0.048	0.581	0.058	0.069	0.032	0.668	0.028	0.28	1.65	11.5	0.07	0.143	<0.100	<0.010	0.041	0.082
NEPH2-29	B07LM22	2	2	15	0.051	0.627	0.068	0.072	0.034	0.718	0.034	0.306	1.77	12.8	0.079	0.163	<0.100	<0.010	0.046	0.089
NEPH2-37	B05LM22	2	2	16	0.047	0.568	0.056	0.068	0.031	0.696	0.027	0.274	1.65	11.8	0.067	0.139	<0.100	<0.010	0.04	0.081
NEPH2-29	B07LM12	2	2	17	0.053	0.636	0.067	0.075	0.034	0.71	0.035	0.314	1.83	13.1	0.081	0.16	<0.100	<0.010	0.048	0.091
NEPH2-34	B01LM12	2	2	18	0.048	0.575	0.052	0.068	0.04	0.705	0.028	0.27	1.69	12.1	0.069	0.143	<0.100	<0.010	0.041	0.076
Batch 1	BCHLM223	2	2	19	0.12	0.833	<0.010	0.076	0.307	2.462	<0.010	0.796	1.33	7.09	<0.010	<0.100	<0.100	0.382	<0.010	0.061
Ustd	USTDLM223	2	2	20	<0.010	0.877	<0.010	0.155	<0.010	2.373	<0.010	0.641	2.1	8.71	<0.010	<0.100	<0.100	0.524	<0.010	<0.010

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	K	La	Mg	Mn	Na	Pb	S	Th	Ti	Zn	Zr
Batch 1	BCHLM311	3	1	1	0.123	0.832	<0.010	0.078	0.306	2.486	<0.010	0.807	1.35	7.13	<0.010	<0.100	<0.100	0.383	<0.010	0.061
Ustd	USTDLM311	3	1	2	<0.010	0.878	<0.010	0.158	<0.010	2.375	<0.010	0.65	2.12	8.77	<0.010	<0.100	<0.100	0.524	<0.010	<0.010
NEPH2-13	B23LM21	3	1	3	0.04	0.525	0.045	0.064	0.029	0.528	0.025	0.303	1.4	12.9	0.057	0.137	<0.100	<0.010	0.037	0.06
NEPH2-16	B21LM11	3	1	4	0.045	0.611	0.051	0.066	0.031	0.558	0.028	0.348	1.57	13	0.065	0.148	<0.100	<0.010	0.046	0.073
NEPH2-20	B27LM11	3	1	5	0.048	0.62	0.053	0.073	0.034	0.579	0.03	0.382	1.71	12.9	0.074	0.161	<0.100	<0.010	0.044	0.079
NEPH2-15	B25LM21	3	1	6	0.042	0.549	0.05	0.078	0.03	0.49	0.027	0.329	1.46	12.7	0.064	0.14	<0.100	<0.010	0.039	0.068
NEPH2-16	B21LM21	3	1	7	0.045	0.584	0.05	0.065	0.031	0.572	0.028	0.346	1.59	12.9	0.065	0.144	<0.100	<0.010	0.045	0.071
NEPH2-25	B19LM11	3	1	8	0.048	0.636	0.055	0.073	0.033	0.603	0.037	0.383	1.8	12.5	0.069	0.161	<0.100	<0.010	0.045	0.08
NEPH2-19	B26LM11	3	1	9	0.043	0.596	0.049	0.069	0.032	0.543	0.043	0.361	1.75	13.5	0.07	0.151	<0.100	<0.010	0.045	0.075
Batch 1	BCHLM312	3	1	10	0.12	0.833	<0.010	0.076	0.303	2.45	<0.010	0.791	1.29	6.96	<0.010	<0.100	<0.100	0.378	<0.010	0.052
Ustd	USTDLM312	3	1	11	<0.010	0.892	<0.010	0.159	<0.010	2.405	<0.010	0.652	2.07	8.84	<0.010	<0.100	<0.100	0.531	<0.010	<0.010
NEPH2-13	B23LM11	3	1	12	0.041	0.533	0.047	0.065	0.03	0.504	0.026	0.313	1.44	12.6	0.061	0.139	<0.100	<0.010	0.038	0.062
NEPH2-19	B26LM21	3	1	13	0.042	0.581	0.048	0.067	0.032	0.561	0.042	0.356	1.59	12.8	0.068	0.155	<0.100	<0.010	0.043	0.072
NEPH2-23	B24LM11	3	1	14	0.049	0.655	0.061	0.072	0.035	0.591	0.031	0.402	1.82	13	0.076	0.167	<0.100	<0.010	0.046	0.087
NEPH2-23	B24LM21	3	1	15	0.048	0.653	0.061	0.068	0.035	0.564	0.031	0.392	1.79	13	0.073	0.164	<0.100	<0.010	0.043	0.086
NEPH2-20	B27LM21	3	1	16	0.047	0.621	0.053	0.073	0.033	0.574	0.032	0.375	1.86	13.6	0.073	0.163	<0.100	<0.010	0.043	0.078
NEPH2-15	B25LM11	3	1	17	0.041	0.551	0.05	0.077	0.031	0.488	0.077	0.324	1.52	12.6	0.062	0.147	<0.100	<0.010	0.042	0.068
NEPH2-25	B19LM21	3	1	18	0.049	0.64	0.055	0.073	0.033	0.566	0.035	0.385	1.73	12	0.07	0.165	<0.100	<0.010	0.046	0.079
Batch 1	BCHLM313	3	1	19	0.122	0.83	<0.010	0.078	0.305	2.465	<0.010	0.803	1.38	7.1	<0.010	<0.100	<0.100	0.384	<0.010	0.061
Ustd	USTDLM313	3	1	20	<0.010	0.875	<0.010	0.158	<0.010	2.386	<0.010	0.653	2.19	8.95	<0.010	<0.100	<0.100	0.526	<0.010	<0.010
Batch 1	BCHLM321	3	2	1	0.121	0.822	<0.010	0.077	0.303	2.455	<0.010	0.81	1.33	7.06	<0.010	<0.100	<0.100	0.382	<0.010	0.062
Ustd	USTDLM321	3	2	2	<0.010	0.855	<0.010	0.158	<0.010	2.34	<0.010	0.654	2.14	8.81	<0.010	<0.100	<0.100	0.524	<0.010	<0.010
NEPH2-13	B23LM12	3	2	3	0.039	0.519	0.046	0.063	0.029	0.491	0.025	0.313	1.41	12.7	0.058	0.135	<0.100	<0.010	0.035	0.063
NEPH2-25	B19LM12	3	2	4	0.047	0.621	0.054	0.072	0.033	0.595	0.037	0.387	1.75	12.4	0.068	0.16	<0.100	<0.010	0.044	0.081
NEPH2-16	B21LM12	3	2	5	0.044	0.605	0.051	0.065	0.031	0.557	0.028	0.353	1.62	13.2	0.064	0.147	<0.100	<0.010	0.045	0.074
NEPH2-13	B23LM22	3	2	6	0.038	0.523	0.045	0.062	0.029	0.526	0.025	0.304	1.43	13.1	0.056	0.132	<0.100	<0.010	0.035	0.061
NEPH2-20	B27LM22	3	2	7	0.045	0.618	0.052	0.071	0.033	0.57	0.032	0.379	1.85	13.5	0.071	0.156	<0.100	<0.010	0.04	0.079
NEPH2-16	B21LM22	3	2	8	0.044	0.597	0.052	0.065	0.031	0.588	0.028	0.355	1.66	13.3	0.063	0.146	<0.100	<0.010	0.042	0.074
NEPH2-19	B26LM12	3	2	9	0.042	0.584	0.049	0.068	0.032	0.54	0.043	0.367	1.72	13.1	0.068	0.149	<0.100	<0.010	0.043	0.077
Batch 1	BCHLM322	3	2	10	0.121	0.816	<0.010	0.077	0.302	2.438	<0.010	0.813	1.29	6.97	<0.010	<0.100	<0.100	0.385	<0.010	0.062
Ustd	USTDLM322	3	2	11	<0.010	0.868	<0.010	0.157	<0.010	2.338	<0.010	0.655	2.14	8.89	<0.010	<0.100	<0.100	0.528	<0.010	<0.010
NEPH2-20	B27LM12	3	2	12	0.046	0.618	0.053	0.072	0.034	0.568	0.03	0.383	1.79	13.1	0.072	0.158	<0.100	<0.010	0.041	0.08
NEPH2-23	B24LM12	3	2	13	0.047	0.64	0.061	0.07	0.035	0.581	0.031	0.404	1.87	13.1	0.074	0.165	<0.100	<0.010	0.043	0.09
NEPH2-15	B25LM22	3	2	14	0.039	0.535	0.049	0.076	0.031	0.479	0.026	0.33	1.54	12.8	0.06	0.134	<0.100	<0.010	0.037	0.068
NEPH2-15	B25LM12	3	2	15	0.04	0.547	0.05	0.077	0.032	0.482	0.078	0.332	1.53	12.6	0.061	0.142	<0.100	<0.010	0.041	0.069
NEPH2-23	B24LM22	3	2	16	0.047	0.639	0.061	0.067	0.035	0.554	0.031	0.397	1.82	13.1	0.073	0.169	<0.100	<0.010	0.042	0.087
NEPH2-19	B26LM22	3	2	17	0.04	0.578	0.048	0.066	0.033	0.552	0.042	0.358	1.66	12.8	0.067	0.144	<0.100	<0.010	0.041	0.074
NEPH2-25	B19LM22	3	2	18	0.047	0.633	0.055	0.072	0.033	0.56	0.035	0.391	1.73	12.3	0.068	0.159	<0.100	<0.010	0.045	0.081
Batch 1	BCHLM323	3	2	19	0.123	0.83	<0.010	0.077	0.305	2.458	<0.010	0.817	1.25	6.68	<0.010	<0.100	<0.100	0.391	<0.010	0.063
Ustd	USTDLM323	3	2	20	<0.010	0.869	<0.010	0.159	<0.010	2.356	<0.010	0.661	2.17	8.93	<0.010	<0.100	<0.100	0.533	<0.010	<0.010

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	K	La	Mg	Mn	Na	Pb	S	Th	Ti	Zn	Zr
Batch 1	BCHLM411	4	1	1	0.122	0.833	<0.010	0.076	0.306	2.49	<0.010	0.809	1.28	6.5	<0.010	<0.100	<0.100	0.385	<0.010	0.048
Ustd	USTDLM411	4	1	2	<0.010	0.869	<0.010	0.157	<0.010	2.35	<0.010	0.651	2.13	8.67	<0.010	<0.100	<0.100	0.527	<0.010	<0.010
NEPH2-33	B15LM11	4	1	3	0.044	0.533	0.047	0.067	0.03	0.582	0.03	0.261	1.5	10.7	0.067	0.133	<0.100	<0.010	0.04	0.074
NEPH2-27	B18LM11	4	1	4	0.045	0.561	0.042	0.063	0.03	0.64	0.028	0.272	1.6	12.1	0.057	0.145	<0.100	<0.010	0.039	0.076
NEPH2-39	B16LM11	4	1	5	0.047	0.55	0.053	0.06	0.03	0.618	0.03	0.273	1.56	10.5	0.073	0.133	<0.100	<0.010	0.039	0.078
NEPH2-28	B20LM11	4	1	6	0.041	0.52	0.048	0.07	0.029	0.594	0.026	0.245	1.41	11.7	0.074	0.133	<0.100	<0.010	0.038	0.072
NEPH2-39	B16LM21	4	1	7	0.048	0.557	0.053	0.059	0.031	0.604	0.031	0.277	1.59	10.8	0.073	0.136	<0.100	<0.010	0.041	0.08
NEPH2-30	B14LM21	4	1	8	0.043	0.532	0.049	0.066	0.03	0.574	0.03	0.255	1.47	11.8	0.069	0.132	<0.100	<0.010	0.038	0.075
NEPH2-36	B22LM21	4	1	9	0.048	0.532	0.048	0.067	0.032	0.617	0.027	0.259	1.52	11.1	0.065	0.133	<0.100	<0.010	0.038	0.077
Batch 1	BCHLM412	4	1	10	0.122	0.837	<0.010	0.077	0.308	2.5	<0.010	0.808	1.29	6.95	<0.010	<0.100	<0.100	0.386	<0.010	0.048
Ustd	USTDLM412	4	1	11	<0.010	0.881	<0.010	0.157	<0.010	2.39	<0.010	0.648	2.11	8.6	<0.010	<0.100	<0.100	0.535	<0.010	<0.010
NEPH2-32	B28LM11	4	1	12	0.051	0.611	0.054	0.071	0.033	0.753	0.029	0.291	1.75	12.5	0.07	0.16	<0.100	<0.010	0.044	0.084
NEPH2-33	B15LM21	4	1	13	0.041	0.531	0.045	0.063	0.029	0.658	0.029	0.246	1.53	11.7	0.062	0.136	<0.100	<0.010	0.036	0.071
NEPH2-28	B20LM21	4	1	14	0.042	0.535	0.052	0.072	0.03	0.563	0.027	0.255	1.4	11.8	0.078	0.133	<0.100	<0.010	0.039	0.076
NEPH2-32	B28LM21	4	1	15	0.05	0.613	0.054	0.069	0.033	0.762	0.029	0.289	1.62	12.2	0.069	0.158	<0.100	<0.010	0.044	0.085
NEPH2-30	B14LM11	4	1	16	0.041	0.532	0.048	0.063	0.03	0.639	0.029	0.244	1.43	11.7	0.064	0.147	<0.100	<0.010	0.226	0.073
NEPH2-27	B18LM21	4	1	17	0.045	0.565	0.044	0.065	0.032	0.651	0.028	0.278	1.5	11.7	0.059	0.154	<0.100	<0.010	0.041	0.079
NEPH2-36	B22LM11	4	1	18	0.047	0.544	0.049	0.068	0.031	0.644	0.027	0.256	1.54	11.5	0.064	0.138	<0.100	<0.010	0.038	0.077
Batch 1	BCHLM413	4	1	19	0.12	0.84	<0.010	0.075	0.306	2.5	<0.010	0.798	1.31	7	<0.010	<0.100	<0.100	0.384	<0.010	0.041
Ustd	USTDLM413	4	1	20	<0.010	0.88	<0.010	0.155	<0.010	2.38	<0.010	0.642	2.11	8.71	<0.010	<0.100	<0.100	0.526	<0.010	<0.010
Batch 1	BCHLM421	4	2	1	0.121	0.836	<0.010	0.076	0.305	2.47	<0.010	0.806	1.24	6.83	<0.010	<0.100	<0.100	0.386	<0.010	0.055
Ustd	USTDLM421	4	2	2	<0.010	0.885	<0.010	0.168	<0.010	2.11	<0.010	0.699	2.06	8.76	<0.010	<0.100	<0.100	0.569	<0.010	<0.010
NEPH2-28	B20LM22	4	2	3	0.042	0.525	0.05	0.073	0.03	0.552	0.026	0.256	1.38	11.9	0.077	0.127	<0.100	<0.010	0.039	0.077
NEPH2-39	B16LM12	4	2	4	0.048	0.551	0.053	0.06	0.03	0.624	0.029	0.275	1.45	10.6	0.073	0.13	<0.100	<0.010	0.039	0.081
NEPH2-30	B14LM12	4	2	5	0.041	0.524	0.047	0.064	0.029	0.624	0.028	0.245	1.44	11.8	0.064	0.133	<0.100	<0.010	0.036	0.076
NEPH2-33	B15LM12	4	2	6	0.044	0.536	0.046	0.066	0.03	0.586	0.029	0.262	1.44	10.9	0.067	0.13	<0.100	<0.010	0.039	0.077
NEPH2-36	B22LM12	4	2	7	0.047	0.545	0.049	0.068	0.031	0.643	0.026	0.257	1.51	11.6	0.064	0.135	<0.100	<0.010	0.038	0.079
NEPH2-30	B14LM22	4	2	8	0.043	0.527	0.049	0.065	0.03	0.581	0.029	0.255	1.45	11.9	0.069	0.127	<0.100	<0.010	0.037	0.078
NEPH2-39	B16LM22	4	2	9	0.048	0.559	0.053	0.059	0.032	0.608	0.03	0.277	1.52	11	0.074	0.133	<0.100	<0.010	0.042	0.082
Batch 1	BCHLM422	4	2	10	0.121	0.831	<0.010	0.077	0.307	2.5	<0.010	0.808	1.26	7.01	<0.010	<0.100	<0.100	0.385	<0.010	0.063
Ustd	USTDLM422	4	2	11	<0.010	0.875	<0.010	0.156	<0.010	2.39	<0.010	0.649	1.97	8.91	<0.010	<0.100	<0.100	0.524	<0.010	<0.010
NEPH2-27	B18LM12	4	2	12	0.044	0.558	0.041	0.063	0.029	0.648	0.026	0.271	1.54	12.2	0.057	0.138	<0.100	<0.010	0.037	0.078
NEPH2-27	B18LM22	4	2	13	0.045	0.562	0.043	0.065	0.031	0.647	0.027	0.279	1.55	11.6	0.058	0.141	<0.100	<0.010	0.039	0.08
NEPH2-28	B20LM12	4	2	14	0.04	0.529	0.048	0.07	0.029	0.6	0.025	0.244	1.38	11.9	0.074	0.127	<0.100	<0.010	0.038	0.075
NEPH2-33	B15LM22	4	2	15	0.041	0.53	0.044	0.063	0.029	0.655	0.028	0.245	1.49	11.8	0.061	0.132	<0.100	<0.010	0.036	0.075
NEPH2-32	B28LM12	4	2	16	0.05	0.612	0.053	0.07	0.032	0.75	0.028	0.289	1.72	12.5	0.068	0.152	<0.100	<0.010	0.043	0.087
NEPH2-32	B28LM22	4	2	17	0.049	0.612	0.053	0.068	0.033	0.748	0.027	0.286	1.64	12.3	0.067	0.159	<0.100	<0.010	0.042	0.087
NEPH2-36	B22LM22	4	2	18	0.048	0.539	0.048	0.066	0.032	0.624	0.026	0.257	1.52	11.2	0.064	0.131	<0.100	<0.010	0.037	0.08
Ustd	USTDLM423	4	2	19	<0.010	0.875	<0.010	0.166	<0.010	2.11	<0.010	0.694	2.11	8.75	<0.010	<0.100	<0.100	0.559	<0.010	<0.010
Batch 1	BCHLM423	4	2	20	0.119	0.845	<0.010	0.076	0.3	2.46	<0.010	0.79	1.24	6.63	<0.010	<0.100	<0.100	0.379	<0.010	0.062

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

Glass ID	PSAL ID	Block	Sub-Block	Analytical Sequence	Al	B	Fe	Li	Ni	Si	U
Batch 1	BCHPF111	1	1	1	2.56	2.49	8.73	2.01	0.545	23.1	<0.100
Ustd	USTDPF111	1	1	2	2.12	2.80	8.64	1.37	0.750	20.4	1.93
NEPH2-17	B12PF11	1	1	3	6.38	1.40	6.58	2.00	0.946	19.4	2.66
NEPH2-14	B13PF21	1	1	4	5.51	1.35	5.87	1.95	0.844	19.7	2.32
NEPH2-18	B04PF21	1	1	5	5.62	1.45	6.17	2.07	0.899	20.6	2.26
NEPH2-22	B10PF11	1	1	6	6.34	1.31	6.63	1.91	0.942	19.7	2.66
NEPH2-24	B17PF21	1	1	7	5.93	1.34	6.08	2.01	0.884	20.5	2.38
NEPH2-18	B04PF11	1	1	8	5.66	1.44	6.16	2.08	0.887	20.7	2.29
NEPH2-21	B02PF21	1	1	9	5.21	1.24	5.49	1.82	0.789	20.2	2.19
Batch 1	BCHPF112	1	1	10	2.60	2.37	8.69	2.02	0.552	23.4	<0.100
Ustd	USTDPF112	1	1	11	2.14	2.75	8.68	1.37	0.761	20.6	1.88
NEPH2-26	B03PF21	1	1	12	7.06	1.31	7.20	1.74	1.08	17.8	2.91
NEPH2-26	B03PF11	1	1	13	7.03	1.20	7.11	1.73	1.03	17.6	2.88
NEPH2-21	B02PF11	1	1	14	5.58	1.35	5.86	1.96	0.882	20.1	2.36
NEPH2-24	B17PF11	1	1	15	5.95	1.36	6.14	2.00	0.898	20.0	2.38
NEPH2-14	B13PF11	1	1	16	5.97	1.43	6.30	2.10	0.910	20.0	2.46
NEPH2-22	B10PF21	1	1	17	6.57	1.34	6.76	1.96	0.983	19.7	2.72
NEPH2-17	B12PF21	1	1	18	6.32	1.32	6.37	1.97	0.920	19.0	2.61
Ustd	USTDPF113	1	1	19	2.16	2.72	8.53	1.38	0.762	20.4	1.90
Batch 1	BCHPF113	1	1	20	2.63	2.39	8.52	2.04	0.552	23.3	<0.100
Batch 1	BCHPF121	1	2	1	2.58	2.45	8.55	2.02	0.568	23.2	<0.100
Ustd	USTDPF121	1	2	2	2.13	2.75	8.71	1.38	0.786	20.5	1.94
NEPH2-26	B03PF12	1	2	3	7.20	1.09	7.46	1.81	1.11	18.1	2.94
NEPH2-24	B17PF22	1	2	4	6.08	1.30	6.36	2.07	0.943	20.6	2.47
NEPH2-17	B12PF12	1	2	5	6.53	1.30	6.82	2.06	0.999	19.8	2.72
NEPH2-14	B13PF12	1	2	6	6.05	1.37	6.55	2.14	0.958	20.5	2.52
NEPH2-21	B02PF22	1	2	7	5.33	1.21	5.87	1.88	0.874	20.8	2.24
NEPH2-21	B02PF12	1	2	8	5.68	1.30	6.23	2.02	0.941	20.5	2.45
NEPH2-26	B03PF22	1	2	9	7.18	1.13	7.52	1.78	1.13	18.2	2.98
Batch 1	BCHPF122	1	2	10	2.62	2.33	8.93	2.06	0.584	23.7	<0.100
Ustd	USTDPF122	1	2	11	2.16	2.75	9.27	1.41	0.811	21.1	1.96
NEPH2-24	B17PF12	1	2	12	6.07	1.42	6.41	2.06	0.962	20.7	2.45
NEPH2-18	B04PF12	1	2	13	5.79	1.43	6.55	2.14	0.947	21.2	2.36
NEPH2-22	B10PF22	1	2	14	6.67	1.29	7.08	2.01	1.01	20.3	2.77
NEPH2-14	B13PF22	1	2	15	5.64	1.26	5.84	1.98	0.860	19.7	2.35
NEPH2-18	B04PF22	1	2	16	5.75	1.38	6.27	2.11	0.921	20.9	2.36
NEPH2-17	B12PF22	1	2	17	6.38	1.27	6.71	2.00	0.982	19.6	2.70
NEPH2-22	B10PF12	1	2	18	6.45	1.24	6.81	1.93	0.996	19.7	2.71
Ustd	USTDPF123	1	2	19	2.14	2.65	8.85	1.38	0.798	20.6	1.98
Batch 1	BCHPF123	1	2	20	2.62	2.38	9.06	2.06	0.595	23.8	<0.100
Batch 1	BHCPF211	2	1	1	2.58	2.50	8.70	2.03	0.542	23.2	<0.100
Ustd	USTDPF211	2	1	2	2.13	2.74	8.65	1.37	0.745	20.4	1.90
NEPH2-37	B05PF21	2	1	3	7.25	1.34	6.32	2.00	1.11	20.0	2.62
NEPH2-40	B06PF21	2	1	4	7.37	1.27	6.29	1.95	1.08	19.7	2.67
NEPH2-29	B07PF11	2	1	5	7.80	1.17	6.74	1.84	1.14	17.6	2.79
NEPH2-38	B11PF11	2	1	6	7.51	1.21	6.61	1.91	1.15	19.1	2.69
NEPH2-37	B05PF11	2	1	7	6.81	1.17	5.92	1.87	1.06	19.4	2.47
NEPH2-31	B08PF11	2	1	8	7.11	1.26	5.93	2.03	1.01	19.4	2.47
NEPH2-34	B01PF11	2	1	9	7.18	1.24	6.17	1.98	1.11	19.6	2.57
Batch 1	BCHPF212	2	1	10	2.60	2.27	8.61	2.03	0.543	23.2	<0.100
Ustd	USTDPF212	2	1	11	2.12	2.68	8.83	1.37	0.766	20.5	1.92
NEPH2-31	B08PF21	2	1	12	7.04	1.36	5.90	2.01	1.02	19.2	2.56
NEPH2-38	B11PF21	2	1	13	7.56	1.25	6.94	1.91	1.20	19.7	2.76
NEPH2-29	B07PF21	2	1	14	7.53	1.15	6.57	1.82	1.12	17.5	2.76
NEPH2-35	B09PF11	2	1	15	7.56	1.14	6.35	1.85	1.09	18.0	2.70
NEPH2-40	B06PF11	2	1	16	7.24	1.20	6.00	1.90	1.06	19.7	2.60
NEPH2-34	B01PF21	2	1	17	7.25	1.24	6.11	2.00	1.10	19.5	2.58
NEPH2-35	B09PF21	2	1	18	7.67	1.16	6.65	1.88	1.15	18.5	2.74
Ustd	USTDPF213	2	1	19	2.16	2.64	8.62	1.39	0.747	20.4	1.94

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

Glass ID	PSAL ID	Block	Sub-Block	Analytical Sequence	Al	B	Fe	Li	Ni	Si	U
Batch 1	BCHPF213	2	1	20	2.62	2.33	8.78	2.05	0.544	23.5	<0.100
Batch 1	BCHPF221	2	2	1	2.57	2.53	8.84	2.04	0.590	23.4	<0.100
Ustd	USTDPF221	2	2	2	2.13	2.79	8.77	1.39	0.800	20.6	1.92
NEPH2-35	B09PF22	2	2	3	7.60	1.17	6.66	1.89	1.17	18.4	2.67
NEPH2-31	B08PF12	2	2	4	7.09	1.29	6.05	2.05	1.07	19.6	2.48
NEPH2-29	B07PF22	2	2	5	7.56	1.17	6.61	1.84	1.17	17.7	2.80
NEPH2-29	B07PF12	2	2	6	7.85	1.17	6.75	1.85	1.17	17.7	2.81
NEPH2-38	B11PF22	2	2	7	7.81	1.29	7.39	2.00	1.32	19.9	2.88
NEPH2-35	B09PF12	2	2	8	7.58	1.18	6.65	1.87	1.18	18.4	2.74
NEPH2-40	B06PF22	2	2	9	7.32	1.25	6.32	1.94	1.12	19.7	2.66
Batch 1	BCHPF222	2	2	10	2.58	2.29	8.65	2.03	0.582	23.3	<0.100
Ustd	USTDPF222	2	2	11	2.12	2.67	8.71	1.38	0.787	20.5	1.97
NEPH2-31	B08PF22	2	2	12	6.98	1.40	6.20	2.02	1.09	19.5	2.54
NEPH2-34	B01PF22	2	2	13	7.33	1.31	6.23	2.03	1.13	19.8	2.64
NEPH2-37	B05PF12	2	2	14	6.84	1.23	6.07	1.88	1.10	19.6	2.47
NEPH2-34	B01PF12	2	2	15	7.22	1.29	6.38	2.01	1.17	19.8	2.64
NEPH2-40	B06PF12	2	2	16	7.30	1.24	6.31	1.94	1.11	19.8	2.63
NEPH2-37	B05PF22	2	2	17	7.20	1.27	6.35	1.99	1.13	20.0	2.61
NEPH2-38	B11PF12	2	2	18	7.63	1.23	6.72	1.95	1.19	19.3	2.77
Ustd	USTDPF223	2	2	19	2.15	2.66	8.87	1.39	0.810	20.7	1.96
Batch 1	BCHPF223	2	2	20	2.58	2.31	8.91	2.04	0.581	23.4	<0.100
Batch 1	BCHPF311	3	1	1	2.60	2.54	8.97	2.06	0.610	23.6	<0.100
Ustd	USTDPF311	3	1	2	2.14	2.75	8.78	1.40	0.817	20.5	1.93
NEPH2-23	B24PF11	3	1	3	6.69	1.25	7.30	1.83	1.09	18.4	2.89
NEPH2-19	B26PF11	3	1	4	6.05	1.30	6.54	2.00	0.984	20.3	2.58
NEPH2-20	B27PF21	3	1	5	6.44	1.23	6.94	1.89	1.05	19.8	2.76
NEPH2-16	B21PF11	3	1	6	6.11	1.32	6.29	2.08	0.946	19.1	2.46
NEPH2-15	B25PF11	3	1	7	5.12	1.27	5.98	1.97	0.915	20.2	2.22
NEPH2-15	B25PF21	3	1	8	5.69	1.39	5.98	2.18	0.905	20.8	2.37
NEPH2-25	B19PF21	3	1	9	6.53	1.23	6.96	1.91	1.06	19.3	2.71
Batch 1	BCHPF312	3	1	10	2.61	2.31	8.91	2.06	0.611	23.6	<0.100
Ustd	USTDPF312	3	1	11	2.16	2.69	8.95	1.40	0.815	20.7	1.98
NEPH2-23	B24PF21	3	1	12	6.55	1.24	6.91	1.78	1.04	18.4	2.81
NEPH2-13	B23PF21	3	1	13	5.57	1.47	5.81	2.24	0.896	20.9	2.37
NEPH2-13	B23PF11	3	1	14	5.05	1.35	5.58	2.05	0.857	20.1	2.17
NEPH2-20	B27PF11	3	1	15	6.65	1.25	7.13	1.95	1.08	19.0	2.78
NEPH2-16	B21PF21	3	1	16	6.03	1.34	6.62	2.09	0.993	20.1	2.53
NEPH2-25	B19PF11	3	1	17	6.57	1.22	7.00	1.92	1.04	19.3	2.76
NEPH2-19	B26PF21	3	1	18	6.18	1.29	6.50	2.03	0.983	19.8	2.61
Ustd	USTDPF313	3	1	19	2.16	2.68	8.98	1.41	0.817	20.6	1.96
Batch 1	BCHPF313	3	1	20	2.60	2.29	8.64	2.05	0.598	23.2	<0.100
Batch 1	BCHPF321	3	2	1	2.49	2.49	8.43	1.95	0.513	22.5	<0.100
Ustd	USTDPF321	3	2	2	2.12	2.84	8.91	1.36	0.762	20.7	1.94
NEPH2-25	B19PF22	3	2	3	6.53	1.35	6.88	1.88	0.977	19.3	2.70
NEPH2-15	B25PF12	3	2	4	5.60	1.50	6.64	2.14	0.967	20.8	2.36
NEPH2-13	B23PF22	3	2	5	5.48	1.54	6.07	2.19	0.862	21.3	2.32
NEPH2-19	B26PF22	3	2	6	6.23	1.37	6.43	2.01	0.913	19.9	2.58
NEPH2-25	B19PF12	3	2	7	6.60	1.30	6.99	1.89	0.982	19.3	2.72
NEPH2-23	B24PF12	3	2	8	6.65	1.22	7.06	1.77	0.998	18.1	2.79
NEPH2-13	B23PF12	3	2	9	5.40	1.45	5.62	2.14	0.803	20.5	2.21
Batch 1	BCHPF322	3	2	10	2.57	2.34	8.70	2.01	0.517	23.1	<0.100
Ustd	USTDPF322	3	2	11	2.13	2.77	8.93	1.36	0.762	20.7	1.94
NEPH2-19	B26PF12	3	2	12	6.40	1.68	6.87	2.07	0.966	20.5	2.70
NEPH2-20	B27PF12	3	2	13	6.56	1.38	7.00	1.90	1.00	19.3	2.71
NEPH2-16	B21PF22	3	2	14	5.96	1.39	6.12	2.02	0.863	19.4	2.44
NEPH2-15	B25PF22	3	2	15	5.65	1.44	5.64	2.13	0.820	21.0	2.29
NEPH2-23	B24PF22	3	2	16	6.71	1.23	7.06	1.78	1.02	18.9	2.83
NEPH2-20	B27PF22	3	2	17	6.46	1.30	7.08	1.86	1.02	19.8	2.71
NEPH2-16	B21PF12	3	2	18	6.08	1.40	6.52	2.05	0.915	19.2	2.47

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

Glass ID	PSAL ID	Block	Sub-Block	Analytical Sequence	Al	B	Fe	Li	Ni	Si	U
Ustd	USTDPF323	3	2	19	2.06	2.67	8.75	1.32	0.755	20.0	1.92
Batch 1	BCHPF323	3	2	20	2.52	2.37	8.97	1.98	0.534	23.1	<0.100
Batch 1	BCHPF411	4	1	1	2.56	2.45	8.49	2.02	0.552	23.0	<0.100
Ustd	USTDPF411	4	1	2	2.09	2.68	8.41	1.36	0.763	20.2	1.95
NEPH2-33	B16PF11	4	1	3	6.84	1.35	5.83	2.03	1.01	20.4	2.41
NEPH2-36	B22PF11	4	1	4	6.32	1.29	5.70	1.98	0.996	20.4	2.21
NEPH2-28	B20PF21	4	1	5	6.06	1.39	6.09	1.98	1.08	18.9	2.42
NEPH2-32	B28PF21	4	1	6	6.87	1.13	6.40	1.72	1.10	17.5	2.52
NEPH2-30	B14PF11	4	1	7	6.34	1.39	5.59	2.16	0.991	20.8	2.26
NEPH2-36	B22PF21	4	1	8	6.83	1.34	5.78	2.12	1.02	20.9	2.31
NEPH2-39	B16PF21	4	1	9	6.71	1.34	5.41	2.17	0.982	20.8	2.26
Batch 1	BCHPF412	4	1	10	2.52	2.20	8.49	1.98	0.542	22.5	<0.100
Ustd	USTDPF412	4	1	11	2.11	2.60	8.35	1.37	0.760	20.2	1.87
NEPH2-33	B15PF11	4	1	12	6.47	1.41	5.47	2.11	0.992	20.5	2.28
NEPH2-30	B14PF21	4	1	13	6.32	1.42	5.66	2.15	1.02	20.8	2.32
NEPH2-27	B18PF21	4	1	14	6.95	1.28	5.36	2.18	0.943	20.8	2.10
NEPH2-27	B18PF11	4	1	15	6.92	1.26	5.33	2.17	0.937	20.6	2.16
NEPH2-32	B28PF11	4	1	16	7.37	1.14	6.16	1.83	1.06	17.5	2.67
NEPH2-39	B16PF21	4	1	17	6.85	1.30	5.90	2.04	1.02	20.7	2.45
NEPH2-28	B20PF11	4	1	18	6.32	1.40	6.10	2.05	1.07	19.5	2.51
Ustd	USTDPF413	4	1	19	2.08	2.58	8.34	1.36	0.763	20.2	1.84
Batch 1	BCHPF413	4	1	20	2.55	2.24	8.50	2.01	0.567	23.1	<0.100
Batch 1	BCHPF421	4	2	1	2.57	2.49	8.97	2.05	0.591	23.7	<0.100
Ustd	USTDPF421	4	2	2	2.11	2.78	9.03	1.38	0.818	20.9	1.92
NEPH2-27	B18PF12	4	2	3	7.05	1.26	5.69	2.24	0.982	21.2	2.20
NEPH2-33	B15PF12	4	2	4	6.59	1.35	5.79	2.14	1.04	21.0	2.31
NEPH2-27	B18PF22	4	2	5	6.95	1.24	5.24	2.16	0.930	20.5	2.20
NEPH2-30	B14PF12	4	2	6	6.38	1.35	5.49	2.13	0.988	20.7	2.35
NEPH2-32	B28PF22	4	2	7	6.94	1.09	6.38	1.70	1.11	17.5	2.63
NEPH2-30	B14PF22	4	2	8	6.37	1.38	5.86	2.15	1.05	21.2	2.40
NEPH2-36	B22PF12	4	2	9	6.39	1.24	5.65	1.98	0.991	20.7	2.27
Batch 1	BCHPF422	4	2	10	2.55	2.32	9.16	2.04	0.609	23.8	<0.100
Ustd	USTDPF422	4	2	11	2.13	2.74	9.42	1.40	0.844	21.2	1.96
NEPH2-39	B16PF12	4	2	12	7.00	1.42	6.22	2.07	1.07	21.1	2.48
NEPH2-32	B28PF12	4	2	13	7.64	1.24	7.03	1.89	1.21	18.6	2.77
NEPH2-36	B22PF22	4	2	14	6.88	1.35	6.13	2.13	1.07	21.2	2.35
NEPH2-28	B20PF22	4	2	15	6.16	1.37	6.16	1.99	1.07	19.1	2.51
NEPH2-28	B20PF12	4	2	16	6.38	1.41	6.22	2.05	1.11	19.6	2.61
NEPH2-33	B15PF22	4	2	17	6.65	1.33	5.65	2.14	1.03	20.8	2.29
NEPH2-39	B16PF22	4	2	18	6.99	1.32	6.19	2.06	1.07	21.1	2.54
Ustd	USTDPF423	4	2	19	2.09	2.66	8.91	1.37	0.815	20.8	1.93
Batch 1	BCHPF422	4	2	20	2.55	2.33	9.03	2.03	0.608	23.9	<0.100
Batch 1	BCHPF111	1	1	1	2.56	2.49	8.73	2.01	0.545	23.1	<0.100
Ustd	USTDPF111	1	1	2	2.12	2.80	8.64	1.37	0.750	20.4	1.93
NEPH2-17	B12PF11	1	1	3	6.38	1.40	6.58	2.00	0.946	19.4	2.66
NEPH2-14	B13PF21	1	1	4	5.51	1.35	5.87	1.95	0.844	19.7	2.32
NEPH2-18	B04PF21	1	1	5	5.62	1.45	6.17	2.07	0.899	20.6	2.26
NEPH2-22	B10PF11	1	1	6	6.34	1.31	6.63	1.91	0.942	19.7	2.66
NEPH2-24	B17PF21	1	1	7	5.93	1.34	6.08	2.01	0.884	20.5	2.38
NEPH2-18	B04PF11	1	1	8	5.66	1.44	6.16	2.08	0.887	20.7	2.29
NEPH2-21	B02PF21	1	1	9	5.21	1.24	5.49	1.82	0.789	20.2	2.19
Batch 1	BCHPF112	1	1	10	2.60	2.37	8.69	2.02	0.552	23.4	<0.100
Ustd	USTDPF112	1	1	11	2.14	2.75	8.68	1.37	0.761	20.6	1.88
NEPH2-26	B03PF21	1	1	12	7.06	1.31	7.20	1.74	1.08	17.8	2.91
NEPH2-26	B03PF11	1	1	13	7.03	1.20	7.11	1.73	1.03	17.6	2.88
NEPH2-21	B02PF11	1	1	14	5.58	1.35	5.86	1.96	0.882	20.1	2.36
NEPH2-24	B17PF11	1	1	15	5.95	1.36	6.14	2.00	0.898	20.0	2.38
NEPH2-14	B13PF11	1	1	16	5.97	1.43	6.30	2.10	0.910	20.0	2.46
NEPH2-22	B10PF21	1	1	17	6.57	1.34	6.76	1.96	0.983	19.7	2.72

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

Glass ID	PSAL ID	Block	Sub-Block	Analytical Sequence	Al	B	Fe	Li	Ni	Si	U
NEPH2-17	B12PF21	1	1	18	6.32	1.32	6.37	1.97	0.920	19.0	2.61
Ustd	USTDPF113	1	1	19	2.16	2.72	8.53	1.38	0.762	20.4	1.90
Batch 1	BCHPF113	1	1	20	2.63	2.39	8.52	2.04	0.552	23.3	<0.100
Batch 1	BCHPF121	1	2	1	2.58	2.45	8.55	2.02	0.568	23.2	<0.100
Ustd	USTDPF121	1	2	2	2.13	2.75	8.71	1.38	0.786	20.5	1.94
NEPH2-26	B03PF12	1	2	3	7.20	1.09	7.46	1.81	1.11	18.1	2.94
NEPH2-24	B17PF22	1	2	4	6.08	1.30	6.36	2.07	0.943	20.6	2.47
NEPH2-17	B12PF12	1	2	5	6.53	1.30	6.82	2.06	0.999	19.8	2.72
NEPH2-14	B13PF12	1	2	6	6.05	1.37	6.55	2.14	0.958	20.5	2.52
NEPH2-21	B02PF22	1	2	7	5.33	1.21	5.87	1.88	0.874	20.8	2.24
NEPH2-21	B02PF12	1	2	8	5.68	1.30	6.23	2.02	0.941	20.5	2.45
NEPH2-26	B03PF22	1	2	9	7.18	1.13	7.52	1.78	1.13	18.2	2.98
Batch 1	BCHPF122	1	2	10	2.62	2.33	8.93	2.06	0.584	23.7	<0.100
Ustd	USTDPF122	1	2	11	2.16	2.75	9.27	1.41	0.811	21.1	1.96
NEPH2-24	B17PF12	1	2	12	6.07	1.42	6.41	2.06	0.962	20.7	2.45
NEPH2-18	B04PF12	1	2	13	5.79	1.43	6.55	2.14	0.947	21.2	2.36
NEPH2-22	B10PF22	1	2	14	6.67	1.29	7.08	2.01	1.01	20.3	2.77
NEPH2-14	B13PF22	1	2	15	5.64	1.26	5.84	1.98	0.860	19.7	2.35
NEPH2-18	B04PF22	1	2	16	5.75	1.38	6.27	2.11	0.921	20.9	2.36
NEPH2-17	B12PF22	1	2	17	6.38	1.27	6.71	2.00	0.982	19.6	2.70
NEPH2-22	B10PF12	1	2	18	6.45	1.24	6.81	1.93	0.996	19.7	2.71
Ustd	USTDPF123	1	2	19	2.14	2.65	8.85	1.38	0.798	20.6	1.98
Batch 1	BCHPF123	1	2	20	2.62	2.38	9.06	2.06	0.595	23.8	<0.100
Batch 1	BHCPF211	2	1	1	2.58	2.50	8.70	2.03	0.542	23.2	<0.100
Ustd	USTDPF211	2	1	2	2.13	2.74	8.65	1.37	0.745	20.4	1.90
NEPH2-37	B05PF21	2	1	3	7.25	1.34	6.32	2.00	1.11	20.0	2.62
NEPH2-40	B06PF21	2	1	4	7.37	1.27	6.29	1.95	1.08	19.7	2.67
NEPH2-29	B07PF11	2	1	5	7.80	1.17	6.74	1.84	1.14	17.6	2.79
NEPH2-38	B11PF11	2	1	6	7.51	1.21	6.61	1.91	1.15	19.1	2.69
NEPH2-37	B05PF11	2	1	7	6.81	1.17	5.92	1.87	1.06	19.4	2.47
NEPH2-31	B08PF11	2	1	8	7.11	1.26	5.93	2.03	1.01	19.4	2.47
NEPH2-34	B01PF11	2	1	9	7.18	1.24	6.17	1.98	1.11	19.6	2.57
Batch 1	BCHPF212	2	1	10	2.60	2.27	8.61	2.03	0.543	23.2	<0.100

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

(100 -Batch 1; 200 -U std)

Glass ID	Glass #	Oxide	Measured (wt%)	Measured Bias-Corrected (wt%)	Targeted (wt%)	Diff of Measured	Diff of Meas BC	% Diff of Measured	% Diff of Meas BC
NEPH2-13	13	Al2O3	10.1561	10.2240	10.2100	-0.0539	0.0140	-0.5%	0.1%
NEPH2-13	13	B2O3	4.6769	4.7259	4.8800	-0.2031	-0.1541	-4.2%	-3.2%
NEPH2-13	13	BaO	0.0441	0.0490	0.0530	-0.0089	-0.0040	-16.8%	-7.5%
NEPH2-13	13	CaO	0.7346	0.7743	0.7760	-0.0414	-0.0017	-5.3%	-0.2%
NEPH2-13	13	Ce2O3	0.0536	0.0536	0.0730	-0.0194	-0.0194	-26.6%	-26.6%
NEPH2-13	13	Cr2O3	0.0928	0.0880	0.0910	0.0018	-0.0030	2.0%	-3.2%
NEPH2-13	13	CuO	0.0366	0.0384	0.0280	0.0086	0.0104	30.8%	37.1%
NEPH2-13	13	Fe2O3	8.2494	8.4485	8.6480	-0.3986	-0.1995	-4.6%	-2.3%
NEPH2-13	13	K2O	0.6171	0.6932	0.5450	0.0721	0.1482	13.2%	27.2%
NEPH2-13	13	La2O3	0.0296	0.0296	0.0310	-0.0014	-0.0014	-4.5%	-4.5%
NEPH2-13	13	Li2O	4.6395	4.7310	4.8800	-0.2405	-0.1490	-4.9%	-3.1%
NEPH2-13	13	MgO	0.5112	0.5422	0.5480	-0.0368	-0.0058	-6.7%	-1.1%
NEPH2-13	13	MnO	1.8335	1.8645	1.9010	-0.0675	-0.0365	-3.6%	-1.9%
NEPH2-13	13	Na2O	17.2881	16.5374	17.6950	-0.4069	-1.1576	-2.3%	-6.5%
NEPH2-13	13	NiO	1.0874	1.1424	1.1920	-0.1046	-0.0496	-8.8%	-4.2%
NEPH2-13	13	PbO	0.0625	0.0625	0.0690	-0.0065	-0.0065	-9.5%	-9.5%
NEPH2-13	13	SO4	0.4067	0.4067	0.4170	-0.0103	-0.0103	-2.5%	-2.5%
NEPH2-13	13	SiO2	44.2835	44.8526	44.9640	-0.6805	-0.1114	-1.5%	-0.2%
NEPH2-13	13	ThO2	0.0569	0.0569	0.0150	0.0419	0.0419	279.3%	279.3%
NEPH2-13	13	TiO2	0.0083	0.0088	0.0070	0.0013	0.0018	19.1%	26.0%
NEPH2-13	13	U3O8	2.6738	2.8050	2.8360	-0.1622	-0.0310	-5.7%	-1.1%
NEPH2-13	13	ZnO	0.0451	0.0451	0.0420	0.0031	0.0031	7.4%	7.4%
NEPH2-13	13	ZrO2	0.0831	0.0831	0.1000	-0.0169	-0.0169	-16.9%	-16.9%
NEPH2-13	13	Sum of Oxides	97.6703	98.2627	100.0010	-2.3307	-1.7383	-2.3%	-1.7%
NEPH2-14	14	Al2O3	10.9449	10.8583	10.9950	-0.0501	-0.1367	-0.5%	-1.2%
NEPH2-14	14	B2O3	4.3549	4.3791	4.6400	-0.2851	-0.2609	-6.1%	-5.6%
NEPH2-14	14	BaO	0.0430	0.0478	0.0570	-0.0140	-0.0092	-24.6%	-16.2%
NEPH2-14	14	CaO	0.7846	0.8386	0.8360	-0.0514	0.0026	-6.1%	0.3%
NEPH2-14	14	Ce2O3	0.0577	0.0577	0.0780	-0.0203	-0.0203	-26.0%	-26.0%
NEPH2-14	14	Cr2O3	0.0983	0.0924	0.0980	0.0003	-0.0056	0.3%	-5.7%
NEPH2-14	14	CuO	0.0391	0.0415	0.0310	0.0081	0.0105	26.2%	33.8%
NEPH2-14	14	Fe2O3	8.7784	9.0130	9.3130	-0.5346	-0.3000	-5.7%	-3.2%
NEPH2-14	14	K2O	0.6408	0.7262	0.5870	0.0538	0.1392	9.2%	23.7%
NEPH2-14	14	La2O3	0.0311	0.0311	0.0340	-0.0029	-0.0029	-8.6%	-8.6%
NEPH2-14	14	Li2O	4.3973	4.4453	4.6400	-0.2427	-0.1947	-5.2%	-4.2%
NEPH2-14	14	MgO	0.5630	0.5976	0.5900	-0.0270	0.0076	-4.6%	1.3%
NEPH2-14	14	MnO	1.9207	1.9800	2.0470	-0.1263	-0.0670	-6.2%	-3.3%
NEPH2-14	14	Na2O	17.1533	16.5866	18.1330	-0.9797	-1.5464	-5.4%	-8.5%
NEPH2-14	14	NiO	1.1363	1.1853	1.2840	-0.1477	-0.0987	-11.5%	-7.7%
NEPH2-14	14	PbO	0.0687	0.0687	0.0740	-0.0053	-0.0053	-7.2%	-7.2%
NEPH2-14	14	SO4	0.4509	0.4509	0.4490	0.0019	0.0019	0.4%	0.4%
NEPH2-14	14	SiO2	42.7325	42.8389	42.8840	-0.1515	-0.0451	-0.4%	-0.1%
NEPH2-14	14	ThO2	0.0569	0.0569	0.0160	0.0409	0.0409	255.6%	255.6%
NEPH2-14	14	TiO2	0.0083	0.0089	0.0080	0.0003	0.0009	4.3%	11.5%
NEPH2-14	14	U3O8	2.8448	3.0051	3.0540	-0.2092	-0.0489	-6.8%	-1.6%
NEPH2-14	14	ZnO	0.0498	0.0498	0.0450	0.0048	0.0048	10.6%	10.6%
NEPH2-14	14	ZrO2	0.0902	0.0902	0.1070	-0.0168	-0.0168	-15.7%	-15.7%
NEPH2-14	14	Sum of Oxides	97.2455	97.4497	100.0000	-2.7545	-2.5503	-2.8%	-2.6%
NEPH2-15	15	Al2O3	10.4206	10.4915	10.4720	-0.0514	0.0195	-0.5%	0.2%
NEPH2-15	15	B2O3	4.5079	4.5547	4.8000	-0.2921	-0.2453	-6.1%	-5.1%
NEPH2-15	15	BaO	0.0452	0.0503	0.0540	-0.0088	-0.0037	-16.3%	-6.9%
NEPH2-15	15	CaO	0.7633	0.8046	0.7960	-0.0327	0.0086	-4.1%	1.1%
NEPH2-15	15	Ce2O3	0.0583	0.0583	0.0750	-0.0167	-0.0167	-22.3%	-22.3%
NEPH2-15	15	Cr2O3	0.1125	0.1068	0.0930	0.0195	0.0138	21.0%	14.8%
NEPH2-15	15	CuO	0.0388	0.0407	0.0290	0.0098	0.0117	33.8%	40.3%
NEPH2-15	15	Fe2O3	8.6640	8.8732	8.8700	-0.2060	0.0032	-2.3%	0.0%

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

(100 -Batch 1; 200 -U std)

Glass ID	Glass #	Oxide	Measured (wt%)	Measured Bias-Corrected (wt%)	Targeted (wt%)	Diff of Measured	Diff of Meas BC	% Diff of Measured	% Diff of Meas BC
NEPH2-15	15	K2O	0.5839	0.6559	0.5590	0.0249	0.0969	4.5%	17.3%
NEPH2-15	15	La2O3	0.0610	0.0610	0.0320	0.0290	0.0290	90.6%	90.6%
NEPH2-15	15	Li2O	4.5319	4.6221	4.8000	-0.2681	-0.1779	-5.6%	-3.7%
NEPH2-15	15	MgO	0.5452	0.5782	0.5620	-0.0168	0.0162	-3.0%	2.9%
NEPH2-15	15	MnO	1.9529	1.9865	1.9490	0.0039	0.0375	0.2%	1.9%
NEPH2-15	15	Na2O	17.0859	16.3433	17.2410	-0.1551	-0.8977	-0.9%	-5.2%
NEPH2-15	15	NiO	1.1475	1.2071	1.2230	-0.0755	-0.0159	-6.2%	-1.3%
NEPH2-15	15	PbO	0.0665	0.0665	0.0710	-0.0045	-0.0045	-6.3%	-6.3%
NEPH2-15	15	SO4	0.4217	0.4217	0.4280	-0.0063	-0.0063	-1.5%	-1.5%
NEPH2-15	15	SiO2	44.2835	44.8526	44.8710	-0.5875	-0.0184	-1.3%	0.0%
NEPH2-15	15	ThO2	0.0569	0.0569	0.0150	0.0419	0.0419	279.3%	279.3%
NEPH2-15	15	TiO2	0.0083	0.0088	0.0080	0.0003	0.0008	4.3%	10.2%
NEPH2-15	15	U3O8	2.7240	2.8577	2.9080	-0.1840	-0.0503	-6.3%	-1.7%
NEPH2-15	15	ZnO	0.0495	0.0495	0.0430	0.0065	0.0065	15.1%	15.1%
NEPH2-15	15	ZrO2	0.0922	0.0922	0.1020	-0.0098	-0.0098	-9.6%	-9.6%
NEPH2-15	15	Sum of Oxides	98.2214	98.8399	100.0010	-1.7796	-1.1611	-1.8%	-1.2%
NEPH2-16	16	Al2O3	11.4220	11.4956	11.2570	0.1650	0.2386	1.5%	2.1%
NEPH2-16	16	B2O3	4.3871	4.4332	4.5600	-0.1729	-0.1268	-3.8%	-2.8%
NEPH2-16	16	BaO	0.0497	0.0552	0.0580	-0.0083	-0.0028	-14.3%	-4.8%
NEPH2-16	16	CaO	0.8385	0.8839	0.8560	-0.0175	0.0279	-2.0%	3.3%
NEPH2-16	16	Ce2O3	0.0597	0.0597	0.0800	-0.0203	-0.0203	-25.3%	-25.3%
NEPH2-16	16	Cr2O3	0.0954	0.0905	0.1000	-0.0046	-0.0095	-4.6%	-9.5%
NEPH2-16	16	CuO	0.0388	0.0407	0.0310	0.0078	0.0097	25.2%	31.3%
NEPH2-16	16	Fe2O3	9.1322	9.3509	9.5350	-0.4028	-0.1841	-4.2%	-1.9%
NEPH2-16	16	K2O	0.6851	0.7696	0.6010	0.0841	0.1686	14.0%	28.1%
NEPH2-16	16	La2O3	0.0328	0.0328	0.0350	-0.0022	-0.0022	-6.2%	-6.2%
NEPH2-16	16	Li2O	4.4350	4.5210	4.5600	-0.1250	-0.0390	-2.7%	-0.9%
NEPH2-16	16	MgO	0.5812	0.6164	0.6040	-0.0228	0.0124	-3.8%	2.1%
NEPH2-16	16	MnO	2.0788	2.1147	2.0950	-0.0162	0.0197	-0.8%	0.9%
NEPH2-16	16	Na2O	17.6588	16.8931	17.7090	-0.0502	-0.8159	-0.3%	-4.6%
NEPH2-16	16	NiO	1.1825	1.2407	1.3140	-0.1315	-0.0733	-10.0%	-5.6%
NEPH2-16	16	PbO	0.0692	0.0692	0.0760	-0.0068	-0.0068	-8.9%	-8.9%
NEPH2-16	16	SO4	0.4382	0.4382	0.4600	-0.0218	-0.0218	-4.7%	-4.7%
NEPH2-16	16	SiO2	41.6094	42.1351	42.7610	-1.1516	-0.6259	-2.7%	-1.5%
NEPH2-16	16	ThO2	0.0569	0.0569	0.0160	0.0409	0.0409	255.6%	255.6%
NEPH2-16	16	TiO2	0.0083	0.0088	0.0080	0.0003	0.0008	4.3%	10.2%
NEPH2-16	16	U3O8	2.9185	3.0616	3.1260	-0.2075	-0.0644	-6.6%	-2.1%
NEPH2-16	16	ZnO	0.0554	0.0554	0.0460	0.0094	0.0094	20.4%	20.4%
NEPH2-16	16	ZrO2	0.0986	0.0986	0.1100	-0.0114	-0.0114	-10.4%	-10.4%
NEPH2-16	16	Sum of Oxides	97.9322	98.5220	99.9980	-2.0658	-1.4760	-2.1%	-1.5%
NEPH2-17	17	Al2O3	12.0975	12.0018	11.7810	0.3165	0.2208	2.7%	1.9%
NEPH2-17	17	B2O3	4.2583	4.2819	4.4000	-0.1417	-0.1181	-3.2%	-2.7%
NEPH2-17	17	BaO	0.0505	0.0562	0.0610	-0.0105	-0.0048	-17.2%	-7.9%
NEPH2-17	17	CaO	0.8325	0.8898	0.8960	-0.0635	-0.0062	-7.1%	-0.7%
NEPH2-17	17	Ce2O3	0.0574	0.0574	0.0840	-0.0266	-0.0266	-31.7%	-31.7%
NEPH2-17	17	Cr2O3	0.1001	0.0942	0.1050	-0.0049	-0.0108	-4.6%	-10.3%
NEPH2-17	17	CuO	0.0410	0.0435	0.0330	0.0080	0.0105	24.2%	31.8%
NEPH2-17	17	Fe2O3	9.4646	9.7162	9.9790	-0.5144	-0.2628	-5.2%	-2.6%
NEPH2-17	17	K2O	0.6610	0.7491	0.6290	0.0320	0.1201	5.1%	19.1%
NEPH2-17	17	La2O3	0.0340	0.0340	0.0360	-0.0020	-0.0020	-5.5%	-5.5%
NEPH2-17	17	Li2O	4.3219	4.3690	4.4000	-0.0781	-0.0310	-1.8%	-0.7%
NEPH2-17	17	MgO	0.6098	0.6473	0.6330	-0.0232	0.0143	-3.7%	2.3%
NEPH2-17	17	MnO	2.1273	2.1930	2.1930	-0.0657	0.0000	-3.0%	0.0%
NEPH2-17	17	Na2O	17.6588	17.0759	18.0210	-0.3622	-0.9451	-2.0%	-5.2%
NEPH2-17	17	NiO	1.2238	1.2761	1.3750	-0.1512	-0.0989	-11.0%	-7.2%
NEPH2-17	17	PbO	0.0738	0.0738	0.0800	-0.0062	-0.0062	-7.8%	-7.8%

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

(100 -Batch 1; 200 -U std)

Glass ID	Glass #	Oxide	Measured (wt%)	Measured Bias-Corrected (wt%)	Targeted (wt%)	Diff of Measured	Diff of Meas BC	% Diff of Measured	% Diff of Meas BC
NEPH2-17	17	SO4	0.4853	0.4853	0.4810	0.0043	0.0043	0.9%	0.9%
NEPH2-17	17	SiO2	41.6094	41.7112	41.3550	0.2544	0.3562	0.6%	0.9%
NEPH2-17	17	ThO2	0.0569	0.0569	0.0170	0.0399	0.0399	234.7%	234.7%
NEPH2-17	17	TiO2	0.0083	0.0089	0.0080	0.0003	0.0009	4.3%	11.5%
NEPH2-17	17	U3O8	3.1514	3.3288	3.2720	-0.1206	0.0568	-3.7%	1.7%
NEPH2-17	17	ZnO	0.0535	0.0535	0.0480	0.0055	0.0055	11.5%	11.5%
NEPH2-17	17	ZrO2	0.1094	0.1094	0.1150	-0.0056	-0.0056	-4.9%	-4.9%
NEPH2-17	17	Sum of Oxides	99.0868	99.3131	100.0020	-0.9152	-0.6889	-0.9%	-0.7%
NEPH2-18	18	Al2O3	10.7796	10.6942	10.7340	0.0456	-0.0398	0.4%	-0.4%
NEPH2-18	18	B2O3	4.5884	4.6142	4.7200	-0.1316	-0.1058	-2.8%	-2.2%
NEPH2-18	18	BaO	0.0449	0.0500	0.0550	-0.0101	-0.0050	-18.3%	-9.2%
NEPH2-18	18	CaO	0.7643	0.8169	0.8160	-0.0517	0.0009	-6.3%	0.1%
NEPH2-18	18	Ce2O3	0.0551	0.0551	0.0760	-0.0209	-0.0209	-27.6%	-27.6%
NEPH2-18	18	Cr2O3	0.0954	0.0897	0.0950	0.0004	-0.0053	0.4%	-5.6%
NEPH2-18	18	CuO	0.0394	0.0418	0.0300	0.0094	0.0118	31.4%	39.4%
NEPH2-18	18	Fe2O3	8.9892	9.2284	9.0920	-0.1028	0.1364	-1.1%	1.5%
NEPH2-18	18	K2O	0.6333	0.7177	0.5730	0.0603	0.1447	10.5%	25.2%
NEPH2-18	18	La2O3	0.0317	0.0317	0.0330	-0.0013	-0.0013	-4.0%	-4.0%
NEPH2-18	18	Li2O	4.5211	4.5703	4.7200	-0.1989	-0.1497	-4.2%	-3.2%
NEPH2-18	18	MgO	0.5423	0.5756	0.5760	-0.0337	-0.0004	-5.9%	-0.1%
NEPH2-18	18	MnO	1.9433	2.0033	1.9980	-0.0547	0.0053	-2.7%	0.3%
NEPH2-18	18	Na2O	16.5467	16.0003	16.8070	-0.2603	-0.8067	-1.5%	-4.8%
NEPH2-18	18	NiO	1.1624	1.2123	1.2530	-0.0906	-0.0407	-7.2%	-3.2%
NEPH2-18	18	PbO	0.0598	0.0598	0.0720	-0.0122	-0.0122	-17.0%	-17.0%
NEPH2-18	18	SO4	0.4322	0.4322	0.4390	-0.0068	-0.0068	-1.6%	-1.6%
NEPH2-18	18	SiO2	44.6044	44.7145	44.7580	-0.1536	-0.0435	-0.3%	-0.1%
NEPH2-18	18	ThO2	0.0569	0.0569	0.0160	0.0409	0.0409	255.6%	255.6%
NEPH2-18	18	TiO2	0.0083	0.0089	0.0080	0.0003	0.0009	4.3%	11.5%
NEPH2-18	18	U3O8	2.7328	2.8864	2.9810	-0.2482	-0.0946	-8.3%	-3.2%
NEPH2-18	18	ZnO	0.0479	0.0479	0.0440	0.0039	0.0039	8.9%	8.9%
NEPH2-18	18	ZrO2	0.0915	0.0915	0.1050	-0.0135	-0.0135	-12.8%	-12.8%
NEPH2-18	18	Sum of Oxides	98.7708	98.9995	100.0010	-1.2302	-1.0015	-1.2%	-1.0%
NEPH2-19	19	Al2O3	11.7432	11.8225	11.5190	0.2242	0.3035	1.9%	2.6%
NEPH2-19	19	B2O3	4.5401	4.5866	4.4800	0.0601	0.1066	1.3%	2.4%
NEPH2-19	19	BaO	0.0466	0.0518	0.0590	-0.0124	-0.0072	-21.0%	-12.2%
NEPH2-19	19	CaO	0.8182	0.8624	0.8760	-0.0578	-0.0136	-6.6%	-1.5%
NEPH2-19	19	Ce2O3	0.0568	0.0568	0.0820	-0.0252	-0.0252	-30.7%	-30.7%
NEPH2-19	19	Cr2O3	0.0987	0.0936	0.1020	-0.0033	-0.0084	-3.3%	-8.2%
NEPH2-19	19	CuO	0.0404	0.0423	0.0320	0.0084	0.0103	26.2%	32.3%
NEPH2-19	19	Fe2O3	9.4146	9.6416	9.7570	-0.3424	-0.1154	-3.5%	-1.2%
NEPH2-19	19	K2O	0.6613	0.7429	0.6150	0.0463	0.1279	7.5%	20.8%
NEPH2-19	19	La2O3	0.0498	0.0498	0.0350	0.0148	0.0148	42.4%	42.4%
NEPH2-19	19	Li2O	4.3650	4.4512	4.4800	-0.1150	-0.0288	-2.6%	-0.6%
NEPH2-19	19	MgO	0.5978	0.6340	0.6180	-0.0202	0.0160	-3.3%	2.6%
NEPH2-19	19	MnO	2.1692	2.2061	2.1440	0.0252	0.0621	1.2%	2.9%
NEPH2-19	19	Na2O	17.5914	16.8250	17.3050	0.2864	-0.4800	1.7%	-2.8%
NEPH2-19	19	NiO	1.2235	1.2858	1.3450	-0.1215	-0.0592	-9.0%	-4.4%
NEPH2-19	19	PbO	0.0735	0.0735	0.0780	-0.0045	-0.0045	-5.7%	-5.7%
NEPH2-19	19	SO4	0.4486	0.4486	0.4710	-0.0224	-0.0224	-4.7%	-4.7%
NEPH2-19	19	SiO2	43.0534	43.6035	42.6180	0.4354	0.9855	1.0%	2.3%
NEPH2-19	19	ThO2	0.0569	0.0569	0.0170	0.0399	0.0399	234.7%	234.7%
NEPH2-19	19	TiO2	0.0083	0.0088	0.0080	0.0003	0.0008	4.3%	10.2%
NEPH2-19	19	U3O8	3.0866	3.2382	3.1990	-0.1124	0.0392	-3.5%	1.2%
NEPH2-19	19	ZnO	0.0535	0.0535	0.0470	0.0065	0.0065	13.9%	13.9%
NEPH2-19	19	ZrO2	0.1006	0.1006	0.1120	-0.0114	-0.0114	-10.1%	-10.1%
NEPH2-19	19	Sum of Oxides	100.2981	100.9363	99.9990	0.2991	0.9373	0.3%	0.9%

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

(100 -Batch 1; 200 -U std)

Glass ID	Glass #	Oxide	Measured (wt%)	Measured Bias-Corrected (wt%)	Targeted (wt%)	Diff of Measured	Diff of Meas BC	% Diff of Measured	% Diff of Meas BC
NEPH2-20	20	Al2O3	12.3337	12.4134	12.3040	0.0297	0.1094	0.2%	0.9%
NEPH2-20	20	B2O3	4.1537	4.1970	4.2400	-0.0863	-0.0430	-2.0%	-1.0%
NEPH2-20	20	BaO	0.0519	0.0577	0.0640	-0.0121	-0.0063	-18.9%	-9.8%
NEPH2-20	20	CaO	0.8665	0.9134	0.9360	-0.0695	-0.0226	-7.4%	-2.4%
NEPH2-20	20	Ce2O3	0.0618	0.0618	0.0880	-0.0262	-0.0262	-29.8%	-29.8%
NEPH2-20	20	Cr2O3	0.1056	0.1002	0.1090	-0.0034	-0.0088	-3.1%	-8.1%
NEPH2-20	20	CuO	0.0419	0.0440	0.0340	0.0079	0.0100	23.3%	29.3%
NEPH2-20	20	Fe2O3	10.0615	10.3034	10.4220	-0.3605	-0.1186	-3.5%	-1.1%
NEPH2-20	20	K2O	0.6899	0.7750	0.6570	0.0329	0.1180	5.0%	18.0%
NEPH2-20	20	La2O3	0.0364	0.0364	0.0380	-0.0016	-0.0016	-4.3%	-4.3%
NEPH2-20	20	Li2O	4.0905	4.1700	4.2400	-0.1495	-0.0700	-3.5%	-1.7%
NEPH2-20	20	MgO	0.6297	0.6679	0.6610	-0.0313	0.0069	-4.7%	1.0%
NEPH2-20	20	MnO	2.3274	2.3672	2.2900	0.0374	0.0772	1.6%	3.4%
NEPH2-20	20	Na2O	17.8947	17.1169	17.8040	0.0907	-0.6871	0.5%	-3.9%
NEPH2-20	20	NiO	1.3202	1.3870	1.4370	-0.1168	-0.0500	-8.1%	-3.5%
NEPH2-20	20	PbO	0.0781	0.0781	0.0830	-0.0049	-0.0049	-5.9%	-5.9%
NEPH2-20	20	SO4	0.4778	0.4778	0.5030	-0.0252	-0.0252	-5.0%	-5.0%
NEPH2-20	20	SiO2	41.6629	42.1953	40.4780	1.1849	1.7173	2.9%	4.2%
NEPH2-20	20	ThO2	0.0569	0.0569	0.0180	0.0389	0.0389	216.1%	216.1%
NEPH2-20	20	TiO2	0.0083	0.0088	0.0090	-0.0007	-0.0002	-7.3%	-2.0%
NEPH2-20	20	U3O8	3.2310	3.3893	3.4170	-0.1860	-0.0277	-5.4%	-0.8%
NEPH2-20	20	ZnO	0.0523	0.0523	0.0500	0.0023	0.0023	4.6%	4.6%
NEPH2-20	20	ZrO2	0.1067	0.1067	0.1200	-0.0133	-0.0133	-11.1%	-11.1%
NEPH2-20	20	Sum of Oxides	100.3395	100.9764	100.0020	0.3375	0.9744	0.3%	1.0%
NEPH2-21	21	Al2O3	10.2978	10.2162	10.9950	-0.6972	-0.7788	-6.3%	-7.1%
NEPH2-21	21	B2O3	4.1054	4.1284	4.6400	-0.5346	-0.5116	-11.5%	-11.0%
NEPH2-21	21	BaO	0.0452	0.0503	0.0570	-0.0118	-0.0067	-20.7%	-11.8%
NEPH2-21	21	CaO	0.7675	0.8202	0.8360	-0.0685	-0.0158	-8.2%	-1.9%
NEPH2-21	21	Ce2O3	0.0603	0.0603	0.0780	-0.0177	-0.0177	-22.7%	-22.7%
NEPH2-21	21	Cr2O3	0.1012	0.0952	0.0980	0.0032	-0.0028	3.3%	-2.9%
NEPH2-21	21	CuO	0.0369	0.0392	0.0310	0.0059	0.0082	19.1%	26.3%
NEPH2-21	21	Fe2O3	8.3816	8.6034	9.3130	-0.9314	-0.7096	-10.0%	-7.6%
NEPH2-21	21	K2O	0.6511	0.7378	0.5870	0.0641	0.1508	10.9%	25.7%
NEPH2-21	21	La2O3	0.0337	0.0337	0.0340	-0.0003	-0.0003	-0.8%	-0.8%
NEPH2-21	21	Li2O	4.1336	4.1785	4.6400	-0.5064	-0.4615	-10.9%	-9.9%
NEPH2-21	21	MgO	0.5605	0.5949	0.5900	-0.0295	0.0049	-5.0%	0.8%
NEPH2-21	21	MnO	1.9917	2.0532	2.0470	-0.0553	0.0062	-2.7%	0.3%
NEPH2-21	21	Na2O	15.8727	15.3479	16.3930	-0.5203	-1.0451	-3.2%	-6.4%
NEPH2-21	21	NiO	1.1090	1.1559	1.2840	-0.1750	-0.1281	-13.6%	-10.0%
NEPH2-21	21	PbO	0.0654	0.0654	0.0740	-0.0086	-0.0086	-11.6%	-11.6%
NEPH2-21	21	SO4	0.4711	0.4711	0.4490	0.0221	0.0221	4.9%	4.9%
NEPH2-21	21	SiO2	43.6417	43.7487	44.6240	-0.9823	-0.8753	-2.2%	-2.0%
NEPH2-21	21	ThO2	0.0569	0.0569	0.0160	0.0409	0.0409	255.6%	255.6%
NEPH2-21	21	TiO2	0.0083	0.0089	0.0080	0.0003	0.0009	4.3%	11.5%
NEPH2-21	21	U3O8	2.7240	2.8772	3.0540	-0.3300	-0.1768	-10.8%	-5.8%
NEPH2-21	21	ZnO	0.0143	0.0143	0.0450	-0.0307	-0.0307	-68.2%	-68.2%
NEPH2-21	21	ZrO2	0.0956	0.0956	0.1070	-0.0114	-0.0114	-10.7%	-10.7%
NEPH2-21	21	Sum of Oxides	95.2255	95.4534	100.0000	-4.7745	-4.5466	-4.8%	-4.5%
NEPH2-22	22	Al2O3	12.2959	12.1986	12.0430	0.2529	0.1556	2.1%	1.3%
NEPH2-22	22	B2O3	4.1698	4.1930	4.3200	-0.1502	-0.1270	-3.5%	-2.9%
NEPH2-22	22	BaO	0.0497	0.0552	0.0620	-0.0123	-0.0068	-19.9%	-10.9%
NEPH2-22	22	CaO	0.8280	0.8849	0.9160	-0.0880	-0.0311	-9.6%	-3.4%
NEPH2-22	22	Ce2O3	0.0609	0.0609	0.0860	-0.0251	-0.0251	-29.2%	-29.2%
NEPH2-22	22	Cr2O3	0.1034	0.0973	0.1070	-0.0036	-0.0097	-3.4%	-9.1%
NEPH2-22	22	CuO	0.0397	0.0422	0.0330	0.0067	0.0092	20.4%	27.7%
NEPH2-22	22	Fe2O3	9.7506	10.0101	10.2000	-0.4494	-0.1899	-4.4%	-1.9%

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

(100 -Batch 1; 200 -U std)

Glass ID	Glass #	Oxide	Measured (wt%)	Measured Bias-Corrected (wt%)	Targeted (wt%)	Diff of Measured	Diff of Meas BC	% Diff of Measured	% Diff of Meas BC
NEPH2-22	22	K2O	0.6911	0.7832	0.6430	0.0481	0.1402	7.5%	21.8%
NEPH2-22	22	La2O3	0.0396	0.0396	0.0370	0.0026	0.0026	7.0%	7.0%
NEPH2-22	22	Li2O	4.2035	4.2494	4.3200	-0.1165	-0.0706	-2.7%	-1.6%
NEPH2-22	22	MgO	0.6094	0.6469	0.6470	-0.0376	-0.0001	-5.8%	0.0%
NEPH2-22	22	MnO	2.1498	2.2163	2.2420	-0.0922	-0.0257	-4.1%	-1.1%
NEPH2-22	22	Na2O	16.5467	15.9996	17.0980	-0.5513	-1.0984	-3.2%	-6.4%
NEPH2-22	22	NiO	1.2505	1.3043	1.4060	-0.1555	-0.1017	-11.1%	-7.2%
NEPH2-22	22	PbO	0.0762	0.0762	0.0810	-0.0048	-0.0048	-5.9%	-5.9%
NEPH2-22	22	SO4	0.4883	0.4883	0.4920	-0.0037	-0.0037	-0.7%	-0.7%
NEPH2-22	22	SiO2	42.4651	42.5705	41.7310	0.7341	0.8395	1.8%	2.0%
NEPH2-22	22	ThO2	0.0569	0.0569	0.0170	0.0399	0.0399	234.7%	234.7%
NEPH2-22	22	TiO2	0.0083	0.0089	0.0090	-0.0007	-0.0001	-7.3%	-0.9%
NEPH2-22	22	U3O8	3.2015	3.3820	3.3450	-0.1435	0.0370	-4.3%	1.1%
NEPH2-22	22	ZnO	0.0523	0.0523	0.0490	0.0033	0.0033	6.7%	6.7%
NEPH2-22	22	ZrO2	0.1027	0.1027	0.1170	-0.0143	-0.0143	-12.3%	-12.3%
NEPH2-22	22	Sum of Oxides	99.2401	99.5191	100.0010	-0.7609	-0.4819	-0.8%	-0.5%
NEPH2-23	23	Al2O3	12.5652	12.6477	12.8280	-0.2628	-0.1803	-2.0%	-1.4%
NEPH2-23	23	B2O3	3.9766	4.0189	4.0800	-0.1034	-0.0611	-2.5%	-1.5%
NEPH2-23	23	BaO	0.0533	0.0593	0.0660	-0.0127	-0.0067	-19.2%	-10.2%
NEPH2-23	23	CaO	0.9049	0.9539	0.9760	-0.0711	-0.0221	-7.3%	-2.3%
NEPH2-23	23	Ce2O3	0.0714	0.0714	0.0910	-0.0196	-0.0196	-21.5%	-21.5%
NEPH2-23	23	Cr2O3	0.1012	0.0960	0.1140	-0.0128	-0.0180	-11.2%	-15.8%
NEPH2-23	23	CuO	0.0438	0.0459	0.0360	0.0078	0.0099	21.7%	27.6%
NEPH2-23	23	Fe2O3	10.1259	10.3690	10.8660	-0.7401	-0.4970	-6.8%	-4.6%
NEPH2-23	23	K2O	0.6896	0.7747	0.6850	0.0046	0.0897	0.7%	13.1%
NEPH2-23	23	La2O3	0.0364	0.0364	0.0390	-0.0026	-0.0026	-6.8%	-6.8%
NEPH2-23	23	Li2O	3.8537	3.9287	4.0800	-0.2263	-0.1513	-5.5%	-3.7%
NEPH2-23	23	MgO	0.6612	0.7013	0.6890	-0.0278	0.0123	-4.0%	1.8%
NEPH2-23	23	MnO	2.3564	2.3968	2.3880	-0.0316	0.0088	-1.3%	0.4%
NEPH2-23	23	Na2O	17.5914	16.8272	17.6260	-0.0346	-0.7988	-0.2%	-4.5%
NEPH2-23	23	NiO	1.3196	1.3863	1.4980	-0.1784	-0.1117	-11.9%	-7.5%
NEPH2-23	23	PbO	0.0797	0.0797	0.0870	-0.0073	-0.0073	-8.4%	-8.4%
NEPH2-23	23	SO4	0.4981	0.4981	0.5240	-0.0259	-0.0259	-4.9%	-4.9%
NEPH2-23	23	SiO2	39.4701	39.9739	39.5620	-0.0919	0.4119	-0.2%	1.0%
NEPH2-23	23	ThO2	0.0569	0.0569	0.0190	0.0379	0.0379	199.4%	199.4%
NEPH2-23	23	TiO2	0.0083	0.0088	0.0090	-0.0007	-0.0002	-7.3%	-2.0%
NEPH2-23	23	U3O8	3.3371	3.5007	3.5630	-0.2259	-0.0623	-6.3%	-1.7%
NEPH2-23	23	ZnO	0.0541	0.0541	0.0520	0.0021	0.0021	4.1%	4.1%
NEPH2-23	23	ZrO2	0.1182	0.1182	0.1250	-0.0068	-0.0068	-5.4%	-5.4%
NEPH2-23	23	Sum of Oxides	97.9733	98.6039	100.0030	-2.0297	-1.3991	-2.0%	-1.4%
NEPH2-24	24	Al2O3	11.3512	11.2613	11.2570	0.0942	0.0043	0.8%	0.0%
NEPH2-24	24	B2O3	4.3630	4.3880	4.5600	-0.1970	-0.1720	-4.3%	-3.8%
NEPH2-24	24	BaO	0.0461	0.0512	0.0580	-0.0119	-0.0068	-20.6%	-11.7%
NEPH2-24	24	CaO	0.7944	0.8490	0.8560	-0.0616	-0.0070	-7.2%	-0.8%
NEPH2-24	24	Ce2O3	0.0612	0.0612	0.0800	-0.0188	-0.0188	-23.5%	-23.5%
NEPH2-24	24	Cr2O3	0.0957	0.0900	0.1000	-0.0043	-0.0100	-4.3%	-10.0%
NEPH2-24	24	CuO	0.0388	0.0412	0.0310	0.0078	0.0102	25.2%	32.8%
NEPH2-24	24	Fe2O3	8.9321	9.1694	9.5350	-0.6029	-0.3656	-6.3%	-3.8%
NEPH2-24	24	K2O	0.6430	0.7286	0.6010	0.0420	0.1276	7.0%	21.2%
NEPH2-24	24	La2O3	0.0334	0.0334	0.0350	-0.0016	-0.0016	-4.5%	-4.5%
NEPH2-24	24	Li2O	4.3812	4.4288	4.5600	-0.1788	-0.1312	-3.9%	-2.9%
NEPH2-24	24	MgO	0.5846	0.6205	0.6040	-0.0194	0.0165	-3.2%	2.7%
NEPH2-24	24	MnO	2.0401	2.1031	2.0950	-0.0549	0.0081	-2.6%	0.4%
NEPH2-24	24	Na2O	15.6705	15.1537	15.9990	-0.3285	-0.8453	-2.1%	-5.3%
NEPH2-24	24	NiO	1.1729	1.2229	1.3140	-0.1411	-0.0911	-10.7%	-6.9%
NEPH2-24	24	PbO	0.0676	0.0676	0.0760	-0.0084	-0.0084	-11.1%	-11.1%

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

(100 -Batch 1; 200 -U std)

Glass ID	Glass #	Oxide	Measured (wt%)	Measured Bias-Corrected (wt%)	Targeted (wt%)	Diff of Measured	Diff of Meas BC	% Diff of Measured	% Diff of Meas BC
NEPH2-24	24	SO4	0.4569	0.4569	0.4600	-0.0031	-0.0031	-0.7%	-0.7%
NEPH2-24	24	SiO2	43.7487	43.8566	44.4710	-0.7223	-0.6144	-1.6%	-1.4%
NEPH2-24	24	ThO2	0.0569	0.0569	0.0160	0.0409	0.0409	255.6%	255.6%
NEPH2-24	24	TiO2	0.0083	0.0089	0.0080	0.0003	0.0009	4.3%	11.5%
NEPH2-24	24	U3O8	2.8537	3.0142	3.1260	-0.2723	-0.1118	-8.7%	-3.6%
NEPH2-24	24	ZnO	0.0504	0.0504	0.0460	0.0044	0.0044	9.6%	9.6%
NEPH2-24	24	ZrO2	0.1000	0.1000	0.1100	-0.0100	-0.0100	-9.1%	-9.1%
NEPH2-24	24	Sum of Oxides	97.5504	97.8138	99.9980	-2.4476	-2.1842	-2.4%	-2.2%
NEPH2-25	25	Al2O3	12.3904	12.4712	12.3040	0.0864	0.1672	0.7%	1.4%
NEPH2-25	25	B2O3	4.1054	4.1482	4.2400	-0.1346	-0.0918	-3.2%	-2.2%
NEPH2-25	25	BaO	0.0533	0.0593	0.0640	-0.0107	-0.0047	-16.7%	-7.4%
NEPH2-25	25	CaO	0.8850	0.9329	0.9360	-0.0510	-0.0031	-5.4%	-0.3%
NEPH2-25	25	Ce2O3	0.0641	0.0641	0.0880	-0.0239	-0.0239	-27.1%	-27.1%
NEPH2-25	25	Cr2O3	0.1060	0.1005	0.1090	-0.0030	-0.0085	-2.8%	-7.8%
NEPH2-25	25	CuO	0.0413	0.0433	0.0340	0.0073	0.0093	21.5%	27.4%
NEPH2-25	25	Fe2O3	9.9471	10.1860	10.4220	-0.4749	-0.2360	-4.6%	-2.3%
NEPH2-25	25	K2O	0.6999	0.7862	0.6570	0.0429	0.1292	6.5%	19.7%
NEPH2-25	25	La2O3	0.0422	0.0422	0.0380	0.0042	0.0042	11.1%	11.1%
NEPH2-25	25	Li2O	4.0905	4.1702	4.2400	-0.1495	-0.0698	-3.5%	-1.6%
NEPH2-25	25	MgO	0.6409	0.6798	0.6610	-0.0201	0.0188	-3.0%	2.8%
NEPH2-25	25	MnO	2.2628	2.3008	2.2900	-0.0272	0.0108	-1.2%	0.5%
NEPH2-25	25	Na2O	16.5804	15.8601	16.7440	-0.1636	-0.8839	-1.0%	-5.3%
NEPH2-25	25	NiO	1.2913	1.3558	1.4370	-0.1457	-0.0812	-10.1%	-5.7%
NEPH2-25	25	PbO	0.0741	0.0741	0.0830	-0.0089	-0.0089	-10.8%	-10.8%
NEPH2-25	25	SO4	0.4831	0.4831	0.5030	-0.0199	-0.0199	-4.0%	-4.0%
NEPH2-25	25	SiO2	41.2885	41.8141	41.5380	-0.2495	0.2761	-0.6%	0.7%
NEPH2-25	25	ThO2	0.0569	0.0569	0.0180	0.0389	0.0389	216.1%	216.1%
NEPH2-25	25	TiO2	0.0083	0.0088	0.0090	-0.0007	-0.0002	-7.3%	-2.0%
NEPH2-25	25	U3O8	3.2104	3.3678	3.4170	-0.2066	-0.0492	-6.0%	-1.4%
NEPH2-25	25	ZnO	0.0560	0.0560	0.0500	0.0060	0.0060	12.0%	12.0%
NEPH2-25	25	ZrO2	0.1084	0.1084	0.1200	-0.0116	-0.0116	-9.7%	-9.7%
NEPH2-25	25	Sum of Oxides	98.4863	99.1697	100.0020	-1.5157	-0.8323	-1.5%	-0.8%
NEPH2-26	26	Al2O3	13.4485	13.3420	13.3520	0.0965	-0.0100	0.7%	-0.1%
NEPH2-26	26	B2O3	3.8075	3.8278	3.9200	-0.1125	-0.0922	-2.9%	-2.4%
NEPH2-26	26	BaO	0.0583	0.0648	0.0690	-0.0107	-0.0042	-15.5%	-6.0%
NEPH2-26	26	CaO	0.9368	1.0012	1.0150	-0.0782	-0.0138	-7.7%	-1.4%
NEPH2-26	26	Ce2O3	0.0735	0.0735	0.0950	-0.0215	-0.0215	-22.6%	-22.6%
NEPH2-26	26	Cr2O3	0.1012	0.0952	0.1190	-0.0178	-0.0238	-14.9%	-20.0%
NEPH2-26	26	CuO	0.0519	0.0551	0.0370	0.0149	0.0181	40.4%	48.9%
NEPH2-26	26	Fe2O3	10.4690	10.7471	11.3090	-0.8400	-0.5619	-7.4%	-5.0%
NEPH2-26	26	K2O	0.7661	0.8681	0.7130	0.0531	0.1551	7.5%	21.7%
NEPH2-26	26	La2O3	0.0815	0.0815	0.0410	0.0405	0.0405	98.8%	98.8%
NEPH2-26	26	Li2O	3.7999	3.8411	3.9200	-0.1201	-0.0789	-3.1%	-2.0%
NEPH2-26	26	MgO	0.6758	0.7173	0.7170	-0.0412	0.0003	-5.8%	0.0%
NEPH2-26	26	MnO	2.2015	2.2695	2.4850	-0.2835	-0.2155	-11.4%	-8.7%
NEPH2-26	26	Na2O	16.8163	16.2610	17.4880	-0.6717	-1.2270	-3.8%	-7.0%
NEPH2-26	26	NiO	1.3838	1.4429	1.5590	-0.1752	-0.1161	-11.2%	-7.4%
NEPH2-26	26	PbO	0.0792	0.0792	0.0900	-0.0108	-0.0108	-12.0%	-12.0%
NEPH2-26	26	SO4	0.5378	0.5378	0.5460	-0.0082	-0.0082	-1.5%	-1.5%
NEPH2-26	26	SiO2	38.3470	38.4409	38.6050	-0.2580	-0.1641	-0.7%	-0.4%
NEPH2-26	26	ThO2	0.0569	0.0569	0.0190	0.0379	0.0379	199.4%	199.4%
NEPH2-26	26	TiO2	0.0083	0.0089	0.0100	-0.0017	-0.0011	-16.6%	-10.8%
NEPH2-26	26	U3O8	3.4521	3.6466	3.7080	-0.2559	-0.0614	-6.9%	-1.7%
NEPH2-26	26	ZnO	0.0594	0.0594	0.0550	0.0044	0.0044	8.1%	8.1%
NEPH2-26	26	ZrO2	0.1168	0.1168	0.1300	-0.0132	-0.0132	-10.1%	-10.1%
NEPH2-26	26	Sum of Oxides	97.3292	97.6347	100.0020	-2.6728	-2.3673	-2.7%	-2.4%

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

(100 -Batch 1; 200 -U std)

Glass ID	Glass #	Oxide	Measured (wt%)	Measured Bias-Corrected (wt%)	Targeted (wt%)	Diff of Measured	Diff of Meas BC	% Diff of Measured	% Diff of Meas BC
NEPH2-27	27	Al2O3	13.1651	13.3256	11.6410	1.5241	1.6846	13.1%	14.5%
NEPH2-27	27	B2O3	4.0571	4.1925	4.8800	-0.8229	-0.6875	-16.9%	-14.1%
NEPH2-27	27	BaO	0.0500	0.0559	0.0560	-0.0060	-0.0001	-10.8%	-0.1%
NEPH2-27	27	CaO	0.7857	0.8184	0.7490	0.0367	0.0694	4.9%	9.3%
NEPH2-27	27	Ce2O3	0.0498	0.0498	0.0750	-0.0252	-0.0252	-33.6%	-33.6%
NEPH2-27	27	Cr2O3	0.0935	0.0899	0.0980	-0.0045	-0.0081	-4.5%	-8.3%
NEPH2-27	27	CuO	0.0382	0.0399	0.0290	0.0092	0.0109	31.7%	37.4%
NEPH2-27	27	Fe2O3	7.7275	7.9150	8.3300	-0.6025	-0.4150	-7.2%	-5.0%
NEPH2-27	27	K2O	0.7788	0.8650	0.6690	0.1098	0.1960	16.4%	29.3%
NEPH2-27	27	La2O3	0.0320	0.0320	0.0320	0.0000	0.0000	-0.1%	-0.1%
NEPH2-27	27	Li2O	4.7095	4.7924	4.8800	-0.1705	-0.0876	-3.5%	-1.8%
NEPH2-27	27	MgO	0.4560	0.4859	0.4150	0.0410	0.0709	9.9%	17.1%
NEPH2-27	27	MnO	1.9981	2.1038	1.8720	0.1261	0.2318	6.7%	12.4%
NEPH2-27	27	Na2O	16.0412	15.7091	16.5140	-0.4728	-0.8049	-2.9%	-4.9%
NEPH2-27	27	NiO	1.2063	1.2332	1.3580	-0.1517	-0.1248	-11.2%	-9.2%
NEPH2-27	27	PbO	0.0622	0.0622	0.0760	-0.0138	-0.0138	-18.1%	-18.1%
NEPH2-27	27	SO4	0.4329	0.4329	0.4020	0.0309	0.0309	7.7%	7.7%
NEPH2-27	27	SiO2	44.4440	44.7284	44.9870	-0.5430	-0.2586	-1.2%	-0.6%
NEPH2-27	27	ThO2	0.0569	0.0569	0.0160	0.0409	0.0409	255.6%	255.6%
NEPH2-27	27	TiO2	0.0083	0.0088	0.0070	0.0013	0.0018	19.1%	25.9%
NEPH2-27	27	U3O8	2.5530	2.7247	2.7650	-0.2120	-0.0403	-7.7%	-1.5%
NEPH2-27	27	ZnO	0.0485	0.0485	0.0420	0.0065	0.0065	15.6%	15.6%
NEPH2-27	27	ZrO2	0.1057	0.1057	0.1070	-0.0013	-0.0013	-1.2%	-1.2%
NEPH2-27	27	Sum of Oxides	98.9002	99.8765	100.0000	-1.0998	-0.1235	-1.1%	-0.1%
NEPH2-28	28	Al2O3	11.7716	11.9151	13.1330	-1.3614	-1.2179	-10.4%	-9.3%
NEPH2-28	28	B2O3	4.4837	4.6329	4.4800	0.0037	0.1529	0.1%	3.4%
NEPH2-28	28	BaO	0.0461	0.0515	0.0630	-0.0169	-0.0115	-26.9%	-18.2%
NEPH2-28	28	CaO	0.7377	0.7685	0.8450	-0.1073	-0.0765	-12.7%	-9.1%
NEPH2-28	28	Ce2O3	0.0580	0.0580	0.0850	-0.0270	-0.0270	-31.8%	-31.8%
NEPH2-28	28	Cr2O3	0.1041	0.1001	0.1100	-0.0059	-0.0099	-5.3%	-9.0%
NEPH2-28	28	CuO	0.0369	0.0386	0.0330	0.0039	0.0056	11.9%	16.8%
NEPH2-28	28	Fe2O3	8.7819	8.9959	9.3980	-0.6161	-0.4021	-6.6%	-4.3%
NEPH2-28	28	K2O	0.6954	0.7723	0.7550	-0.0596	0.0173	-7.9%	2.3%
NEPH2-28	28	La2O3	0.0305	0.0305	0.0360	-0.0055	-0.0055	-15.3%	-15.3%
NEPH2-28	28	Li2O	4.3435	4.4202	4.4800	-0.1365	-0.0598	-3.0%	-1.3%
NEPH2-28	28	MgO	0.4146	0.4417	0.4680	-0.0534	-0.0263	-11.4%	-5.6%
NEPH2-28	28	MnO	1.7980	1.8928	2.1120	-0.3140	-0.2192	-14.9%	-10.4%
NEPH2-28	28	Na2O	15.9401	15.6100	17.0930	-1.1529	-1.4830	-6.7%	-8.7%
NEPH2-28	28	NiO	1.3775	1.4082	1.5320	-0.1545	-0.1238	-10.1%	-8.1%
NEPH2-28	28	PbO	0.0816	0.0816	0.0860	-0.0044	-0.0044	-5.1%	-5.1%
NEPH2-28	28	SO4	0.3895	0.3895	0.4530	-0.0635	-0.0635	-14.0%	-14.0%
NEPH2-28	28	SiO2	41.2350	41.4987	41.5240	-0.2890	-0.0253	-0.7%	-0.1%
NEPH2-28	28	ThO2	0.0569	0.0569	0.0180	0.0389	0.0389	216.1%	216.1%
NEPH2-28	28	TiO2	0.0083	0.0088	0.0080	0.0003	0.0008	4.3%	10.1%
NEPH2-28	28	U3O8	2.9627	3.1620	3.1200	-0.1573	0.0420	-5.0%	1.3%
NEPH2-28	28	ZnO	0.0479	0.0479	0.0480	-0.0001	-0.0001	-0.2%	-0.2%
NEPH2-28	28	ZrO2	0.1013	0.1013	0.1200	-0.0187	-0.0187	-15.6%	-15.6%
NEPH2-28	28	Sum of Oxides	95.5028	96.4829	100.0000	-4.4972	-3.5171	-4.5%	-3.5%
NEPH2-29	29	Al2O3	14.5208	14.4807	14.6260	-0.1052	-0.1453	-0.7%	-1.0%
NEPH2-29	29	B2O3	3.7512	3.8202	4.0800	-0.3288	-0.2598	-8.1%	-6.4%
NEPH2-29	29	BaO	0.0592	0.0653	0.0710	-0.0118	-0.0057	-16.7%	-8.0%
NEPH2-29	29	CaO	0.8853	0.9329	0.9410	-0.0557	-0.0081	-5.9%	-0.9%
NEPH2-29	29	Ce2O3	0.0796	0.0796	0.0950	-0.0154	-0.0154	-16.2%	-16.2%
NEPH2-29	29	Cr2O3	0.1082	0.1022	0.1230	-0.0148	-0.0208	-12.1%	-16.9%
NEPH2-29	29	CuO	0.0422	0.0440	0.0370	0.0052	0.0070	14.2%	18.9%
NEPH2-29	29	Fe2O3	9.5325	9.7854	10.4660	-0.9335	-0.6806	-8.9%	-6.5%

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

(100 -Batch 1; 200 -U std)

Glass ID	Glass #	Oxide	Measured (wt%)	Measured Bias-Corrected (wt%)	Targeted (wt%)	Diff of Measured	Diff of Meas BC	% Diff of Measured	% Diff of Meas BC
NEPH2-29	29	K2O	0.8595	0.9683	0.8400	0.0195	0.1283	2.3%	15.3%
NEPH2-29	29	La2O3	0.0408	0.0408	0.0400	0.0008	0.0008	1.9%	1.9%
NEPH2-29	29	Li2O	3.9560	3.9959	4.0800	-0.1240	-0.0841	-3.0%	-2.1%
NEPH2-29	29	MgO	0.5207	0.5491	0.5220	-0.0013	0.0271	-0.2%	5.2%
NEPH2-29	29	MnO	2.2822	2.3235	2.3520	-0.0698	-0.0285	-3.0%	-1.2%
NEPH2-29	29	Na2O	17.5240	16.6209	17.6710	-0.1470	-1.0501	-0.8%	-5.9%
NEPH2-29	29	NiO	1.4634	1.5333	1.7060	-0.2426	-0.1727	-14.2%	-10.1%
NEPH2-29	29	PbO	0.0878	0.0878	0.0960	-0.0082	-0.0082	-8.6%	-8.6%
NEPH2-29	29	SO4	0.4868	0.4868	0.5050	-0.0182	-0.0182	-3.6%	-3.6%
NEPH2-29	29	SiO2	37.7052	37.9339	38.0610	-0.3558	-0.1271	-0.9%	-0.3%
NEPH2-29	29	ThO2	0.0569	0.0569	0.0200	0.0369	0.0369	184.5%	184.5%
NEPH2-29	29	TiO2	0.0083	0.0088	0.0090	-0.0007	-0.0002	-7.3%	-2.6%
NEPH2-29	29	U3O8	3.2900	3.4692	3.4740	-0.1840	-0.0048	-5.3%	-0.1%
NEPH2-29	29	ZnO	0.0591	0.0591	0.0530	0.0061	0.0061	11.6%	11.6%
NEPH2-29	29	ZrO2	0.1233	0.1233	0.1340	-0.0107	-0.0107	-8.0%	-8.0%
NEPH2-29	29	Sum of Oxides	97.4429	97.5678	100.0020	-2.5591	-2.4342	-2.6%	-2.4%
NEPH2-30	30	Al2O3	12.0030	12.1494	11.9390	0.0640	0.2104	0.5%	1.8%
NEPH2-30	30	B2O3	4.4596	4.6090	4.8000	-0.3404	-0.1910	-7.1%	-4.0%
NEPH2-30	30	BaO	0.0469	0.0525	0.0580	-0.0111	-0.0055	-19.2%	-9.5%
NEPH2-30	30	CaO	0.7398	0.7707	0.7690	-0.0292	0.0017	-3.8%	0.2%
NEPH2-30	30	Ce2O3	0.0565	0.0565	0.0770	-0.0205	-0.0205	-26.6%	-26.6%
NEPH2-30	30	Cr2O3	0.0943	0.0906	0.1000	-0.0057	-0.0094	-5.7%	-9.4%
NEPH2-30	30	CuO	0.0372	0.0389	0.0300	0.0072	0.0089	24.1%	29.6%
NEPH2-30	30	Fe2O3	8.0778	8.2755	8.5440	-0.4662	-0.2685	-5.5%	-3.1%
NEPH2-30	30	K2O	0.7282	0.8088	0.6860	0.0422	0.1228	6.1%	17.9%
NEPH2-30	30	La2O3	0.0340	0.0340	0.0330	0.0010	0.0010	3.1%	3.1%
NEPH2-30	30	Li2O	4.6234	4.7052	4.8000	-0.1766	-0.0948	-3.7%	-2.0%
NEPH2-30	30	MgO	0.4142	0.4413	0.4260	-0.0118	0.0153	-2.8%	3.6%
NEPH2-30	30	MnO	1.8690	1.9678	1.9200	-0.0510	0.0478	-2.7%	2.5%
NEPH2-30	30	Na2O	15.9064	15.5770	16.0300	-0.1236	-0.4530	-0.8%	-2.8%
NEPH2-30	30	NiO	1.2881	1.3168	1.3930	-0.1049	-0.0762	-7.5%	-5.5%
NEPH2-30	30	PbO	0.0716	0.0716	0.0780	-0.0064	-0.0064	-8.2%	-8.2%
NEPH2-30	30	SO4	0.4037	0.4037	0.4120	-0.0083	-0.0083	-2.0%	-2.0%
NEPH2-30	30	SiO2	44.6579	44.9437	44.8940	-0.2361	0.0497	-0.5%	0.1%
NEPH2-30	30	ThO2	0.0569	0.0569	0.0170	0.0399	0.0399	234.7%	234.7%
NEPH2-30	30	TiO2	0.0083	0.0088	0.0070	0.0013	0.0018	19.1%	25.9%
NEPH2-30	30	U3O8	2.7505	2.9355	2.8360	-0.0855	0.0995	-3.0%	3.5%
NEPH2-30	30	ZnO	0.1049	0.1049	0.0430	0.0619	0.0619	143.9%	143.9%
NEPH2-30	30	ZrO2	0.1020	0.1020	0.1090	-0.0070	-0.0070	-6.4%	-6.4%
NEPH2-30	30	Sum of Oxides	98.5342	99.5211	100.0010	-1.4668	-0.4799	-1.5%	-0.5%
NEPH2-31	31	Al2O3	13.3304	13.2933	13.1330	0.1974	0.1603	1.5%	1.2%
NEPH2-31	31	B2O3	4.2744	4.3529	4.4800	-0.2056	-0.1271	-4.6%	-2.8%
NEPH2-31	31	BaO	0.0572	0.0632	0.0630	-0.0058	0.0002	-9.2%	0.3%
NEPH2-31	31	CaO	0.7986	0.8415	0.8450	-0.0464	-0.0035	-5.5%	-0.4%
NEPH2-31	31	Ce2O3	0.0673	0.0673	0.0850	-0.0177	-0.0177	-20.8%	-20.8%
NEPH2-31	31	Cr2O3	0.0961	0.0908	0.1100	-0.0139	-0.0192	-12.6%	-17.5%
NEPH2-31	31	CuO	0.0448	0.0466	0.0330	0.0118	0.0136	35.6%	41.3%
NEPH2-31	31	Fe2O3	8.6068	8.8343	9.3980	-0.7912	-0.5637	-8.4%	-6.0%
NEPH2-31	31	K2O	0.7682	0.8655	0.7550	0.0132	0.1105	1.8%	14.6%
NEPH2-31	31	La2O3	0.0325	0.0325	0.0360	-0.0035	-0.0035	-9.6%	-9.6%
NEPH2-31	31	Li2O	4.3650	4.4091	4.4800	-0.1150	-0.0709	-2.6%	-1.6%
NEPH2-31	31	MgO	0.4672	0.4927	0.4680	-0.0008	0.0247	-0.2%	5.3%
NEPH2-31	31	MnO	2.0885	2.1262	2.1120	-0.0235	0.0142	-1.1%	0.7%
NEPH2-31	31	Na2O	16.2434	15.4064	16.5330	-0.2896	-1.1266	-1.8%	-6.8%
NEPH2-31	31	NiO	1.3329	1.3959	1.5320	-0.1991	-0.1361	-13.0%	-8.9%
NEPH2-31	31	PbO	0.0811	0.0811	0.0860	-0.0049	-0.0049	-5.7%	-5.7%

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

(100 -Batch 1; 200 -U std)

Glass ID	Glass #	Oxide	Measured (wt%)	Measured Bias-Corrected (wt%)	Targeted (wt%)	Diff of Measured	Diff of Meas BC	% Diff of Measured	% Diff of Meas BC
NEPH2-31	31	SO4	0.4262	0.4262	0.4530	-0.0268	-0.0268	-5.9%	-5.9%
NEPH2-31	31	SiO2	41.5559	41.8079	42.0840	-0.5281	-0.2761	-1.3%	-0.7%
NEPH2-31	31	ThO2	0.0569	0.0569	0.0180	0.0389	0.0389	216.1%	216.1%
NEPH2-31	31	TiO2	0.0083	0.0088	0.0080	0.0003	0.0008	4.3%	9.5%
NEPH2-31	31	U3O8	2.9627	3.1243	3.1200	-0.1573	0.0043	-5.0%	0.1%
NEPH2-31	31	ZnO	0.0517	0.0517	0.0480	0.0037	0.0037	7.6%	7.6%
NEPH2-31	31	ZrO2	0.1131	0.1131	0.1200	-0.0069	-0.0069	-5.7%	-5.7%
NEPH2-31	31	Sum of Oxides	97.8294	97.9881	100.0000	-2.1706	-2.0119	-2.2%	-2.0%
NEPH2-32	32	Al2O3	13.6138	13.7796	14.3270	-0.7132	-0.5474	-5.0%	-3.8%
NEPH2-32	32	B2O3	3.7029	3.8251	4.1600	-0.4571	-0.3349	-11.0%	-8.1%
NEPH2-32	32	BaO	0.0558	0.0625	0.0690	-0.0132	-0.0065	-19.1%	-9.4%
NEPH2-32	32	CaO	0.8563	0.8920	0.9220	-0.0657	-0.0300	-7.1%	-3.2%
NEPH2-32	32	Ce2O3	0.0627	0.0627	0.0930	-0.0303	-0.0303	-32.6%	-32.6%
NEPH2-32	32	Cr2O3	0.1016	0.0976	0.1200	-0.0184	-0.0224	-15.3%	-18.6%
NEPH2-32	32	CuO	0.0410	0.0428	0.0360	0.0050	0.0068	13.9%	18.9%
NEPH2-32	32	Fe2O3	9.2823	9.5009	10.2520	-0.9697	-0.7511	-9.5%	-7.3%
NEPH2-32	32	K2O	0.9074	1.0078	0.8230	0.0844	0.1848	10.3%	22.5%
NEPH2-32	32	La2O3	0.0331	0.0331	0.0390	-0.0059	-0.0059	-15.0%	-15.0%
NEPH2-32	32	Li2O	3.8429	3.9106	4.1600	-0.3171	-0.2494	-7.6%	-6.0%
NEPH2-32	32	MgO	0.4788	0.5101	0.5110	-0.0322	-0.0009	-6.3%	-0.2%
NEPH2-32	32	MnO	2.1724	2.2873	2.3040	-0.1316	-0.0167	-5.7%	-0.7%
NEPH2-32	32	Na2O	16.6815	16.3361	17.0360	-0.3545	-0.6999	-2.1%	-4.1%
NEPH2-32	32	NiO	1.4252	1.4552	1.6720	-0.2468	-0.2168	-14.8%	-13.0%
NEPH2-32	32	PbO	0.0738	0.0738	0.0940	-0.0202	-0.0202	-21.5%	-21.5%
NEPH2-32	32	SO4	0.4711	0.4711	0.4950	-0.0239	-0.0239	-4.8%	-4.8%
NEPH2-32	32	SiO2	38.0261	38.2603	39.2730	-1.2469	-1.0127	-3.2%	-2.6%
NEPH2-32	32	ThO2	0.0569	0.0569	0.0200	0.0369	0.0369	184.5%	184.5%
NEPH2-32	32	TiO2	0.0083	0.0088	0.0090	-0.0007	-0.0002	-7.3%	-2.1%
NEPH2-32	32	U3O8	3.1219	3.3318	3.4030	-0.2811	-0.0712	-8.3%	-2.1%
NEPH2-32	32	ZnO	0.0538	0.0538	0.0520	0.0018	0.0018	3.5%	3.5%
NEPH2-32	32	ZrO2	0.1158	0.1158	0.1310	-0.0152	-0.0152	-11.6%	-11.6%
NEPH2-32	32	Sum of Oxides	95.1856	96.1760	100.0010	-4.8154	-3.8250	-4.8%	-3.8%
NEPH2-33	33	Al2O3	12.5416	12.6947	12.2380	0.3036	0.4567	2.5%	3.7%
NEPH2-33	33	B2O3	4.3791	4.5258	4.7200	-0.3409	-0.1942	-7.2%	-4.1%
NEPH2-33	33	BaO	0.0475	0.0531	0.0590	-0.0115	-0.0059	-19.6%	-10.0%
NEPH2-33	33	CaO	0.7451	0.7762	0.7880	-0.0429	-0.0118	-5.4%	-1.5%
NEPH2-33	33	Ce2O3	0.0533	0.0533	0.0790	-0.0257	-0.0257	-32.5%	-32.5%
NEPH2-33	33	Cr2O3	0.0946	0.0910	0.1030	-0.0084	-0.0120	-8.1%	-11.7%
NEPH2-33	33	CuO	0.0369	0.0386	0.0310	0.0059	0.0076	19.1%	24.4%
NEPH2-33	33	Fe2O3	8.1278	8.3263	8.7570	-0.6292	-0.4307	-7.2%	-4.9%
NEPH2-33	33	K2O	0.7472	0.8299	0.7030	0.0442	0.1269	6.3%	18.0%
NEPH2-33	33	La2O3	0.0340	0.0340	0.0330	0.0010	0.0010	3.1%	3.1%
NEPH2-33	33	Li2O	4.5319	4.6112	4.7200	-0.1881	-0.1088	-4.0%	-2.3%
NEPH2-33	33	MgO	0.4204	0.4479	0.4360	-0.0156	0.0119	-3.6%	2.7%
NEPH2-33	33	MnO	1.9239	2.0251	1.9680	-0.0441	0.0571	-2.2%	2.9%
NEPH2-33	33	Na2O	15.1987	14.8839	15.5650	-0.3663	-0.6811	-2.4%	-4.4%
NEPH2-33	33	NiO	1.2954	1.3238	1.4280	-0.1326	-0.1042	-9.3%	-7.3%
NEPH2-33	33	PbO	0.0692	0.0692	0.0800	-0.0108	-0.0108	-13.5%	-13.5%
NEPH2-33	33	SO4	0.3977	0.3977	0.4230	-0.0253	-0.0253	-6.0%	-6.0%
NEPH2-33	33	SiO2	44.2300	44.5066	44.7820	-0.5520	-0.2754	-1.2%	-0.6%
NEPH2-33	33	ThO2	0.0569	0.0569	0.0170	0.0399	0.0399	234.7%	234.7%
NEPH2-33	33	TiO2	0.0083	0.0088	0.0080	0.0003	0.0008	4.3%	10.1%
NEPH2-33	33	U3O8	2.7387	2.9239	2.9070	-0.1683	0.0169	-5.8%	0.6%
NEPH2-33	33	ZnO	0.0470	0.0470	0.0440	0.0030	0.0030	6.8%	6.8%
NEPH2-33	33	ZrO2	0.1003	0.1003	0.1120	-0.0117	-0.0117	-10.4%	-10.4%
NEPH2-33	33	Sum of Oxides	97.8254	98.8252	100.0010	-2.1756	-1.1758	-2.2%	-1.2%

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

(100 -Batch 1; 200 -U std)

Glass ID	Glass #	Oxide	Measured (wt%)	Measured Bias-Corrected (wt%)	Targeted (wt%)	Diff of Measured	Diff of Meas BC	% Diff of Measured	% Diff of Meas BC
NEPH2-34	34	Al2O3	13.6894	13.6517	13.4320	0.2574	0.2197	1.9%	1.6%
NEPH2-34	34	B2O3	4.0893	4.1643	4.4000	-0.3107	-0.2357	-7.1%	-5.4%
NEPH2-34	34	BaO	0.0553	0.0610	0.0650	-0.0097	-0.0040	-15.0%	-6.1%
NEPH2-34	34	CaO	0.7993	0.8422	0.8650	-0.0657	-0.0228	-7.6%	-2.6%
NEPH2-34	34	Ce2O3	0.0612	0.0612	0.0870	-0.0258	-0.0258	-29.7%	-29.7%
NEPH2-34	34	Cr2O3	0.1027	0.0970	0.1130	-0.0103	-0.0160	-9.1%	-14.2%
NEPH2-34	34	CuO	0.0457	0.0476	0.0340	0.0117	0.0136	34.4%	40.0%
NEPH2-34	34	Fe2O3	8.8963	9.1317	9.6120	-0.7157	-0.4803	-7.4%	-5.0%
NEPH2-34	34	K2O	0.8321	0.9374	0.7720	0.0601	0.1654	7.8%	21.4%
NEPH2-34	34	La2O3	0.0337	0.0337	0.0370	-0.0033	-0.0033	-8.9%	-8.9%
NEPH2-34	34	Li2O	4.3166	4.3601	4.4000	-0.0834	-0.0399	-1.9%	-0.9%
NEPH2-34	34	MgO	0.4585	0.4835	0.4790	-0.0205	0.0045	-4.3%	0.9%
NEPH2-34	34	MnO	2.1498	2.1877	2.1600	-0.0102	0.0277	-0.5%	1.3%
NEPH2-34	34	Na2O	16.2771	15.4385	16.1080	0.1691	-0.6695	1.0%	-4.2%
NEPH2-34	34	NiO	1.4347	1.5031	1.5670	-0.1323	-0.0639	-8.4%	-4.1%
NEPH2-34	34	PbO	0.0776	0.0776	0.0880	-0.0104	-0.0104	-11.9%	-11.9%
NEPH2-34	34	SO4	0.4374	0.4374	0.4640	-0.0266	-0.0266	-5.7%	-5.7%
NEPH2-34	34	SiO2	42.0907	42.3459	41.9310	0.1597	0.4149	0.4%	1.0%
NEPH2-34	34	ThO2	0.0569	0.0569	0.0190	0.0379	0.0379	199.4%	199.4%
NEPH2-34	34	TiO2	0.0083	0.0088	0.0080	0.0003	0.0008	4.3%	9.5%
NEPH2-34	34	U3O8	3.0748	3.2421	3.1900	-0.1152	0.0521	-3.6%	1.6%
NEPH2-34	34	ZnO	0.0523	0.0523	0.0490	0.0033	0.0033	6.7%	6.7%
NEPH2-34	34	ZrO2	0.1057	0.1057	0.1230	-0.0173	-0.0173	-14.1%	-14.1%
NEPH2-34	34	Sum of Oxides	99.1454	99.3274	100.0030	-0.8576	-0.6756	-0.9%	-0.7%
NEPH2-35	35	Al2O3	14.3649	14.3250	14.3270	0.0379	-0.0020	0.3%	0.0%
NEPH2-35	35	B2O3	3.7431	3.8119	4.1600	-0.4169	-0.3481	-10.0%	-8.4%
NEPH2-35	35	BaO	0.0575	0.0635	0.0690	-0.0115	-0.0055	-16.7%	-8.0%
NEPH2-35	35	CaO	0.8546	0.9004	0.9220	-0.0674	-0.0216	-7.3%	-2.3%
NEPH2-35	35	Ce2O3	0.0694	0.0694	0.0930	-0.0236	-0.0236	-25.4%	-25.4%
NEPH2-35	35	Cr2O3	0.0979	0.0925	0.1200	-0.0221	-0.0275	-18.4%	-22.9%
NEPH2-35	35	CuO	0.0432	0.0450	0.0360	0.0072	0.0090	20.0%	25.0%
NEPH2-35	35	Fe2O3	9.4039	9.6528	10.2520	-0.8481	-0.5992	-8.3%	-5.8%
NEPH2-35	35	K2O	0.8495	0.9571	0.8230	0.0265	0.1341	3.2%	16.3%
NEPH2-35	35	La2O3	0.0367	0.0367	0.0390	-0.0024	-0.0024	-6.0%	-6.0%
NEPH2-35	35	Li2O	4.0313	4.0720	4.1600	-0.1287	-0.0880	-3.1%	-2.1%
NEPH2-35	35	MgO	0.4983	0.5255	0.5110	-0.0127	0.0145	-2.5%	2.8%
NEPH2-35	35	MnO	2.2531	2.2936	2.3040	-0.0509	-0.0104	-2.2%	-0.5%
NEPH2-35	35	Na2O	16.4456	15.5982	16.5160	-0.0704	-0.9178	-0.4%	-5.6%
NEPH2-35	35	NiO	1.4602	1.5296	1.6720	-0.2118	-0.1424	-12.7%	-8.5%
NEPH2-35	35	PbO	0.0878	0.0878	0.0940	-0.0062	-0.0062	-6.6%	-6.6%
NEPH2-35	35	SO4	0.4614	0.4614	0.4950	-0.0336	-0.0336	-6.8%	-6.8%
NEPH2-35	35	SiO2	39.2027	39.4405	39.7930	-0.5903	-0.3525	-1.5%	-0.9%
NEPH2-35	35	ThO2	0.0569	0.0569	0.0200	0.0369	0.0369	184.5%	184.5%
NEPH2-35	35	TiO2	0.0083	0.0088	0.0090	-0.0007	-0.0002	-7.3%	-2.6%
NEPH2-35	35	U3O8	3.1986	3.3730	3.4030	-0.2044	-0.0300	-6.0%	-0.9%
NEPH2-35	35	ZnO	0.0560	0.0560	0.0520	0.0040	0.0040	7.7%	7.7%
NEPH2-35	35	ZrO2	0.1145	0.1145	0.1310	-0.0165	-0.0165	-12.6%	-12.6%
NEPH2-35	35	Sum of Oxides	97.3954	97.5719	100.0010	-2.6056	-2.4291	-2.6%	-2.4%
NEPH2-36	36	Al2O3	12.4801	12.6323	12.5360	-0.0559	0.0963	-0.4%	0.8%
NEPH2-36	36	B2O3	4.2020	4.3422	4.6400	-0.4380	-0.2978	-9.4%	-6.4%
NEPH2-36	36	BaO	0.0530	0.0594	0.0600	-0.0070	-0.0006	-11.6%	-1.1%
NEPH2-36	36	CaO	0.7556	0.7871	0.8070	-0.0514	-0.0199	-6.4%	-2.5%
NEPH2-36	36	Ce2O3	0.0568	0.0568	0.0810	-0.0242	-0.0242	-29.9%	-29.9%
NEPH2-36	36	Cr2O3	0.0983	0.0945	0.1050	-0.0067	-0.0105	-6.4%	-10.0%
NEPH2-36	36	CuO	0.0394	0.0412	0.0310	0.0084	0.0102	27.2%	32.8%
NEPH2-36	36	Fe2O3	8.3137	8.5149	8.9710	-0.6573	-0.4561	-7.3%	-5.1%

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

(100 -Batch 1; 200 -U std)

Glass ID	Glass #	Oxide	Measured (wt%)	Measured Bias-Corrected (wt%)	Targeted (wt%)	Diff of Measured	Diff of Meas BC	% Diff of Measured	% Diff of Meas BC
NEPH2-36	36	K2O	0.7613	0.8456	0.7200	0.0413	0.1256	5.7%	17.4%
NEPH2-36	36	La2O3	0.0311	0.0311	0.0340	-0.0029	-0.0029	-8.6%	-8.6%
NEPH2-36	36	Li2O	4.4188	4.4969	4.6400	-0.2212	-0.1431	-4.8%	-3.1%
NEPH2-36	36	MgO	0.4266	0.4545	0.4470	-0.0204	0.0075	-4.6%	1.7%
NEPH2-36	36	MnO	1.9659	2.0697	2.0160	-0.0501	0.0537	-2.5%	2.7%
NEPH2-36	36	Na2O	15.2998	14.9830	15.1210	0.1788	-0.1380	1.2%	-0.9%
NEPH2-36	36	NiO	1.2970	1.3257	1.4630	-0.1660	-0.1373	-11.3%	-9.4%
NEPH2-36	36	PbO	0.0692	0.0692	0.0820	-0.0128	-0.0128	-15.6%	-15.6%
NEPH2-36	36	SO4	0.4022	0.4022	0.4330	-0.0308	-0.0308	-7.1%	-7.1%
NEPH2-36	36	SiO2	44.4974	44.7790	44.6490	-0.1516	0.1300	-0.3%	0.3%
NEPH2-36	36	ThO2	0.0569	0.0569	0.0170	0.0399	0.0399	234.7%	234.7%
NEPH2-36	36	TiO2	0.0083	0.0088	0.0080	0.0003	0.0008	4.3%	10.1%
NEPH2-36	36	U3O8	2.6945	2.8759	2.9780	-0.2835	-0.1021	-9.5%	-3.4%
NEPH2-36	36	ZnO	0.0470	0.0470	0.0450	0.0020	0.0020	4.4%	4.4%
NEPH2-36	36	ZrO2	0.1057	0.1057	0.1150	-0.0093	-0.0093	-8.1%	-8.1%
NEPH2-36	36	Sum of Oxides	98.0807	99.0795	99.9990	-1.9183	-0.9195	-1.9%	-0.9%
NEPH2-37	37	Al2O3	13.2737	13.2369	13.4320	-0.1583	-0.1951	-1.2%	-1.5%
NEPH2-37	37	B2O3	4.0329	4.1071	4.4000	-0.3671	-0.2929	-8.3%	-6.7%
NEPH2-37	37	BaO	0.0542	0.0598	0.0650	-0.0108	-0.0052	-16.7%	-8.0%
NEPH2-37	37	CaO	0.8038	0.8470	0.8650	-0.0612	-0.0180	-7.1%	-2.1%
NEPH2-37	37	Ce2O3	0.0676	0.0676	0.0870	-0.0194	-0.0194	-22.2%	-22.2%
NEPH2-37	37	Cr2O3	0.1019	0.0963	0.1130	-0.0111	-0.0167	-9.8%	-14.8%
NEPH2-37	37	CuO	0.0391	0.0407	0.0340	0.0051	0.0067	15.1%	19.8%
NEPH2-37	37	Fe2O3	8.8141	9.0476	9.6120	-0.7979	-0.5644	-8.3%	-5.9%
NEPH2-37	37	K2O	0.8194	0.9232	0.7720	0.0474	0.1512	6.1%	19.6%
NEPH2-37	37	La2O3	0.0325	0.0325	0.0370	-0.0045	-0.0045	-12.0%	-12.0%
NEPH2-37	37	Li2O	4.1659	4.2079	4.4000	-0.2341	-0.1921	-5.3%	-4.4%
NEPH2-37	37	MgO	0.4660	0.4914	0.4790	-0.0130	0.0124	-2.7%	2.6%
NEPH2-37	37	MnO	2.1111	2.1499	2.1600	-0.0489	-0.0101	-2.3%	-0.5%
NEPH2-37	37	Na2O	15.7379	14.9269	15.5580	0.1799	-0.6311	1.2%	-4.1%
NEPH2-37	37	NiO	1.3998	1.4668	1.5670	-0.1673	-0.1002	-10.7%	-6.4%
NEPH2-37	37	PbO	0.0746	0.0746	0.0880	-0.0134	-0.0134	-15.2%	-15.2%
NEPH2-37	37	SO4	0.4232	0.4232	0.4640	-0.0408	-0.0408	-8.8%	-8.8%
NEPH2-37	37	SiO2	42.2512	42.5076	42.4810	-0.2298	0.0266	-0.5%	0.1%
NEPH2-37	37	ThO2	0.0569	0.0569	0.0190	0.0379	0.0379	199.4%	199.4%
NEPH2-37	37	TiO2	0.0083	0.0088	0.0080	0.0003	0.0008	4.3%	9.5%
NEPH2-37	37	U3O8	2.9981	3.1616	3.1900	-0.1919	-0.0284	-6.0%	-0.9%
NEPH2-37	37	ZnO	0.0513	0.0513	0.0490	0.0023	0.0023	4.8%	4.8%
NEPH2-37	37	ZrO2	0.1118	0.1118	0.1230	-0.0112	-0.0112	-9.1%	-9.1%
NEPH2-37	37	Sum of Oxides	97.8955	98.0974	100.0030	-2.1075	-1.9056	-2.1%	-1.9%
NEPH2-38	38	Al2O3	14.4122	14.3730	14.0290	0.3832	0.3440	2.7%	2.5%
NEPH2-38	38	B2O3	4.0088	4.0824	4.2400	-0.2312	-0.1576	-5.5%	-3.7%
NEPH2-38	38	BaO	0.0631	0.0696	0.0680	-0.0049	0.0016	-7.2%	2.4%
NEPH2-38	38	CaO	0.8332	0.8780	0.9030	-0.0698	-0.0250	-7.7%	-2.8%
NEPH2-38	38	Ce2O3	0.0633	0.0633	0.0910	-0.0277	-0.0277	-30.5%	-30.5%
NEPH2-38	38	Cr2O3	0.1173	0.1108	0.1180	-0.0007	-0.0072	-0.6%	-6.1%
NEPH2-38	38	CuO	0.0432	0.0450	0.0350	0.0082	0.0100	23.4%	28.5%
NEPH2-38	38	Fe2O3	9.8864	10.1475	10.0390	-0.1526	0.1085	-1.5%	1.1%
NEPH2-38	38	K2O	0.8535	0.9615	0.8060	0.0475	0.1555	5.9%	19.3%
NEPH2-38	38	La2O3	0.0320	0.0320	0.0380	-0.0060	-0.0060	-15.9%	-15.9%
NEPH2-38	38	Li2O	4.1820	4.2242	4.2400	-0.0580	-0.0158	-1.4%	-0.4%
NEPH2-38	38	MgO	0.4933	0.5202	0.5000	-0.0067	0.0202	-1.3%	4.0%
NEPH2-38	38	MnO	2.2822	2.3217	2.2560	0.0262	0.0657	1.2%	2.9%
NEPH2-38	38	Na2O	16.1086	15.2787	15.8500	0.2586	-0.5713	1.6%	-3.6%
NEPH2-38	38	NiO	1.5461	1.6190	1.6370	-0.0909	-0.0180	-5.6%	-1.1%
NEPH2-38	38	PbO	0.0862	0.0862	0.0920	-0.0058	-0.0058	-6.3%	-6.3%

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

(100 -Batch 1; 200 -U std)

Glass ID	Glass #	Oxide	Measured (wt%)	Measured Bias-Corrected (wt%)	Targeted (wt%)	Diff of Measured	Diff of Meas BC	% Diff of Measured	% Diff of Meas BC
NEPH2-38	38	SO4	0.4479	0.4479	0.4840	-0.0361	-0.0361	-7.5%	-7.5%
NEPH2-38	38	SiO2	41.7164	41.9693	41.0360	0.6803	0.9333	1.7%	2.3%
NEPH2-38	38	ThO2	0.0569	0.0569	0.0200	0.0369	0.0369	184.5%	184.5%
NEPH2-38	38	TiO2	0.0083	0.0088	0.0090	-0.0007	-0.0002	-7.3%	-2.6%
NEPH2-38	38	U3O8	3.2723	3.4502	3.3320	-0.0597	0.1182	-1.8%	3.5%
NEPH2-38	38	ZnO	0.0526	0.0526	0.0510	0.0016	0.0016	3.1%	3.1%
NEPH2-38	38	ZrO2	0.1192	0.1192	0.1280	-0.0088	-0.0088	-6.9%	-6.9%
NEPH2-38	38	Sum of Oxides	100.6847	100.9180	100.0020	0.6827	0.9160	0.7%	0.9%
NEPH2-39	39	Al2O3	13.0139	13.1722	12.8350	0.1789	0.3372	1.4%	2.6%
NEPH2-39	39	B2O3	4.3308	4.4732	4.5600	-0.2292	-0.0868	-5.0%	-1.9%
NEPH2-39	39	BaO	0.0533	0.0597	0.0620	-0.0087	-0.0023	-14.0%	-3.8%
NEPH2-39	39	CaO	0.7755	0.8079	0.8260	-0.0505	-0.0181	-6.1%	-2.2%
NEPH2-39	39	Ce2O3	0.0621	0.0621	0.0830	-0.0209	-0.0209	-25.2%	-25.2%
NEPH2-39	39	Cr2O3	0.0870	0.0836	0.1080	-0.0210	-0.0244	-19.5%	-22.6%
NEPH2-39	39	CuO	0.0385	0.0402	0.0320	0.0065	0.0082	20.3%	25.6%
NEPH2-39	39	Fe2O3	8.4781	8.6740	9.1840	-0.7059	-0.5100	-7.7%	-5.6%
NEPH2-39	39	K2O	0.7390	0.8209	0.7370	0.0020	0.0839	0.3%	11.4%
NEPH2-39	39	La2O3	0.0352	0.0352	0.0350	0.0002	0.0002	0.5%	0.5%
NEPH2-39	39	Li2O	4.4888	4.5685	4.5600	-0.0712	0.0085	-1.6%	0.2%
NEPH2-39	39	MgO	0.4569	0.4867	0.4580	-0.0011	0.0287	-0.2%	6.3%
NEPH2-39	39	MnO	1.9755	2.0789	2.0640	-0.0885	0.0149	-4.3%	0.7%
NEPH2-39	39	Na2O	14.4573	14.1579	14.6970	-0.2397	-0.5391	-1.6%	-3.7%
NEPH2-39	39	NiO	1.3177	1.3456	1.4980	-0.1803	-0.1524	-12.0%	-10.2%
NEPH2-39	39	PbO	0.0789	0.0789	0.0840	-0.0051	-0.0051	-6.1%	-6.1%
NEPH2-39	39	SO4	0.3985	0.3985	0.4430	-0.0445	-0.0445	-10.1%	-10.1%
NEPH2-39	39	SiO2	44.7649	45.0471	44.4970	0.2679	0.5501	0.6%	1.2%
NEPH2-39	39	ThO2	0.0569	0.0569	0.0180	0.0389	0.0389	216.1%	216.1%
NEPH2-39	39	TiO2	0.0083	0.0088	0.0080	0.0003	0.0008	4.3%	10.1%
NEPH2-39	39	U3O8	2.8684	3.0608	3.0490	-0.1806	0.0118	-5.9%	0.4%
NEPH2-39	39	ZnO	0.0501	0.0501	0.0460	0.0041	0.0041	8.9%	8.9%
NEPH2-39	39	ZrO2	0.1084	0.1084	0.1170	-0.0086	-0.0086	-7.3%	-7.3%
NEPH2-39	39	Sum of Oxides	98.6439	99.6760	100.0010	-1.3571	-0.3250	-1.4%	-0.3%
NEPH2-40	40	Al2O3	13.8075	13.7693	13.7300	0.0775	0.0393	0.6%	0.3%
NEPH2-40	40	B2O3	3.9927	4.0661	4.3200	-0.3273	-0.2539	-7.6%	-5.9%
NEPH2-40	40	BaO	0.0539	0.0595	0.0660	-0.0121	-0.0065	-18.4%	-9.9%
NEPH2-40	40	CaO	0.8238	0.8680	0.8840	-0.0602	-0.0160	-6.8%	-1.8%
NEPH2-40	40	Ce2O3	0.0662	0.0662	0.0890	-0.0228	-0.0228	-25.6%	-25.6%
NEPH2-40	40	Cr2O3	0.0972	0.0918	0.1150	-0.0178	-0.0232	-15.5%	-20.2%
NEPH2-40	40	CuO	0.0388	0.0404	0.0340	0.0048	0.0064	14.1%	18.9%
NEPH2-40	40	Fe2O3	8.9070	9.1427	9.8250	-0.9180	-0.6823	-9.3%	-6.9%
NEPH2-40	40	K2O	0.8459	0.9530	0.7890	0.0569	0.1640	7.2%	20.8%
NEPH2-40	40	La2O3	0.0343	0.0343	0.0370	-0.0027	-0.0027	-7.3%	-7.3%
NEPH2-40	40	Li2O	4.1605	4.2025	4.3200	-0.1595	-0.1175	-3.7%	-2.7%
NEPH2-40	40	MgO	0.4722	0.4979	0.4900	-0.0178	0.0079	-3.6%	1.6%
NEPH2-40	40	MnO	2.1466	2.1848	2.2080	-0.0614	-0.0232	-2.8%	-1.0%
NEPH2-40	40	Na2O	15.4683	14.6712	15.1640	0.3043	-0.4928	2.0%	-3.2%
NEPH2-40	40	NiO	1.3902	1.4564	1.6020	-0.2118	-0.1456	-13.2%	-9.1%
NEPH2-40	40	PbO	0.0803	0.0803	0.0900	-0.0097	-0.0097	-10.8%	-10.8%
NEPH2-40	40	SO4	0.4292	0.4292	0.4740	-0.0448	-0.0448	-9.5%	-9.5%
NEPH2-40	40	SiO2	42.1977	42.4538	42.2990	-0.1013	0.1548	-0.2%	0.4%
NEPH2-40	40	ThO2	0.0569	0.0569	0.0190	0.0379	0.0379	199.4%	199.4%
NEPH2-40	40	TiO2	0.0083	0.0088	0.0090	-0.0007	-0.0002	-7.3%	-2.6%
NEPH2-40	40	U3O8	3.1131	3.2828	3.2610	-0.1479	0.0218	-4.5%	0.7%
NEPH2-40	40	ZnO	0.0532	0.0532	0.0500	0.0032	0.0032	6.4%	6.4%
NEPH2-40	40	ZrO2	0.1152	0.1152	0.1260	-0.0108	-0.0108	-8.6%	-8.6%
NEPH2-40	40	Sum of Oxides	98.3589	98.5842	100.0010	-1.6421	-1.4168	-1.6%	-1.4%

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

(100 -Batch 1; 200 -U std)

Glass ID	Glass #	Oxide	Measured (wt%)	Measured Bias-Corrected (wt%)	Targeted (wt%)	Diff of Measured	Diff of Meas BC	% Diff of Measured	% Diff of Meas BC
Batch 1	100	Al2O3	4.8678	4.8770	4.8770	-0.0092	0.0000	-0.2%	0.0%
Batch 1	100	B2O3	7.6486	7.7770	7.7770	-0.1284	0.0000	-1.7%	0.0%
Batch 1	100	BaO	0.1358	0.1510	0.1510	-0.0152	0.0000	-10.0%	0.0%
Batch 1	100	CaO	1.1570	1.2200	1.2200	-0.0630	0.0000	-5.2%	0.0%
Batch 1	100	Ce2O3	0.0059	0.0059	0.0000	0.0059	0.0059		
Batch 1	100	Cr2O3	0.1128	0.1070	0.1070	0.0058	0.0000	5.4%	0.0%
Batch 1	100	CuO	0.3805	0.3990	0.3990	-0.0185	0.0000	-4.6%	0.0%
Batch 1	100	Fe2O3	12.5236	12.8390	12.8390	-0.3154	0.0000	-2.5%	0.0%
Batch 1	100	K2O	2.9616	3.3270	3.3270	-0.3654	0.0000	-11.0%	0.0%
Batch 1	100	La2O3	0.0059	0.0059	0.0000	0.0059	0.0059		
Batch 1	100	Li2O	4.3659	4.4290	4.4290	-0.0631	0.0000	-1.4%	0.0%
Batch 1	100	MgO	1.3381	1.4190	1.4190	-0.0809	0.0000	-5.7%	0.0%
Batch 1	100	MnO	1.6769	1.7260	1.7260	-0.0491	0.0000	-2.8%	0.0%
Batch 1	100	Na2O	9.3523	9.0030	9.0030	0.3493	0.0000	3.9%	0.0%
Batch 1	100	NiO	0.7227	0.7510	0.7510	-0.0283	0.0000	-3.8%	0.0%
Batch 1	100	PbO	0.0054	0.0054	0.0000	0.0054	0.0054		
Batch 1	100	SO4	0.1498	0.1498	0.0000	0.1498	0.1498		
Batch 1	100	SiO2	49.8813	50.2200	50.2200	-0.3387	0.0000	-0.7%	0.0%
Batch 1	100	ThO2	0.0569	0.0569	0.0000	0.0569	0.0569		
Batch 1	100	TiO2	0.6396	0.6770	0.6770	-0.0374	0.0000	-5.5%	0.0%
Batch 1	100	U3O8	0.0590	0.0623	0.0000	0.0590	0.0623		
Batch 1	100	ZnO	0.0062	0.0062	0.0000	0.0062	0.0062		
Batch 1	100	ZrO2	0.0798	0.0798	0.0980	-0.0182	-0.0182	-18.6%	-18.6%
Batch 1	100	Sum of Oxides	98.1333	99.2941	99.0200	-0.8867	0.2741	-0.9%	0.3%
Ustd	200	Al2O3	4.0183	4.0260	4.1000	-0.0817	-0.0740	-2.0%	-1.8%
Ustd	200	B2O3	8.7259	8.8723	9.2090	-0.4831	-0.3367	-5.2%	-3.7%
Ustd	200	BaO	0.0056	0.0062	0.0000	0.0056	0.0062		
Ustd	200	CaO	1.2182	1.2846	1.3010	-0.0828	-0.0164	-6.4%	-1.3%
Ustd	200	Ce2O3	0.0059	0.0059	0.0000	0.0059	0.0059		
Ustd	200	Cr2O3	0.2318	0.2199	0.0000	0.2318	0.2199		
Ustd	200	CuO	0.0063	0.0066	0.0000	0.0063	0.0066		
Ustd	200	Fe2O3	12.5629	12.8781	13.1960	-0.6331	-0.3179	-4.8%	-2.4%
Ustd	200	K2O	2.8203	3.1686	2.9990	-0.1787	0.1696	-6.0%	5.7%
Ustd	200	La2O3	0.0059	0.0059	0.0000	0.0059	0.0059		
Ustd	200	Li2O	2.9665	3.0094	3.0570	-0.0905	-0.0476	-3.0%	-1.6%
Ustd	200	MgO	1.0885	1.1543	1.2100	-0.1215	-0.0557	-10.0%	-4.6%
Ustd	200	MnO	2.7164	2.7964	2.8920	-0.1756	-0.0956	-6.1%	-3.3%
Ustd	200	Na2O	11.7540	11.3166	11.7950	-0.0410	-0.4784	-0.3%	-4.1%
Ustd	200	NiO	0.9975	1.0376	1.1200	-0.1225	-0.0824	-10.9%	-7.4%
Ustd	200	PbO	0.0054	0.0054	0.0000	0.0054	0.0054		
Ustd	200	SO4	0.1498	0.1498	0.0000	0.1498	0.1498		
Ustd	200	SiO2	43.9804	44.2809	45.3530	-1.3726	-1.0721	-3.0%	-2.4%
Ustd	200	ThO2	0.0569	0.0569	0.0000	0.0569	0.0569		
Ustd	200	TiO2	0.8828	0.9344	1.0490	-0.1662	-0.1146	-15.8%	-10.9%
Ustd	200	U3O8	2.2768	2.4060	2.4060	-0.1292	0.0000	-5.4%	0.0%
Ustd	200	ZnO	0.0062	0.0062	0.0000	0.0062	0.0062		
Ustd	200	ZrO2	0.0068	0.0068	0.0000	0.0068	0.0068		
Ustd	200	Sum of Oxides	96.4890	97.6346	99.6870	-3.1980	-2.0524	-3.2%	-2.1%

Table C5. Summary of PSAL Elemental Data for Neph2-21, Neph2-27, and Neph2-28 Remeasurements

Sample Preparation: $LiBO_2$ and Na_2O_2/NaOH fusions

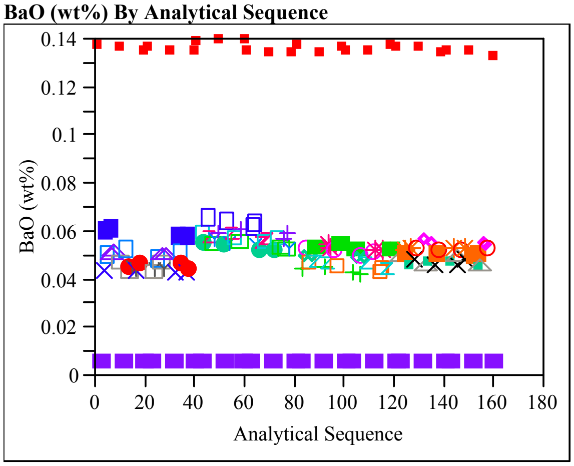
(wt%)	Neph2-21 (A) 05-1249	Neph2-21 (B) 05-1249	Neph2-27 (A) 05-1250	Neph2-27 (B) 05-1250	Neph2-28 (A) 05-1251	Neph2-28 (B) 05-1251
Al	5.71	5.87	6.71	6.85	6.38	6.40
B	1.55	1.55	1.47	1.49	1.65	1.65
Ba	0.043	0.043	0.045	0.047	0.040	0.041
Ca	0.694	0.625	0.613	0.653	0.585	0.619
Cr	0.071	0.069	0.069	0.068	0.078	0.079
Cu	0.027	0.027	0.028	0.028	0.031	0.028
Ce	0.047	0.047	0.038	0.038	0.045	0.046
Fe	6.78	6.75	5.95	6.08	6.92	6.79
K	0.583	0.572	0.692	0.662	0.636	0.661
Li	2.08	2.14	2.17	2.19	2.11	2.11
Mn	1.64	1.64	1.66	1.72	1.53	1.50
Mg	0.336	0.334	0.251	0.266	0.237	0.240
Na	11.8	11.6	11.9	12.2	11.1	11.1
Ni	0.973	0.966	1.00	1.02	1.16	1.13
Pb	0.057	0.06	0.058	0.059	0.067	0.068
S	0.168	0.15	0.156	0.149	0.158	0.170
Si	20.9	21.0	20.8	21.0	19.7	20
Th	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100
Ti	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
U	2.54	2.6	2.26	2.33	2.78	2.77
Zn	<0.010	<0.010	0.035	0.035	0.036	0.043
Zr	0.075	0.074	0.077	0.079	0.076	0.075

Table C6. Comparison of Target Versus Measured for Neph2-21, Neph2-27, and Neph2-28 Remeasurements

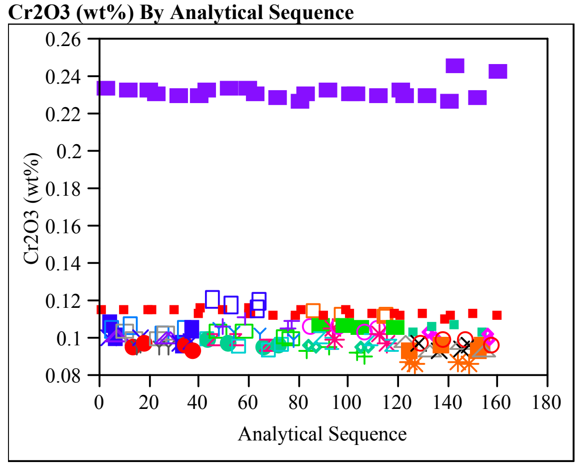
Oxide	Glass	Original Measurement	Target	Re-Measurement	Glass	Original Measurement	Target	Re-Measurement	Glass	Original Measurement	Target	Re-Measurement
Al2O3 (wt%)	21	10.298	10.995	10.94	27	13.165	11.641	12.811	28	11.772	13.133	12.074
B2O3 (wt%)	21	4.105	4.64	4.991	27	4.057	4.88	4.765	28	4.484	4.48	5.313
BaO (wt%)	21	0.045	0.057	0.048	27	0.05	0.056	0.051	28	0.046	0.063	0.045
CaO (wt%)	21	0.767	0.836	0.923	27	0.786	0.749	0.886	28	0.738	0.845	0.842
Ce2O3 (wt%)	21	0.06	0.078	0.082	27	0.05	0.075	0.08	28	0.058	0.085	0.092
Cr2O3 (wt%)	21	0.101	0.098	0.039	27	0.094	0.098	0.041	28	0.104	0.11	0.043
CuO (wt%)	21	0.037	0.031	0.059	27	0.038	0.029	0.048	28	0.037	0.033	0.057
Fe2O3 (wt%)	21	8.382	9.313	9.672	27	7.728	8.33	8.6	28	8.782	9.398	9.801
K2O (wt%)	21	0.651	0.587	0.696	27	0.779	0.669	0.816	28	0.695	0.755	0.781
La2O3 (wt%)	21	0.034	0.034	0	27	0.032	0.032	0	28	0.03	0.036	0
Li2O (wt%)	21	4.134	4.64	4.543	27	4.709	4.88	4.693	28	4.343	4.48	4.543
MgO (wt%)	21	0.561	0.59	0.556	27	0.456	0.415	0.429	28	0.415	0.468	0.396
MnO (wt%)	21	1.992	2.047	2.118	27	1.998	1.872	2.182	28	1.798	2.112	1.956
Na2O (wt%)	21	15.873	16.393	15.772	27	16.041	16.514	16.243	28	15.94	17.093	14.963
NiO (wt%)	21	1.109	1.284	1.234	27	1.206	1.358	1.285	28	1.377	1.532	1.457
PbO (wt%)	21	0.065	0.074	0.063	27	0.062	0.076	0.063	28	0.082	0.086	0.073
SO4 (wt%)	21	0.471	0.449	0.476	27	0.433	0.402	0.457	28	0.389	0.453	0.491
SiO2 (wt%)	21	43.642	44.624	44.818	27	44.444	44.987	44.711	28	41.235	41.524	42.465
ThO2 (wt%)	21	0.057	0.016	0.057	27	0.057	0.016	0.057	28	0.057	0.018	0.057
TiO2 (wt%)	21	0.008	0.008	0.008	27	0.008	0.007	0.008	28	0.008	0.008	0.008
U3O8 (wt%)	21	2.724	3.054	3.031	27	2.553	2.765	2.706	28	2.963	3.12	3.272
ZnO (wt%)	21	0.014	0.045	0.006	27	0.049	0.042	0.044	28	0.048	0.048	0.049
ZrO2 (wt%)	21	0.096	0.107	0.101	27	0.106	0.107	0.105	28	0.101	0.12	0.102
SUM	21	95.225	100	100.231	27	98.9	100	101.082	28	95.503	100	98.88

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

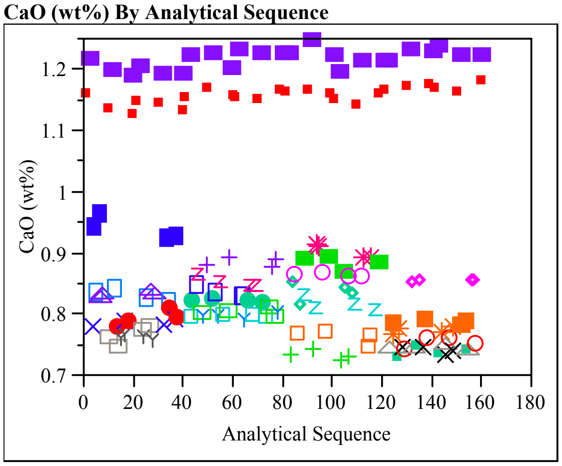
BaO (wt%) By Analytical Sequence



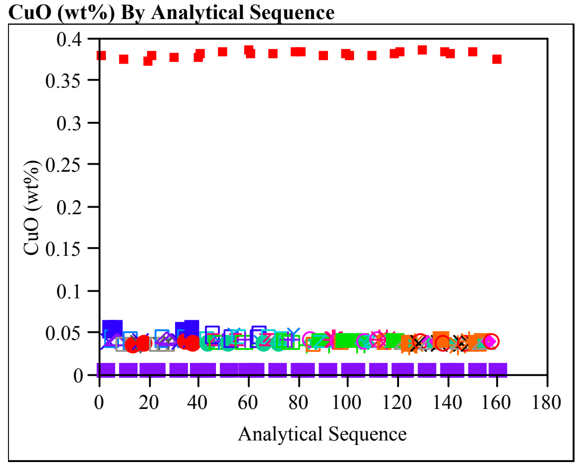
Cr2O3 (wt%) By Analytical Sequence



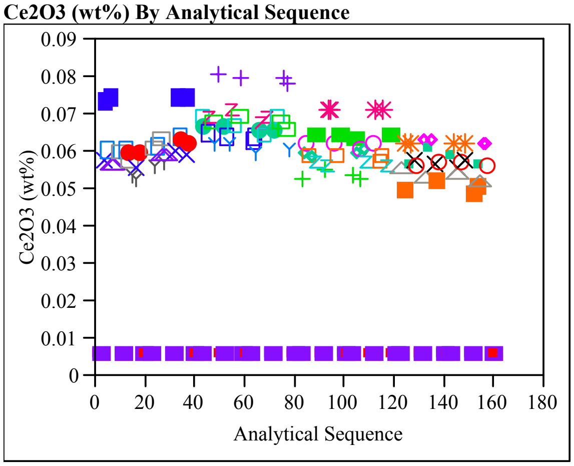
CaO (wt%) By Analytical Sequence



CuO (wt%) By Analytical Sequence



Ce2O3 (wt%) By Analytical Sequence



K2O (wt%) By Analytical Sequence

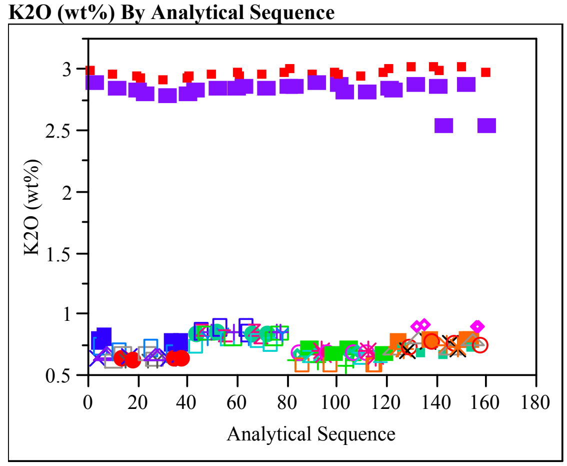
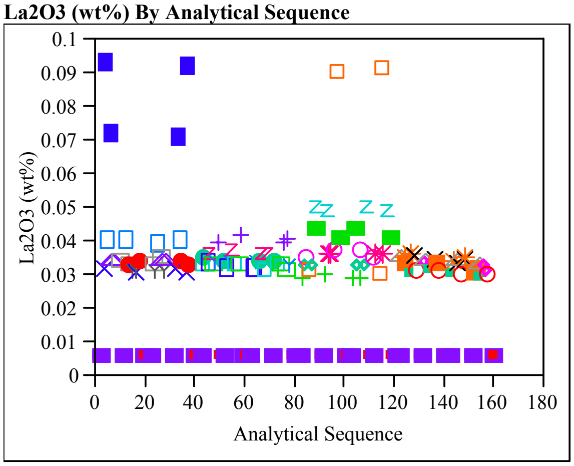
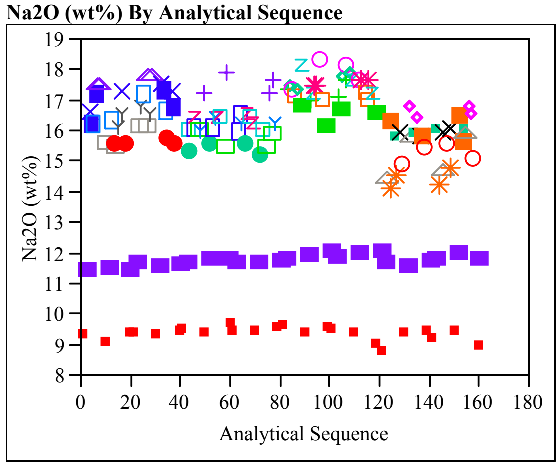


Exhibit C1. Oxide Measurements in Analytical Sequence for Samples Prepared Using the LM Method

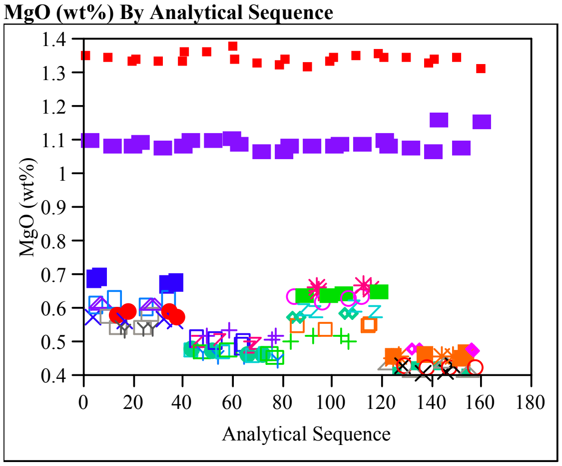
La2O3 (wt%) By Analytical Sequence



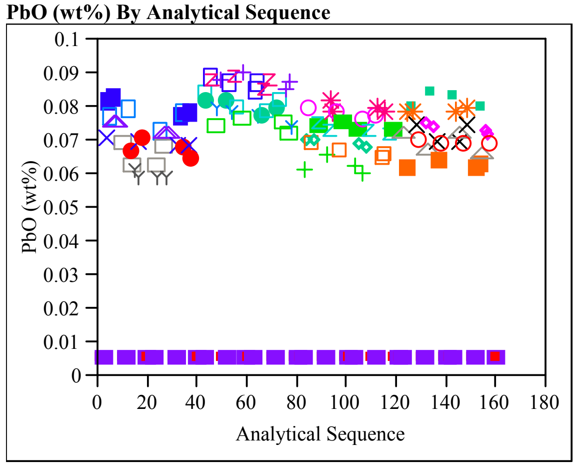
Na2O (wt%) By Analytical Sequence



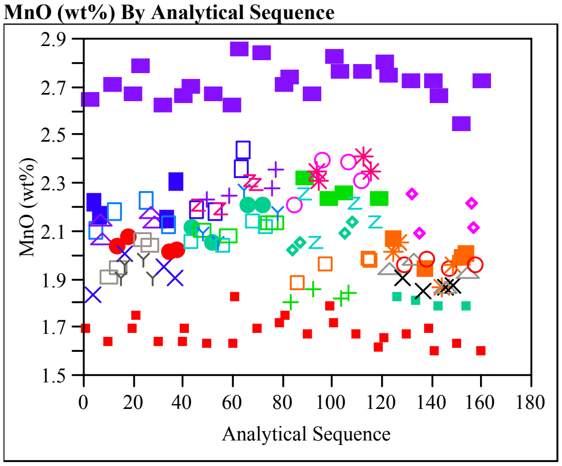
MgO (wt%) By Analytical Sequence



PbO (wt%) By Analytical Sequence



MnO (wt%) By Analytical Sequence



SO4 (wt%) By Analytical Sequence

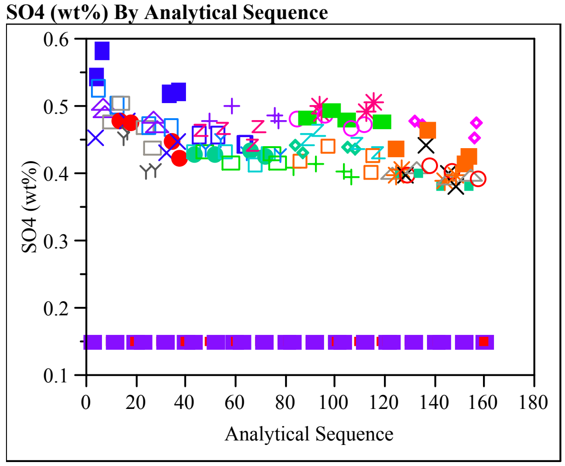
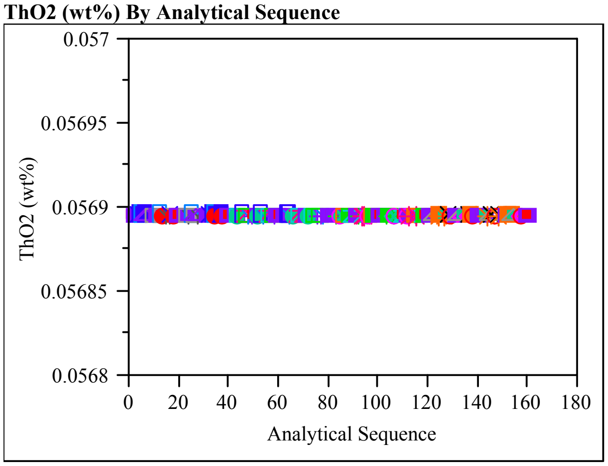
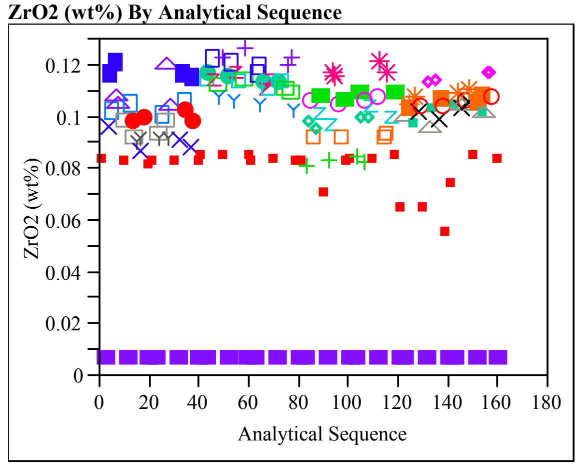


Exhibit C1. Oxide Measurements in Analytical Sequence for Samples Prepared Using the LM Method

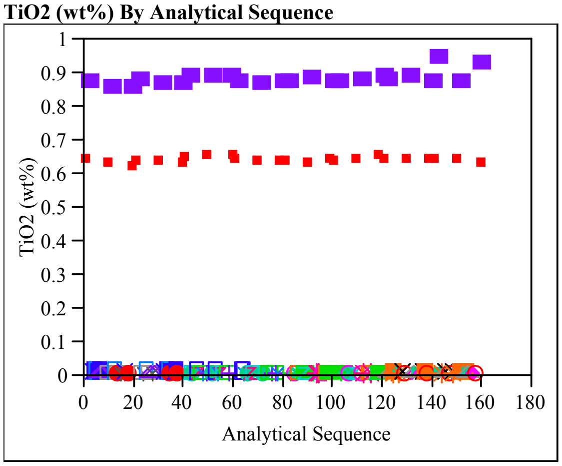
ThO2 (wt%) By Analytical Sequence



ZrO2 (wt%) By Analytical Sequence



TiO2 (wt%) By Analytical Sequence



ZnO (wt%) By Analytical Sequence

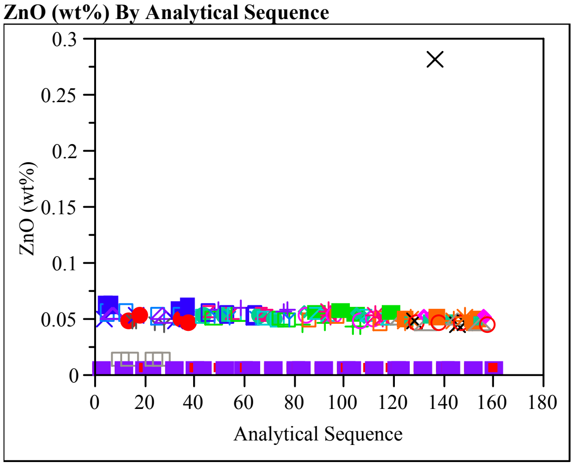
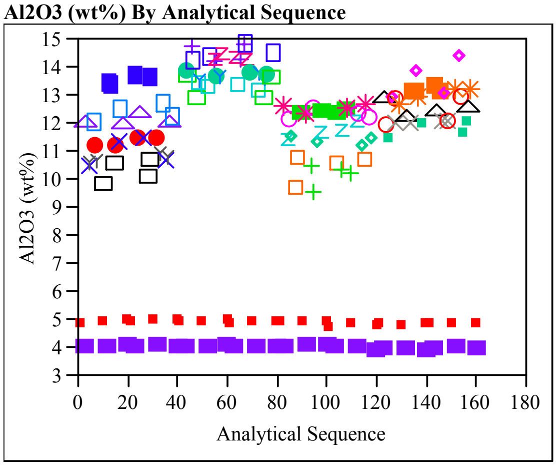
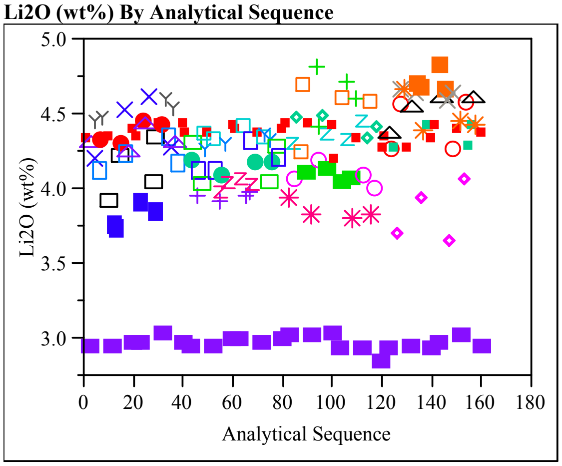


Exhibit C2. Oxide Measurements in Analytical Sequence for Samples Prepared Using the PF Method

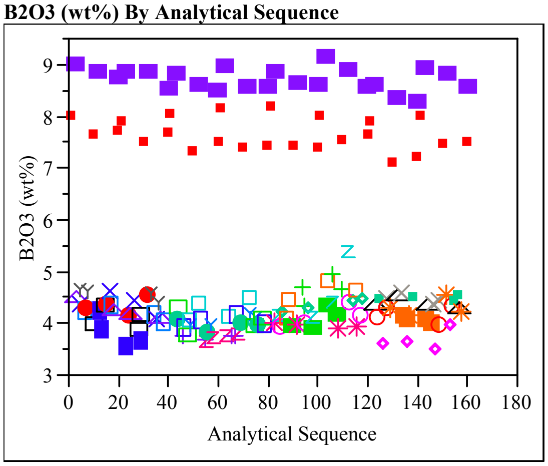
Al2O3 (wt%) By Analytical Sequence



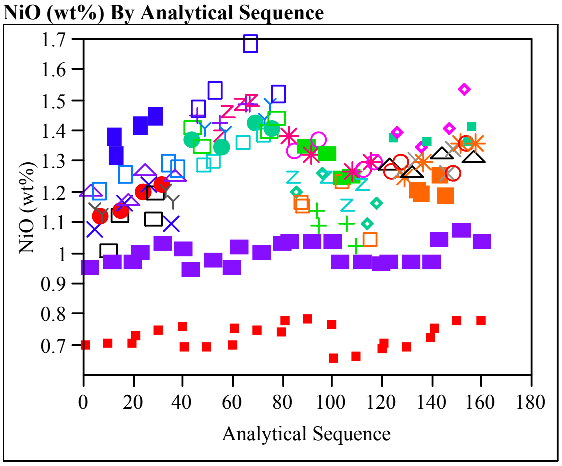
Li2O (wt%) By Analytical Sequence



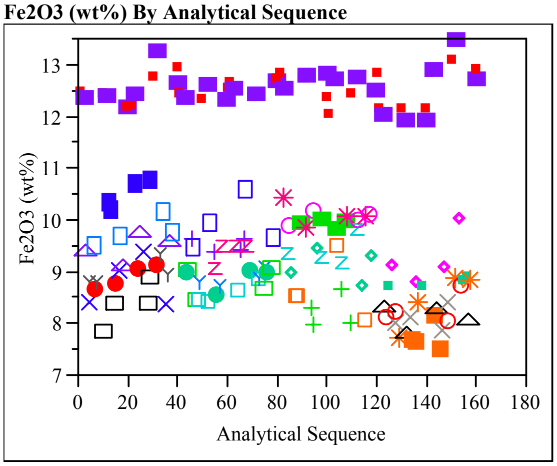
B2O3 (wt%) By Analytical Sequence



NiO (wt%) By Analytical Sequence



Fe2O3 (wt%) By Analytical Sequence



SiO2 (wt%) By Analytical Sequence

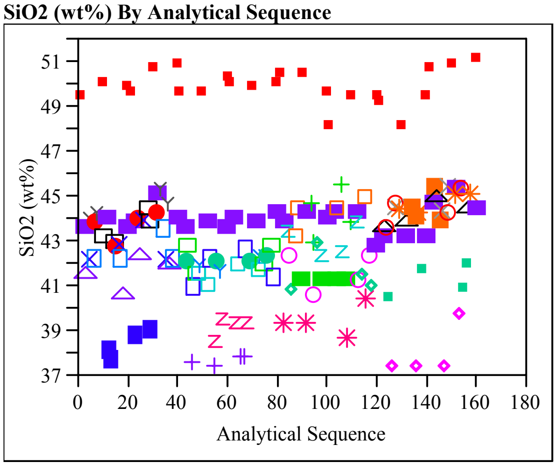


Exhibit C2. Oxide Measurements in Analytical Sequence for Samples Prepared Using the PF Method

U3O8 (wt%) By Analytical Sequence

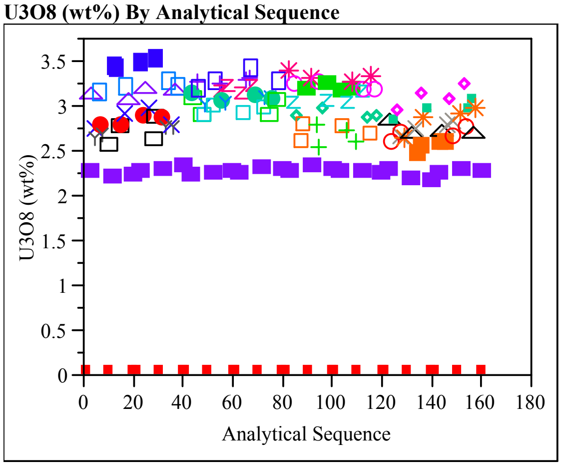
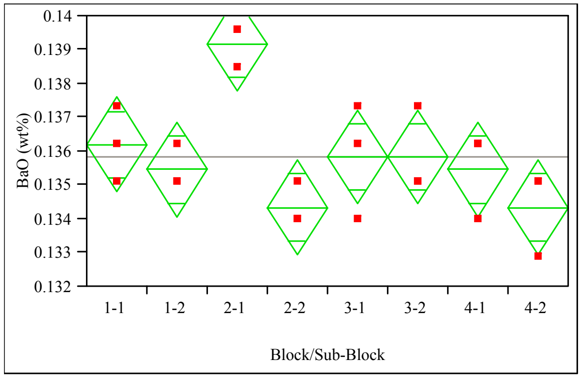


Exhibit C3. PSAL Measurements by Analytical Block for Samples of the Standard Glasses Prepared Using the LM Method

Glass ID=Batch 1

Oneway Analysis of BaO (wt%) By Block/Sub-Block
Reference value 0.151 wt%



Oneway Anova
Summary of Fit

Rsquare	0.698795
Adj Rsquare	0.567018
Root Mean Square Error	0.00114
Mean of Response	0.135841
Observations (or Sum Wgts)	24

Analysis of Variance

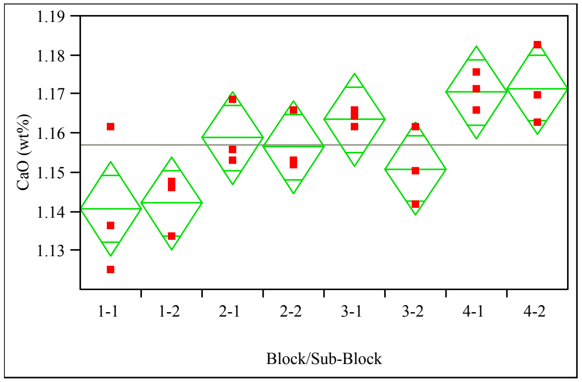
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	7	0.00004820	0.0000069	5.3029	0.0028
Error	16	0.00002078	0.0000013		
C. Total	23	0.00006898			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.136213	0.00066	0.13482	0.13761
1-2	3	0.135469	0.00066	0.13407	0.13686
2-1	3	0.139190	0.00066	0.13780	0.14059
2-2	3	0.134352	0.00066	0.13296	0.13575
3-1	3	0.135841	0.00066	0.13445	0.13724
3-2	3	0.135841	0.00066	0.13445	0.13724
4-1	3	0.135469	0.00066	0.13407	0.13686
4-2	3	0.134352	0.00066	0.13296	0.13575

Std Error uses a pooled estimate of error variance

Oneway Analysis of CaO (wt%) By Block/Sub-Block
Reference value 1.220 wt%



Oneway Anova
Summary of Fit

Rsquare	0.656392
Adj Rsquare	0.506063
Root Mean Square Error	0.009728
Mean of Response	1.156963
Observations (or Sum Wgts)	24

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	7	0.00289218	0.000413	4.3664	0.0070
Error	16	0.00151400	0.000095		
C. Total	23	0.00440619			

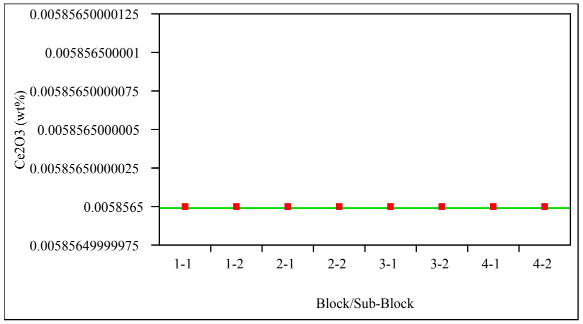
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	1.14081	0.00562	1.1289	1.1527
1-2	3	1.14221	0.00562	1.1303	1.1541
2-1	3	1.15900	0.00562	1.1471	1.1709
2-2	3	1.15667	0.00562	1.1448	1.1686
3-1	3	1.16367	0.00562	1.1518	1.1756
3-2	3	1.15108	0.00562	1.1392	1.1630
4-1	3	1.17066	0.00562	1.1588	1.1826
4-2	3	1.17160	0.00562	1.1597	1.1835

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

Oneway Analysis of Ce2O3 (wt%) By Block/Sub-Block
Reference value 0 wt%



Oneway Anova
Summary of Fit

Rsquare	.
Adj Rsquare	.
Root Mean Square Error	0
Mean of Response	0.005857
Observations (or Sum Wgts)	24

Analysis of Variance

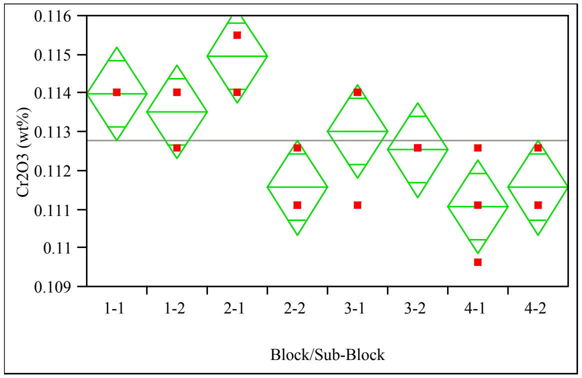
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	7	0	0	.	.
Error	16	0	0		
C. Total	23	0			

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
3-1	3	0.005857	0	0.00586	0.00586
3-2	3	0.005857	0	0.00586	0.00586
4-1	3	0.005857	0	0.00586	0.00586
4-2	3	0.005857	0	0.00586	0.00586

Std Error uses a pooled estimate of error variance

Oneway Analysis of Cr2O3 (wt%) By Block/Sub-Block
Reference value 0.107 wt%



Oneway Anova
Summary of Fit

Rsquare	0.710526
Adj Rsquare	0.583882
Root Mean Square Error	0.00099
Mean of Response	0.112787
Observations (or Sum Wgts)	24

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	7	0.00003845	0.0000055	5.6104	0.0021
Error	16	0.00001567	9.7913e-7		
C. Total	23	0.00005412			

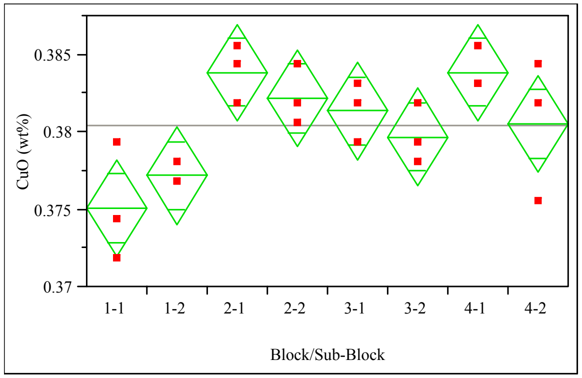
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.114005	0.00057	0.11279	0.11522
1-2	3	0.113518	0.00057	0.11231	0.11473
2-1	3	0.114979	0.00057	0.11377	0.11619
2-2	3	0.111569	0.00057	0.11036	0.11278
3-1	3	0.113030	0.00057	0.11182	0.11424
3-2	3	0.112543	0.00057	0.11133	0.11375
4-1	3	0.111082	0.00057	0.10987	0.11229
4-2	3	0.111569	0.00057	0.11036	0.11278

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

Oneway Analysis of CuO (wt%) By Block/Sub-Block
Reference value 0.399 wt%



Oneway Anova
Summary of Fit

Rsquare	0.658047
Adj Rsquare	0.508442
Root Mean Square Error	0.002555
Mean of Response	0.380495
Observations (or Sum Wgts)	24

Analysis of Variance

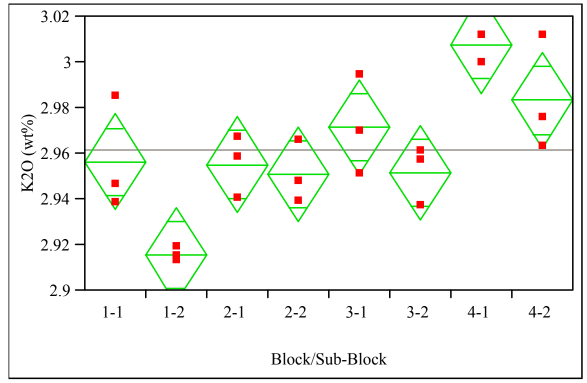
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	7	0.00020103	0.000029	4.3986	0.0067
Error	16	0.00010447	0.000007		
C. Total	23	0.00030550			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.375123	0.00148	0.37200	0.37825
1-2	3	0.377209	0.00148	0.37408	0.38034
2-1	3	0.383885	0.00148	0.38076	0.38701
2-2	3	0.382216	0.00148	0.37909	0.38534
3-1	3	0.381382	0.00148	0.37825	0.38451
3-2	3	0.379713	0.00148	0.37659	0.38284
4-1	3	0.383885	0.00148	0.38076	0.38701
4-2	3	0.380547	0.00148	0.37742	0.38367

Std Error uses a pooled estimate of error variance

Oneway Analysis of K2O (wt%) By Block/Sub-Block
Reference value 3.327 wt%



Oneway Anova
Summary of Fit

Rsquare	0.766501
Adj Rsquare	0.664345
Root Mean Square Error	0.017043
Mean of Response	2.961559
Observations (or Sum Wgts)	24

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	7	0.01525543	0.002179	7.5032	0.0004
Error	16	0.00464727	0.000290		
C. Total	23	0.01990269			

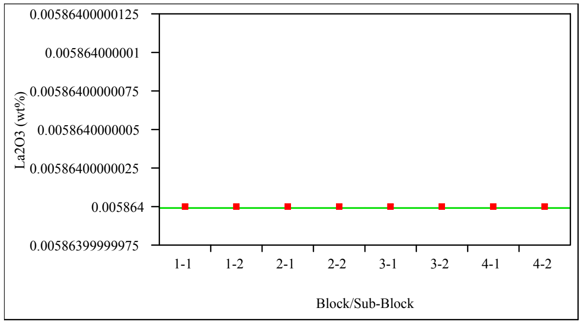
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	2.95649	0.00984	2.9356	2.9773
1-2	3	2.91553	0.00984	2.8947	2.9364
2-1	3	2.95529	0.00984	2.9344	2.9761
2-2	3	2.95087	0.00984	2.9300	2.9717
3-1	3	2.97175	0.00984	2.9509	2.9926
3-2	3	2.95167	0.00984	2.9308	2.9725
4-1	3	3.00748	0.00984	2.9866	3.0283
4-2	3	2.98339	0.00984	2.9625	3.0043

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

Oneway Analysis of La2O3 (wt%) By Block/Sub-Block
Reference value 0 wt%



Oneway Anova
Summary of Fit

Rsquare	.
Adj Rsquare	.
Root Mean Square Error	0
Mean of Response	0.005864
Observations (or Sum Wgts)	24

Analysis of Variance

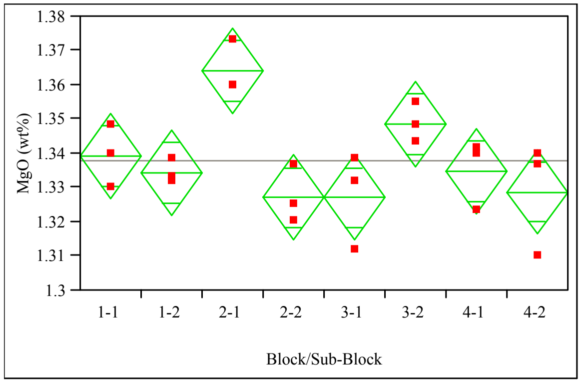
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	7	0	0	.	.
Error	16	0	0		
C. Total	23	0			

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
3-1	3	0.005864	0	0.00586	0.00586
3-2	3	0.005864	0	0.00586	0.00586
4-1	3	0.005864	0	0.00586	0.00586
4-2	3	0.005864	0	0.00586	0.00586

Std Error uses a pooled estimate of error variance

Oneway Analysis of MgO (wt%) By Block/Sub-Block
Reference value 1.419 wt%



Oneway Anova
Summary of Fit

Rsquare	0.676749
Adj Rsquare	0.535327
Root Mean Square Error	0.010127
Mean of Response	1.33811
Observations (or Sum Wgts)	24

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	7	0.00343516	0.000491	4.7853	0.0046
Error	16	0.00164081	0.000103		
C. Total	23	0.00507597			

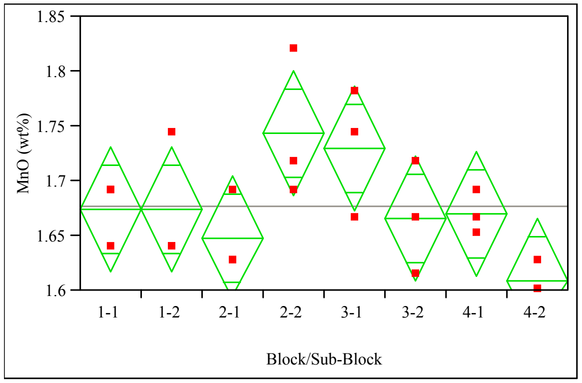
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	1.33935	0.00585	1.3270	1.3517
1-2	3	1.33438	0.00585	1.3220	1.3468
2-1	3	1.36423	0.00585	1.3518	1.3766
2-2	3	1.32719	0.00585	1.3148	1.3396
3-1	3	1.32719	0.00585	1.3148	1.3396
3-2	3	1.34875	0.00585	1.3364	1.3611
4-1	3	1.33493	0.00585	1.3225	1.3473
4-2	3	1.32885	0.00585	1.3165	1.3412

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

Oneway Analysis of MnO (wt%) By Block/Sub-Block
Reference value 1.726 wt%



Oneway Anova
Summary of Fit

Rsquare	0.525146
Adj Rsquare	0.317397
Root Mean Square Error	0.04648
Mean of Response	1.676946
Observations (or Sum Wgts)	24

Analysis of Variance

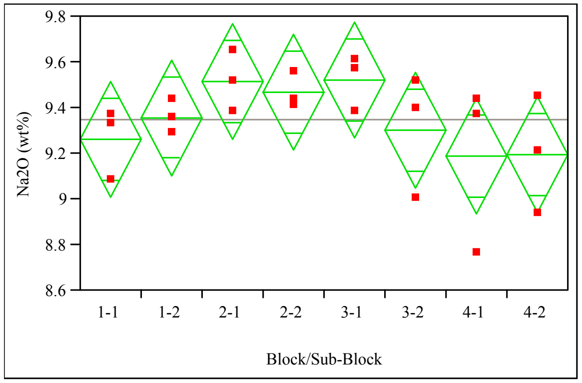
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	7	0.03822745	0.005461	2.5278	0.0590
Error	16	0.03456656	0.002160		
C. Total	23	0.07279401			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	1.67426	0.02684	1.6174	1.7311
1-2	3	1.67426	0.02684	1.6174	1.7311
2-1	3	1.64843	0.02684	1.5915	1.7053
2-2	3	1.74312	0.02684	1.6862	1.8000
3-1	3	1.73021	0.02684	1.6733	1.7871
3-2	3	1.66565	0.02684	1.6088	1.7225
4-1	3	1.66995	0.02684	1.6131	1.7268
4-2	3	1.60970	0.02684	1.5528	1.6666

Std Error uses a pooled estimate of error variance

Oneway Analysis of Na2O (wt%) By Block/Sub-Block
Reference value 9.003 wt%



Oneway Anova
Summary of Fit

Rsquare	0.362344
Adj Rsquare	0.083369
Root Mean Square Error	0.207193
Mean of Response	9.352312
Observations (or Sum Wgts)	24

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	7	0.3903064	0.055758	1.2988	0.3122
Error	16	0.6868653	0.042929		
C. Total	23	1.0771717			

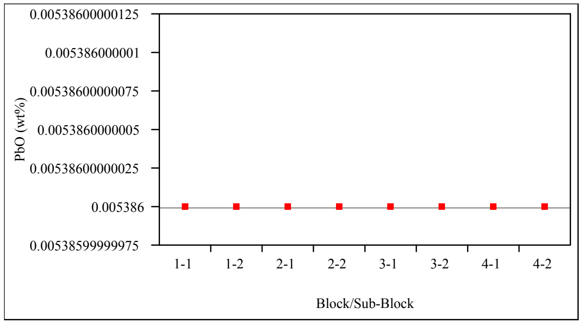
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	9.26076	0.11962	9.0072	9.5143
1-2	3	9.35961	0.11962	9.1060	9.6132
2-1	3	9.51688	0.11962	9.2633	9.7705
2-2	3	9.46745	0.11962	9.2139	9.7210
3-1	3	9.52137	0.11962	9.2678	9.7750
3-2	3	9.30569	0.11962	9.0521	9.5593
4-1	3	9.18887	0.11962	8.9353	9.4425
4-2	3	9.19785	0.11962	8.9443	9.4514

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

Oneway Analysis of PbO (wt%) By Block/Sub-Block
Reference value 0 wt%



Oneway Anova
Summary of Fit

Rsquare	4
Adj Rsquare	5.3125
Root Mean Square Error	.
Mean of Response	0.005386
Observations (or Sum Wgts)	24

Analysis of Variance

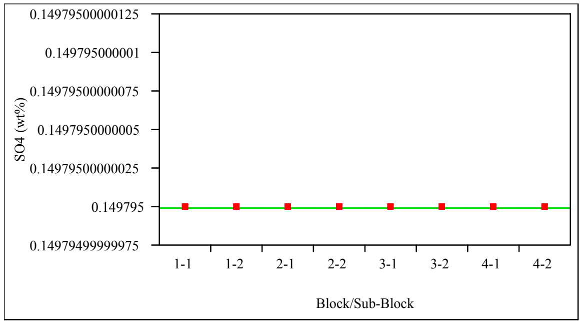
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	7	7.2222e-35	1.032e-35	-3.0476	-1.0000
Error	16	-5.417e-35	-3.39e-36		
C. Total	23	1.8056e-35			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.005386	.	.	.
1-2	3	0.005386	.	.	.
2-1	3	0.005386	.	.	.
2-2	3	0.005386	.	.	.
3-1	3	0.005386	.	.	.
3-2	3	0.005386	.	.	.
4-1	3	0.005386	.	.	.
4-2	3	0.005386	.	.	.

Std Error uses a pooled estimate of error variance

Oneway Analysis of SO4 (wt%) By Block/Sub-Block
Reference value 0 wt%



Oneway Anova
Summary of Fit

Rsquare	.
Adj Rsquare	.
Root Mean Square Error	0
Mean of Response	0.149795
Observations (or Sum Wgts)	24

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	7	0	0	.	.
Error	16	0	0		
C. Total	23	0			

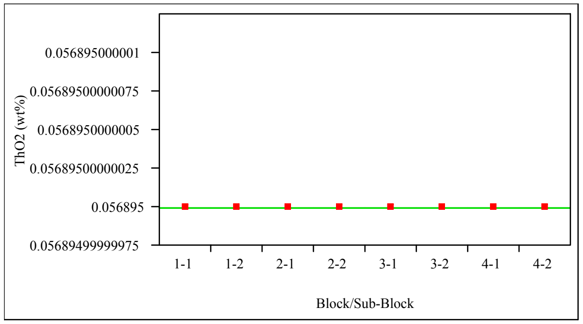
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.149795	0	0.14979	0.14979
1-2	3	0.149795	0	0.14979	0.14979
2-1	3	0.149795	0	0.14979	0.14979
2-2	3	0.149795	0	0.14979	0.14979
3-1	3	0.149795	0	0.14979	0.14979
3-2	3	0.149795	0	0.14979	0.14979
4-1	3	0.149795	0	0.14979	0.14979
4-2	3	0.149795	0	0.14979	0.14979

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

Oneway Analysis of ThO2 (wt%) By Block/Sub-Block
Reference value 0 wt%



Oneway Anova
Summary of Fit

Rsquare	.
Adj Rsquare	.
Root Mean Square Error	0
Mean of Response	0.056895
Observations (or Sum Wgts)	24

Analysis of Variance

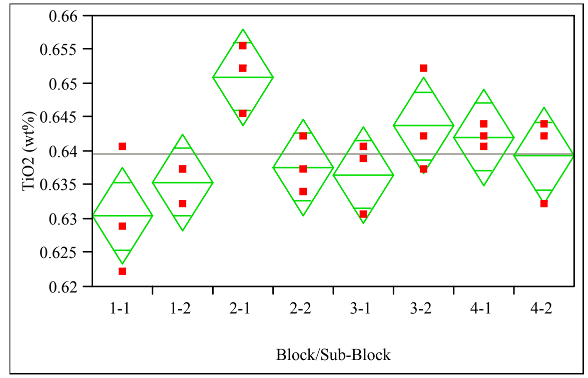
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	7	0	0	.	.
Error	16	0	0		
C. Total	23	0			

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
3-1	3	0.056895	0	0.05690	0.05690
3-2	3	0.056895	0	0.05690	0.05690
4-1	3	0.056895	0	0.05690	0.05690
4-2	3	0.056895	0	0.05690	0.05690

Std Error uses a pooled estimate of error variance

Oneway Analysis of TiO2 (wt%) By Block/Sub-Block
Reference value 0.677 wt%



Oneway Anova
Summary of Fit

Rsquare	0.600242
Adj Rsquare	0.425348
Root Mean Square Error	0.005788
Mean of Response	0.639609
Observations (or Sum Wgts)	24

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	7	0.00080487	0.000115	3.4320	0.0195
Error	16	0.00053604	0.000034		
C. Total	23	0.00134092			

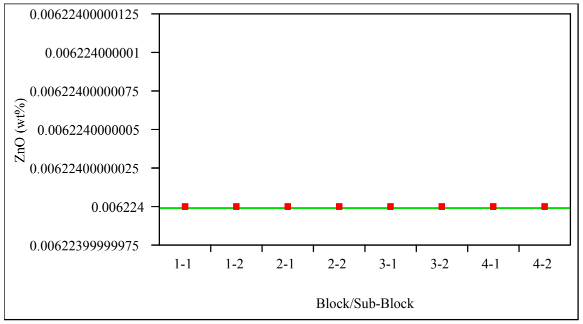
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.630504	0.00334	0.62342	0.63759
1-2	3	0.635508	0.00334	0.62842	0.64259
2-1	3	0.651076	0.00334	0.64399	0.65816
2-2	3	0.637732	0.00334	0.63065	0.64482
3-1	3	0.636620	0.00334	0.62954	0.64370
3-2	3	0.643848	0.00334	0.63676	0.65093
4-1	3	0.642180	0.00334	0.63510	0.64926
4-2	3	0.639400	0.00334	0.63232	0.64648

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

Oneway Analysis of ZnO (wt%) By Block/Sub-Block
Reference value 0 wt%



Oneway Anova
Summary of Fit

Rsquare	.
Adj Rsquare	.
Root Mean Square Error	0
Mean of Response	0.006224
Observations (or Sum Wgts)	24

Analysis of Variance

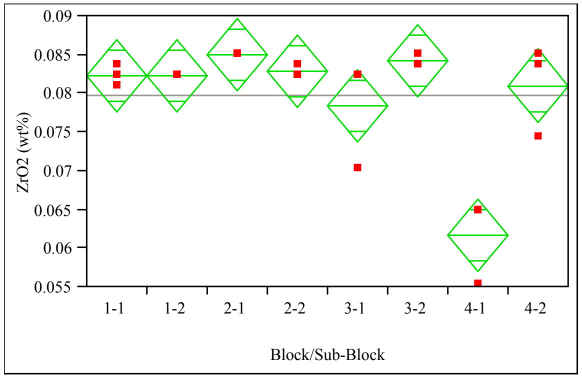
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	7	0	0	.	.
Error	16	0	0		
C. Total	23	0			

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
3-1	3	0.006224	0	0.00622	0.00622
3-2	3	0.006224	0	0.00622	0.00622
4-1	3	0.006224	0	0.00622	0.00622
4-2	3	0.006224	0	0.00622	0.00622

Std Error uses a pooled estimate of error variance

Oneway Analysis of ZrO2 (wt%) By Block/Sub-Block
Reference value 0.098 wt%



Oneway Anova
Summary of Fit

Rsquare	0.837761
Adj Rsquare	0.766781
Root Mean Square Error	0.003821
Mean of Response	0.079753
Observations (or Sum Wgts)	24

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	7	0.00120602	0.000172	11.8028	<.0001
Error	16	0.00023356	0.000015		
C. Total	23	0.00143958			

Means for Oneway Anova

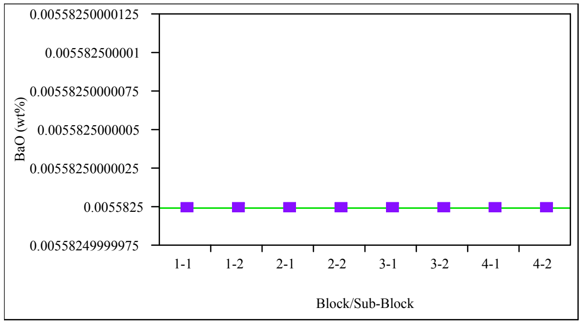
Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.082399	0.00221	0.07772	0.08707
1-2	3	0.082399	0.00221	0.07772	0.08707
2-1	3	0.085100	0.00221	0.08042	0.08978
2-2	3	0.082849	0.00221	0.07817	0.08753
3-1	3	0.078346	0.00221	0.07367	0.08302
3-2	3	0.084200	0.00221	0.07952	0.08888
4-1	3	0.061687	0.00221	0.05701	0.06636
4-2	3	0.081048	0.00221	0.07637	0.08572

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

Glass ID=Ustd

Oneway Analysis of BaO (wt%) By Block/Sub-Block
Reference value 0 wt%



Oneway Anova
Summary of Fit

Rsquare	.
Adj Rsquare	.
Root Mean Square Error	0
Mean of Response	0.005583
Observations (or Sum Wgts)	24

Analysis of Variance

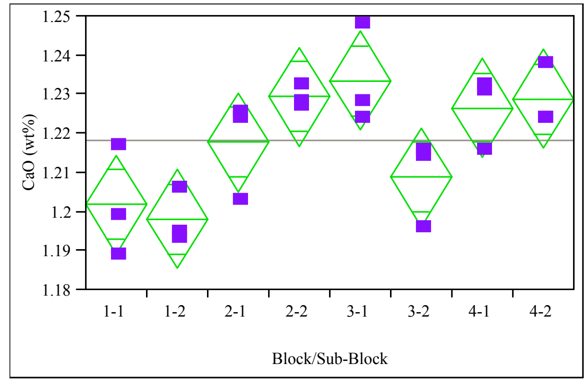
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	7	0	0	.	.
Error	16	0	0		
C. Total	23	0			

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
3-1	3	0.005583	0	0.00558	0.00558
3-2	3	0.005583	0	0.00558	0.00558
4-1	3	0.005583	0	0.00558	0.00558
4-2	3	0.005583	0	0.00558	0.00558

Std Error uses a pooled estimate of error variance

Oneway Analysis of CaO (wt%) By Block/Sub-Block
Reference value 1.301 wt%



Oneway Anova
Summary of Fit

Rsquare	0.697586
Adj Rsquare	0.56528
Root Mean Square Error	0.010294
Mean of Response	1.218178
Observations (or Sum Wgts)	24

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	7	0.00391087	0.000559	5.2725	0.0028
Error	16	0.00169542	0.000106		
C. Total	23	0.00560629			

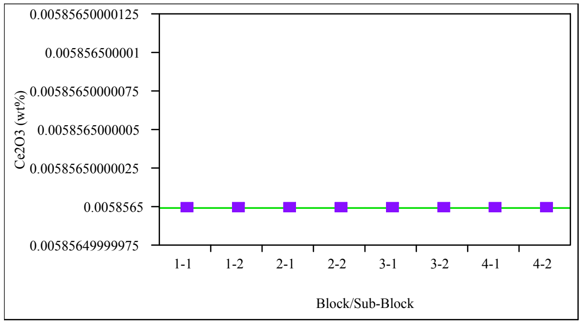
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	1.20191	0.00594	1.1893	1.2145
1-2	3	1.19818	0.00594	1.1856	1.2108
2-1	3	1.21777	0.00594	1.2052	1.2304
2-2	3	1.22943	0.00594	1.2168	1.2420
3-1	3	1.23363	0.00594	1.2210	1.2462
3-2	3	1.20891	0.00594	1.1963	1.2215
4-1	3	1.22663	0.00594	1.2140	1.2392
4-2	3	1.22896	0.00594	1.2164	1.2416

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

Oneway Analysis of Ce2O3 (wt%) By Block/Sub-Block
Reference value 0 wt%



Oneway Anova
Summary of Fit

Rsquare	.
Adj Rsquare	.
Root Mean Square Error	0
Mean of Response	0.005857
Observations (or Sum Wgts)	24

Analysis of Variance

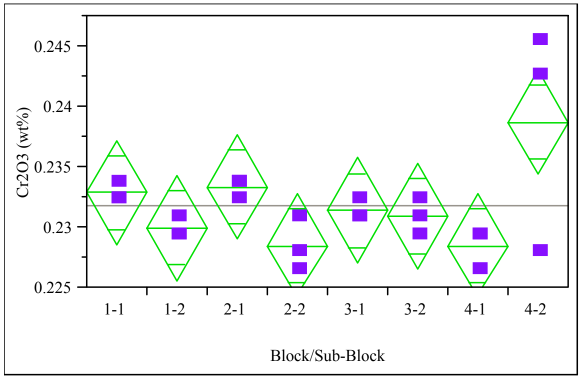
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	7	0	0	.	.
Error	16	0	0		
C. Total	23	0			

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
3-1	3	0.005857	0	0.00586	0.00586
3-2	3	0.005857	0	0.00586	0.00586
4-1	3	0.005857	0	0.00586	0.00586
4-2	3	0.005857	0	0.00586	0.00586

Std Error uses a pooled estimate of error variance

Oneway Analysis of Cr2O3 (wt%) By Block/Sub-Block
Reference value 0 wt%



Oneway Anova
Summary of Fit

Rsquare	0.535568
Adj Rsquare	0.332379
Root Mean Square Error	0.003555
Mean of Response	0.231785
Observations (or Sum Wgts)	24

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	7	0.00023321	0.000033	2.6358	0.0514
Error	16	0.00020223	0.000013		
C. Total	23	0.00043544			

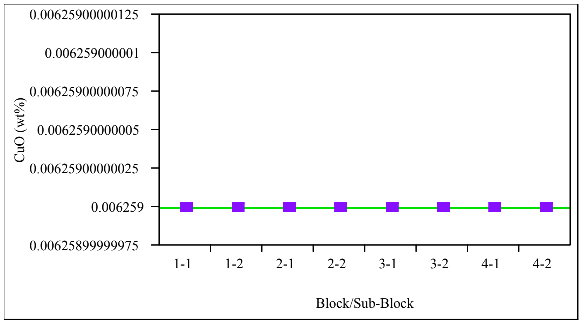
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.232882	0.00205	0.22853	0.23723
1-2	3	0.229958	0.00205	0.22561	0.23431
2-1	3	0.233369	0.00205	0.22902	0.23772
2-2	3	0.228497	0.00205	0.22415	0.23285
3-1	3	0.231420	0.00205	0.22707	0.23577
3-2	3	0.230933	0.00205	0.22658	0.23528
4-1	3	0.228497	0.00205	0.22415	0.23285
4-2	3	0.238728	0.00205	0.23438	0.24308

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

Oneway Analysis of CuO (wt%) By Block/Sub-Block
Reference value 0 wt%



Oneway Anova
Summary of Fit

Rsquare	.
Adj Rsquare	.
Root Mean Square Error	0
Mean of Response	0.006259
Observations (or Sum Wgts)	24

Analysis of Variance

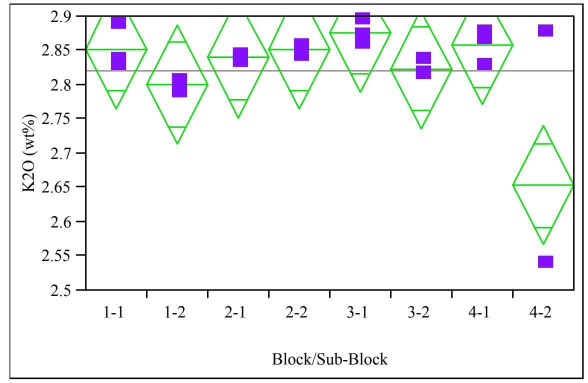
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	7	0	0	.	.
Error	16	0	0		
C. Total	23	0			

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
3-1	3	0.006259	0	0.00626	0.00626
3-2	3	0.006259	0	0.00626	0.00626
4-1	3	0.006259	0	0.00626	0.00626
4-2	3	0.006259	0	0.00626	0.00626

Std Error uses a pooled estimate of error variance

Oneway Analysis of K2O (wt%) By Block/Sub-Block
Reference value 2.999 wt%



Oneway Anova
Summary of Fit

Rsquare	0.568067
Adj Rsquare	0.379096
Root Mean Square Error	0.070955
Mean of Response	2.82032
Observations (or Sum Wgts)	24

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	7	0.10594143	0.015134	3.0061	0.0323
Error	16	0.08055324	0.005035		
C. Total	23	0.18649467			

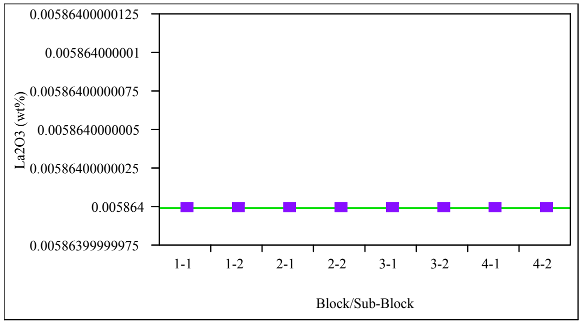
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	2.85330	0.04097	2.7665	2.9401
1-2	3	2.80110	0.04097	2.7143	2.8879
2-1	3	2.84005	0.04097	2.7532	2.9269
2-2	3	2.85330	0.04097	2.7665	2.9401
3-1	3	2.87739	0.04097	2.7905	2.9642
3-2	3	2.82439	0.04097	2.7375	2.9112
4-1	3	2.85892	0.04097	2.7721	2.9458
4-2	3	2.65414	0.04097	2.5673	2.7410

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

Oneway Analysis of La2O3 (wt%) By Block/Sub-Block
Reference value 0 wt%



Oneway Anova
Summary of Fit

Rsquare	.
Adj Rsquare	.
Root Mean Square Error	0
Mean of Response	0.005864
Observations (or Sum Wgts)	24

Analysis of Variance

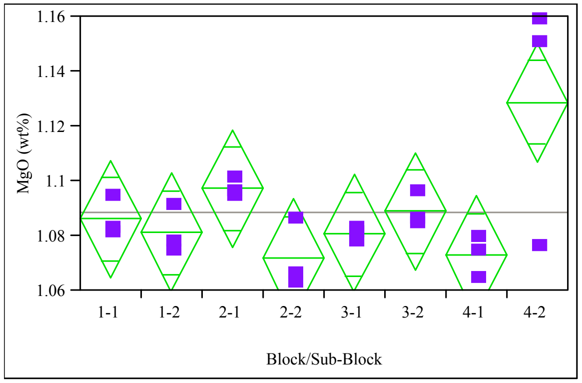
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	7	0	0	.	.
Error	16	0	0		
C. Total	23	0			

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
3-1	3	0.005864	0	0.00586	0.00586
3-2	3	0.005864	0	0.00586	0.00586
4-1	3	0.005864	0	0.00586	0.00586
4-2	3	0.005864	0	0.00586	0.00586

Std Error uses a pooled estimate of error variance

Oneway Analysis of MgO (wt%) By Block/Sub-Block
Reference value 1.21 wt%



Oneway Anova
Summary of Fit

Rsquare	0.58498
Adj Rsquare	0.403408
Root Mean Square Error	0.017634
Mean of Response	1.088467
Observations (or Sum Wgts)	24

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	7	0.00701320	0.001002	3.2218	0.0249
Error	16	0.00497559	0.000311		
C. Total	23	0.01198879			

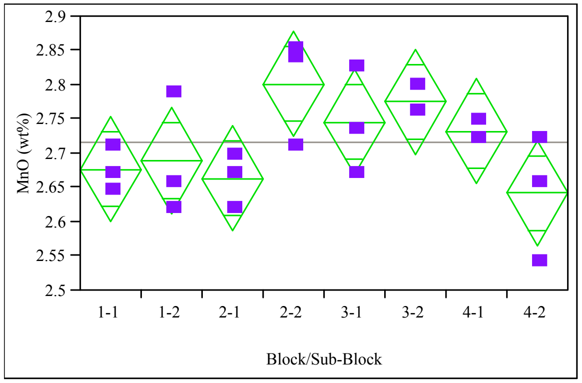
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	1.08619	0.01018	1.0646	1.1078
1-2	3	1.08121	0.01018	1.0596	1.1028
2-1	3	1.09724	0.01018	1.0757	1.1188
2-2	3	1.07181	0.01018	1.0502	1.0934
3-1	3	1.08066	0.01018	1.0591	1.1022
3-2	3	1.08895	0.01018	1.0674	1.1105
4-1	3	1.07292	0.01018	1.0513	1.0945
4-2	3	1.12875	0.01018	1.1072	1.1503

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

Oneway Analysis of MnO (wt%) By Block/Sub-Block
Reference value 2.892 wt%



Oneway Anova
Summary of Fit

Rsquare	0.515074
Adj Rsquare	0.302919
Root Mean Square Error	0.062925
Mean of Response	2.716362
Observations (or Sum Wgts)	24

Analysis of Variance

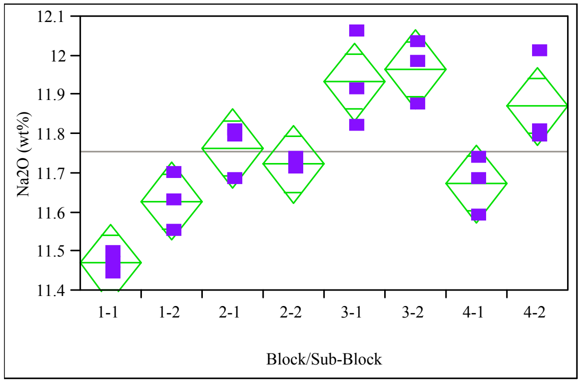
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	7	0.06729226	0.009613	2.4278	0.0672
Error	16	0.06335350	0.003960		
C. Total	23	0.13064576			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	2.67709	0.03633	2.6001	2.7541
1-2	3	2.69000	0.03633	2.6130	2.7670
2-1	3	2.66418	0.03633	2.5872	2.7412
2-2	3	2.80190	0.03633	2.7249	2.8789
3-1	3	2.74595	0.03633	2.6689	2.8230
3-2	3	2.77608	0.03633	2.6991	2.8531
4-1	3	2.73304	0.03633	2.6560	2.8101
4-2	3	2.64266	0.03633	2.5656	2.7197

Std Error uses a pooled estimate of error variance

Oneway Analysis of Na2O (wt%) By Block/Sub-Block
Reference value 11.795 wt%



Oneway Anova
Summary of Fit

Rsquare	0.846315
Adj Rsquare	0.779077
Root Mean Square Error	0.0813
Mean of Response	11.754
Observations (or Sum Wgts)	24

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	7	0.58237426	0.083196	12.5870	<.0001
Error	16	0.10575545	0.006610		
C. Total	23	0.68812971			

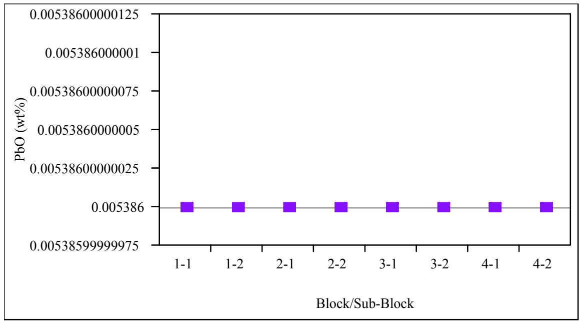
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	11.4715	0.04694	11.372	11.571
1-2	3	11.6287	0.04694	11.529	11.728
2-1	3	11.7635	0.04694	11.664	11.863
2-2	3	11.7231	0.04694	11.624	11.823
3-1	3	11.9343	0.04694	11.835	12.034
3-2	3	11.9657	0.04694	11.866	12.065
4-1	3	11.6737	0.04694	11.574	11.773
4-2	3	11.8714	0.04694	11.772	11.971

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

Oneway Analysis of PbO (wt%) By Block/Sub-Block
Reference value 0 wt%



Oneway Anova
Summary of Fit

Rsquare	4
Adj Rsquare	5.3125
Root Mean Square Error	.
Mean of Response	0.005386
Observations (or Sum Wgts)	24

Analysis of Variance

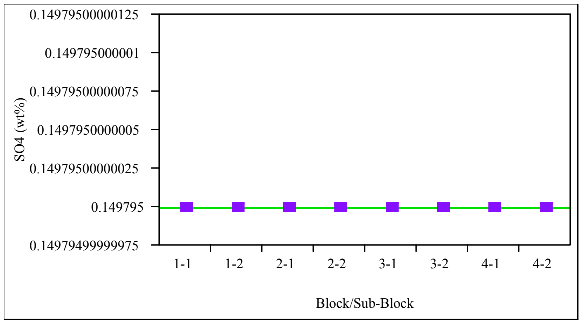
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	7	7.2222e-35	1.032e-35	-3.0476	-1.0000
Error	16	-5.417e-35	-3.39e-36		
C. Total	23	1.8056e-35			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.005386	.	.	.
1-2	3	0.005386	.	.	.
2-1	3	0.005386	.	.	.
2-2	3	0.005386	.	.	.
3-1	3	0.005386	.	.	.
3-2	3	0.005386	.	.	.
4-1	3	0.005386	.	.	.
4-2	3	0.005386	.	.	.

Std Error uses a pooled estimate of error variance

Oneway Analysis of SO4 (wt%) By Block/Sub-Block
Reference value 0 wt%



Oneway Anova
Summary of Fit

Rsquare	.
Adj Rsquare	.
Root Mean Square Error	0
Mean of Response	0.149795
Observations (or Sum Wgts)	24

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	7	0	0	.	.
Error	16	0	0		
C. Total	23	0			

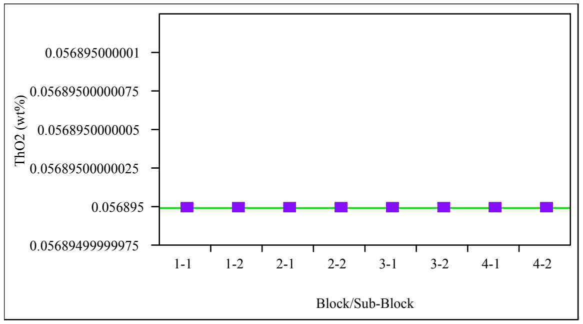
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.149795	0	0.14979	0.14979
1-2	3	0.149795	0	0.14979	0.14979
2-1	3	0.149795	0	0.14979	0.14979
2-2	3	0.149795	0	0.14979	0.14979
3-1	3	0.149795	0	0.14979	0.14979
3-2	3	0.149795	0	0.14979	0.14979
4-1	3	0.149795	0	0.14979	0.14979
4-2	3	0.149795	0	0.14979	0.14979

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

Oneway Analysis of ThO2 (wt%) By Block/Sub-Block
Reference value 0 wt%



Oneway Anova
Summary of Fit

Rsquare	.
Adj Rsquare	.
Root Mean Square Error	0
Mean of Response	0.056895
Observations (or Sum Wgts)	24

Analysis of Variance

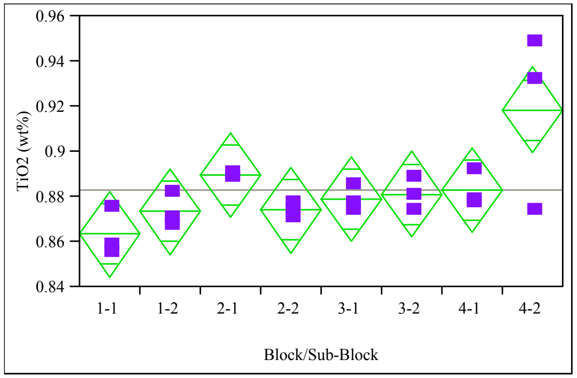
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	7	0	0	.	.
Error	16	0	0		
C. Total	23	0			

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
3-1	3	0.056895	0	0.05690	0.05690
3-2	3	0.056895	0	0.05690	0.05690
4-1	3	0.056895	0	0.05690	0.05690
4-2	3	0.056895	0	0.05690	0.05690

Std Error uses a pooled estimate of error variance

Oneway Analysis of TiO2 (wt%) By Block/Sub-Block
Reference value 1.049 wt%



Oneway Anova
Summary of Fit

Rsquare	0.59652
Adj Rsquare	0.419997
Root Mean Square Error	0.015423
Mean of Response	0.882789
Observations (or Sum Wgts)	24

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	7	0.00562705	0.000804	3.3793	0.0207
Error	16	0.00380608	0.000238		
C. Total	23	0.00943313			

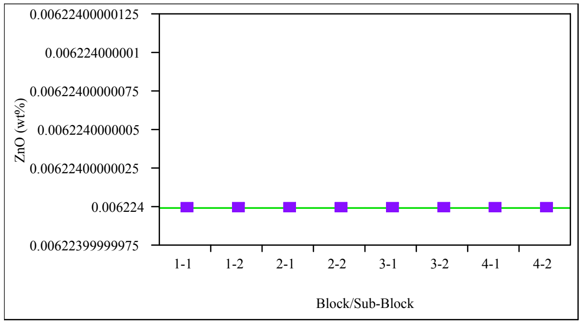
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.863468	0.00890	0.84459	0.88235
1-2	3	0.873476	0.00890	0.85460	0.89235
2-1	3	0.889600	0.00890	0.87072	0.90848
2-2	3	0.874032	0.00890	0.85515	0.89291
3-1	3	0.879036	0.00890	0.86016	0.89791
3-2	3	0.881260	0.00890	0.86238	0.90014
4-1	3	0.882928	0.00890	0.86405	0.90181
4-2	3	0.918512	0.00890	0.89963	0.93739

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

Oneway Analysis of ZnO (wt%) By Block/Sub-Block
Reference value 0 wt%



Oneway Anova
Summary of Fit

Rsquare	.
Adj Rsquare	.
Root Mean Square Error	0
Mean of Response	0.006224
Observations (or Sum Wgts)	24

Analysis of Variance

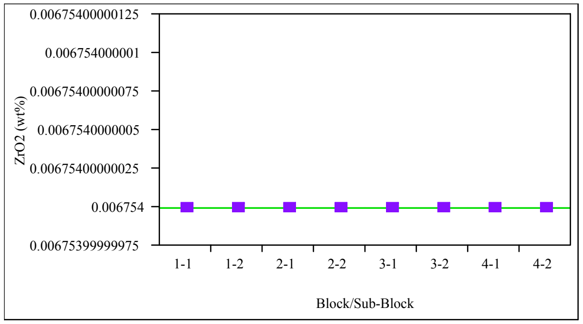
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	7	0	0	.	.
Error	16	0	0		
C. Total	23	0			

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
3-1	3	0.006224	0	0.00622	0.00622
3-2	3	0.006224	0	0.00622	0.00622
4-1	3	0.006224	0	0.00622	0.00622
4-2	3	0.006224	0	0.00622	0.00622

Std Error uses a pooled estimate of error variance

Oneway Analysis of ZrO2 (wt%) By Block/Sub-Block
Reference value 0 wt%



Oneway Anova
Summary of Fit

Rsquare	.
Adj Rsquare	.
Root Mean Square Error	0
Mean of Response	0.006754
Observations (or Sum Wgts)	24

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	7	0	0	.	.
Error	16	0	0		
C. Total	23	0			

Means for Oneway Anova

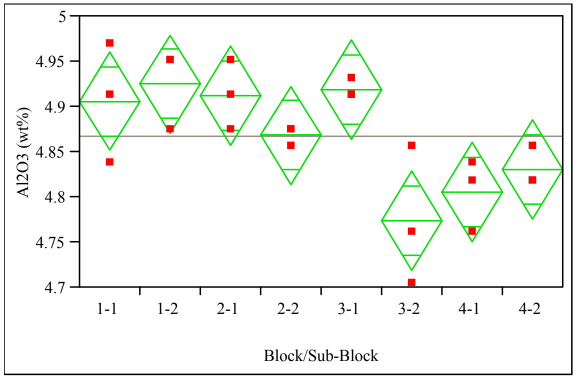
Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.006754	0	0.00675	0.00675
1-2	3	0.006754	0	0.00675	0.00675
2-1	3	0.006754	0	0.00675	0.00675
2-2	3	0.006754	0	0.00675	0.00675
3-1	3	0.006754	0	0.00675	0.00675
3-2	3	0.006754	0	0.00675	0.00675
4-1	3	0.006754	0	0.00675	0.00675
4-2	3	0.006754	0	0.00675	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

Glass ID=Batch 1

Oneway Analysis of Al2O3 (wt%) By Block/Sub-Block
Reference value 4.877 wt%



Oneway Anova
Summary of Fit

Rsquare	0.68957
Adj Rsquare	0.553756
Root Mean Square Error	0.04448
Mean of Response	4.867824
Observations (or Sum Wgts)	24

Analysis of Variance

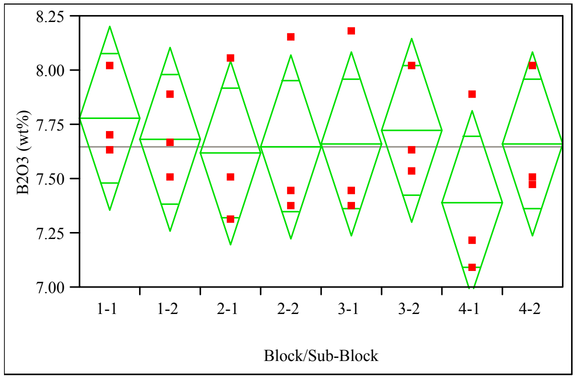
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	7	0.07031827	0.010045	5.0773	0.0034
Error	16	0.03165586	0.001978		
C. Total	23	0.10197413			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	4.90640	0.02568	4.8520	4.9608
1-2	3	4.92530	0.02568	4.8709	4.9797
2-1	3	4.91270	0.02568	4.8583	4.9671
2-2	3	4.86861	0.02568	4.8142	4.9231
3-1	3	4.91900	0.02568	4.8646	4.9734
3-2	3	4.77414	0.02568	4.7197	4.8286
4-1	3	4.80563	0.02568	4.7512	4.8601
4-2	3	4.83082	0.02568	4.7764	4.8853

Std Error uses a pooled estimate of error variance

Oneway Analysis of B2O3 (wt%) By Block/Sub-Block
Reference value 7.777 wt%



Oneway Anova
Summary of Fit

Rsquare	0.124351
Adj Rsquare	-0.25874
Root Mean Square Error	0.34617
Mean of Response	7.648604
Observations (or Sum Wgts)	24

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	7	0.2722832	0.038898	0.3246	0.9316
Error	16	1.9173437	0.119834		
C. Total	23	2.1896269			

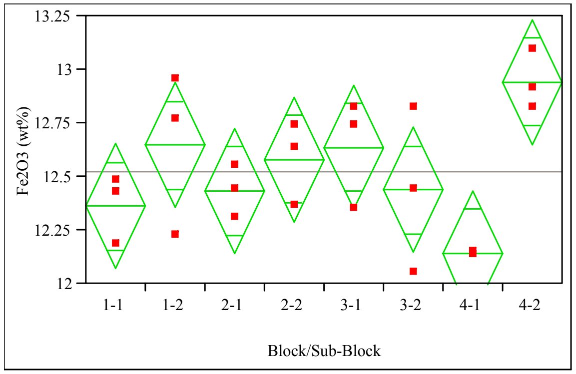
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	7.78143	0.19986	7.3577	8.2051
1-2	3	7.68483	0.19986	7.2611	8.1085
2-1	3	7.62043	0.19986	7.1967	8.0441
2-2	3	7.65263	0.19986	7.2289	8.0763
3-1	3	7.66336	0.19986	7.2397	8.0870
3-2	3	7.72776	0.19986	7.3041	8.1514
4-1	3	7.39504	0.19986	6.9713	7.8187
4-2	3	7.66336	0.19986	7.2397	8.0870

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

Oneway Analysis of Fe_2O_3 (wt%) By Block/Sub-Block
Reference value 12.839 wt%



Oneway Anova
Summary of Fit

Rsquare	0.566949
Adj Rsquare	0.377489
Root Mean Square Error	0.23777
Mean of Response	12.52358
Observations (or Sum Wgts)	24

Analysis of Variance

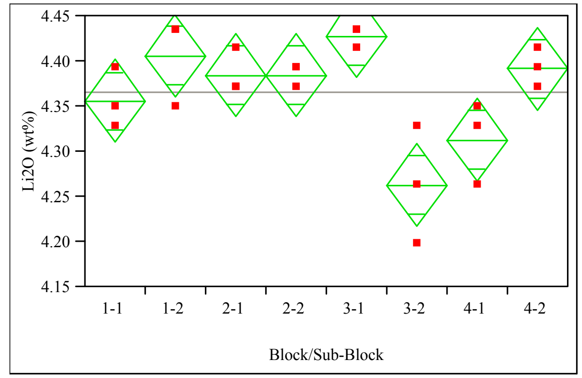
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	7	1.1842413	0.169177	2.9924	0.0329
Error	16	0.9045568	0.056535		
C. Total	23	2.0887981			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	12.3621	0.13728	12.071	12.653
1-2	3	12.6481	0.13728	12.357	12.939
2-1	3	12.4336	0.13728	12.143	12.725
2-2	3	12.5814	0.13728	12.290	12.872
3-1	3	12.6385	0.13728	12.348	12.930
3-2	3	12.4384	0.13728	12.147	12.729
4-1	3	12.1429	0.13728	11.852	12.434
4-2	3	12.9436	0.13728	12.653	13.235

Std Error uses a pooled estimate of error variance

Oneway Analysis of Li_2O (wt%) By Block/Sub-Block
Reference value 4.429 wt%



Oneway Anova
Summary of Fit

Rsquare	0.733272
Adj Rsquare	0.616578
Root Mean Square Error	0.037289
Mean of Response	4.365902
Observations (or Sum Wgts)	24

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	7	0.06116240	0.008737	6.2837	0.0012
Error	16	0.02224790	0.001390		
C. Total	23	0.08341030			

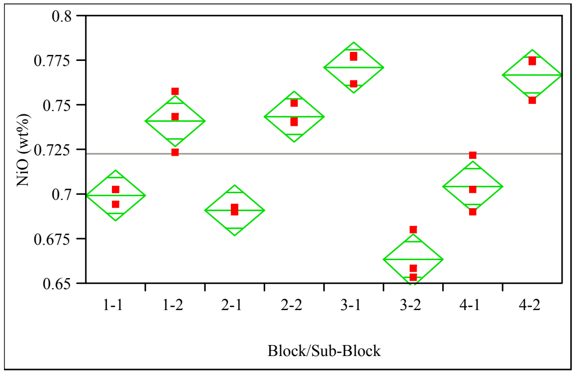
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	4.35603	0.02153	4.3104	4.4017
1-2	3	4.40627	0.02153	4.3606	4.4519
2-1	3	4.38474	0.02153	4.3391	4.4304
2-2	3	4.38474	0.02153	4.3391	4.4304
3-1	3	4.42780	0.02153	4.3822	4.4734
3-2	3	4.26274	0.02153	4.2171	4.3084
4-1	3	4.31298	0.02153	4.2673	4.3586
4-2	3	4.39192	0.02153	4.3463	4.4376

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

Oneway Analysis of NiO (wt%) By Block/Sub-Block
Reference value 0.751 wt%



Oneway Anova
Summary of Fit

Rsquare	0.936187
Adj Rsquare	0.908268
Root Mean Square Error	0.011587
Mean of Response	0.722674
Observations (or Sum Wgts)	24

Analysis of Variance

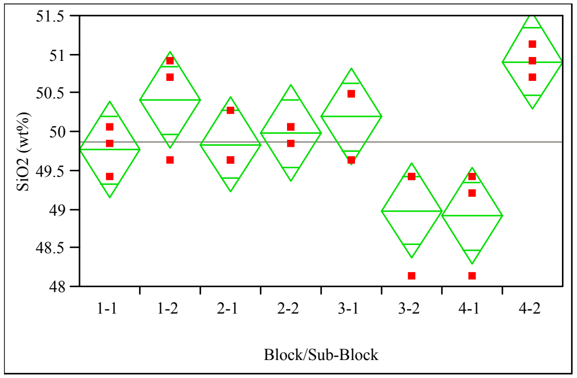
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	7	0.03151585	0.004502	33.5331	<.0001
Error	16	0.00214821	0.000134		
C. Total	23	0.03366407			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.699451	0.00669	0.68527	0.71363
1-2	3	0.741019	0.00669	0.72684	0.75520
2-1	3	0.690968	0.00669	0.67679	0.70515
2-2	3	0.743564	0.00669	0.72938	0.75775
3-1	3	0.771559	0.00669	0.75738	0.78574
3-2	3	0.663397	0.00669	0.64921	0.67758
4-1	3	0.704541	0.00669	0.69036	0.71872
4-2	3	0.766893	0.00669	0.75271	0.78108

Std Error uses a pooled estimate of error variance

Oneway Analysis of SiO2 (wt%) By Block/Sub-Block
Reference value 50.22 wt%



Oneway Anova
Summary of Fit

Rsquare	0.701559
Adj Rsquare	0.570991
Root Mean Square Error	0.505497
Mean of Response	49.88135
Observations (or Sum Wgts)	24

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	7	9.610869	1.37298	5.3731	0.0026
Error	16	4.088433	0.25553		
C. Total	23	13.699303			

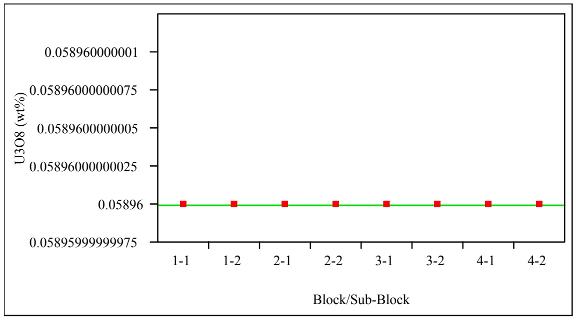
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	49.7744	0.29185	49.156	50.393
1-2	3	50.4162	0.29185	49.797	51.035
2-1	3	49.8457	0.29185	49.227	50.464
2-2	3	49.9883	0.29185	49.370	50.607
3-1	3	50.2022	0.29185	49.584	50.821
3-2	3	48.9900	0.29185	48.371	49.609
4-1	3	48.9187	0.29185	48.300	49.537
4-2	3	50.9153	0.29185	50.297	51.534

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

Oneway Analysis of U3O8 (wt%) By Block/Sub-Block
Reference value 50.22 wt%



Oneway Anova
Summary of Fit

Rsquare	1
Adj Rsquare	1
Root Mean Square Error	0
Mean of Response	0.05896
Observations (or Sum Wgts)	24

Analysis of Variance

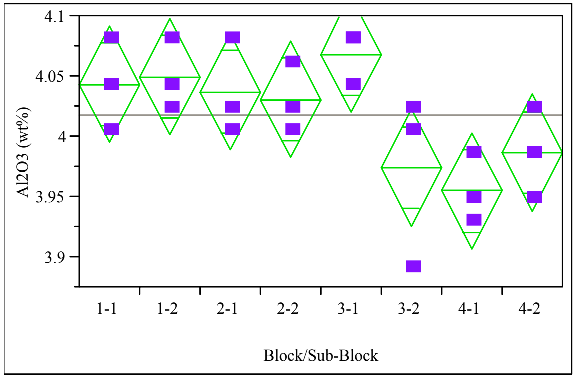
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	7	4.6222e-33	6.603e-34	.	.
Error	16	0	0		
C. Total	23	4.6222e-33			

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
3-1	3	0.058960	0	0.05896	0.05896
3-2	3	0.058960	0	0.05896	0.05896
4-1	3	0.058960	0	0.05896	0.05896
4-2	3	0.058960	0	0.05896	0.05896

Std Error uses a pooled estimate of error variance

Glass ID=Ustd
Oneway Analysis of Al2O3 (wt%) By Block/Sub-Block
Reference value 4.1 wt%



Oneway Anova
Summary of Fit

Rsquare	0.581673
Adj Rsquare	0.398655
Root Mean Square Error	0.039522
Mean of Response	4.018337
Observations (or Sum Wgts)	24

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	7	0.03475005	0.004964	3.1782	0.0263
Error	16	0.02499147	0.001562		
C. Total	23	0.05974152			

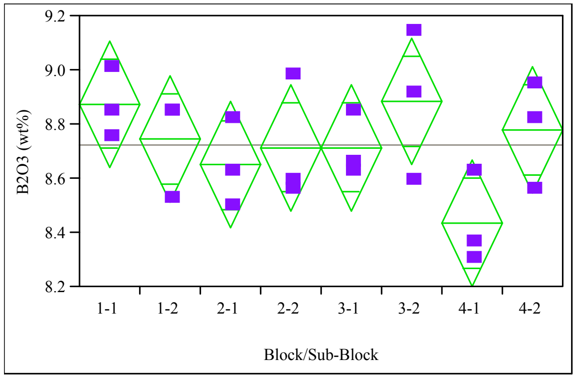
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	4.04353	0.02282	3.9952	4.0919
1-2	3	4.04983	0.02282	4.0015	4.0982
2-1	3	4.03723	0.02282	3.9889	4.0856
2-2	3	4.03093	0.02282	3.9826	4.0793
3-1	3	4.06872	0.02282	4.0204	4.1171
3-2	3	3.97425	0.02282	3.9259	4.0226
4-1	3	3.95535	0.02282	3.9070	4.0037
4-2	3	3.98684	0.02282	3.9385	4.0352

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

Oneway Analysis of B2O3 (wt%) By Block/Sub-Block
Reference value 9.209 wt%



Oneway Anova
Summary of Fit

Rsquare	0.42268
Adj Rsquare	0.170103
Root Mean Square Error	0.190492
Mean of Response	8.725929
Observations (or Sum Wgts)	24

Analysis of Variance

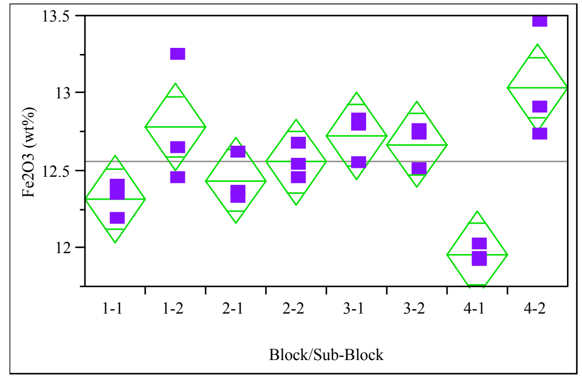
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	7	0.4250780	0.060725	1.6735	0.1861
Error	16	0.5805943	0.036287		
C. Total	23	1.0056723			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	8.87619	0.10998	8.6430	9.1093
1-2	3	8.74739	0.10998	8.5142	8.9805
2-1	3	8.65080	0.10998	8.4176	8.8839
2-2	3	8.71520	0.10998	8.4820	8.9483
3-1	3	8.71520	0.10998	8.4820	8.9483
3-2	3	8.88692	0.10998	8.6538	9.1201
4-1	3	8.43614	0.10998	8.2030	8.6693
4-2	3	8.77959	0.10998	8.5464	9.0127

Std Error uses a pooled estimate of error variance

Oneway Analysis of Fe2O3 (wt%) By Block/Sub-Block
Reference value 13.196 wt%



Oneway Anova
Summary of Fit

Rsquare	0.72985
Adj Rsquare	0.61166
Root Mean Square Error	0.228473
Mean of Response	12.56289
Observations (or Sum Wgts)	24

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	7	2.2564095	0.322344	6.1752	0.0013
Error	16	0.8351956	0.052200		
C. Total	23	3.0916051			

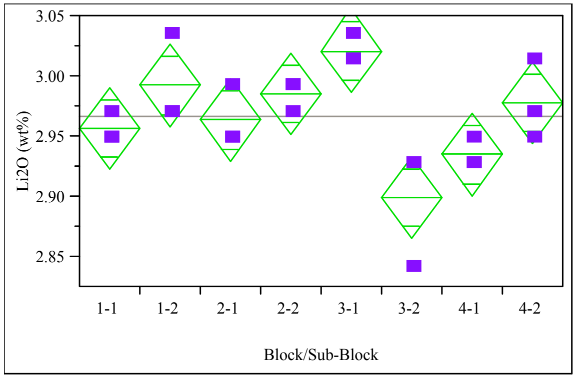
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	12.3192	0.13191	12.040	12.599
1-2	3	12.7863	0.13191	12.507	13.066
2-1	3	12.4384	0.13191	12.159	12.718
2-2	3	12.5575	0.13191	12.278	12.837
3-1	3	12.7291	0.13191	12.449	13.009
3-2	3	12.6719	0.13191	12.392	12.952
4-1	3	11.9618	0.13191	11.682	12.241
4-2	3	13.0389	0.13191	12.759	13.318

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

Oneway Analysis of Li2O (wt%) By Block/Sub-Block
Reference value 3.057 wt%



Oneway Anova
Summary of Fit

Rsquare	0.703566
Adj Rsquare	0.573877
Root Mean Square Error	0.027794
Mean of Response	2.966517
Observations (or Sum Wgts)	24

Analysis of Variance

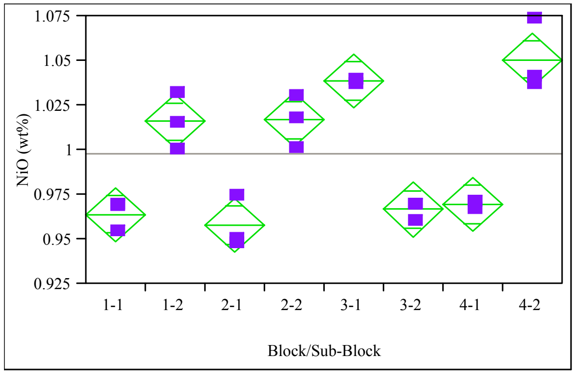
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	7	0.02933555	0.004191	5.4250	0.0025
Error	16	0.01235994	0.000772		
C. Total	23	0.04169549			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	2.95665	0.01605	2.9226	2.9907
1-2	3	2.99253	0.01605	2.9585	3.0265
2-1	3	2.96383	0.01605	2.9298	2.9978
2-2	3	2.98535	0.01605	2.9513	3.0194
3-1	3	3.02124	0.01605	2.9872	3.0553
3-2	3	2.89924	0.01605	2.8652	2.9333
4-1	3	2.93512	0.01605	2.9011	2.9691
4-2	3	2.97818	0.01605	2.9442	3.0122

Std Error uses a pooled estimate of error variance

Oneway Analysis of NiO (wt%) By Block/Sub-Block
Reference value 1.12 wt%



Oneway Anova
Summary of Fit

Rsquare	0.923307
Adj Rsquare	0.889753
Root Mean Square Error	0.012263
Mean of Response	0.997534
Observations (or Sum Wgts)	24

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	7	0.02896822	0.004138	27.5175	<.0001
Error	16	0.00240621	0.000150		
C. Total	23	0.03137444			

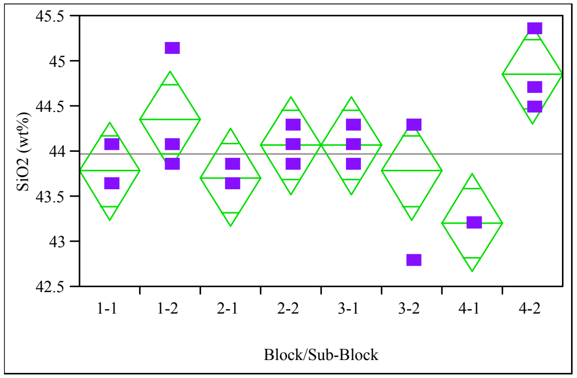
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.96413	0.00708	0.9491	0.9791
1-2	3	1.01588	0.00708	1.0009	1.0309
2-1	3	0.95777	0.00708	0.9428	0.9728
2-2	3	1.01673	0.00708	1.0017	1.0317
3-1	3	1.03878	0.00708	1.0238	1.0538
3-2	3	0.96668	0.00708	0.9517	0.9817
4-1	3	0.96964	0.00708	0.9546	0.9847
4-2	3	1.05066	0.00708	1.0357	1.0657

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

Oneway Analysis of SiO2 (wt%) By Block/Sub-Block
Reference value 45.353 wt%



Oneway Anova
Summary of Fit

Rsquare	0.610122
Adj Rsquare	0.43955
Root Mean Square Error	0.445331
Mean of Response	43.98044
Observations (or Sum Wgts)	24

Analysis of Variance

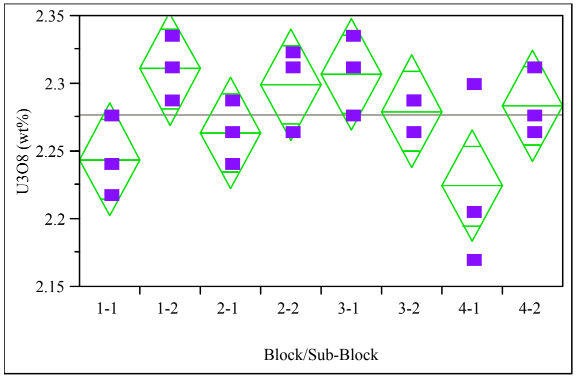
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	7	4.9656159	0.709374	3.5769	0.0165
Error	16	3.1731124	0.198320		
C. Total	23	8.1387283			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	43.7843	0.25711	43.239	44.329
1-2	3	44.3548	0.25711	43.810	44.900
2-1	3	43.7130	0.25711	43.168	44.258
2-2	3	44.0696	0.25711	43.525	44.615
3-1	3	44.0696	0.25711	43.525	44.615
3-2	3	43.7843	0.25711	43.239	44.329
4-1	3	43.2139	0.25711	42.669	43.759
4-2	3	44.8540	0.25711	44.309	45.399

Std Error uses a pooled estimate of error variance

Oneway Analysis of U3O8 (wt%) By Block/Sub-Block
Reference value 2.406 wt%



Oneway Anova
Summary of Fit

Rsquare	0.52039
Adj Rsquare	0.31056
Root Mean Square Error	0.033784
Mean of Response	2.276839
Observations (or Sum Wgts)	24

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Block	7	0.01981481	0.002831	2.4801	0.0628
Error	16	0.01826207	0.001141		
C. Total	23	0.03807687			

Means for Oneway Anova

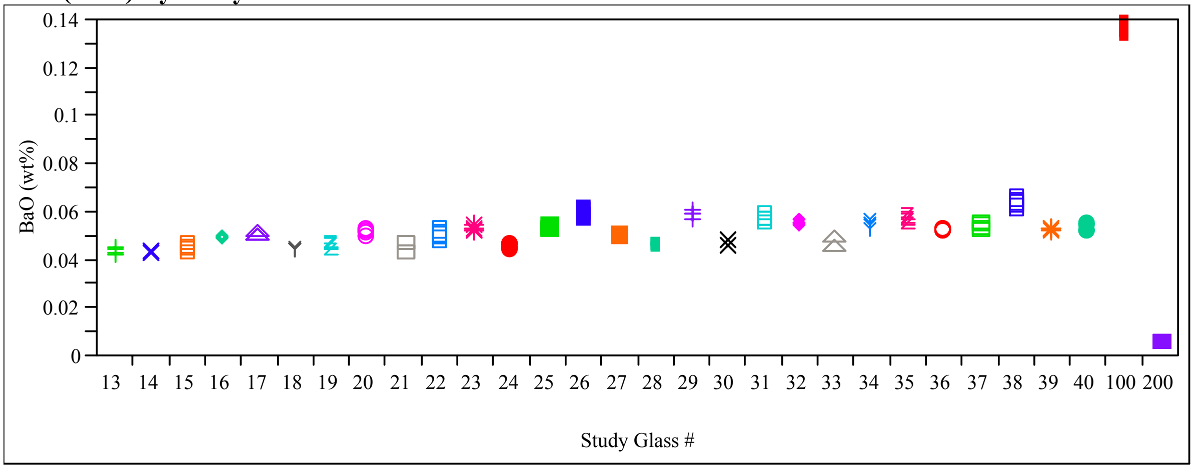
Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	2.24441	0.01951	2.2031	2.2858
1-2	3	2.31123	0.01951	2.2699	2.3526
2-1	3	2.26406	0.01951	2.2227	2.3054
2-2	3	2.29944	0.01951	2.2581	2.3408
3-1	3	2.30730	0.01951	2.2660	2.3487
3-2	3	2.27979	0.01951	2.2384	2.3211
4-1	3	2.22476	0.01951	2.1834	2.2661
4-2	3	2.28372	0.01951	2.2424	2.3251

Std Error uses a pooled estimate of error variance

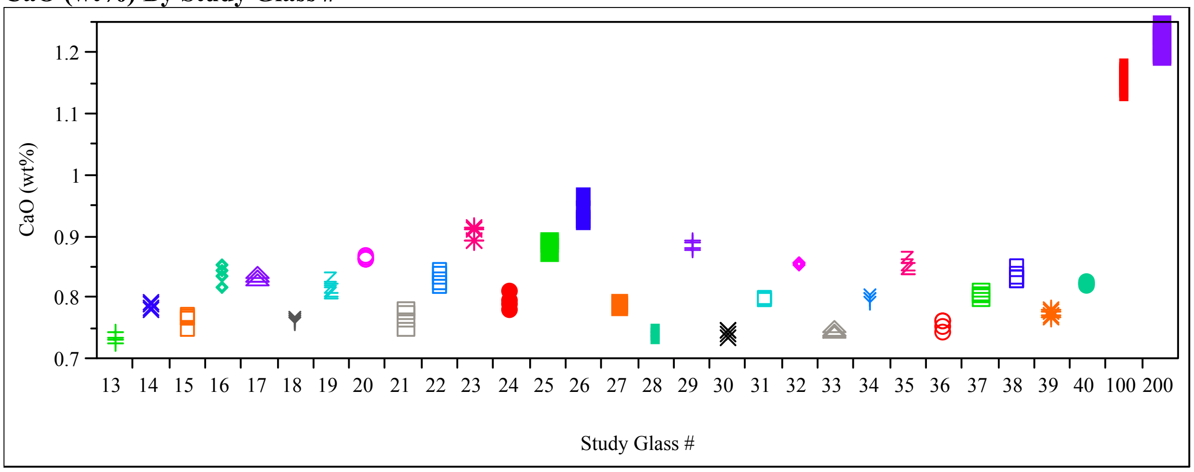
Exhibit C5. Measured and Measured Bias-Corrected Oxide Weight Percents by Glass # for the Glasses Prepared Using the LM Method

(100 – Batch 1; 200 – Ustd)

BaO (wt%) By Study Glass #



CaO (wt%) By Study Glass #



Ce2O3 (wt%) By Study Glass #

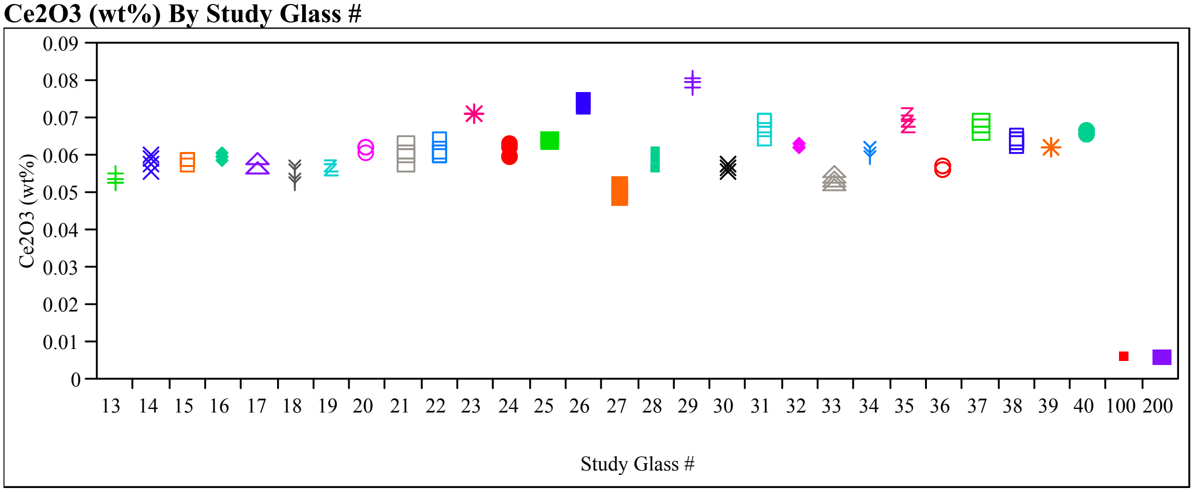
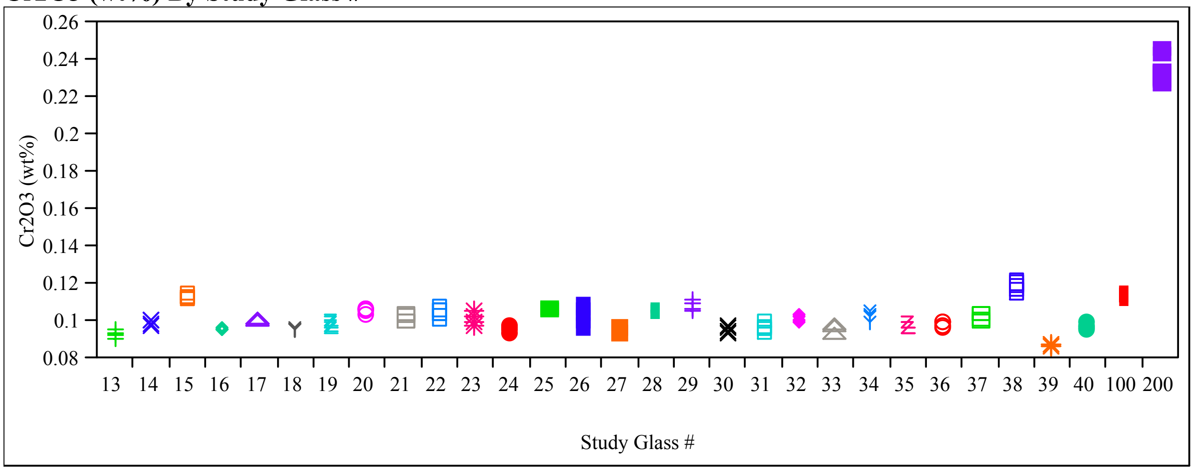


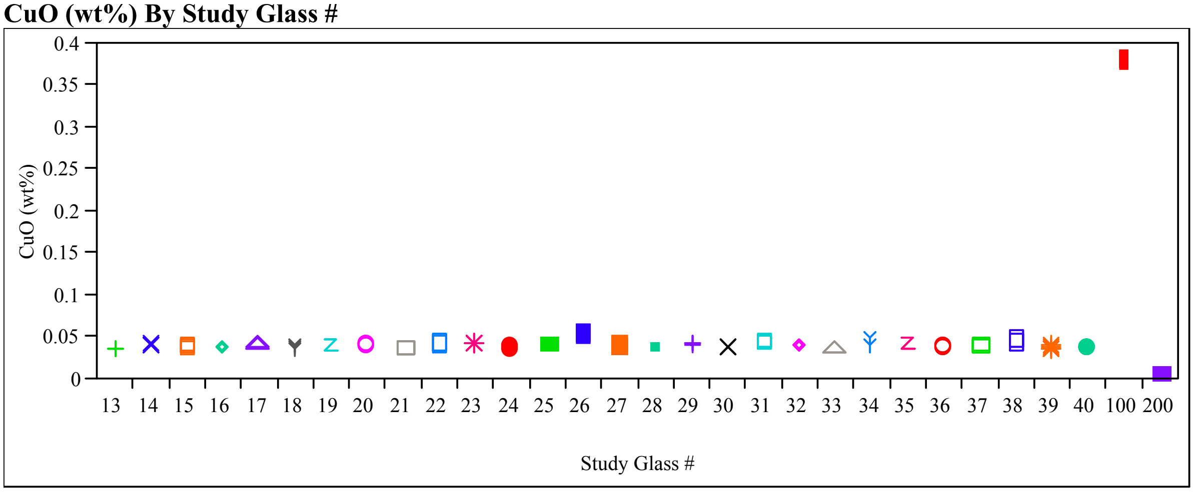
Exhibit C5. Measured and Measured Bias-Corrected Oxide Weight Percents by Glass # for the Glasses Prepared Using the LM Method

(100 – Batch 1; 200 – Ustd)

Cr2O3 (wt%) By Study Glass #



CuO (wt%) By Study Glass #



K2O (wt%) By Study Glass #

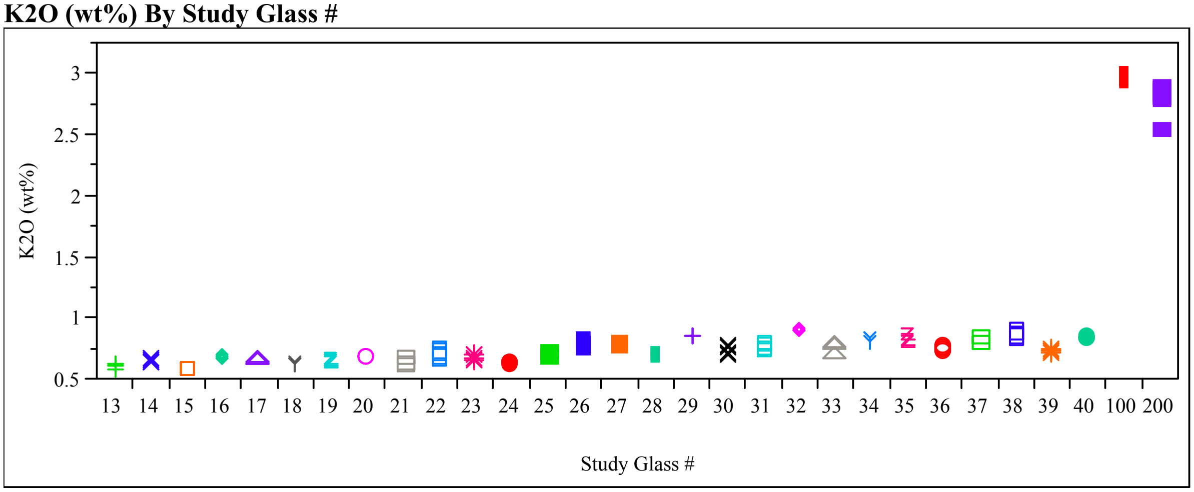
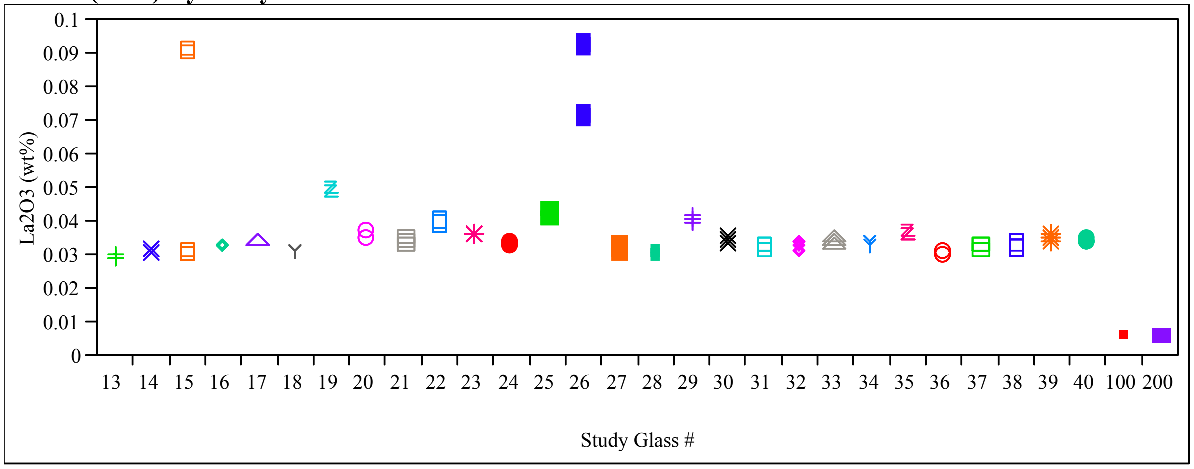
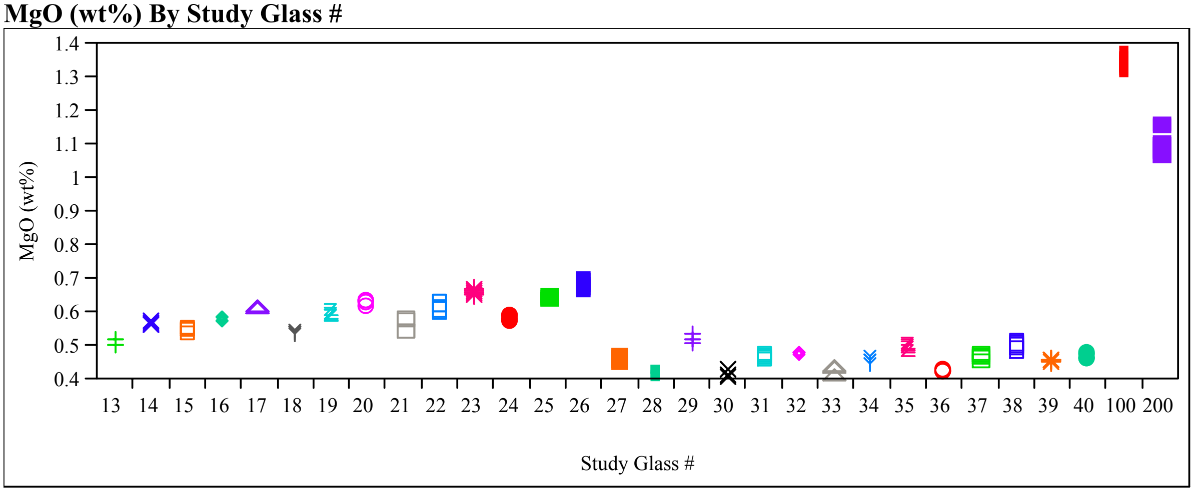


Exhibit C5. Measured and Measured Bias-Corrected Oxide Weight Percents by Glass # for the Glasses Prepared Using the LM Method
(100 – Batch 1; 200 – Ustd)

La2O3 (wt%) By Study Glass #



MgO (wt%) By Study Glass #



MnO (wt%) By Study Glass #

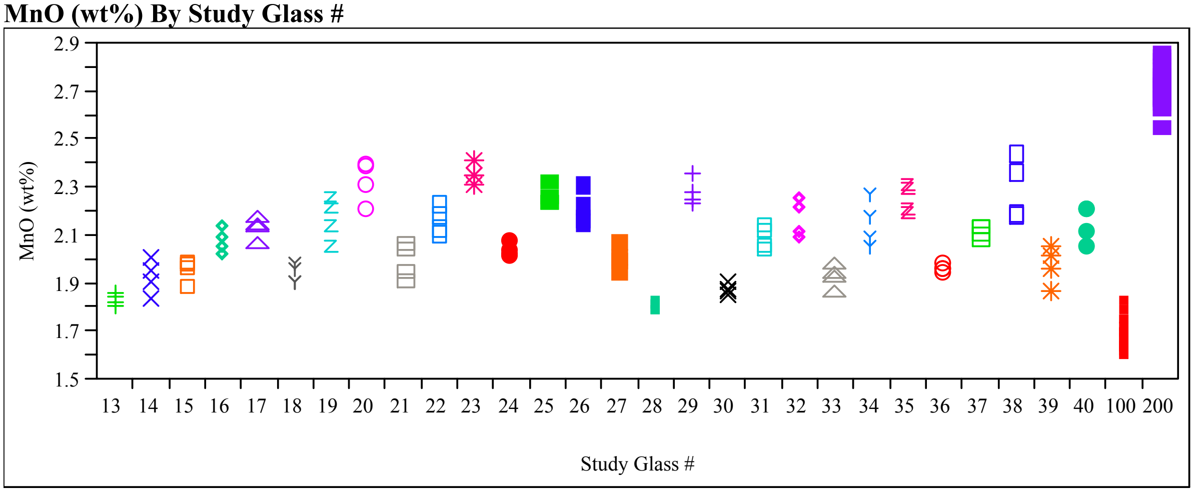
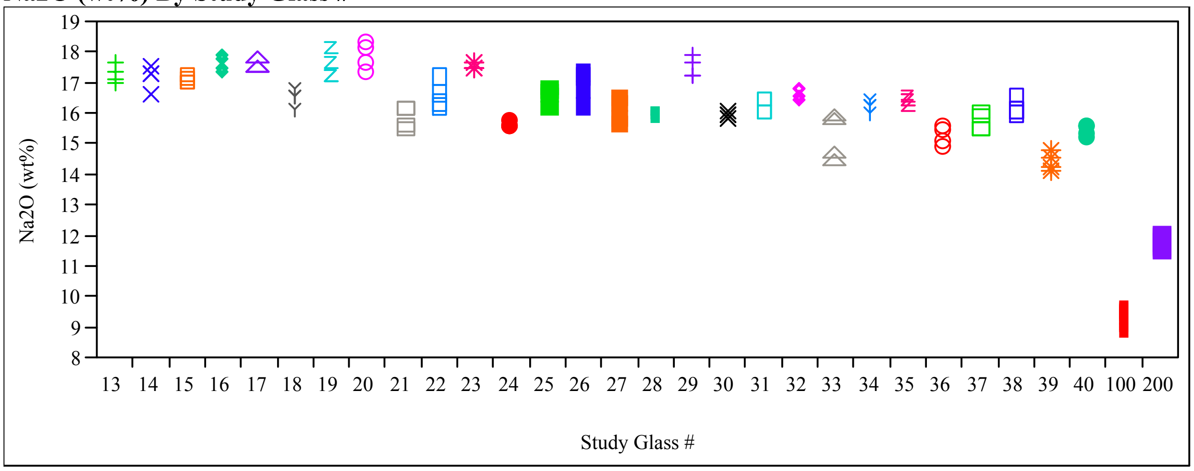


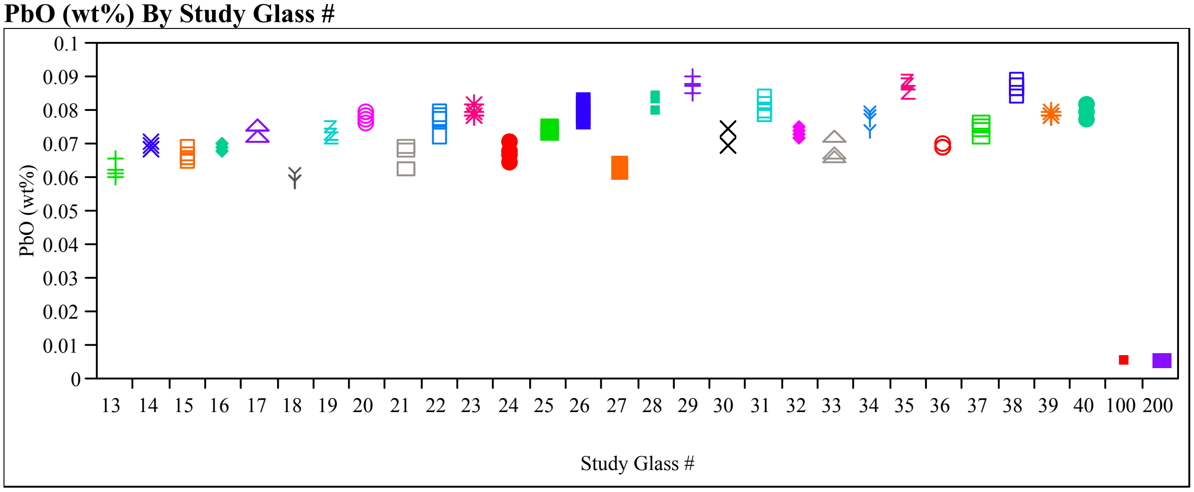
Exhibit C5. Measured and Measured Bias-Corrected Oxide Weight Percents by Glass # for the Glasses Prepared Using the LM Method

(100 – Batch 1; 200 – Ustd)

Na2O (wt%) By Study Glass #



PbO (wt%) By Study Glass #



SO4 (wt%) By Study Glass #

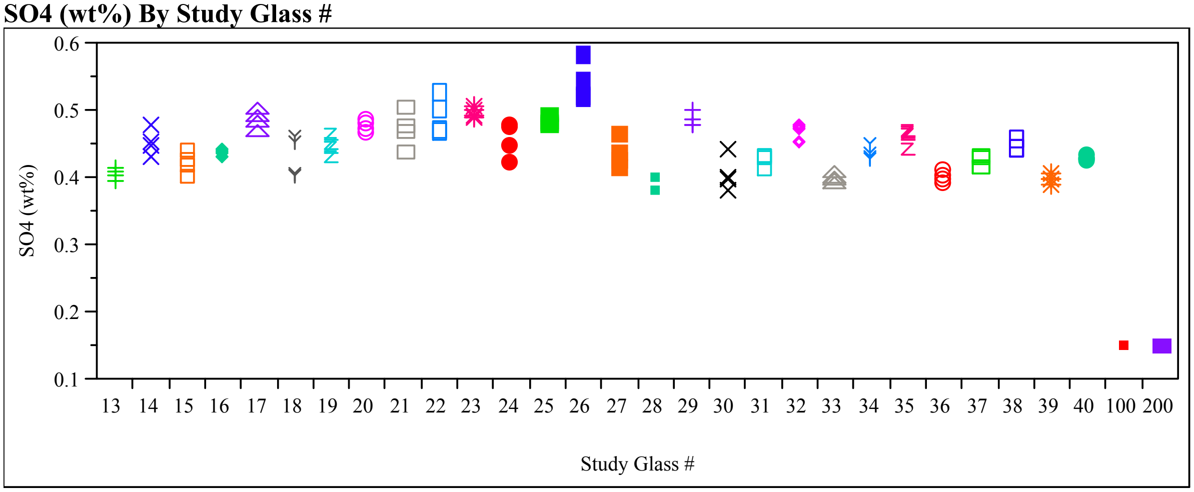
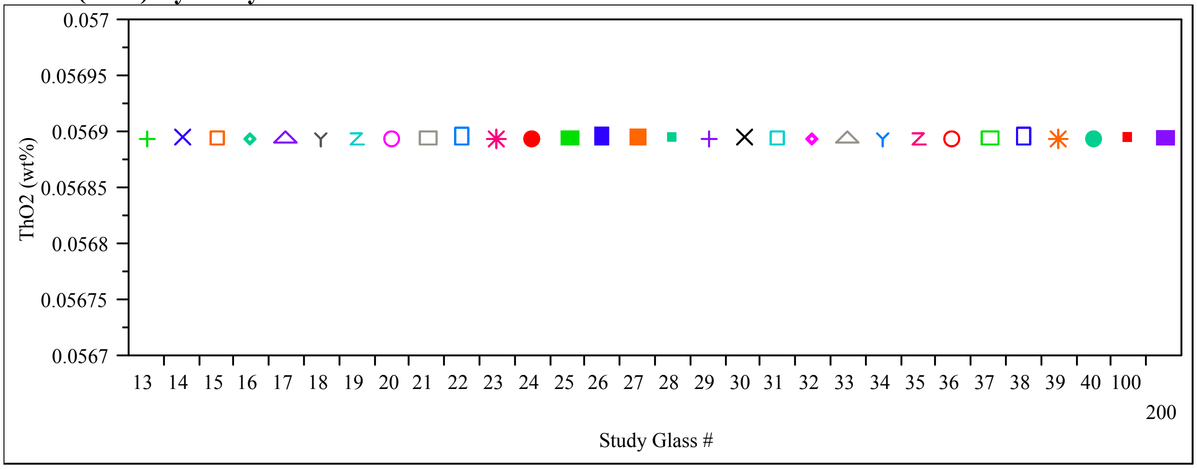


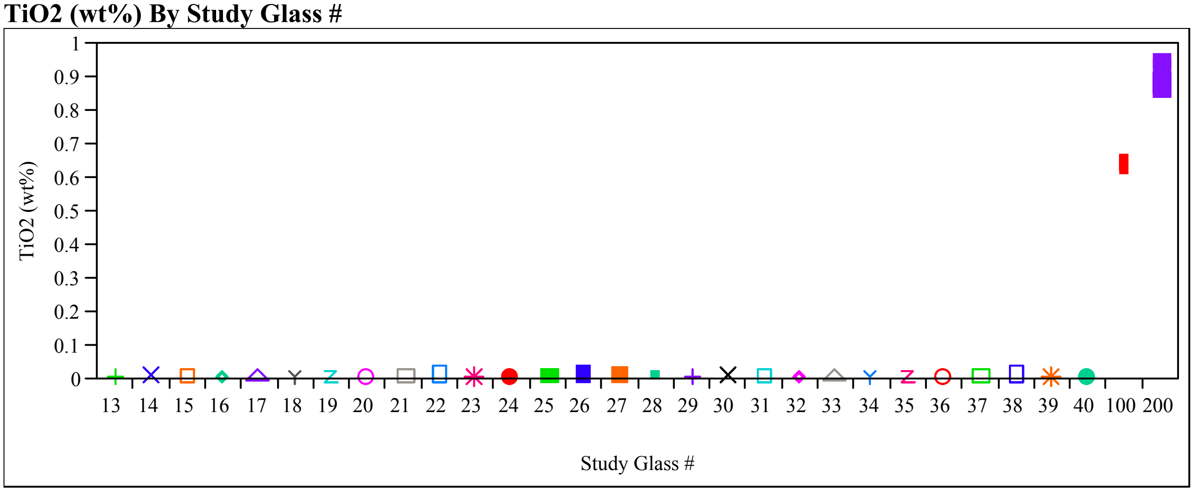
Exhibit C5. Measured and Measured Bias-Corrected Oxide Weight Percents by Glass # for the Glasses Prepared Using the LM Method

(100 – Batch 1; 200 – Ustd)

ThO2 (wt%) By Study Glass #



TiO2 (wt%) By Study Glass #



ZnO (wt%) By Study Glass #

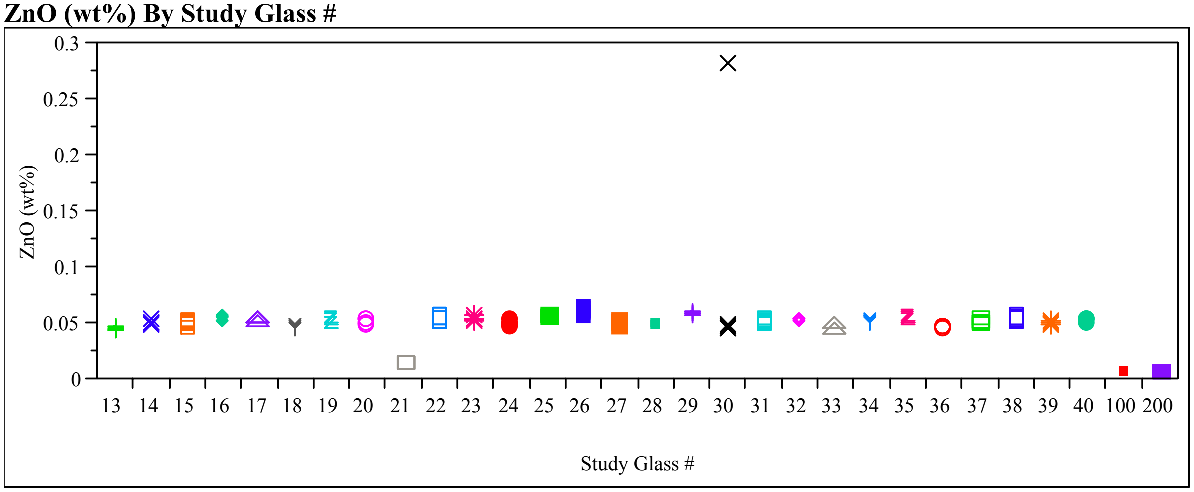
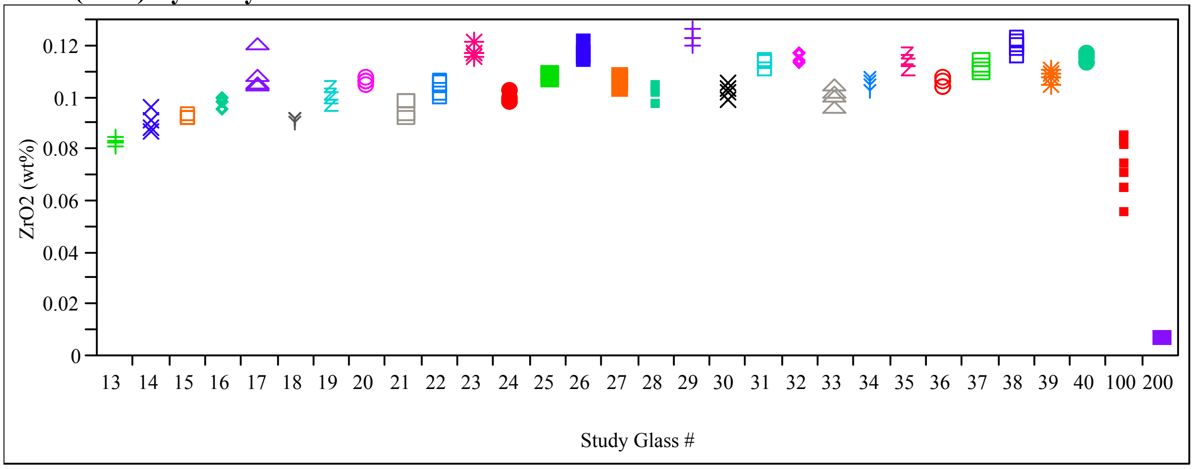


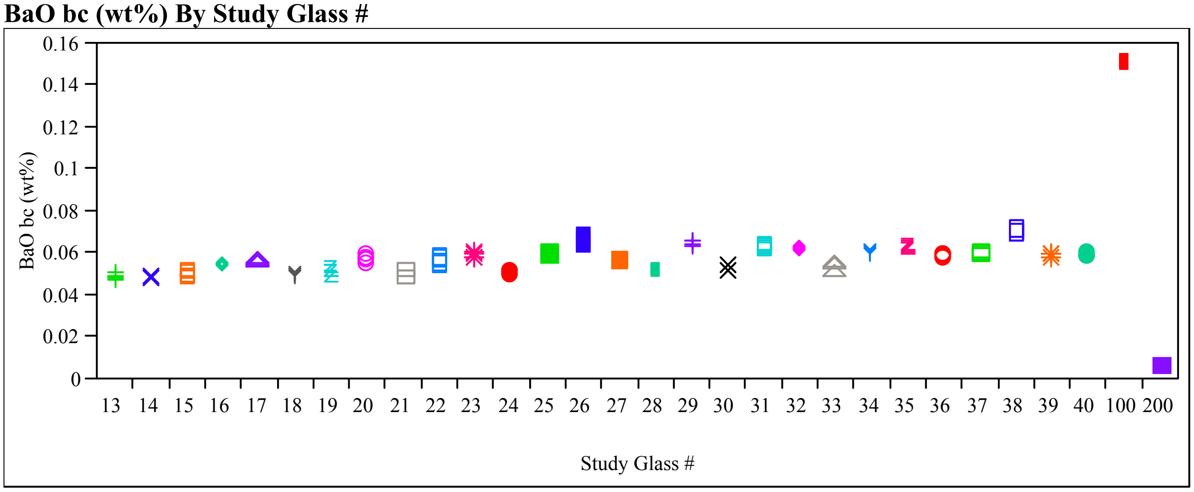
Exhibit C5. Measured and Measured Bias-Corrected Oxide Weight Percents by Glass # for the Glasses Prepared Using the LM Method

(100 – Batch 1; 200 – Ustd)

ZrO2 (wt%) By Study Glass #



BaO bc (wt%) By Study Glass #



CaO bc (wt%) By Study Glass #

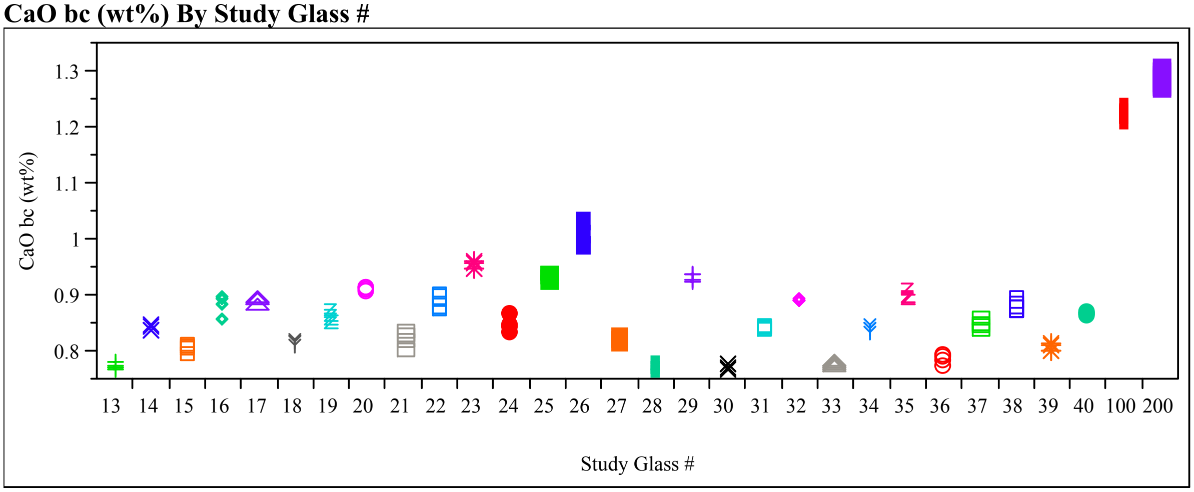
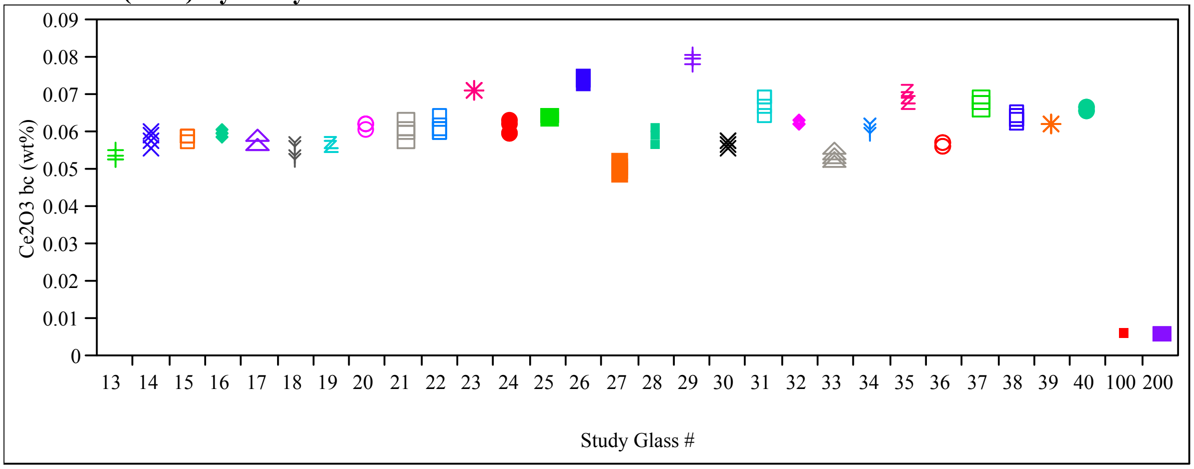


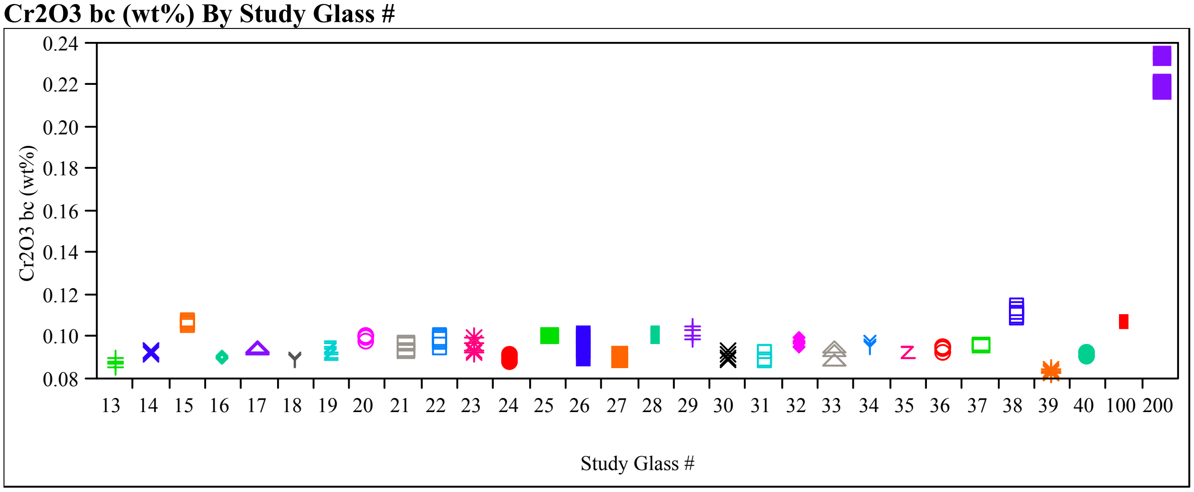
Exhibit C5. Measured and Measured Bias-Corrected Oxide Weight Percents by Glass # for the Glasses Prepared Using the LM Method

(100 – Batch 1; 200 – Ustd)

Ce2O3 bc (wt%) By Study Glass #



Cr2O3 bc (wt%) By Study Glass #



CuO bc (wt%) By Study Glass #

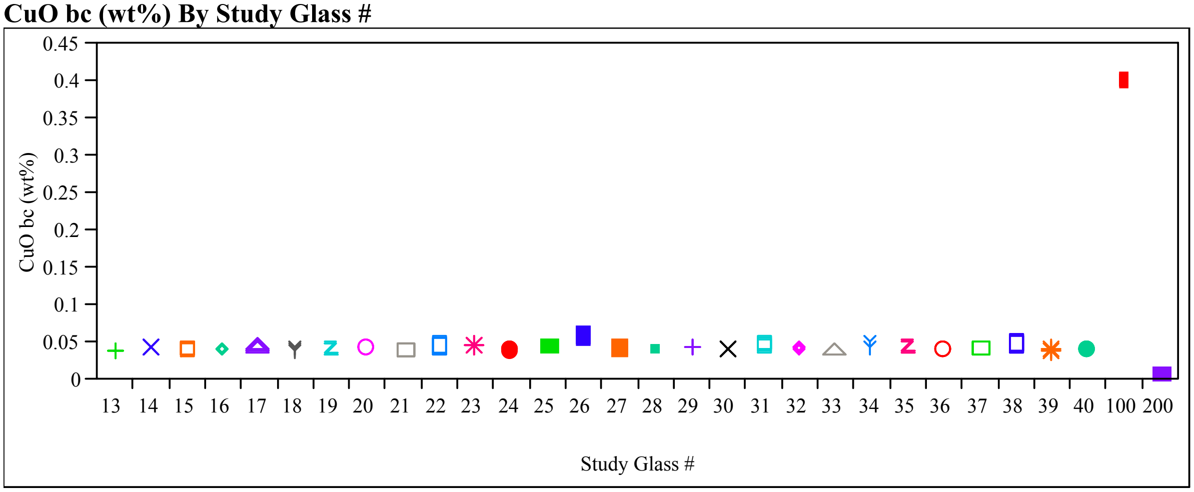
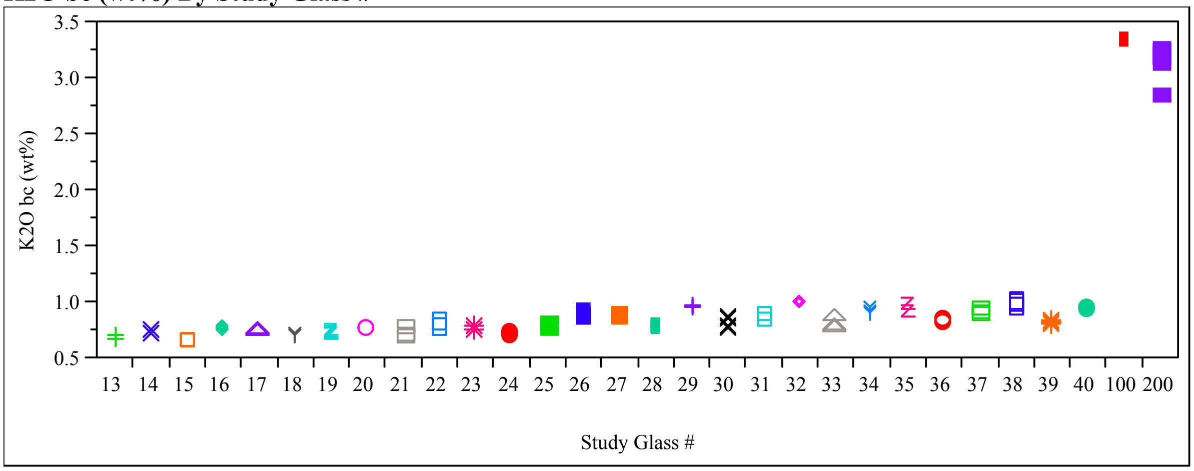


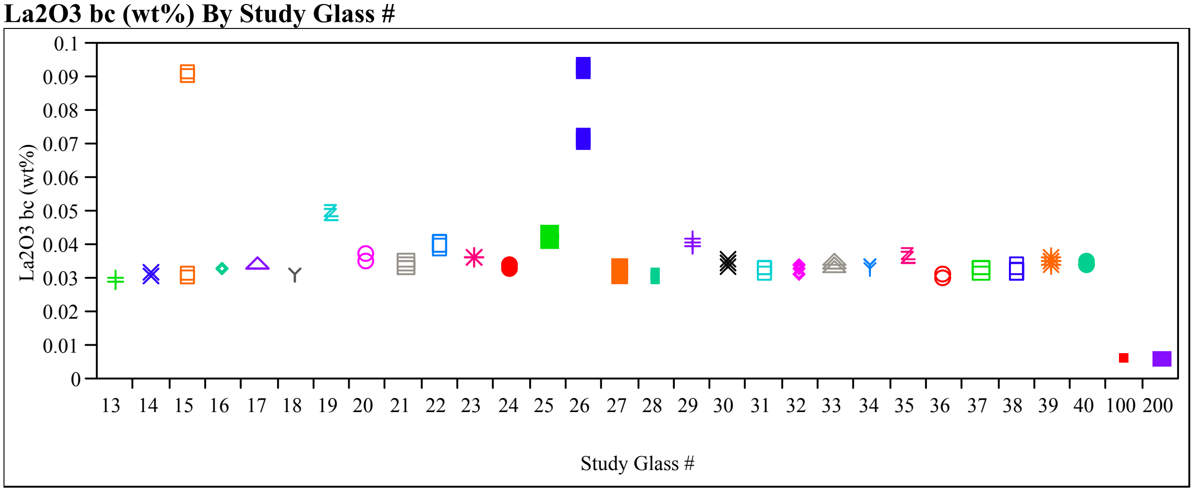
Exhibit C5. Measured and Measured Bias-Corrected Oxide Weight Percents by Glass # for the Glasses Prepared Using the LM Method

(100 – Batch 1; 200 – Ustd)

K2O bc (wt%) By Study Glass #



La2O3 bc (wt%) By Study Glass #



MgO bc (wt%) By Study Glass #

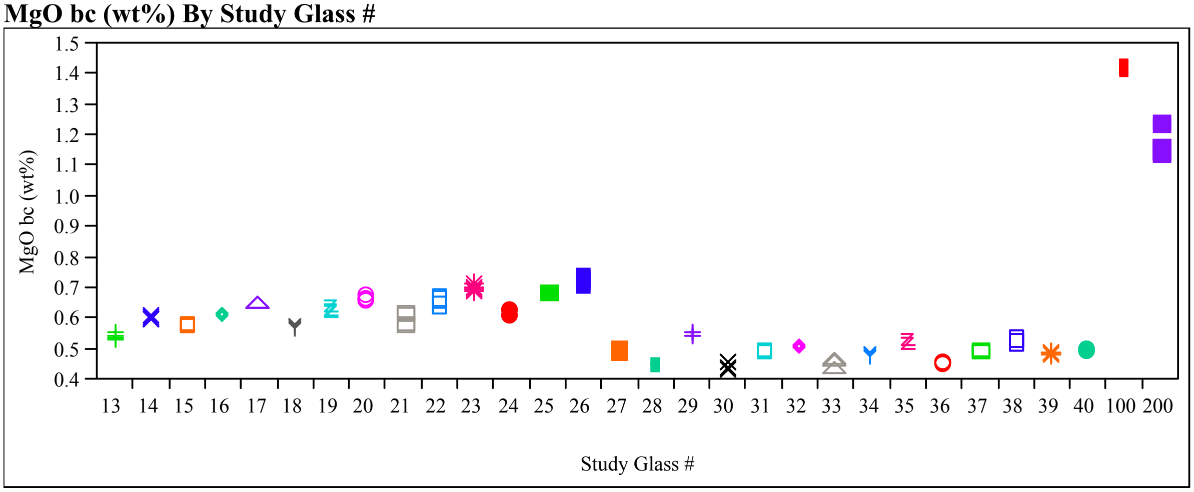
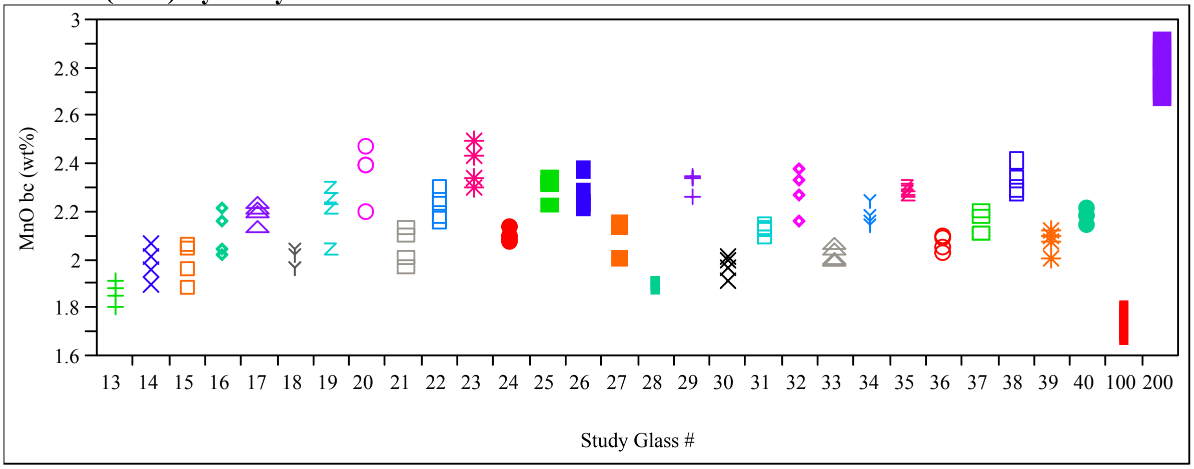


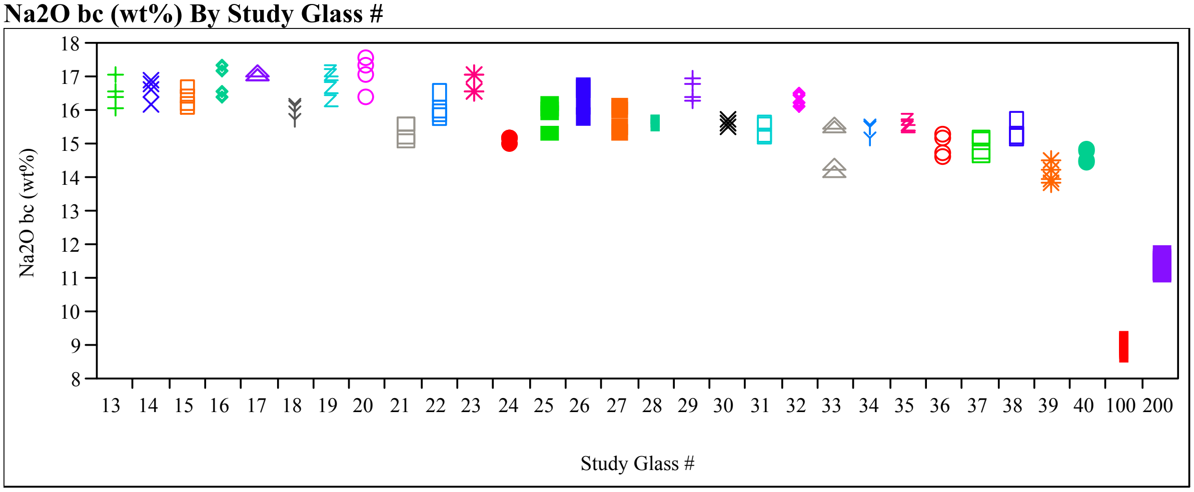
Exhibit C5. Measured and Measured Bias-Corrected Oxide Weight Percents by Glass # for the Glasses Prepared Using the LM Method

(100 – Batch 1; 200 – Ustd)

MnO bc (wt%) By Study Glass #



Na2O bc (wt%) By Study Glass #



PbO bc (wt%) By Study Glass #

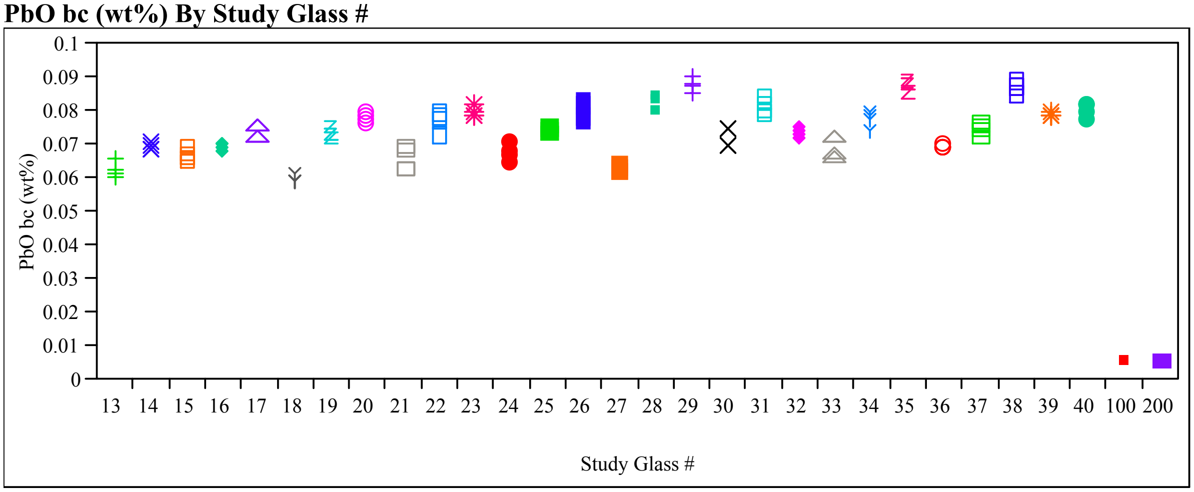
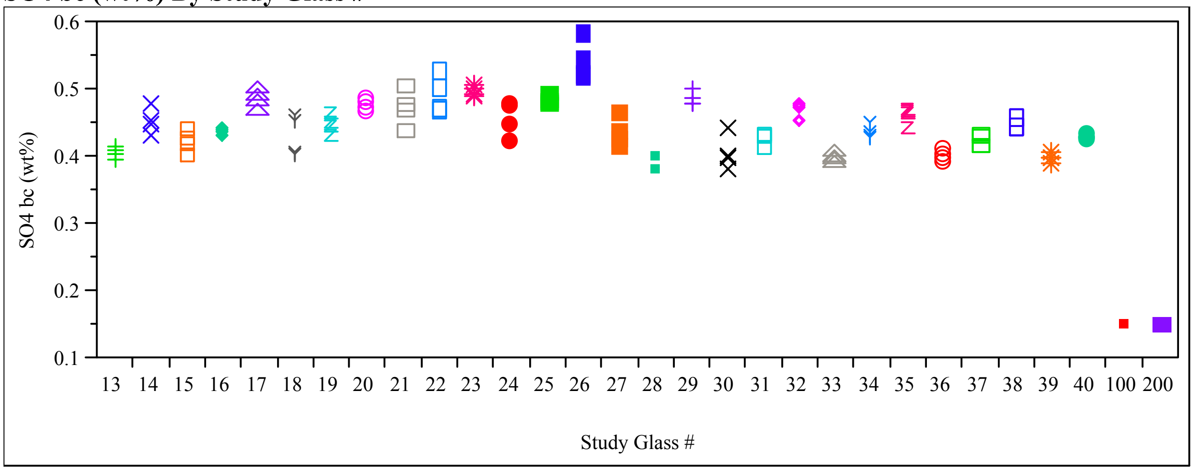


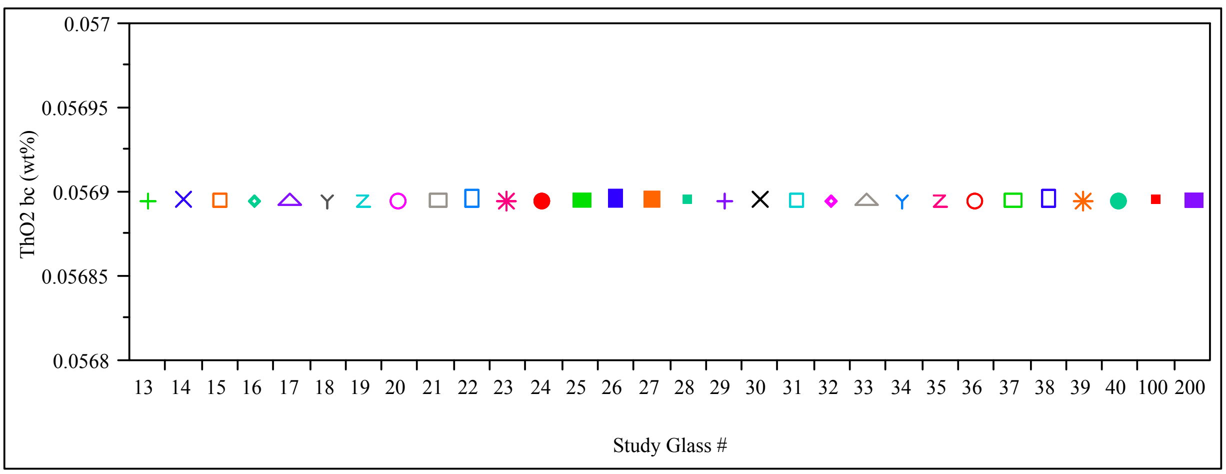
Exhibit C5. Measured and Measured Bias-Corrected Oxide Weight Percents by Glass # for the Glasses Prepared Using the LM Method

(100 – Batch 1; 200 – Ustd)

SO4 bc (wt%) By Study Glass #



ThO2 bc (wt%) By Study Glass #



TiO2 bc (wt%) By Study Glass #

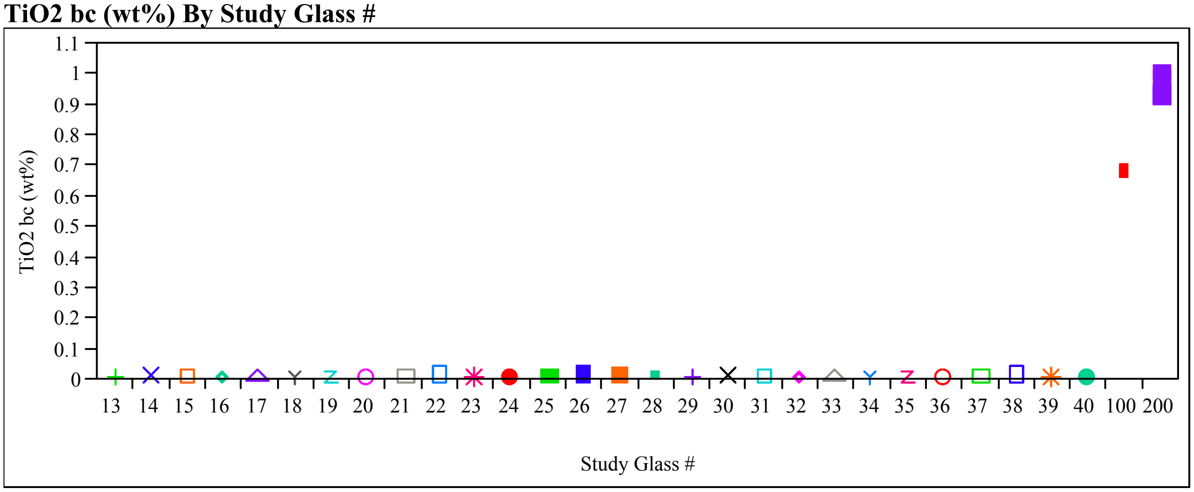
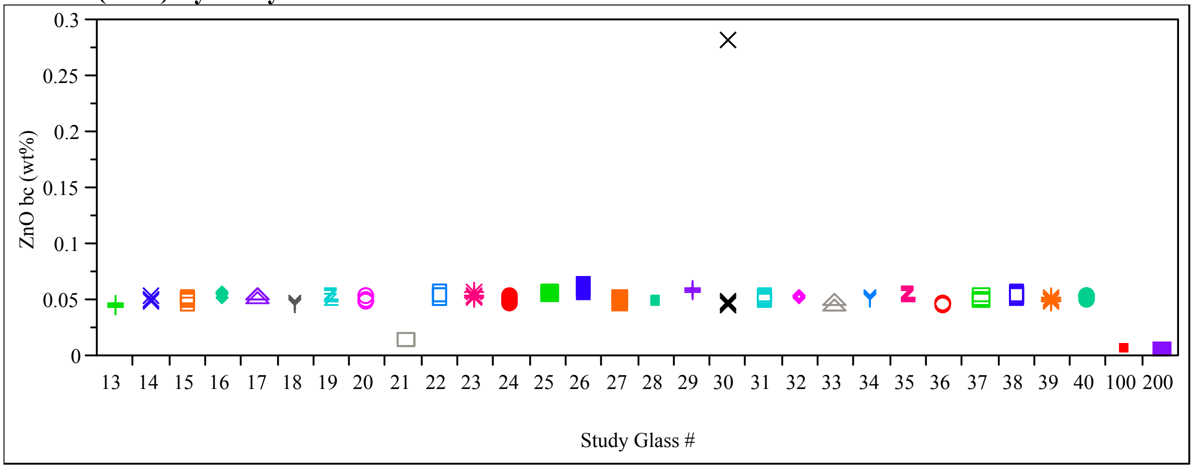


Exhibit C5. Measured and Measured Bias-Corrected Oxide Weight Percents by Glass # for the Glasses Prepared Using the LM Method

(100 – Batch 1; 200 – Ustd)

ZnO bc (wt%) By Study Glass #



ZrO2 bc (wt%) By Study Glass #

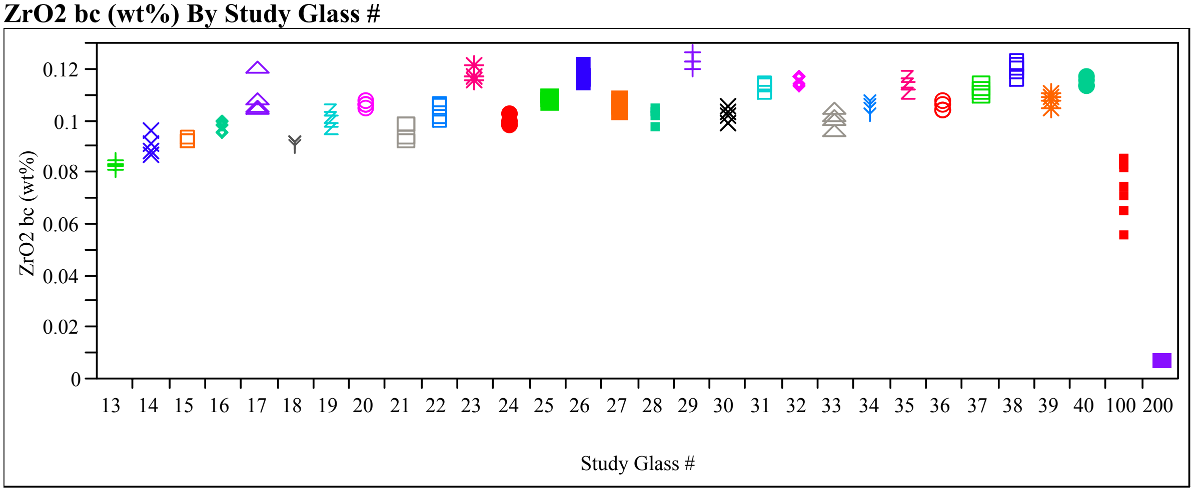
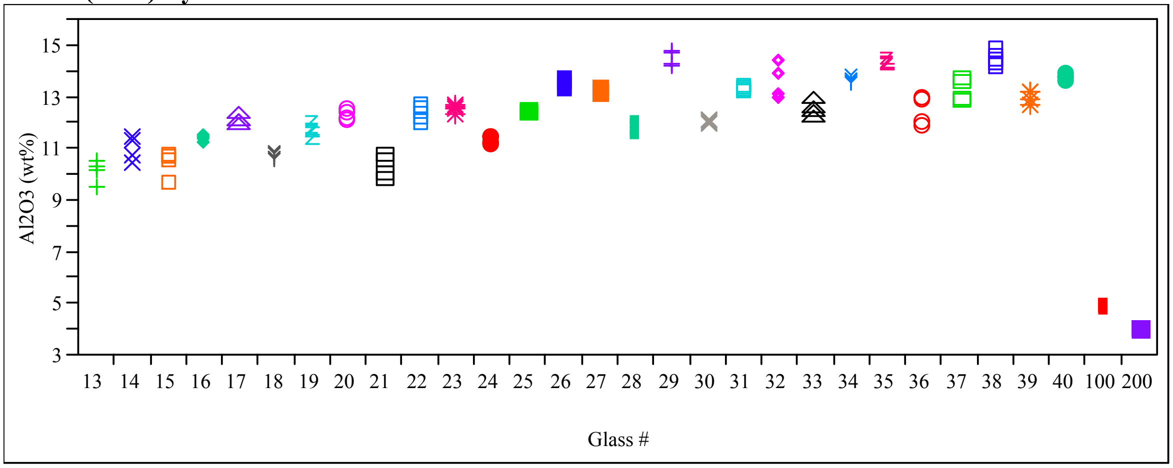


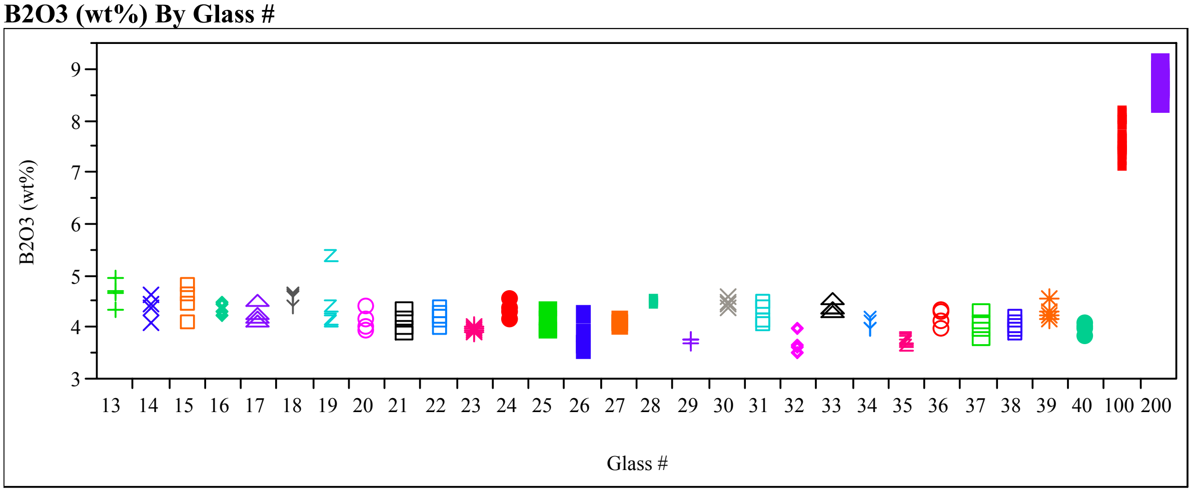
Exhibit C6. Measured and Measured Bias-Corrected Oxide Weight Percents by Glass # for the Glasses Prepared Using the PF Method

(100 – Batch 1; 200 – Ustd)

Al2O3 (wt%) By Glass #



B2O3 (wt%) By Glass #



Fe2O3 (wt%) By Glass #

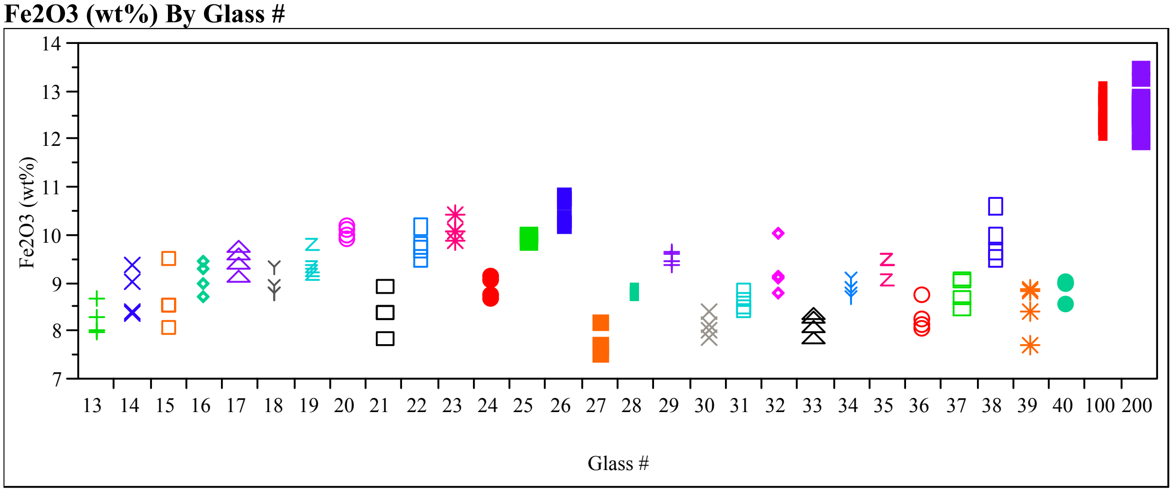
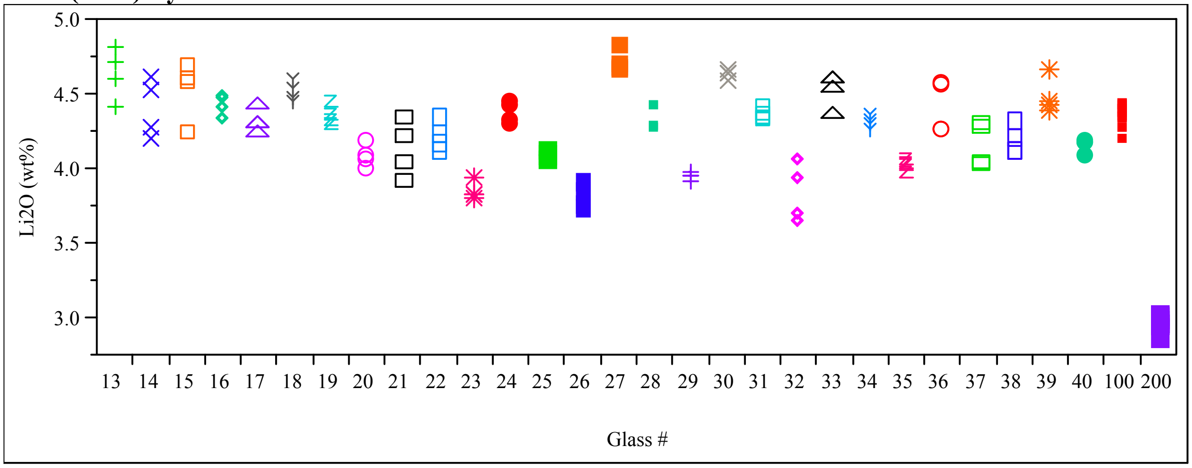


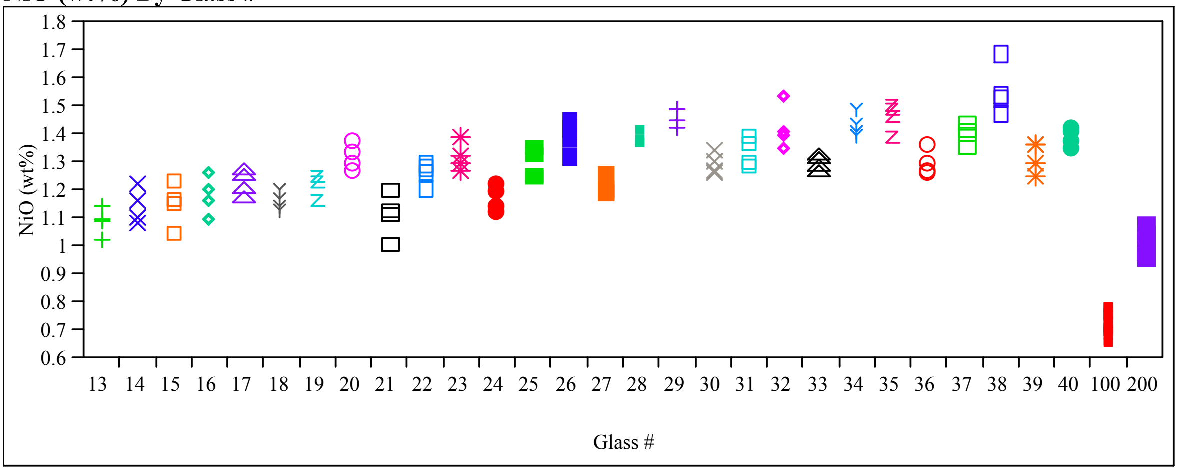
Exhibit C6. Measured and Measured Bias-Corrected Oxide Weight Percents by Glass # for the Glasses Prepared Using the PF Method

(100 – Batch 1; 200 – Ustd)

Li2O (wt%) By Glass #



NiO (wt%) By Glass #



SiO2 (wt%) By Glass #

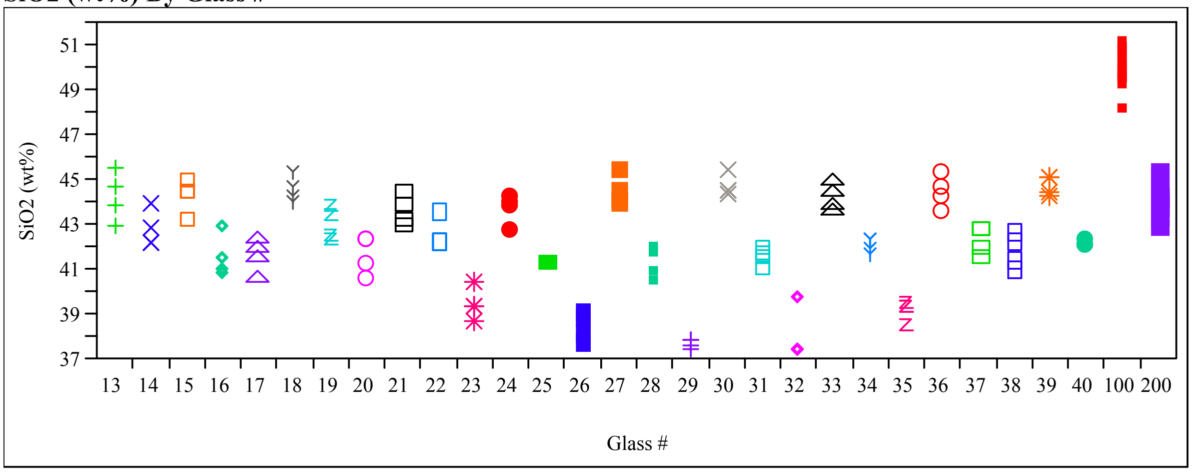
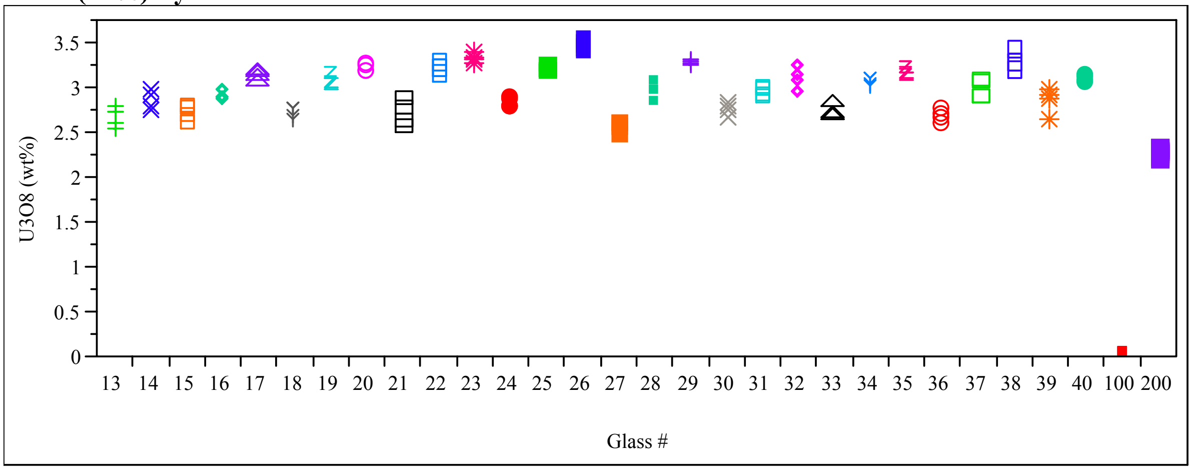


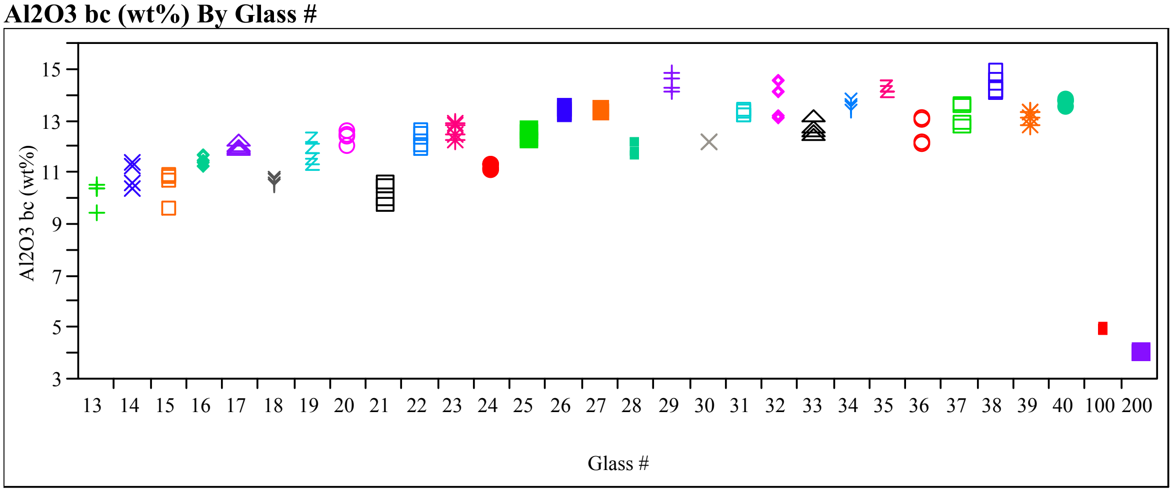
Exhibit C6. Measured and Measured Bias-Corrected Oxide Weight Percents by Glass # for the Glasses Prepared Using the PF Method

(100 – Batch 1; 200 – Ustd)

U3O8 (wt%) By Glass #



Al2O3 bc (wt%) By Glass #



B2O3 bc (wt%) By Glass #

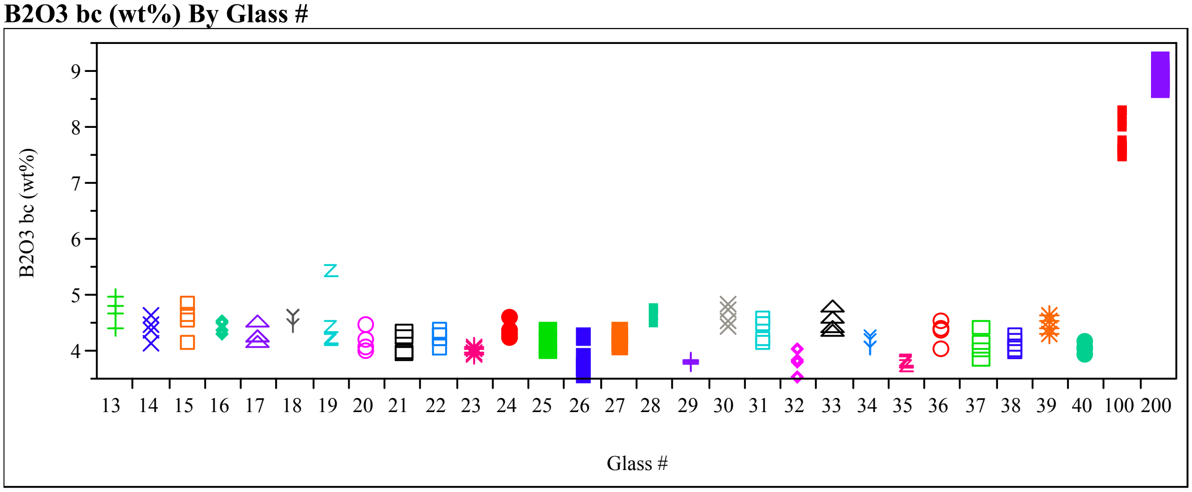
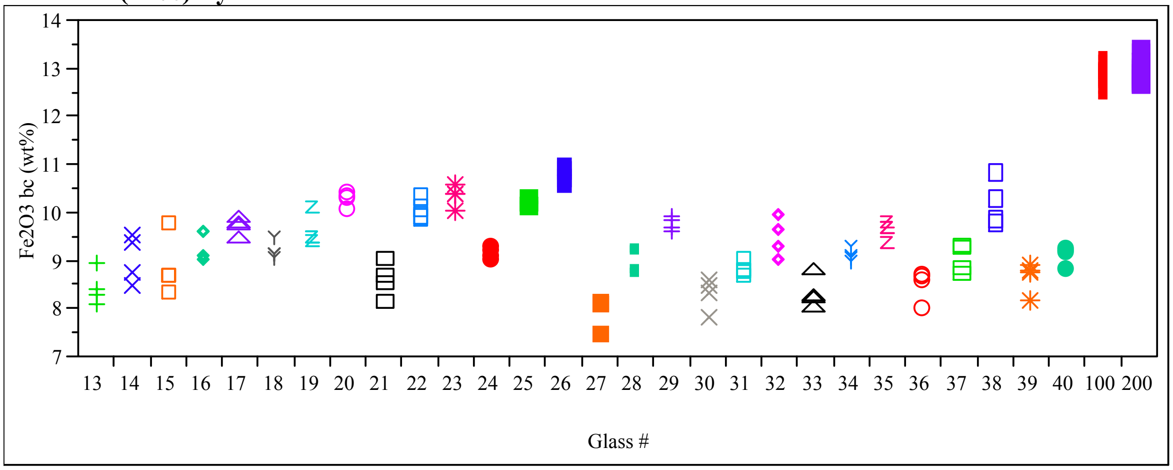


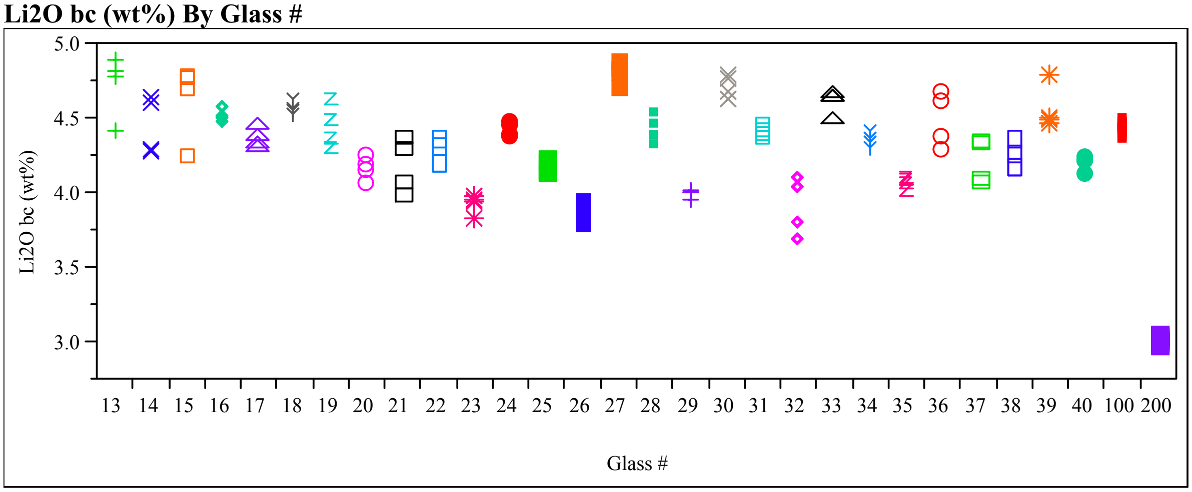
Exhibit C6. Measured and Measured Bias-Corrected Oxide Weight Percents by Glass # for the Glasses Prepared Using the PF Method

(100 – Batch 1; 200 – Ustd)

Fe2O3 bc (wt%) By Glass #



Li2O bc (wt%) By Glass #



NiO bc (wt%) By Glass #

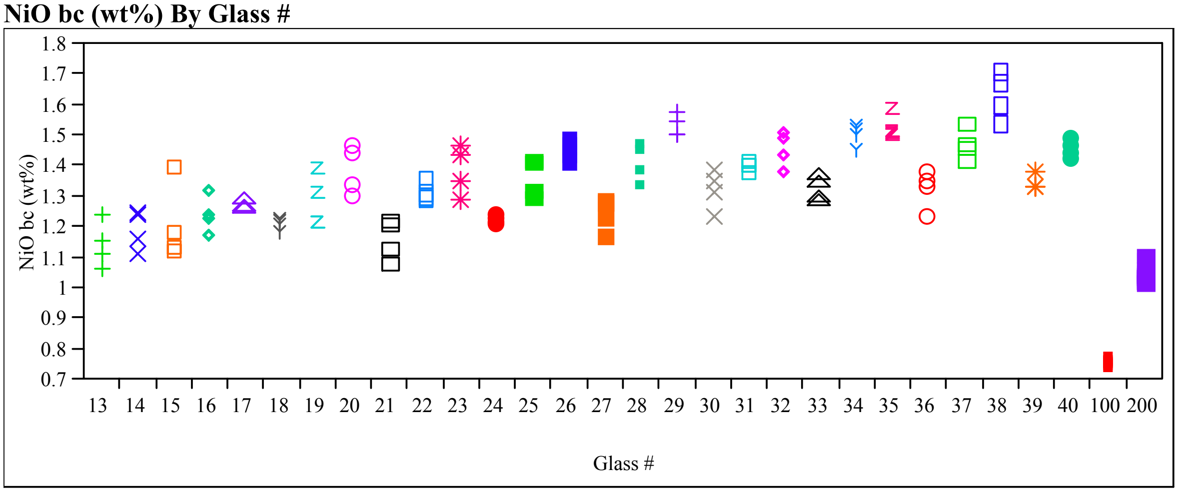
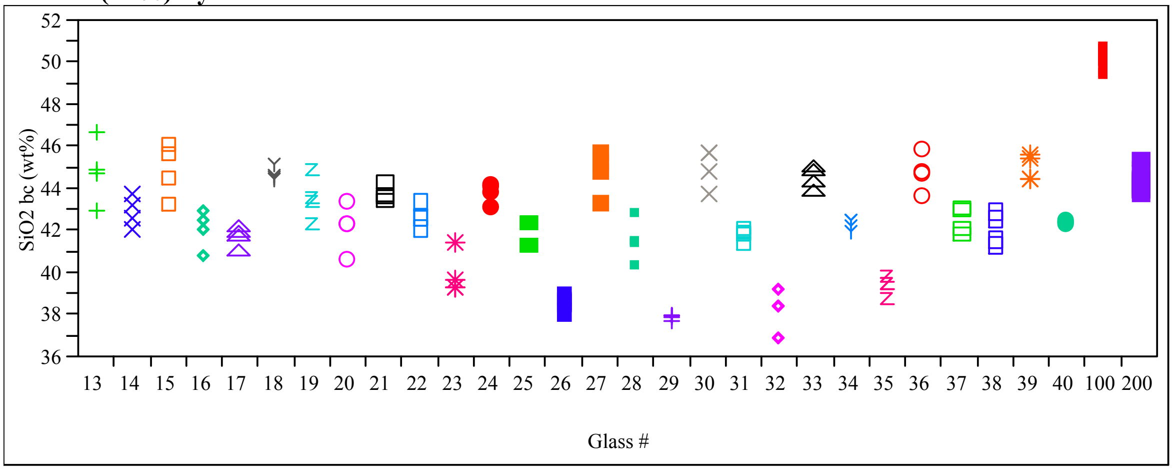


Exhibit C6. Measured and Measured Bias-Corrected Oxide Weight Percents by Glass # for the Glasses Prepared Using the PF Method

(100 – Batch 1; 200 – Ustd)

SiO2 bc (wt%) By Glass #



U3O8 bc (wt%) By Glass #

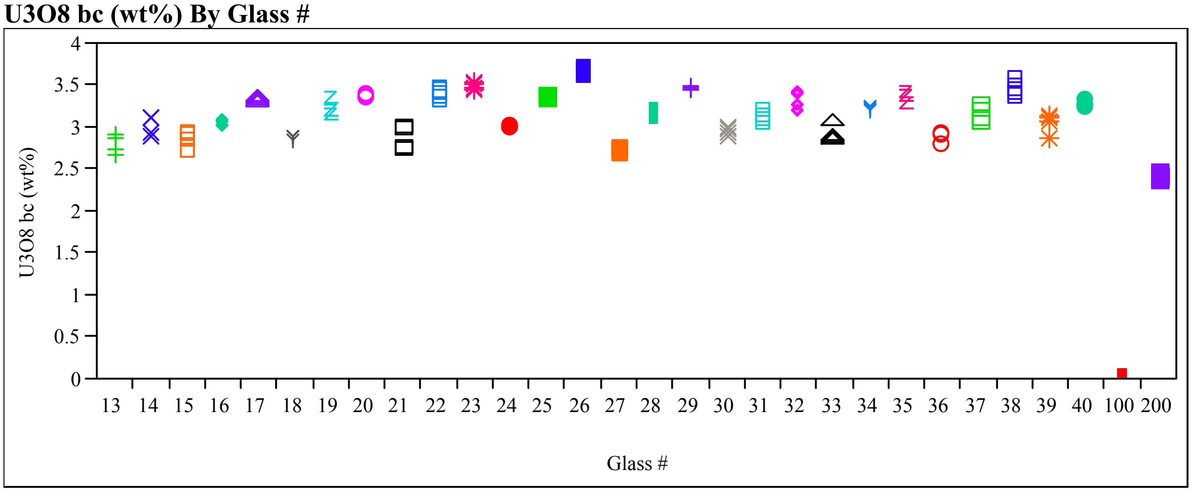
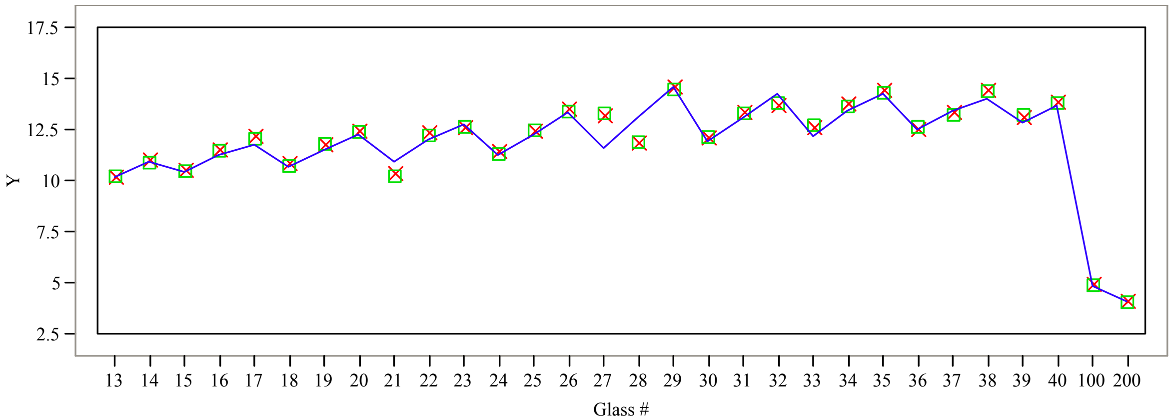


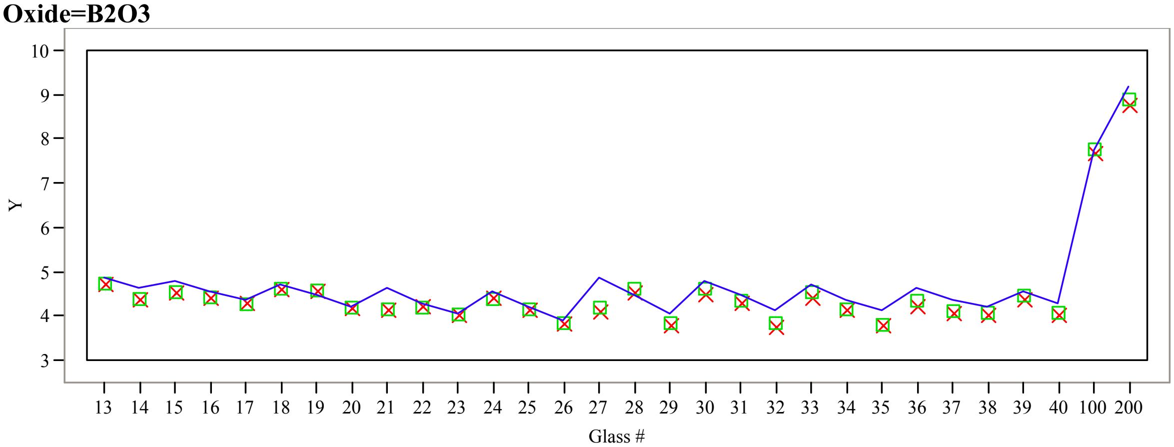
Exhibit C7. Average Measured and Bias-Corrected (bc) Versus Targeted Compositions by Glass # by Oxide

(100 – Batch 1; 200 – Ustd)

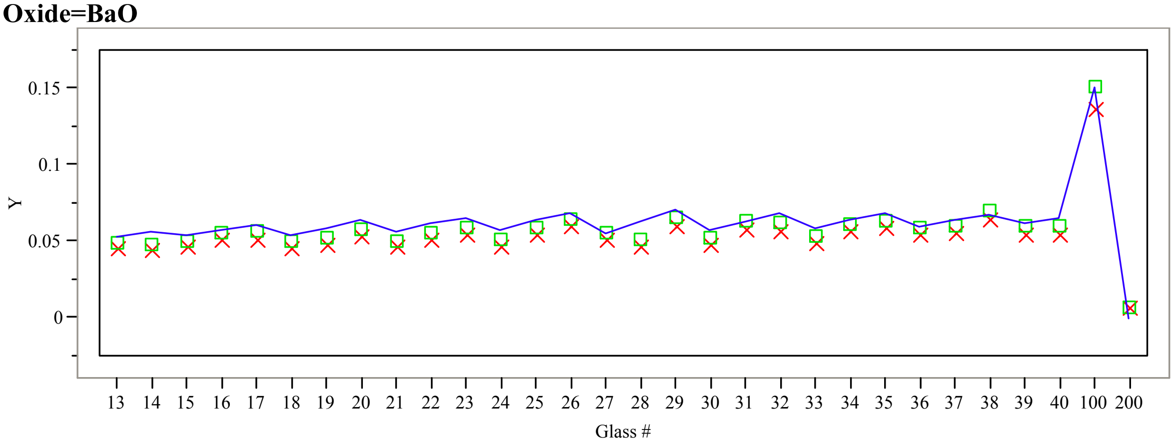
Oxide=Al2O3



Oxide=B2O3



Oxide=BaO

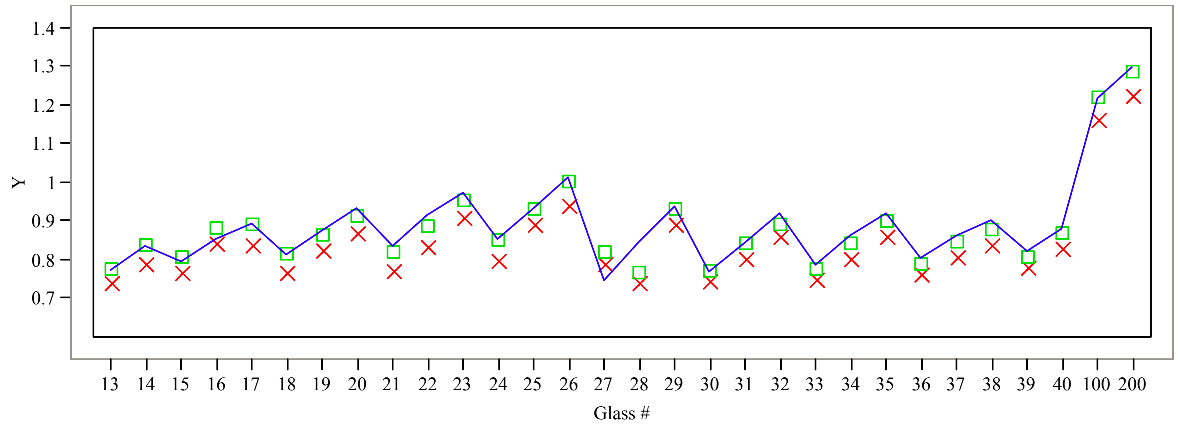


Y × Measured (wt%) Measured bc (wt%) Targeted (wt%)

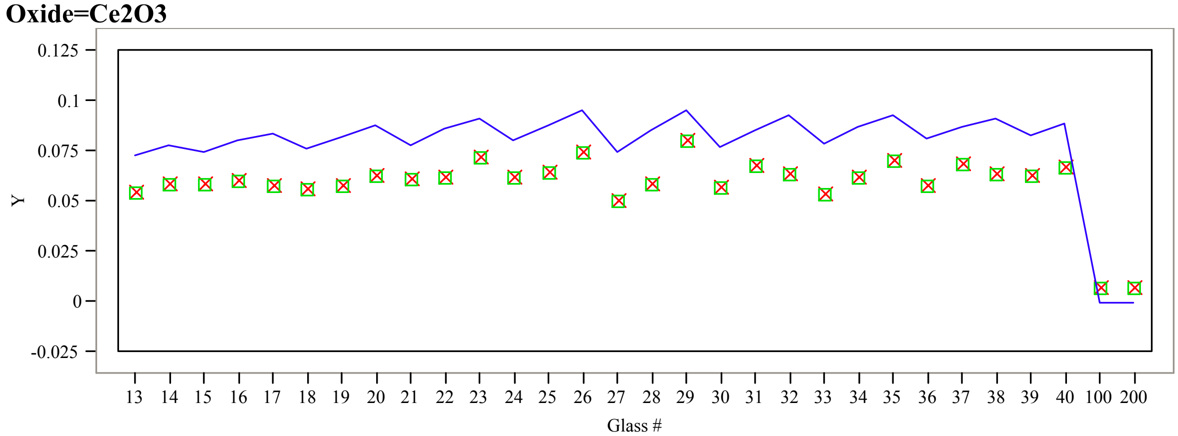
Exhibit C7. Average Measured and Bias-Corrected (bc) Versus Targeted Compositions by Glass # by Oxide

(100 – Batch 1; 200 – Ustd)

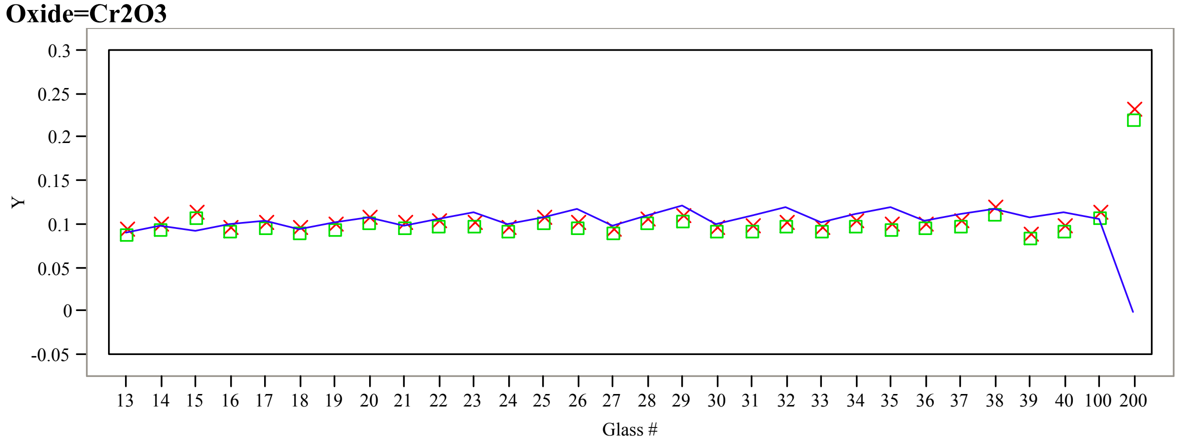
Oxide=CaO



Oxide=Ce2O3



Oxide=Cr2O3

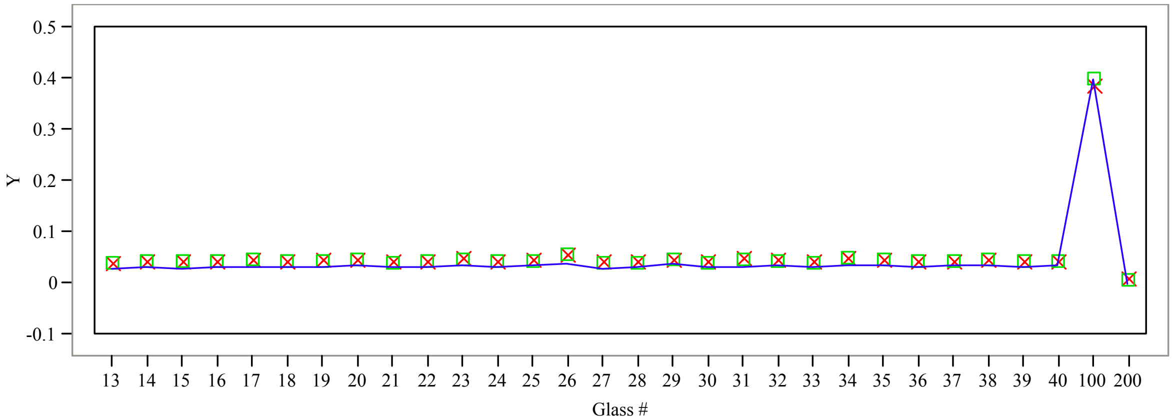


Y ✕ Measured (wt%) ▫ Measured bc (wt%) — Targeted (wt%)

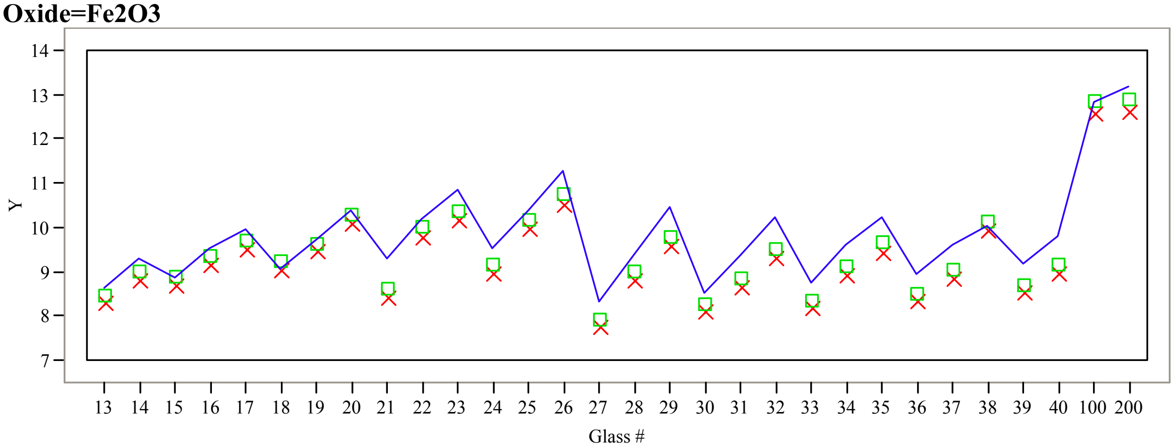
Exhibit C7. Average Measured and Bias-Corrected (bc) Versus Targeted Compositions by Glass # by Oxide

(100 – Batch 1; 200 – Ustd)

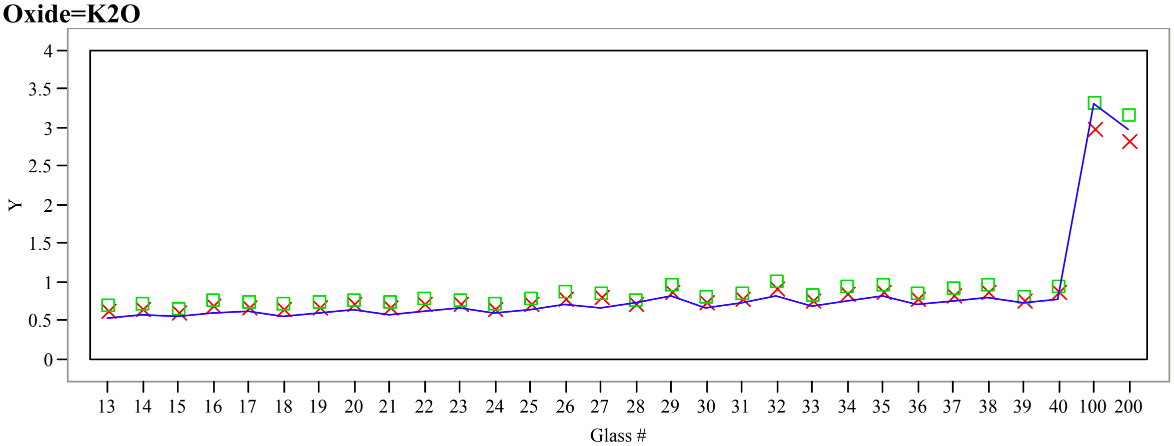
Oxide=CuO



Oxide=Fe2O3



Oxide=K2O

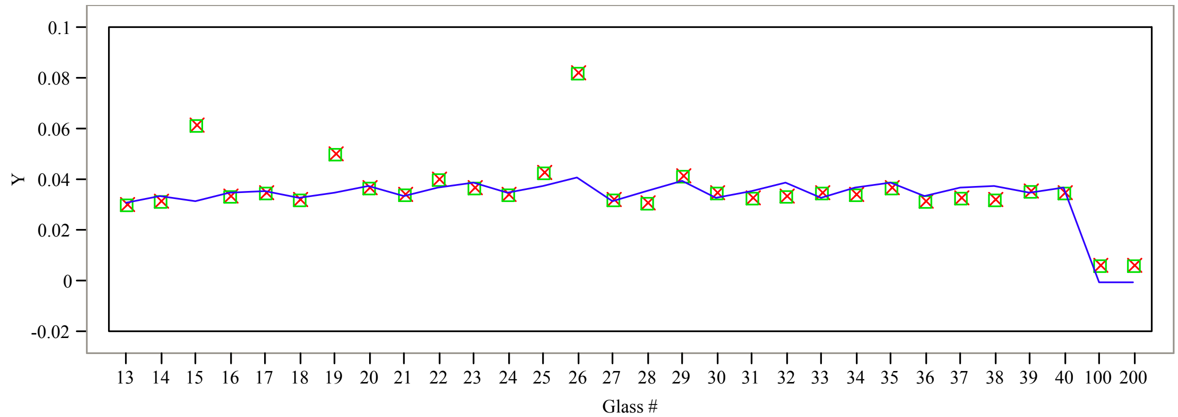


Y × Measured (wt%) ▫ Measured bc (wt%) — Targeted (wt%)

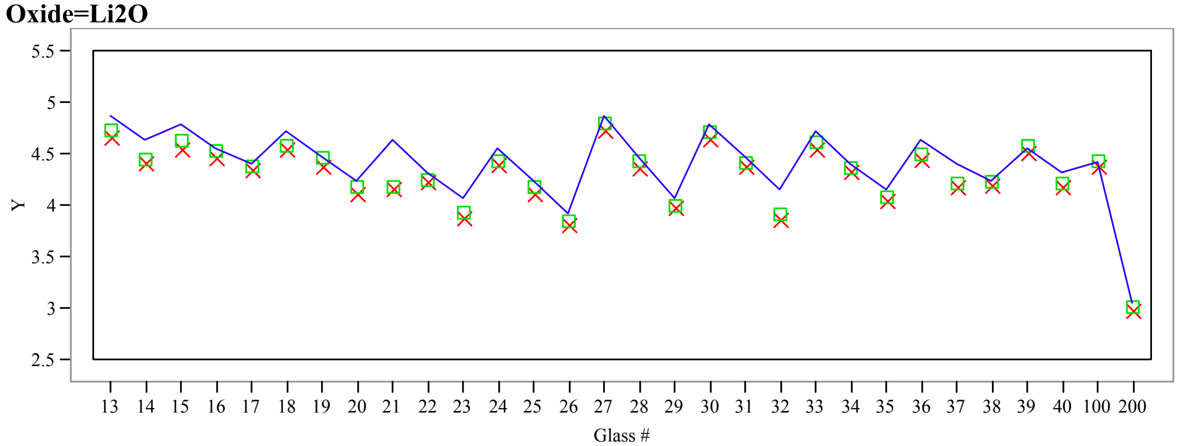
Exhibit C7. Average Measured and Bias-Corrected (bc) Versus Targeted Compositions by Glass # by Oxide

(100 – Batch 1; 200 – Ustd)

Oxide=La2O3



Oxide=Li2O



Oxide=MgO

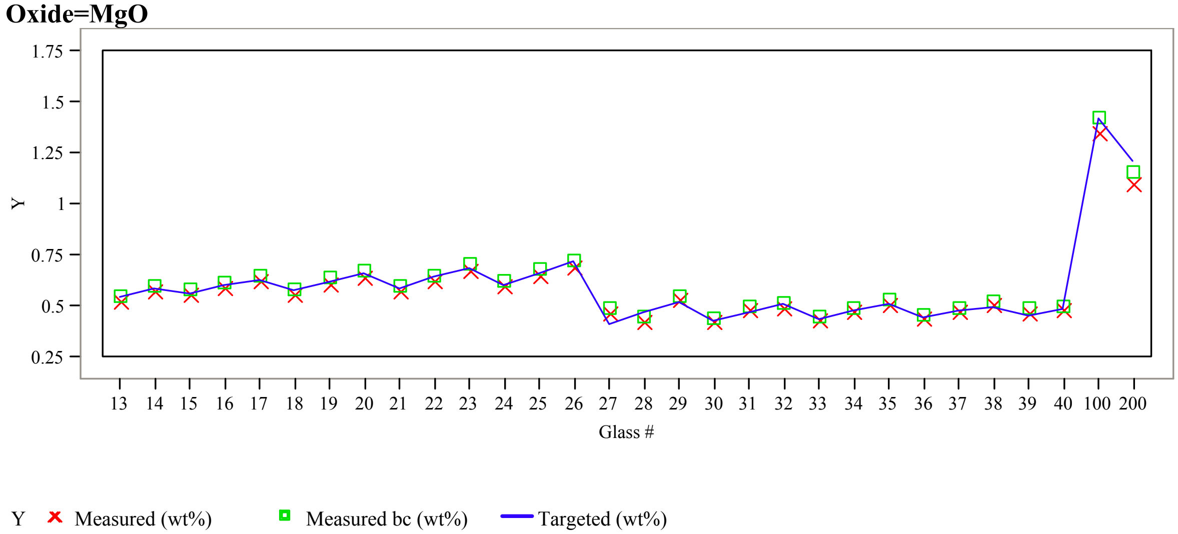
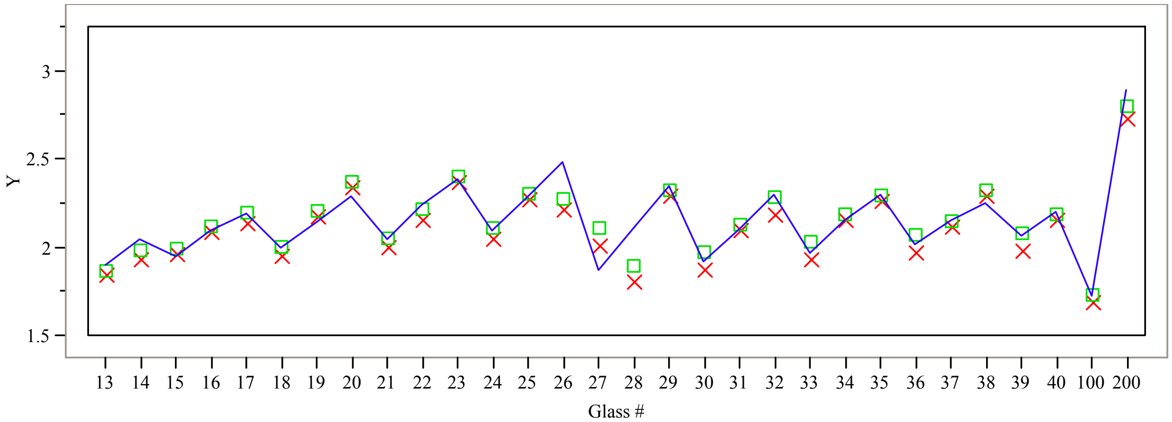


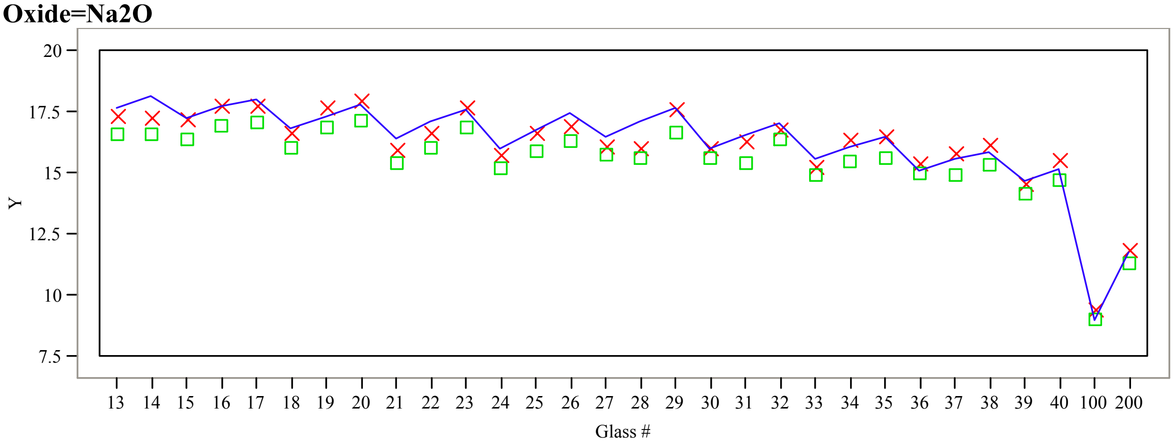
Exhibit C7. Average Measured and Bias-Corrected (bc) Versus Targeted Compositions by Glass # by Oxide

(100 – Batch 1; 200 – Ustd)

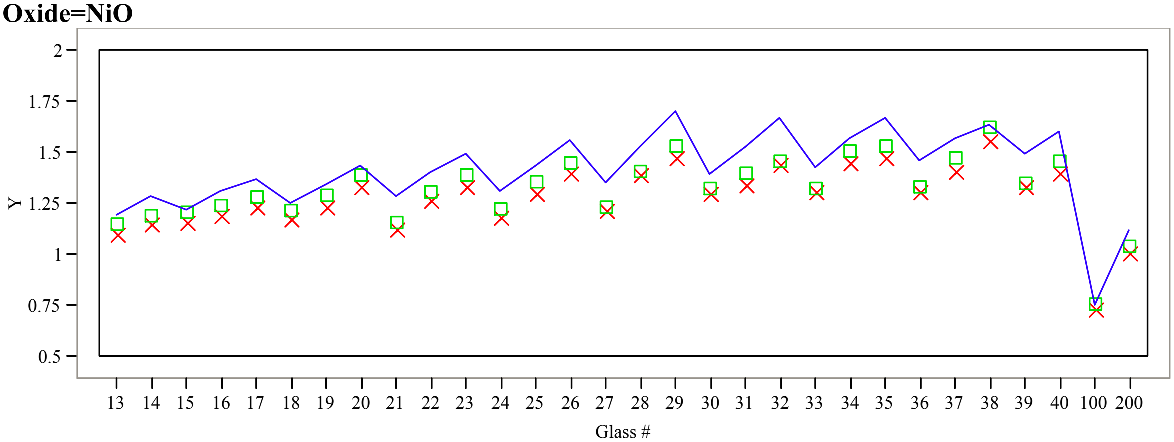
Oxide=MnO



Oxide=Na2O



Oxide=NiO

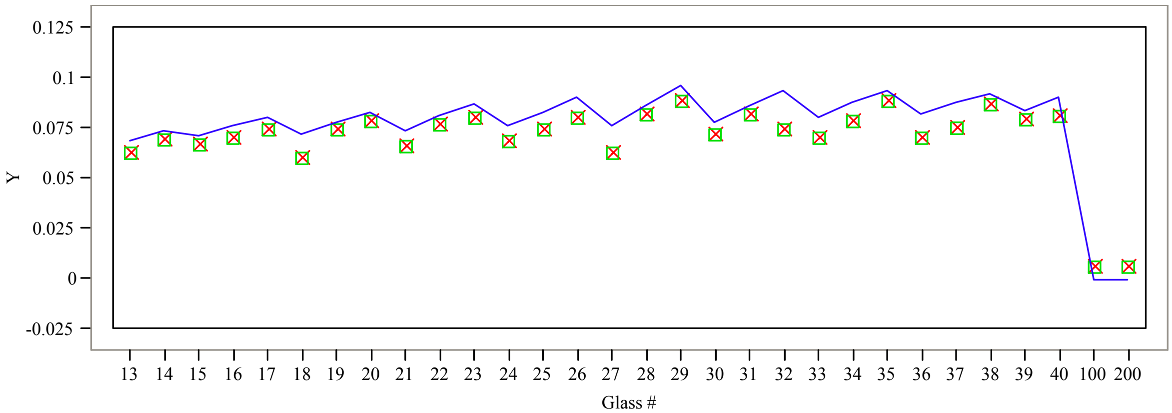


Y ✕ Measured (wt%) ▫ Measured bc (wt%) — Targeted (wt%)

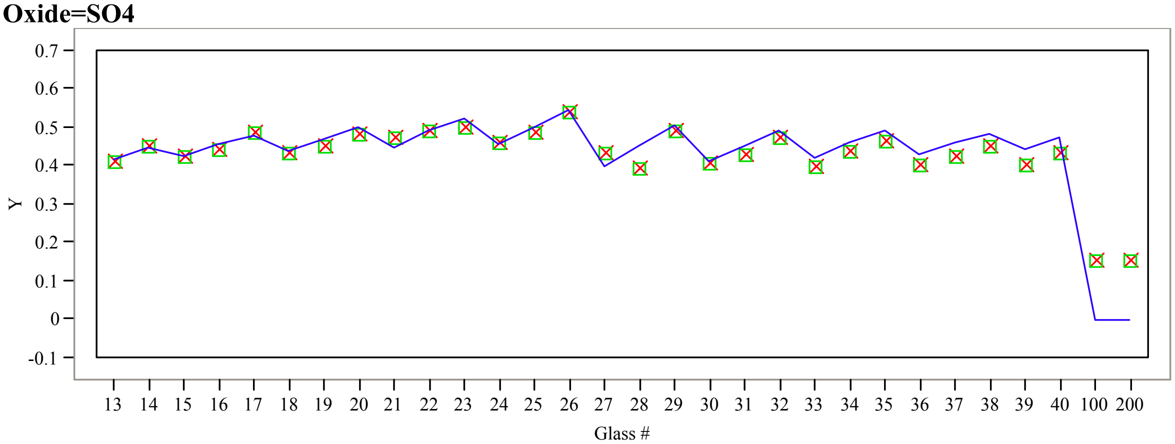
Exhibit C7. Average Measured and Bias-Corrected (bc) Versus Targeted Compositions by Glass # by Oxide

(100 – Batch 1; 200 – Ustd)

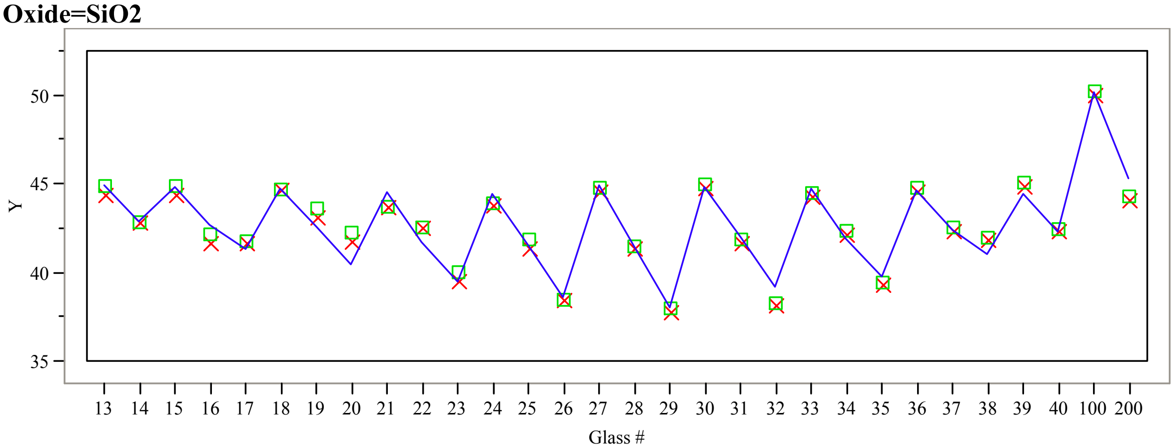
Oxide=PbO



Oxide=SO4



Oxide=SiO2

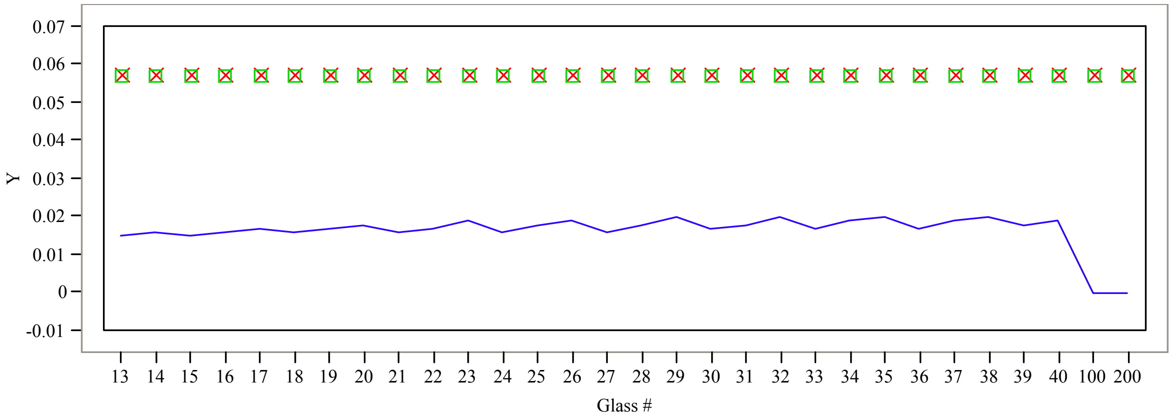


Y Measured (wt%) Measured bc (wt%) Targeted (wt%)

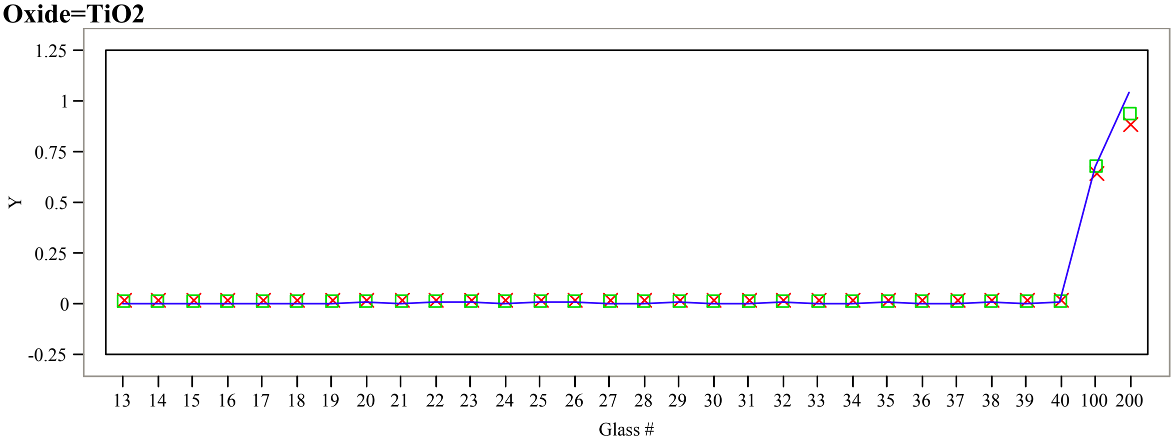
Exhibit C7. Average Measured and Bias-Corrected (bc) Versus Targeted Compositions by Glass # by Oxide

(100 – Batch 1; 200 – Ustd)

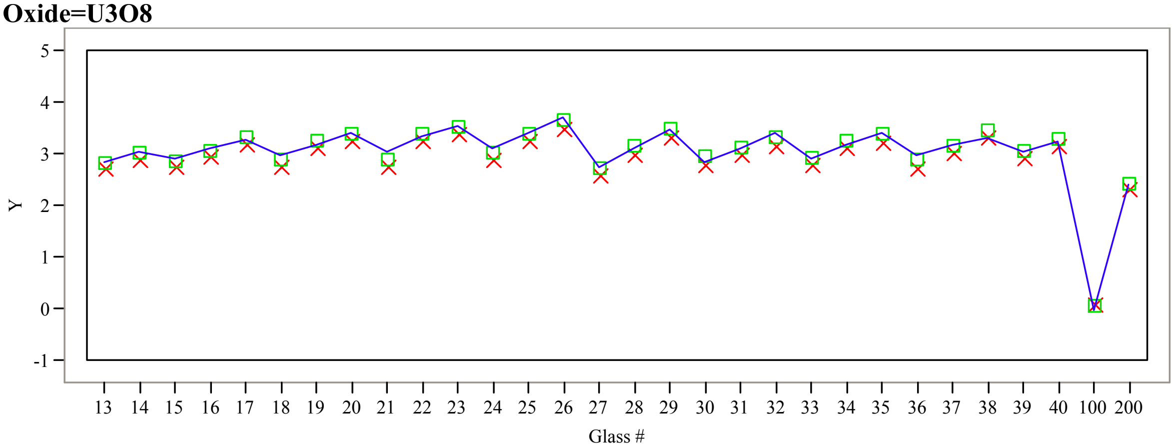
Oxide=ThO2



Oxide=TiO2



Oxide=U3O8

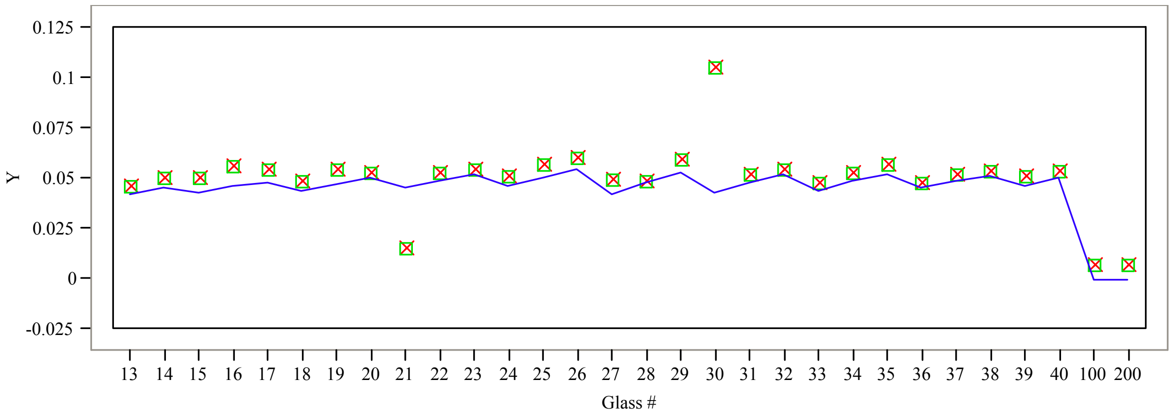


Y ✕ Measured (wt%) ◻ Measured bc (wt%) — Targeted (wt%)

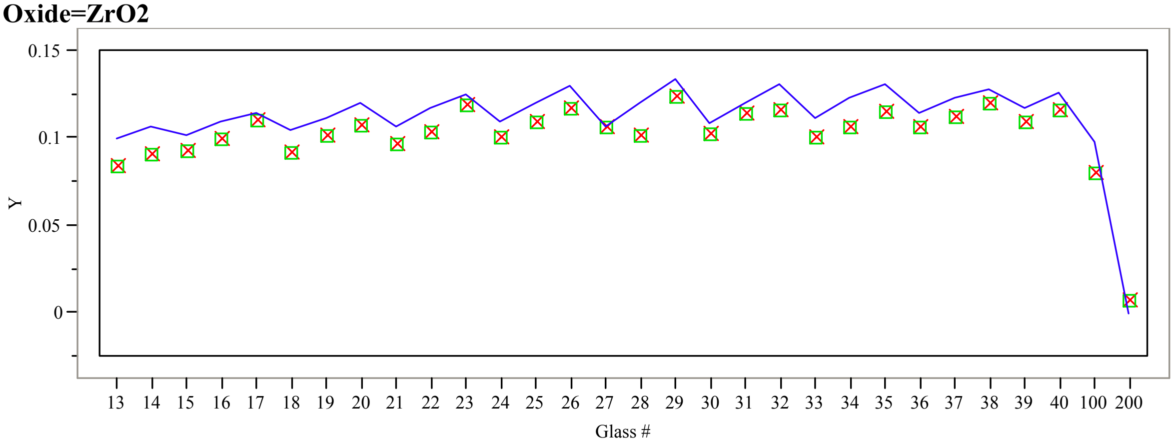
Exhibit C7. Average Measured and Bias-Corrected (bc) Versus Targeted Compositions by Glass # by Oxide

(100 – Batch 1; 200 – Ustd)

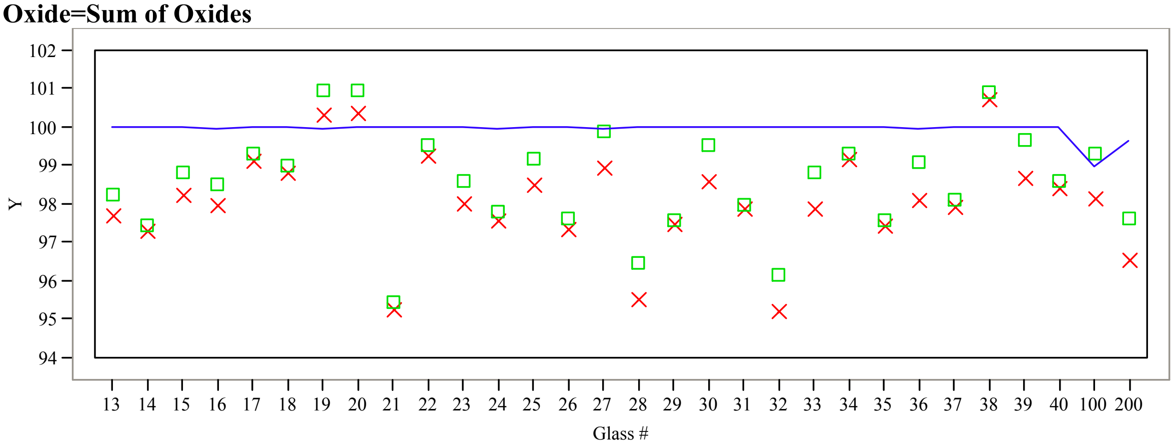
Oxide=ZnO



Oxide=ZrO2



Oxide=Sum of Oxides



Y × Measured (wt%) ◻ Measured bc (wt%) — Targeted (wt%)

Exhibit C8. Measurement and Re-Measurement of Select Study Glasses

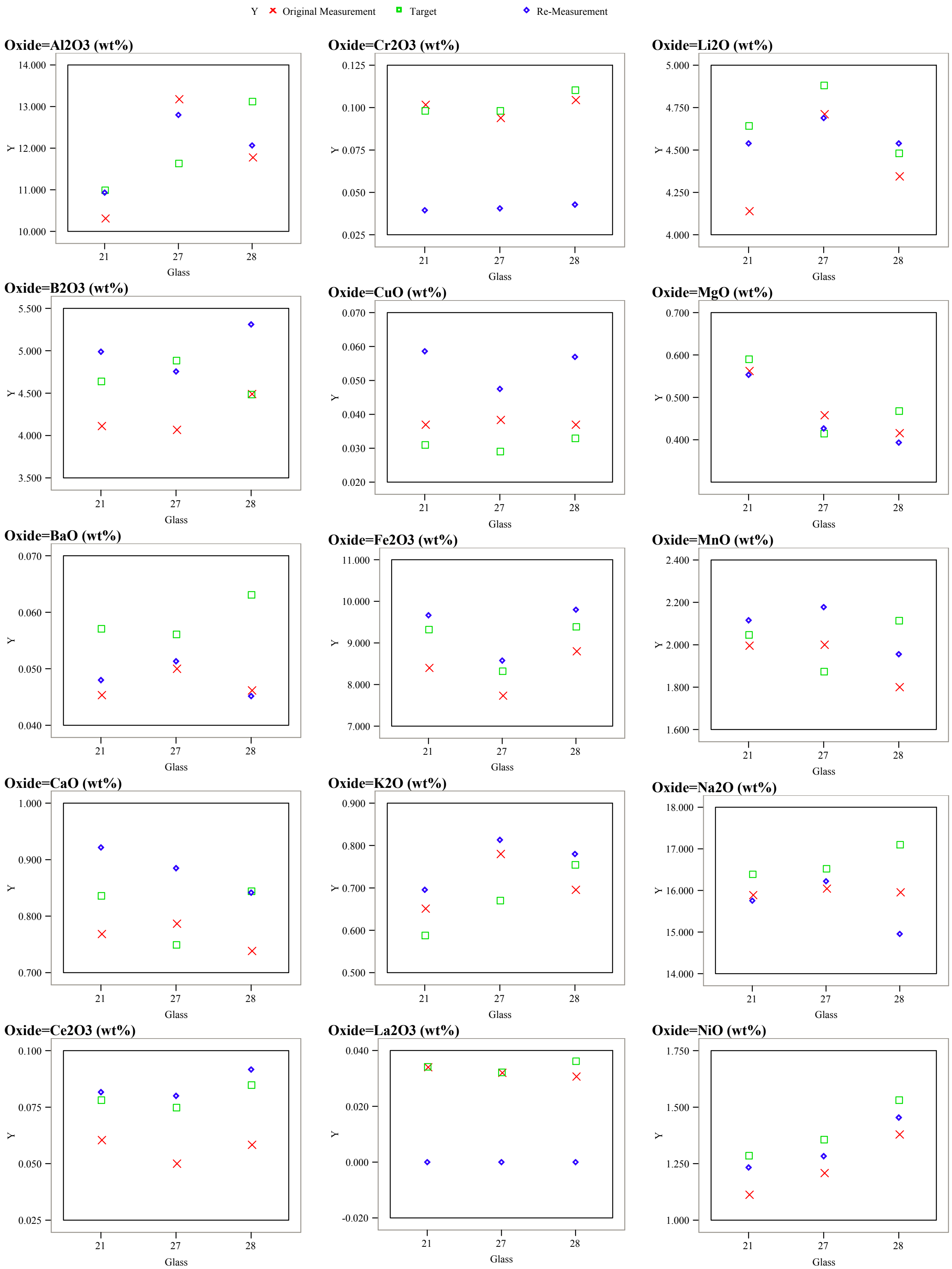
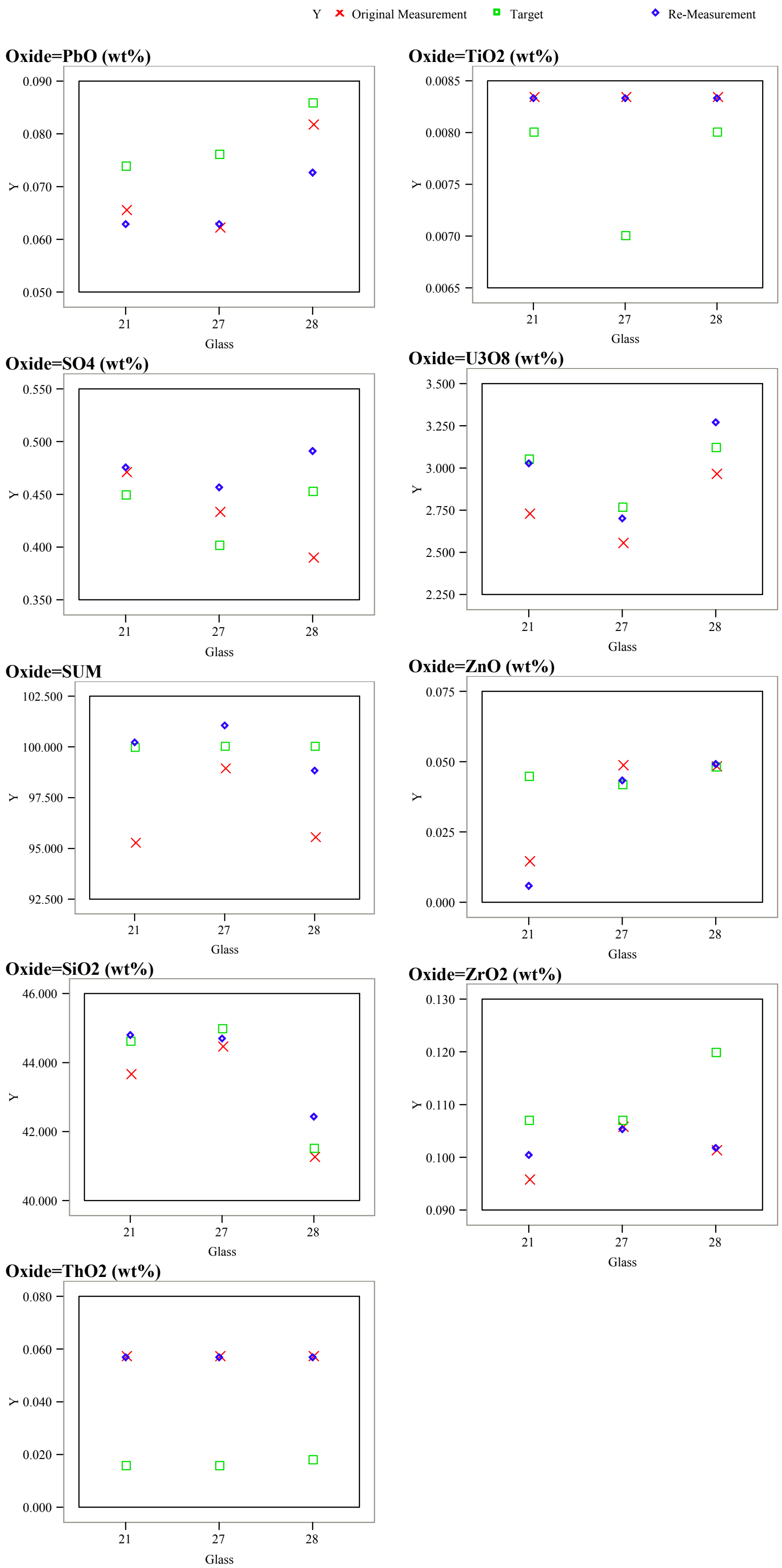


Exhibit C8. Measurement and Re-Measurement of Select Study Glasses



APPENDIX D

Tables and Exhibits Supporting the Analysis of the PCT Results for the Nepheline Phase 2 Study Glasses

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

Part	Glass ID	Heat Treatment	Laboratory ID	Block	Seq	B ar	Ba ar	Cd ar	Cr ar	Fe ar	Li ar	Na ar	Pb ar	Si ar	Th ar	U ar
1	Soln Std		std-b1-1	1	1	20.5	<0.010	<0.010	<0.050	4.33	10.1	82.1	<0.020	49.9	<0.500	<0.100
1	NEPH2-21ccc	ccc	C51	1	2	8.38	<0.010	<0.010	<0.050	7.94	12.5	83.4	<0.020	78.2	<0.500	2.32
1	NEPH2-17	quenched	C92	1	3	8.89	<0.010	<0.010	<0.050	10.1	12.3	119	<0.020	82.9	<0.500	2.63
1	NEPH2-22	quenched	C67	1	4	7.64	<0.010	<0.010	<0.050	7.83	10.6	94.5	<0.020	74.4	<0.500	2.05
1	NEPH2-26	quenched	C59	1	5	7.74	<0.010	<0.010	<0.050	9.65	10.4	111	<0.020	75	<0.500	2.24
1	NEPH2-18	quenched	C69	1	6	8	<0.010	<0.010	<0.050	9.64	12.1	95	<0.020	82.3	<0.500	2.19
1	NEPH2-13ccc	ccc	C83	1	7	9.4	<0.010	<0.010	<0.050	12.6	15.2	106	<0.020	93.3	<0.500	3.35
1	NEPH2-24	quenched	C34	1	8	7.41	<0.010	<0.010	<0.050	7.61	11	84	<0.020	76.8	<0.500	1.98
1	NEPH2-18ccc	ccc	C15	1	9	8.64	<0.010	<0.010	<0.050	9.57	13.3	91.1	<0.020	85.8	<0.500	2.69
1	NEPH2-15	quenched	C52	1	10	8.71	<0.010	<0.010	<0.050	12.1	12.8	104	<0.020	90.6	<0.500	2.7
1	NEPH2-23	quenched	C70	1	11	8.05	<0.010	<0.010	<0.050	9.84	10.5	112	<0.020	77	<0.500	2.91
1	NEPH2-13	quenched	C89	1	12	8.85	<0.010	<0.010	<0.050	12.6	13.6	113	<0.020	92.9	<0.500	2.8
1	ARM-1		C84	1	13	11.3	<0.010	<0.010	<0.050	0.448	9.06	24.1	<0.020	39.7	<0.500	<0.100
1	EA		C44	1	14	38.9	<0.010	<0.010	<0.050	<0.010	12	105	<0.020	56.9	<0.500	<0.100
1	NEPH2-15ccc	ccc	C76	1	15	9.34	<0.010	<0.010	<0.050	11.2	14.8	96	<0.020	89.9	<0.500	2.51
1	NEPH2-21	quenched	C03	1	16	7.75	<0.010	<0.010	<0.050	7.91	11.6	89.9	<0.020	78.8	<0.500	2.24
1	Soln Std		std-b1-2	1	17	20	<0.010	<0.010	<0.050	4.17	10.1	83	<0.020	49.6	<0.500	<0.100
1	NEPH2-16ccc	ccc	C32	1	18	15.5	<0.010	<0.010	<0.050	10.6	21.2	128	<0.020	106	<0.500	3.12
1	NEPH2-20ccc	ccc	C14	1	19	70.2	<0.010	<0.010	<0.050	0.174	74.5	405	<0.020	199	<0.500	9.76
1	NEPH2-19	quenched	C71	1	20	8.41	<0.010	<0.010	<0.050	9.94	11.4	99.2	<0.020	78.2	<0.500	2.32
1	NEPH2-24ccc	ccc	C49	1	21	8.09	<0.010	<0.010	<0.050	7.15	12.3	76.7	<0.020	76.5	<0.500	2
1	NEPH2-14	quenched	C82	1	22	9.24	<0.010	<0.010	<0.050	12.1	13.5	123	<0.020	90.8	<0.500	2.63
1	NEPH2-20	quenched	C06	1	23	8.43	<0.010	<0.010	<0.050	9.13	11.5	115	<0.020	78	<0.500	2.2
1	NEPH2-19ccc	ccc	C68	1	24	17.4	<0.010	<0.010	<0.050	11.5	23.9	133	<0.020	112	<0.500	3.6
1	NEPH2-23ccc	ccc	C56	1	25	77.1	<0.010	<0.010	<0.050	0.538	80.7	443	<0.020	190	<0.500	10.71
1	blank		C85	1	26	0.799	<0.010	<0.010	<0.050	0.442	0.852	0.193	<0.020	<0.010	<0.500	<0.100
1	NEPH2-22ccc	ccc	C81	1	27	19.6	<0.010	<0.010	<0.050	15.1	31.7	138	<0.020	127	<0.500	3.8
1	NEPH2-25	quenched	C66	1	28	7.86	<0.010	<0.010	<0.050	8.28	10.8	92.7	<0.020	73	<0.500	1.82
1	NEPH2-26ccc	ccc	C29	1	29	276	<0.010	<0.010	<0.050	0.08	142	1320	<0.020	590	<0.500	4.54
1	NEPH2-14ccc	ccc	C42	1	30	18.5	<0.010	<0.010	<0.050	14.9	23.9	145	<0.020	116	<0.500	3.48
1	NEPH2-17ccc	ccc	C09	1	31	29.3	<0.010	<0.010	<0.050	17.9	44.9	226	<0.020	157	<0.500	5.24
1	NEPH2-16	quenched	C72	1	32	9.36	<0.010	<0.010	<0.050	12.5	12.8	111	<0.020	87.3	<0.500	2.48
1	NEPH2-25ccc	ccc	C20	1	33	36.1	<0.010	<0.010	<0.050	19.1	50.5	224	<0.020	156	<0.500	6.21
1	Soln Std		std-b1-3	1	34	20.4	<0.010	<0.010	<0.050	4.08	10.3	82.3	<0.020	48.9	<0.500	<0.100
1	Soln Std		std-b2-1	2	1	20.2	<0.010	<0.010	<0.050	3.96	10.3	83.3	<0.020	50.8	<0.500	<0.100
1	NEPH2-26ccc	ccc	C10	2	2	284	<0.010	<0.010	<0.050	<0.010	142	1350	<0.020	600	<0.500	4.94
1	NEPH2-15	quenched	C47	2	3	10.7	<0.010	<0.010	<0.050	11	12.9	104	<0.020	92.7	<0.500	2.53
1	NEPH2-19ccc	ccc	C33	2	4	18.1	<0.010	<0.010	<0.050	16.9	23.5	135	<0.020	120	<0.500	3.61
1	NEPH2-14ccc	ccc	C18	2	5	16.3	<0.010	<0.010	<0.050	12.8	23.1	144	<0.020	119	<0.500	3.31
1	NEPH2-23	quenched	C11	2	6	8.01	<0.010	<0.010	<0.050	8.94	10.9	112	<0.020	78.2	<0.500	2.18

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

Part	Glass ID	Heat Treatment	Laboratory ID	Block	Seq	B ar	Ba ar	Cd ar	Cr ar	Fe ar	Li ar	Na ar	Pb ar	Si ar	Th ar	U ar
1	NEPH2-17	quenched	C58	2	7	8.38	<0.010	<0.010	<0.050	10.2	12.2	116	<0.020	84.3	<0.500	2.61
1	NEPH2-21ccc	ccc	C02	2	8	7.69	<0.010	<0.010	<0.050	8.65	12.6	81.7	<0.020	80.1	<0.500	2.18
1	NEPH2-13ccc	ccc	C62	2	9	9.01	<0.010	<0.010	<0.050	11.7	15.6	109	<0.020	96.2	<0.500	2.42
1	ARM-1		C38	2	10	10.8	<0.010	<0.010	<0.050	<0.010	9.03	26.2	<0.020	40.3	<0.500	<0.100
1	NEPH2-26	quenched	C63	2	11	7.25	<0.010	<0.010	<0.050	9.19	10.3	111	<0.020	77.2	<0.500	2.48
1	NEPH2-20	quenched	C40	2	12	7.94	<0.010	<0.010	<0.050	7.83	11.3	115	<0.020	80.4	<0.500	2.09
1	NEPH2-16	quenched	C19	2	13	8.2	<0.010	<0.010	<0.050	10.2	12.6	112	<0.020	88	<0.500	2.37
1	NEPH2-18ccc	ccc	C16	2	14	7.86	<0.010	<0.010	<0.050	10.6	13.5	88.6	<0.020	85.5	<0.500	3.17
1	NEPH2-25	quenched	C88	2	15	7.03	<0.010	<0.010	<0.050	7.22	10.8	94	<0.020	74.8	<0.500	1.59
1	NEPH2-19	quenched	C07	2	16	7.36	<0.010	<0.010	<0.050	7.4	11.4	102	<0.020	78.7	<0.500	1.99
1	Soln Std		std-b2-2	2	17	19.1	<0.010	<0.010	<0.050	3.72	10	83.3	<0.020	49.7	<0.500	<0.100
1	NEPH2-14	quenched	C36	2	18	8.77	<0.010	<0.010	<0.050	11.8	13	121	<0.020	89.5	<0.500	3.5
1	NEPH2-17ccc	ccc	C22	2	19	27.4	<0.010	<0.010	<0.050	17.6	42.7	211	<0.020	145	<0.500	5.73
1	NEPH2-18	quenched	C75	2	20	7.55	<0.010	<0.010	<0.050	8.6	11.9	92.9	<0.020	82.2	<0.500	2.2
1	NEPH2-24	quenched	C73	2	21	6.78	<0.010	<0.010	<0.050	7.21	11.1	83.1	<0.020	76.3	<0.500	1.83
1	NEPH2-22	quenched	C17	2	22	6.96	<0.010	<0.010	<0.050	7.26	10.5	93.1	<0.020	75.2	<0.500	2.12
1	NEPH2-15ccc	ccc	C01	2	23	8.31	<0.010	<0.010	<0.050	9.27	14.7	97.4	<0.020	87.4	<0.500	2.12
1	NEPH2-21	quenched	C43	2	24	6.38	<0.010	<0.010	<0.050	7.87	10.7	83.5	<0.020	72.7	<0.500	2.08
1	NEPH2-23ccc	ccc	C86	2	25	74.1	<0.010	<0.010	<0.050	<0.010	77.4	433	<0.020	187	<0.500	10.11
1	NEPH2-16ccc	ccc	C25	2	26	15.2	<0.010	<0.010	<0.050	11.9	21.4	133	<0.020	109	<0.500	3.32
1	NEPH2-20ccc	ccc	C08	2	27	70.8	<0.010	<0.010	<0.050	<0.010	75.8	413	<0.020	197	<0.500	9.82
1	NEPH2-25ccc	ccc	C55	2	28	37.3	<0.010	<0.010	<0.050	16.1	51.4	237	<0.020	160	<0.500	5.6
1	EA		C53	2	29	36.4	<0.010	<0.010	<0.050	<0.010	11.5	101	<0.020	54	<0.500	<0.100
1	NEPH2-22ccc	ccc	C35	2	30	19.6	<0.010	<0.010	<0.050	15.5	32.4	141	<0.020	130	<0.500	4.02
1	NEPH2-13	quenched	C64	2	31	8.54	<0.010	<0.010	<0.050	14.3	14.3	115	<0.020	92.1	<0.500	2.55
1	NEPH2-24ccc	ccc	C27	2	32	7.24	<0.010	<0.010	<0.050	6.78	12.3	78.4	<0.020	75.2	<0.500	1.86
1	Soln Std		std-b2-3	2	33	19	<0.010	<0.010	<0.050	4.31	10.1	81.7	<0.020	49.5	<0.500	<0.100
1	Soln Std		std-b-3-1	3	1	20.5	<0.010	<0.010	<0.050	4.19	10	88	<0.020	51.6	<0.500	<0.100
1	NEPH2-22	quenched	C91	3	2	7.56	<0.010	<0.010	<0.050	6.62	10.6	96.6	<0.020	76.8	<0.500	1.94
1	NEPH2-16ccc	ccc	C41	3	3	15.5	<0.010	<0.010	<0.050	13.1	21.2	137	<0.020	114	<0.500	3.73
1	NEPH2-25ccc	ccc	C23	3	4	38.5	<0.010	<0.010	<0.050	18.6	52.3	231	<0.020	153	<0.500	6.68
1	NEPH2-14ccc	ccc	C26	3	5	16.4	<0.010	<0.010	<0.050	11.4	22.8	144	<0.020	119	<0.500	3.24
1	NEPH2-15	quenched	C30	3	6	8.12	<0.010	<0.010	<0.050	11.1	12.6	105	<0.020	90.1	<0.500	2.34
1	NEPH2-19	quenched	C65	3	7	7.72	<0.010	<0.010	<0.050	7.99	11.4	102	<0.020	81.4	<0.500	2.24
1	NEPH2-24	quenched	C74	3	8	6.87	<0.010	<0.010	<0.050	7.43	11	85.1	<0.020	78	<0.500	1.95
1	NEPH2-15ccc	ccc	C37	3	9	8.94	<0.010	<0.010	<0.050	11.1	15	101	<0.020	94.5	<0.500	2.48
1	NEPH2-13ccc	ccc	C87	3	10	8.96	<0.010	<0.010	<0.050	12.3	15.5	112	<0.020	97.6	<0.500	2.49
1	NEPH2-17	quenched	C04	3	11	8.21	<0.010	<0.010	<0.050	8.84	11.9	119	<0.020	85	<0.500	2.5
1	NEPH2-13	quenched	C50	3	12	8.34	<0.010	<0.010	<0.050	13.4	13.1	118	<0.020	95.9	<0.500	3.41
1	NEPH2-20	quenched	C39	3	13	7.85	<0.010	<0.010	<0.050	7.9	11	116	<0.020	79.9	<0.500	2.25

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

Part	Glass ID	Heat Treatment	Laboratory ID	Block	Seq	B ar	Ba ar	Cd ar	Cr ar	Fe ar	Li ar	Na ar	Pb ar	Si ar	Th ar	U ar
1	NEPH2-24ccc	ccc	C90	3	14	7.38	<0.010	<0.010	<0.050	7	12.1	80.9	<0.020	78.6	<0.500	1.77
1	NEPH2-19ccc	ccc	C78	3	15	16.8	<0.010	<0.010	<0.050	10.8	23.2	138	<0.020	114	<0.500	3.24
1	NEPH2-17ccc	ccc	C80	3	16	27.1	<0.010	<0.010	<0.050	16.7	42.2	204	<0.020	142	<0.500	6.41
1	Soln Std		std-b3-2	3	17	19.6	<0.010	<0.010	<0.050	4.15	10	83.6	<0.020	51.2	<0.500	<0.100
1	NEPH2-18	quenched	C12	3	18	8.06	<0.010	<0.010	<0.050	9.36	11.8	95.2	<0.020	85.2	<0.500	2.41
1	NEPH2-26ccc	ccc	C77	3	19	269	<0.010	<0.010	<0.050	<0.010	138	1280	<0.020	575	<0.500	4.61
1	NEPH2-21	quenched	C57	3	20	9.49	<0.010	<0.010	<0.050	7.89	11.2	89.1	<0.020	78.1	<0.500	2.2
1	NEPH2-14	quenched	C28	3	21	9.26	<0.010	<0.010	<0.050	13.6	13.4	125	<0.020	94.9	<0.500	3.02
1	EA		C61	3	22	37.5	<0.010	<0.010	<0.050	<0.010	11.4	105	<0.020	56	<0.500	<0.100
1	NEPH2-25	quenched	C79	3	23	7.69	<0.010	<0.010	<0.050	7.06	10.7	97.6	<0.020	75.5	<0.500	1.76
1	blank		C21	3	24	<0.030	<0.010	<0.010	<0.050	<0.010	0.749	<0.100	<0.020	<0.010	<0.500	<0.100
1	NEPH2-18ccc	ccc	C05	3	25	7.84	<0.010	<0.010	<0.050	8.93	13.5	94.1	<0.020	84.6	<0.500	2.27
1	NEPH2-26	quenched	C48	3	26	7.29	<0.010	<0.010	<0.050	7.96	10.3	117	<0.020	76.1	<0.500	2.26
1	NEPH2-21ccc	ccc	C60	3	27	7.63	<0.010	<0.010	<0.050	6.47	12.4	89.2	<0.020	80.4	<0.500	2.01
1	NEPH2-23ccc	ccc	C54	3	28	77.5	<0.010	<0.010	<0.050	<0.010	79.4	441	<0.020	180	<0.500	11.2
1	NEPH2-23	quenched	C31	3	29	8.53	<0.010	<0.010	<0.050	8.71	10.9	117	<0.020	78.9	<0.500	2.4
1	ARM-1		C46	3	30	11.9	<0.010	<0.010	<0.050	<0.010	9.39	26	<0.020	42	<0.500	<0.100
1	NEPH2-16	quenched	C24	3	31	12.1	<0.010	<0.010	<0.050	10.8	12.4	115	<0.020	86.9	<0.500	2.4
1	NEPH2-20ccc	ccc	C13	3	32	71	<0.010	<0.010	<0.050	<0.010	75.3	414	<0.020	200	<0.500	8.78
1	NEPH2-22ccc	ccc	C45	3	33	19.6	<0.010	<0.010	<0.050	16	31.5	143	<0.020	131	<0.500	4.32
1	Soln Std		std-b3-3	3	34	19.9	<0.010	<0.010	<0.050	4.3	10.1	84.8	<0.020	51.1	<0.500	<0.100
2	Std Soln		std-b1-1	1	1	20.6	<0.010	<0.010	<0.050	4.01	9.88	84.7	<0.020	51.9	<0.500	<0.100
2	NEPH2-27ccc	ccc	D49	1	2	18.3	<0.010	<0.010	<0.050	10.2	31.2	122	<0.020	126	<0.500	4.06
2	NEPH2-36	quenched	D63	1	3	6.31	<0.010	<0.010	<0.050	6.13	9.34	63.1	<0.020	67.6	<0.500	1.5
2	NEPH2-33ccc	ccc	D78	1	4	88.4	<0.010	<0.010	<0.050	0.125	104	311	<0.020	204	<0.500	7.99
2	NEPH2-39ccc	ccc	D56	1	5	9.61	<0.010	<0.010	<0.050	8.37	13.5	64.6	<0.020	78.3	<0.500	1.97
2	NEPH2-29	quenched	D05	1	6	7.69	<0.010	<0.010	<0.050	9.78	9.45	106	<0.020	73.7	<0.500	2.63
2	NEPH2-32ccc	ccc	D53	1	7	256	<0.010	<0.010	<0.050	<0.010	130	1100	<0.020	488	<0.500	3.7
2	NEPH2-32	quenched	D87	1	8	10.6	<0.010	<0.010	<0.050	7.27	9.43	95.2	<0.020	70.7	<0.500	1.79
2	NEPH2-31ccc	ccc	D09	1	9	45.4	<0.010	<0.010	<0.050	11.3	55.4	193	<0.020	165	<0.500	6.31
2	NEPH2-29ccc	ccc	D02	1	10	311	<0.010	<0.010	<0.050	0.118	123	1410	<0.020	495	<0.500	3.58
2	NEPH2-28	quenched	D44	1	11	12.8	<0.010	<0.010	<0.050	8.95	10.5	91.6	<0.020	76.4	<0.500	1.87
2	NEPH2-35ccc	ccc	D36	1	12	8.94	<0.010	<0.010	<0.050	7.27	12.2	69.2	<0.020	75.7	<0.500	1.75
2	NEPH2-28ccc	ccc	D37	1	13	21	<0.010	<0.010	<0.050	14.1	25.4	130	<0.020	113	<0.500	3.28
2	NEPH2-34ccc	ccc	D54	1	14	254	<0.010	<0.010	<0.050	<0.010	153	1020	<0.020	491	<0.500	3.81
2	EA		D07	1	15	41	<0.010	<0.010	<0.050	0.118	11	100	<0.020	55.2	<0.500	<0.100
2	NEPH2-38ccc	ccc	D20	1	16	74.8	<0.010	<0.010	<0.050	1.13	75.2	239	<0.020	172	<0.500	7.13
2	Std Soln		std-b1-2	1	17	22.1	<0.010	<0.010	<0.050	4.12	9.78	86	<0.020	51.2	<0.500	<0.100
2	NEPH2-38	quenched	D01	1	18	7.48	<0.010	<0.010	<0.050	6.14	8.73	77.5	<0.020	64.1	<0.500	1.52
2	NEPH2-40	quenched	D03	1	19	6.47	<0.010	<0.010	<0.050	5.67	8.58	66	<0.020	62.1	<0.500	1.2

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

Part	Glass ID	Heat Treatment	Laboratory ID	Block	Seq	B ar	Ba ar	Cd ar	Cr ar	Fe ar	Li ar	Na ar	Pb ar	Si ar	Th ar	U ar
2	NEPH2-30	quenched	D32	1	20	7.28	<0.010	<0.010	<0.050	10.3	10.5	79.6	<0.020	76.4	<0.500	1.97
2	NEPH2-31	quenched	D45	1	21	7.2	<0.010	<0.010	<0.050	7.69	9.73	85.2	<0.020	70.1	<0.500	1.67
2	NEPH2-36ccc	ccc	D52	1	22	8.85	<0.010	<0.010	<0.050	7.66	13.1	69.6	<0.020	75.9	<0.500	1.85
2	NEPH2-40ccc	ccc	D10	1	23	18.3	<0.010	<0.010	<0.050	11.2	28.1	104	<0.020	104	<0.500	3.33
2	NEPH2-34	quenched	D92	1	24											
2	NEPH2-37	quenched	D16	1	25	6.47	<0.010	<0.010	<0.050	6.07	8.51	70.3	<0.020	62.6	<0.500	1.55
2	NEPH2-37ccc	ccc	D14	1	26	30.4	<0.010	<0.010	<0.050	13.6	44.4	146	<0.020	136	<0.500	4.66
2	NEPH2-30ccc	ccc	D06	1	27	7.8	<0.010	<0.010	<0.050	9.58	11.8	75.5	<0.020	73.4	<0.500	1.93
2	NEPH2-39	quenched	D58	1	28	6.08	<0.010	<0.010	<0.050	6.34	9.08	61.6	<0.020	64.8	<0.500	1.29
2	NEPH2-35	quenched	D40	1	29	6.48	<0.010	<0.010	<0.050	5.87	9.62	69.4	<0.020	68.6	<0.500	1.32
2	ARM-1		D81	1	30	12.2	<0.010	<0.010	<0.050	<0.010	9.25	26.1	<0.020	42.2	<0.500	<0.100
2	blank		D76	1	31	0.112	<0.010	<0.010	<0.050	0.023	0.767	<0.100	<0.020	<0.010	<0.500	<0.100
2	NEPH2-27	quenched	D19	1	32	6.3	<0.010	<0.010	<0.050	9.67	10.4	88.6	<0.020	75.2	<0.500	2.11
2	NEPH2-33	quenched	D59	1	33	6.58	<0.010	<0.010	<0.050	7.41	9.49	80.8	<0.020	68.6	<0.500	1.54
2	Std Soln		std-b1-3	1	34	20.4	<0.010	<0.010	<0.050	4.19	9.78	85	<0.020	51.5	<0.500	<0.100
2	Std Soln		std-b2-1	2	1	21.4	<0.010	<0.010	<0.050	3.84	9.83	83	<0.020	51.5	<0.500	<0.100
2	NEPH2-36ccc	ccc	D74	2	2	9.27	<0.010	<0.010	<0.050	6.76	13.5	68	<0.020	78.2	<0.500	1.95
2	NEPH2-40ccc	ccc	D38	2	3	18	<0.010	<0.010	<0.050	10.7	28.3	98.2	<0.020	109	<0.500	3.22
2	NEPH2-30	quenched	D69	2	4	6.93	<0.010	<0.010	<0.050	9.25	10.6	76.5	<0.020	75.1	<0.500	2.17
2	NEPH2-31	quenched	D51	2	5	6.88	<0.010	<0.010	<0.050	7.06	9.96	83.7	<0.020	71.7	<0.500	1.7
2	NEPH2-35ccc	ccc	D31	2	6	7.29	<0.010	<0.010	<0.050	6.82	12.3	67.5	<0.020	76.5	<0.500	1.73
2	NEPH2-29ccc	ccc	D04	2	7	304	<0.010	<0.010	<0.050	<0.010	123	1370	<0.020	482	<0.500	3.2
2	NEPH2-30ccc	ccc	D68	2	8	12	<0.010	<0.010	<0.050	9.72	12.5	75.2	<0.020	78.9	<0.500	2.18
2	NEPH2-33ccc	ccc	D50	2	9	81.4	<0.010	<0.010	<0.050	0.136	92.6	292	<0.020	181	<0.500	8.48
2	NEPH2-39ccc	ccc	D57	2	10	9.58	<0.010	<0.010	<0.050	7.41	13.2	62.7	<0.020	74.6	<0.500	1.92
2	NEPH2-29	quenched	D67	2	11	7.62	<0.010	<0.010	<0.050	8.77	9.71	105	<0.020	73.1	<0.500	2.13
2	NEPH2-38	quenched	D84	2	12	6.41	<0.010	<0.010	<0.050	5.79	9.01	76.5	<0.020	66.2	<0.500	1.48
2	NEPH2-27ccc	ccc	D71	2	13	18.8	<0.010	<0.010	<0.050	11.2	32.1	119	<0.020	125	<0.500	3.28
2	NEPH2-28	quenched	D22	2	14	8.26	<0.010	<0.010	<0.050	8.22	10.3	87.8	<0.020	74.2	<0.500	2.24
2	NEPH2-38ccc	ccc	D89	2	15	73.5	<0.010	<0.010	<0.050	0.584	74.4	245	<0.020	169	<0.500	6.99
2	NEPH2-31ccc	ccc	D08	2	16	45.6	<0.010	<0.010	<0.050	9.24	55.8	191	<0.020	164	<0.500	6.83
2	Std Soln		std-b2-2	2	17	21.1	<0.010	<0.010	<0.050	3.9	9.99	82.4	<0.020	51.8	<0.500	<0.100
2	NEPH2-35	quenched	D83	2	18	7.14	<0.010	<0.010	<0.050	5.72	9.69	65.4	<0.020	67.7	<0.500	1.44
2	ARM-1		D75	2	19	11.9	<0.010	<0.010	<0.050	0.2	9.25	23.7	<0.020	41.8	<0.500	<0.100
2	NEPH2-37ccc	ccc	D35	2	20	30.1	<0.010	<0.010	<0.050	13	43.8	131	<0.020	131	<0.500	5.37
2	NEPH2-33	quenched	D73	2	21	6.45	<0.010	<0.010	<0.050	8.08	9.08	71.4	<0.020	64.9	<0.500	1.78
2	NEPH2-32	quenched	D79	2	22	6.61	<0.010	<0.010	<0.050	6.92	9.15	91.9	<0.020	67.4	<0.500	1.67
2	NEPH2-27	quenched	D24	2	23	6	<0.010	<0.010	<0.050	8.95	9.96	81.7	<0.020	71.8	<0.500	2.36
2	NEPH2-28ccc	ccc	D15	2	24	20	<0.010	<0.010	<0.050	14.3	25.4	125	<0.020	111	<0.500	3.28
2	NEPH2-34ccc	ccc	D17	2	25	251	<0.010	<0.010	<0.050	<0.010	147	1010	<0.020	486	<0.500	3.82

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

Part	Glass ID	Heat Treatment	Laboratory ID	Block	Seq	B ar	Ba ar	Cd ar	Cr ar	Fe ar	Li ar	Na ar	Pb ar	Si ar	Th ar	U ar
2	NEPH2-32ccc	ccc	D21	2	26	257	<0.010	<0.010	<0.050	<0.010	128	1110	<0.020	482	<0.500	3.83
2	NEPH2-40	quenched	D86	2	27	10.1	<0.010	<0.010	<0.050	5.82	8.4	60.9	<0.020	62	<0.500	1.49
2	NEPH2-36	quenched	D34	2	28	7.47	<0.010	<0.010	<0.050	6	9.45	61.5	<0.020	67.6	<0.500	1.54
2	NEPH2-34	quenched	D25	2	29	6.86	<0.010	<0.010	<0.050	6.26	8.94	81.2	<0.020	65.6	<0.500	1.6
2	EA		D27	2	30	38.2	<0.010	<0.010	<0.050	<0.010	11.2	97.8	<0.020	56.2	<0.500	<0.100
2	NEPH2-37	quenched	D70	2	31	6.86	<0.010	<0.010	<0.050	5.74	8.81	66.6	<0.020	64.2	<0.500	1.47
2	NEPH2-39	quenched	D55	2	32	6.06	<0.010	<0.010	<0.050	6.23	9.12	57.2	<0.020	65.1	<0.500	1.38
2	Std Soln		std-b2-3	2	33	20.4	<0.010	<0.010	<0.050	4.11	9.81	79.3	<0.020	51	<0.500	<0.100
2	Std Soln		std-b-3-1	3	1	21.2	<0.010	<0.010	<0.050	3.9	9.74	81.8	<0.020	52	<0.500	<0.100
2	NEPH2-36	quenched	D91	3	2	6.27	<0.010	<0.010	<0.050	6.5	9.01	60.8	<0.020	67.1	<0.500	1.73
2	NEPH2-37	quenched	D42	3	3	6.02	<0.010	<0.010	<0.050	5.24	9	69.3	<0.020	65.8	<0.500	1.4
2	NEPH2-29ccc	ccc	D48	3	4	300	<0.010	<0.010	<0.050	<0.010	122	1370	<0.020	480	<0.500	3.14
2	NEPH2-40	quenched	D33	3	5	9.7	<0.010	<0.010	<0.050	5.42	8.67	62.5	<0.020	64.1	<0.500	1.4
2	blank		D72	3	6	0.559	<0.010	<0.010	<0.050	<0.010	0.691	<0.100	<0.020	<0.010	<0.500	<0.100
2	NEPH2-32	quenched	D85	3	7	6.81	<0.010	<0.010	<0.050	7.41	9.32	94.4	<0.020	70.2	<0.500	1.76
2	NEPH2-39	quenched	D11	3	8	5.69	<0.010	<0.010	<0.050	5.94	8.87	56.2	<0.020	64.8	<0.500	1.41
2	NEPH2-38	quenched	D66	3	9	5.91	<0.010	<0.010	<0.050	6.13	8.79	76.2	<0.020	66.4	<0.500	1.37
2	NEPH2-32ccc	ccc	D61	3	10	260	<0.010	<0.010	<0.050	<0.010	127	1130	<0.020	482	<0.500	3.56
2	NEPH2-34ccc	ccc	D77	3	11	254	<0.010	<0.010	<0.050	<0.010	146	1010	<0.020	487	<0.500	3.63
2	NEPH2-31ccc	ccc	D43	3	12	47.5	<0.010	<0.010	<0.050	9.23	54.8	190	<0.020	164	<0.500	6.8
2	NEPH2-39ccc	ccc	D46	3	13	9.6	<0.010	<0.010	<0.050	7.7	13	63	<0.020	76	<0.500	1.89
2	NEPH2-33ccc	ccc	D64	3	14	77.1	<0.010	<0.010	<0.050	0.317	90	281	<0.020	192	<0.500	8.81
2	ARM-1		D90	3	15	13.8	<0.010	<0.010	<0.050	<0.010	9.37	24.8	<0.020	43.3	<0.500	<0.100
2	NEPH2-36ccc	ccc	D30	3	16	9.09	<0.010	<0.010	<0.050	7.37	13.3	68.5	<0.020	77.1	<0.500	2.03
2	Std Soln		std-b3-2	3	17	20.2	<0.010	<0.010	<0.050	4.02	9.69	80.8	<0.020	51.3	<0.500	<0.100
2	NEPH2-38ccc	ccc	D28	3	18	72.6	<0.010	<0.010	<0.050	0.898	73.1	246	<0.020	169	<0.500	6.75
2	NEPH2-30ccc	ccc	D47	3	19	8.66	<0.010	<0.010	<0.050	9.72	11.7	72.4	<0.020	75.2	<0.500	2.14
2	NEPH2-33	quenched	D12	3	20	6.33	<0.010	<0.010	<0.050	5.79	9	74.4	<0.020	64.6	<0.500	1.59
2	NEPH2-40ccc	ccc	D60	3	21	16.6	<0.010	<0.010	<0.050	9.82	26.6	95.7	<0.020	102	<0.500	3.71
2	NEPH2-35ccc	ccc	D18	3	22	7.3	<0.010	<0.010	<0.050	6.93	11.9	68.4	<0.020	74.9	<0.500	1.65
2	NEPH2-27ccc	ccc	D26	3	23	17.9	<0.010	<0.010	<0.050	11.3	31.2	118	<0.020	121	<0.500	3.35
2	NEPH2-37ccc	ccc	D41	3	24	29.2	<0.010	<0.010	<0.050	12.1	43.1	133	<0.020	132	<0.500	5.39
2	NEPH2-34	quenched	D13	3	25	6.36	<0.010	<0.010	<0.050	6.93	8.74	83.5	<0.020	65.3	<0.500	1.6
2	NEPH2-29	quenched	D82	3	26	6.71	<0.010	<0.010	<0.050	8.51	9.25	104	<0.020	70	<0.500	2.07
2	EA		D65	3	27	36.8	<0.010	<0.010	<0.050	<0.010	11.1	100	<0.020	56.1	<0.500	<0.100
2	NEPH2-35	quenched	D39	3	28	6.34	<0.010	<0.010	<0.050	5.86	9.45	67.1	<0.020	66.4	<0.500	1.3
2	NEPH2-31	quenched	D62	3	29	6.47	<0.010	<0.010	<0.050	7.03	9.63	83.5	<0.020	69.7	<0.500	1.62
2	NEPH2-28ccc	ccc	D23	3	30	19.1	<0.010	<0.010	<0.050	14.3	24.9	123	<0.020	115	<0.500	3.42
2	NEPH2-27	quenched	D80	3	31	5.92	<0.010	<0.010	<0.050	9.76	9.85	84.1	<0.020	71.1	<0.500	2.34
2	NEPH2-28	quenched	D29	3	32	7.63	<0.010	<0.010	<0.050	10.5	10.4	90.4	<0.020	74.4	<0.500	1.91

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

Part	Glass ID	Heat Treatment	Laboratory ID	Block	Seq	B ar	Ba ar	Cd ar	Cr ar	Fe ar	Li ar	Na ar	Pb ar	Si ar	Th ar	U ar
2	NEPH2-30	quenched	D88	3	33	6.12	<0.010	<0.010	<0.050	10.1	10.2	75.5	<0.020	72	<0.500	1.99
2	Std Soln		std-b3-3	3	34	19.4	<0.010	<0.010	<0.050	3.99	9.62	81.7	<0.020	51.1	<0.500	<0.100
3	Std Soln		STD-B1-1	1	1	19.3	<0.100	<0.100	<0.100	3.99	9.65	86.7	<0.200	48.6	<0.100	<0.100
3	ARM-1		E06	1	2	8.69	<0.100	<0.100	<0.100	0.171	8.43	24.8	<0.200	37.9	<0.100	<0.100
3	EA		E03	1	3	19	<0.100	<0.100	<0.100	0.26	7.16	64.5	<0.200	37.4	<0.100	<0.100
3	NEPH2-35	quenched	E01	1	4	4.74	<0.100	<0.100	<0.100	6.87	9.25	95.5	<0.200	68	<0.100	1.43
3	NEPH2-33	quenched	E12	1	5	4.55	<0.100	<0.100	<0.100	6.24	9.98	77.1	<0.200	68.8	<0.100	1.34
3	Std Soln		STD-B1-2	1	6	18.4	<0.100	<0.100	<0.100	4.04	9.73	88.6	<0.200	49.5	<0.100	<0.100
3	NEPH2-34	quenched	E25	1	7	5.66	<0.100	<0.100	<0.100	5.68	9.28	86.2	<0.200	66	<0.100	1.25
3	NEPH2-33ccc	ccc	E24	1	8	<0.100	<0.100	<0.100	<0.100	7.31	14.7	84.4	<0.200	74.7	<0.100	1.46
3	NEPH2-35ccc	ccc	E05	1	9	260	<0.100	<0.100	<0.100	6.35	132	1145	<0.200	527	<0.100	15.9
3	NEPH2-34ccc	ccc	E21	1	10	55.2	<0.100	<0.100	<0.100	<0.040	77.6	304	<0.200	174	<0.100	8.01
3	blank		E22	1	11	<0.100	<0.100	<0.100	<0.100	<0.040	<1.00	0.398	<0.200	<0.200	<0.100	<0.100
3	Std Soln		STD-B-1-3	1	12	18.4	<0.100	<0.100	<0.100	4.1	9.67	88	<0.200	50	<0.100	<0.100
3	Std Soln		STD-B2-1	2	1	20.6	<0.100	<0.100	<0.100	4.05	9.89	86	<0.200	48.1	<0.100	<0.100
3	NEPH2-33ccc	ccc	E19	2	2	8.44	<0.100	<0.100	<0.100	10.2	18	83.1	<0.200	69.9	<0.100	1.65
3	NEPH2-34	quenched	E13	2	3	6.25	<0.100	<0.100	<0.100	5.4	9.5	84.9	<0.200	62.9	<0.100	1.42
3	EA		E02	2	4	20.3	<0.100	<0.100	<0.100	0.287	7.49	65.8	<0.200	36.2	<0.100	<0.100
3	ARM-1		E11	2	5	10.7	<0.100	<0.100	<0.100	<0.040	8.73	24.9	<0.200	37.2	<0.100	<0.100
3	Std Soln		STD-B2-2	2	6	19.8	<0.100	<0.100	<0.100	4.04	9.91	86.2	<0.200	48.2	<0.100	<0.100
3	NEPH2-35	quenched	E14	2	7	6.94	<0.100	<0.100	<0.100	7.02	9.38	93.5	<0.200	64.8	<0.100	1.59
3	NEPH2-35ccc	ccc	E20	2	8	269	<0.100	<0.100	<0.100	7.33	134	1124	<0.200	504	<0.100	14
3	NEPH2-33	quenched	E04	2	9	6.77	<0.100	<0.100	<0.100	6.57	10.1	76	<0.200	67	<0.100	1.63
3	NEPH2-34ccc	ccc	E23	2	10	67.1	<0.100	<0.100	<0.100	8.73	77	287	<0.200	170	<0.100	8.25
3	Std Soln		STDB2-3	2	11	19.8	<0.100	<0.100	<0.100	4.09	9.95	85.9	<0.200	48.6	<0.100	<0.100
3	Std Soln		STD-B3-1	3	1	20	<0.100	<0.100	<0.100	3.85	9.63	86.3	<0.200	47.5	<0.100	<0.100
3	EA		E18	3	2	26.8	<0.100	<0.100	<0.100	<0.040	8.14	79.8	<0.200	39.5	<0.100	<0.100
3	ARM-1		E09	3	3	11.3	<0.100	<0.100	<0.100	0.424	8.63	25.4	<0.200	37.4	<0.100	<0.100
3	blank		E10	3	4	<0.100	<0.100	<0.100	<0.100	0.625	<1.00	0.719	<0.200	<0.200	<0.100	<0.100
3	NEPH2-35ccc	ccc	E08	3	5	273	<0.100	<0.100	<0.100	6.07	133	1116	<0.200	509	<0.100	13.1
3	Std Soln		STD-B3-2	3	6	20.5	<0.100	<0.100	<0.100	4.15	9.82	85.3	<0.200	48.8	<0.100	<0.100
3	NEPH2-33ccc	ccc	E17	3	7	15.7	<0.100	<0.100	<0.100	9.74	15.9	86.4	<0.200	77.9	<0.100	2.39
3	NEPH2-34ccc	ccc	E26	3	8	70.9	<0.100	<0.100	<0.100	18	76.7	299	<0.200	187	<0.100	8.39
3	NEPH2-34	quenched	E15	3	9	6.53	<0.100	<0.100	<0.100	5.36	9.36	85	<0.200	64	<0.100	1.56
3	NEPH2-35	quenched	E07	3	10	6.58	<0.100	<0.100	<0.100	6.82	9.12	93.5	<0.200	64.9	<0.100	1.6
3	NEPH2-33	quenched	E16	3	11	6.87	<0.100	<0.100	<0.100	6.5	10.2	78	<0.200	68.9	<0.100	1.68
3	Std Soln		STD-B3-3	3	12	20	<0.100	<0.100	<0.100	4.13	9.77	84.5	<0.200	48.5	<0.100	<0.100

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

Part	Glass ID	Heat Treatment	Laboratory ID	Block	Seq	B (ppm)	Ba (ppm)	Cd (ppm)	Cr (pp)	Fe (ppm)	Li (ppm)	Na (ppm)	Pb (ppm)	Si (ppm)	Th (ppm)	U (ppm)
1	Soln Std		std-b1-1	1	1	20.500	0.005	0.005	0.025	4.330	10.100	82.100	0.010	49.900	0.250	0.050
1	NEPH2-21ccc	ccc	C51	1	2	13.967	0.008	0.008	0.042	13.234	20.834	139.003	0.017	130.336	0.417	3.867
1	NEPH2-17	quenched	C92	1	3	14.817	0.008	0.008	0.042	16.834	20.500	198.337	0.017	138.169	0.417	4.383
1	NEPH2-22	quenched	C67	1	4	12.734	0.008	0.008	0.042	13.050	17.667	157.503	0.017	124.002	0.417	3.417
1	NEPH2-26	quenched	C59	1	5	12.900	0.008	0.008	0.042	16.084	17.334	185.004	0.017	125.003	0.417	3.733
1	NEPH2-18	quenched	C69	1	6	13.334	0.008	0.008	0.042	16.067	20.167	158.337	0.017	137.169	0.417	3.650
1	NEPH2-13ccc	ccc	C83	1	7	15.667	0.008	0.008	0.042	21.000	25.334	176.670	0.017	155.503	0.417	5.583
1	NEPH2-24	quenched	C34	1	8	12.350	0.008	0.008	0.042	12.684	18.334	140.003	0.017	128.003	0.417	3.300
1	NEPH2-18ccc	ccc	C15	1	9	14.400	0.008	0.008	0.042	15.950	22.167	151.836	0.017	143.003	0.417	4.483
1	NEPH2-15	quenched	C52	1	10	14.517	0.008	0.008	0.042	20.167	21.334	173.337	0.017	151.003	0.417	4.500
1	NEPH2-23	quenched	C70	1	11	13.417	0.008	0.008	0.042	16.400	17.500	186.670	0.017	128.336	0.417	4.850
1	NEPH2-13	quenched	C89	1	12	14.750	0.008	0.008	0.042	21.000	22.667	188.337	0.017	154.836	0.417	4.667
1	ARM-1		C84	1	13	18.834	0.008	0.008	0.042	0.747	15.100	40.167	0.017	66.168	0.417	0.083
1	EA		C44	1	14	648.335	0.083	0.083	0.417	0.083	200.000	1750.004	0.167	948.335	4.167	0.833
1	NEPH2-15ccc	ccc	C76	1	15	15.567	0.008	0.008	0.042	18.667	24.667	160.003	0.017	149.836	0.417	4.183
1	NEPH2-21	quenched	C03	1	16	12.917	0.008	0.008	0.042	13.184	19.334	149.836	0.017	131.336	0.417	3.733
1	Soln Std		std-b1-2	1	17	20.000	0.005	0.005	0.025	4.170	10.100	83.000	0.010	49.600	0.250	0.050
1	NEPH2-16ccc	ccc	C32	1	18	25.834	0.008	0.008	0.042	17.667	35.334	213.338	0.017	176.670	0.417	5.200
1	NEPH2-20ccc	ccc	C14	1	19	117.002	0.008	0.008	0.042	0.290	124.169	675.014	0.017	331.673	0.417	16.267
1	NEPH2-19	quenched	C71	1	20	14.017	0.008	0.008	0.042	16.567	19.000	165.337	0.017	130.336	0.417	3.867
1	NEPH2-24ccc	ccc	C49	1	21	13.484	0.008	0.008	0.042	11.917	20.500	127.836	0.017	127.503	0.417	3.333
1	NEPH2-14	quenched	C82	1	22	15.400	0.008	0.008	0.042	20.167	22.500	205.004	0.017	151.336	0.417	4.383
1	NEPH2-20	quenched	C06	1	23	14.050	0.008	0.008	0.042	15.217	19.167	191.671	0.017	130.003	0.417	3.667
1	NEPH2-19ccc	ccc	C68	1	24	29.001	0.008	0.008	0.042	19.167	39.834	221.671	0.017	186.670	0.417	6.000
1	NEPH2-23ccc	ccc	C56	1	25	128.503	0.008	0.008	0.042	0.897	134.503	738.348	0.017	316.673	0.417	17.850
1	blank		C85	1	26	1.332	0.008	0.008	0.042	0.737	1.420	0.322	0.017	0.008	0.417	0.083
1	NEPH2-22ccc	ccc	C81	1	27	32.667	0.008	0.008	0.042	25.167	52.834	230.005	0.017	211.671	0.417	6.333
1	NEPH2-25	quenched	C66	1	28	13.100	0.008	0.008	0.042	13.800	18.000	154.503	0.017	121.669	0.417	3.033
1	NEPH2-26ccc	ccc	C29	1	29	460.009	0.008	0.008	0.042	0.133	236.671	2200.044	0.017	983.353	0.417	7.567
1	NEPH2-14ccc	ccc	C42	1	30	30.834	0.008	0.008	0.042	24.834	39.834	241.672	0.017	193.337	0.417	5.800
1	NEPH2-17ccc	ccc	C09	1	31	48.834	0.008	0.008	0.042	29.834	74.835	376.674	0.017	261.672	0.417	8.734

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

Part	Glass ID	Heat Treatment	Laboratory ID	Block	Seq	B (ppm)	Ba (ppm)	Cd (ppm)	Cr (pp)	Fe (ppm)	Li (ppm)	Na (ppm)	Pb (ppm)	Si (ppm)	Th (ppm)	U (ppm)
1	NEPH2-16	quenched	C72	1	32	15.600	0.008	0.008	0.042	20.834	21.334	185.004	0.017	145.503	0.417	4.133
1	NEPH2-25ccc	ccc	C20	1	33	60.168	0.008	0.008	0.042	31.834	84.168	373.341	0.017	260.005	0.417	10.350
1	Soln Std		std-b1-3	1	34	20.400	0.005	0.005	0.025	4.080	10.300	82.300	0.010	48.900	0.250	0.050
1	Soln Std		std-b2-1	2	1	20.200	0.005	0.005	0.025	3.960	10.300	83.300	0.010	50.800	0.250	0.050
1	NEPH2-26ccc	ccc	C10	2	2	473.343	0.008	0.008	0.042	0.008	236.671	2250.045	0.017	1000.020	0.417	8.233
1	NEPH2-15	quenched	C47	2	3	17.834	0.008	0.008	0.042	18.334	21.500	173.337	0.017	154.503	0.417	4.217
1	NEPH2-19ccc	ccc	C33	2	4	30.167	0.008	0.008	0.042	28.167	39.167	225.005	0.017	200.004	0.417	6.017
1	NEPH2-14ccc	ccc	C18	2	5	27.167	0.008	0.008	0.042	21.334	38.501	240.005	0.017	198.337	0.417	5.517
1	NEPH2-23	quenched	C11	2	6	13.350	0.008	0.008	0.042	14.900	18.167	186.670	0.017	130.336	0.417	3.633
1	NEPH2-17	quenched	C58	2	7	13.967	0.008	0.008	0.042	17.000	20.334	193.337	0.017	140.503	0.417	4.350
1	NEPH2-21ccc	ccc	C02	2	8	12.817	0.008	0.008	0.042	14.417	21.000	136.169	0.017	133.503	0.417	3.633
1	NEPH2-13ccc	ccc	C62	2	9	15.017	0.008	0.008	0.042	19.500	26.001	181.670	0.017	160.337	0.417	4.033
1	ARM-1		C38	2	10	18.000	0.008	0.008	0.042	0.008	15.050	43.668	0.017	67.168	0.417	0.083
1	NEPH2-26	quenched	C63	2	11	12.084	0.008	0.008	0.042	15.317	17.167	185.004	0.017	128.669	0.417	4.133
1	NEPH2-20	quenched	C40	2	12	13.234	0.008	0.008	0.042	13.050	18.834	191.671	0.017	134.003	0.417	3.483
1	NEPH2-16	quenched	C19	2	13	13.667	0.008	0.008	0.042	17.000	21.000	186.670	0.017	146.670	0.417	3.950
1	NEPH2-18ccc	ccc	C16	2	14	13.100	0.008	0.008	0.042	17.667	22.500	147.670	0.017	142.503	0.417	5.283
1	NEPH2-25	quenched	C88	2	15	11.717	0.008	0.008	0.042	12.034	18.000	156.670	0.017	124.669	0.417	2.650
1	NEPH2-19	quenched	C07	2	16	12.267	0.008	0.008	0.042	12.334	19.000	170.003	0.017	131.169	0.417	3.317
1	Soln Std		std-b2-2	2	17	19.100	0.005	0.005	0.025	3.720	10.000	83.300	0.010	49.700	0.250	0.050
1	NEPH2-14	quenched	C36	2	18	14.617	0.008	0.008	0.042	19.667	21.667	201.671	0.017	149.170	0.417	5.833
1	NEPH2-17ccc	ccc	C22	2	19	45.668	0.008	0.008	0.042	29.334	71.168	351.674	0.017	241.672	0.417	9.550
1	NEPH2-18	quenched	C75	2	20	12.584	0.008	0.008	0.042	14.334	19.834	154.836	0.017	137.003	0.417	3.667
1	NEPH2-24	quenched	C73	2	21	11.300	0.008	0.008	0.042	12.017	18.500	138.503	0.017	127.169	0.417	3.050
1	NEPH2-22	quenched	C17	2	22	11.600	0.008	0.008	0.042	12.100	17.500	155.170	0.017	125.336	0.417	3.533
1	NEPH2-15ccc	ccc	C01	2	23	13.850	0.008	0.008	0.042	15.450	24.500	162.337	0.017	145.670	0.417	3.533
1	NEPH2-21	quenched	C43	2	24	10.634	0.008	0.008	0.042	13.117	17.834	139.169	0.017	121.169	0.417	3.467
1	NEPH2-23ccc	ccc	C86	2	25	123.502	0.008	0.008	0.042	0.008	129.003	721.681	0.017	311.673	0.417	16.850
1	NEPH2-16ccc	ccc	C25	2	26	25.334	0.008	0.008	0.042	19.834	35.667	221.671	0.017	181.670	0.417	5.533
1	NEPH2-20ccc	ccc	C08	2	27	118.002	0.008	0.008	0.042	0.008	126.336	688.347	0.017	328.340	0.417	16.367
1	NEPH2-25ccc	ccc	C55	2	28	62.168	0.008	0.008	0.042	26.834	85.668	395.008	0.017	266.672	0.417	9.334

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

Part	Glass ID	Heat Treatment	Laboratory ID	Block	Seq	B (ppm)	Ba (ppm)	Cd (ppm)	Cr (pp)	Fe (ppm)	Li (ppm)	Na (ppm)	Pb (ppm)	Si (ppm)	Th (ppm)	U (ppm)
1	EA		C53	2	29	606.668	0.083	0.083	0.417	0.083	191.667	1683.337	0.167	900.002	4.167	0.833
1	NEPH2-22ccc	ccc	C35	2	30	32.667	0.008	0.008	0.042	25.834	54.001	235.005	0.017	216.671	0.417	6.700
1	NEPH2-13	quenched	C64	2	31	14.234	0.008	0.008	0.042	23.834	23.834	191.671	0.017	153.503	0.417	4.250
1	NEPH2-24ccc	ccc	C27	2	32	12.067	0.008	0.008	0.042	11.300	20.500	130.669	0.017	125.336	0.417	3.100
1	Soln Std		std-b2-3	2	33	19.000	0.005	0.005	0.025	4.310	10.100	81.700	0.010	49.500	0.250	0.050
1	Soln Std		std-b-3-1	3	1	20.500	0.005	0.005	0.025	4.190	10.000	88.000	0.010	51.600	0.250	0.050
1	NEPH2-22	quenched	C91	3	2	12.600	0.008	0.008	0.042	11.034	17.667	161.003	0.017	128.003	0.417	3.233
1	NEPH2-16ccc	ccc	C41	3	3	25.834	0.008	0.008	0.042	21.834	35.334	228.338	0.017	190.004	0.417	6.217
1	NEPH2-25ccc	ccc	C23	3	4	64.168	0.008	0.008	0.042	31.001	87.168	385.008	0.017	255.005	0.417	11.134
1	NEPH2-14ccc	ccc	C26	3	5	27.334	0.008	0.008	0.042	19.000	38.001	240.005	0.017	198.337	0.417	5.400
1	NEPH2-15	quenched	C30	3	6	13.534	0.008	0.008	0.042	18.500	21.000	175.004	0.017	150.170	0.417	3.900
1	NEPH2-19	quenched	C65	3	7	12.867	0.008	0.008	0.042	13.317	19.000	170.003	0.017	135.669	0.417	3.733
1	NEPH2-24	quenched	C74	3	8	11.450	0.008	0.008	0.042	12.384	18.334	141.836	0.017	130.003	0.417	3.250
1	NEPH2-15ccc	ccc	C37	3	9	14.900	0.008	0.008	0.042	18.500	25.001	168.337	0.017	157.503	0.417	4.133
1	NEPH2-13ccc	ccc	C87	3	10	14.934	0.008	0.008	0.042	20.500	25.834	186.670	0.017	162.670	0.417	4.150
1	NEPH2-17	quenched	C04	3	11	13.684	0.008	0.008	0.042	14.734	19.834	198.337	0.017	141.670	0.417	4.167
1	NEPH2-13	quenched	C50	3	12	13.900	0.008	0.008	0.042	22.334	21.834	196.671	0.017	159.837	0.417	5.683
1	NEPH2-20	quenched	C39	3	13	13.084	0.008	0.008	0.042	13.167	18.334	193.337	0.017	133.169	0.417	3.750
1	NEPH2-24ccc	ccc	C90	3	14	12.300	0.008	0.008	0.042	11.667	20.167	134.836	0.017	131.003	0.417	2.950
1	NEPH2-19ccc	ccc	C78	3	15	28.001	0.008	0.008	0.042	18.000	38.667	230.005	0.017	190.004	0.417	5.400
1	NEPH2-17ccc	ccc	C80	3	16	45.168	0.008	0.008	0.042	27.834	70.335	340.007	0.017	236.671	0.417	10.684
1	Soln Std		std-b3-2	3	17	19.600	0.005	0.005	0.025	4.150	10.000	83.600	0.010	51.200	0.250	0.050
1	NEPH2-18	quenched	C12	3	18	13.434	0.008	0.008	0.042	15.600	19.667	158.670	0.017	142.003	0.417	4.017
1	NEPH2-26ccc	ccc	C77	3	19	448.342	0.008	0.008	0.042	0.008	230.005	2133.376	0.017	958.353	0.417	7.683
1	NEPH2-21	quenched	C57	3	20	15.817	0.008	0.008	0.042	13.150	18.667	148.503	0.017	130.169	0.417	3.667
1	NEPH2-14	quenched	C28	3	21	15.434	0.008	0.008	0.042	22.667	22.334	208.338	0.017	158.170	0.417	5.033
1	EA		C61	3	22	625.001	0.083	0.083	0.417	0.083	190.000	1750.004	0.167	933.335	4.167	0.833
1	NEPH2-25	quenched	C79	3	23	12.817	0.008	0.008	0.042	11.767	17.834	162.670	0.017	125.836	0.417	2.933
1	blank		C21	3	24	0.025	0.008	0.008	0.042	0.008	1.248	0.083	0.017	0.008	0.417	0.083
1	NEPH2-18ccc	ccc	C05	3	25	13.067	0.008	0.008	0.042	14.884	22.500	156.836	0.017	141.003	0.417	3.783
1	NEPH2-26	quenched	C48	3	26	12.150	0.008	0.008	0.042	13.267	17.167	195.004	0.017	126.836	0.417	3.767

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

Part	Glass ID	Heat Treatment	Laboratory ID	Block	Seq	B (ppm)	Ba (ppm)	Cd (ppm)	Cr (pp)	Fe (ppm)	Li (ppm)	Na (ppm)	Pb (ppm)	Si (ppm)	Th (ppm)	U (ppm)
1	NEPH2-21ccc	ccc	C60	3	27	12.717	0.008	0.008	0.042	10.784	20.667	148.670	0.017	134.003	0.417	3.350
1	NEPH2-23ccc	ccc	C54	3	28	129.169	0.008	0.008	0.042	0.008	132.336	735.015	0.017	300.006	0.417	18.667
1	NEPH2-23	quenched	C31	3	29	14.217	0.008	0.008	0.042	14.517	18.167	195.004	0.017	131.503	0.417	4.000
1	ARM-1		C46	3	30	19.834	0.008	0.008	0.042	0.008	15.650	43.334	0.017	70.001	0.417	0.083
1	NEPH2-16	quenched	C24	3	31	20.167	0.008	0.008	0.042	18.000	20.667	191.671	0.017	144.836	0.417	4.000
1	NEPH2-20ccc	ccc	C13	3	32	118.336	0.008	0.008	0.042	0.008	125.503	690.014	0.017	333.340	0.417	14.634
1	NEPH2-22ccc	ccc	C45	3	33	32.667	0.008	0.008	0.042	26.667	52.501	238.338	0.017	218.338	0.417	7.200
1	Soln Std		std-b3-3	3	34	19.900	0.005	0.005	0.025	4.300	10.100	84.800	0.010	51.100	0.250	0.050
2	Std Soln		std-b1-1	1	1	20.600	0.005	0.005	0.025	4.010	9.880	84.700	0.010	51.900	0.250	0.050
2	NEPH2-27ccc	ccc	D49	1	2	30.501	0.008	0.008	0.042	17.000	52.001	203.337	0.017	210.004	0.417	6.767
2	NEPH2-36	quenched	D63	1	3	10.517	0.008	0.008	0.042	10.217	15.567	105.169	0.017	112.669	0.417	2.500
2	NEPH2-33ccc	ccc	D78	1	4	147.336	0.008	0.008	0.042	0.208	173.337	518.344	0.017	340.007	0.417	13.317
2	NEPH2-39ccc	ccc	D56	1	5	16.017	0.008	0.008	0.042	13.950	22.500	107.669	0.017	130.503	0.417	3.283
2	NEPH2-29	quenched	D05	1	6	12.817	0.008	0.008	0.042	16.300	15.750	176.670	0.017	122.836	0.417	4.383
2	NEPH2-32ccc	ccc	D53	1	7	426.675	0.008	0.008	0.042	0.008	216.671	1833.370	0.017	813.350	0.417	6.167
2	NEPH2-32	quenched	D87	1	8	17.667	0.008	0.008	0.042	12.117	15.717	158.670	0.017	117.836	0.417	2.983
2	NEPH2-31ccc	ccc	D09	1	9	75.668	0.008	0.008	0.042	18.834	92.335	321.673	0.017	275.006	0.417	10.517
2	NEPH2-29ccc	ccc	D02	1	10	518.344	0.008	0.008	0.042	0.197	205.004	2350.047	0.017	825.017	0.417	5.967
2	NEPH2-28	quenched	D44	1	11	21.334	0.008	0.008	0.042	14.917	17.500	152.670	0.017	127.336	0.417	3.117
2	NEPH2-35ccc	ccc	D36	1	12	14.900	0.008	0.008	0.042	12.117	20.334	115.336	0.017	126.169	0.417	2.917
2	NEPH2-28ccc	ccc	D37	1	13	35.001	0.008	0.008	0.042	23.500	42.334	216.671	0.017	188.337	0.417	5.467
2	NEPH2-34ccc	ccc	D54	1	14	423.342	0.008	0.008	0.042	0.008	255.005	1700.034	0.017	818.350	0.417	6.350
2	EA		D07	1	15	683.335	0.083	0.083	0.417	1.967	183.334	1666.670	0.167	920.002	4.167	0.833
2	NEPH2-38ccc	ccc	D20	1	16	124.669	0.008	0.008	0.042	1.883	125.336	398.341	0.017	286.672	0.417	11.884
2	Std Soln		std-b1-2	1	17	22.100	0.005	0.005	0.025	4.120	9.780	86.000	0.010	51.200	0.250	0.050
2	NEPH2-38	quenched	D01	1	18	12.467	0.008	0.008	0.042	10.234	14.550	129.169	0.017	106.835	0.417	2.533
2	NEPH2-40	quenched	D03	1	19	10.784	0.008	0.008	0.042	9.450	14.300	110.002	0.017	103.502	0.417	2.000
2	NEPH2-30	quenched	D32	1	20	12.134	0.008	0.008	0.042	17.167	17.500	132.669	0.017	127.336	0.417	3.283
2	NEPH2-31	quenched	D45	1	21	12.000	0.008	0.008	0.042	12.817	16.217	142.003	0.017	116.836	0.417	2.783
2	NEPH2-36ccc	ccc	D52	1	22	14.750	0.008	0.008	0.042	12.767	21.834	116.002	0.017	126.503	0.417	3.083
2	NEPH2-40ccc	ccc	D10	1	23	30.501	0.008	0.008	0.042	18.667	46.834	173.337	0.017	173.337	0.417	5.550

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

Part	Glass ID	Heat Treatment	Laboratory ID	Block	Seq	B (ppm)	Ba (ppm)	Cd (ppm)	Cr (pp)	Fe (ppm)	Li (ppm)	Na (ppm)	Pb (ppm)	Si (ppm)	Th (ppm)	U (ppm)
2	NEPH2-34	quenched	D92	1	24	.	.	.	.	.	.	.	.	.	.	.
2	NEPH2-37	quenched	D16	1	25	10.784	0.008	0.008	0.042	10.117	14.184	117.169	0.017	104.335	0.417	2.583
2	NEPH2-37ccc	ccc	D14	1	26	50.668	0.008	0.008	0.042	22.667	74.001	243.338	0.017	226.671	0.417	7.767
2	NEPH2-30ccc	ccc	D06	1	27	13.000	0.008	0.008	0.042	15.967	19.667	125.836	0.017	122.336	0.417	3.217
2	NEPH2-39	quenched	D58	1	28	10.134	0.008	0.008	0.042	10.567	15.134	102.669	0.017	108.002	0.417	2.150
2	NEPH2-35	quenched	D40	1	29	10.800	0.008	0.008	0.042	9.784	16.034	115.669	0.017	114.336	0.417	2.200
2	ARM-1		D81	1	30	20.334	0.008	0.008	0.042	0.008	15.417	43.501	0.017	70.335	0.417	0.083
2	blank		D76	1	31	0.187	0.008	0.008	0.042	0.038	1.278	0.083	0.017	0.008	0.417	0.083
2	NEPH2-27	quenched	D19	1	32	10.500	0.008	0.008	0.042	16.117	17.334	147.670	0.017	125.336	0.417	3.517
2	NEPH2-33	quenched	D59	1	33	10.967	0.008	0.008	0.042	12.350	15.817	134.669	0.017	114.336	0.417	2.567
2	Std Soln		std-b1-3	1	34	20.400	0.005	0.005	0.025	4.190	9.780	85.000	0.010	51.500	0.250	0.050
2	Std Soln		std-b2-1	2	1	21.400	0.005	0.005	0.025	3.840	9.830	83.000	0.010	51.500	0.250	0.050
2	NEPH2-36ccc	ccc	D74	2	2	15.450	0.008	0.008	0.042	11.267	22.500	113.336	0.017	130.336	0.417	3.250
2	NEPH2-40ccc	ccc	D38	2	3	30.001	0.008	0.008	0.042	17.834	47.168	163.670	0.017	181.670	0.417	5.367
2	NEPH2-30	quenched	D69	2	4	11.550	0.008	0.008	0.042	15.417	17.667	127.503	0.017	125.169	0.417	3.617
2	NEPH2-31	quenched	D51	2	5	11.467	0.008	0.008	0.042	11.767	16.600	139.503	0.017	119.502	0.417	2.833
2	NEPH2-35ccc	ccc	D31	2	6	12.150	0.008	0.008	0.042	11.367	20.500	112.502	0.017	127.503	0.417	2.883
2	NEPH2-29ccc	ccc	D04	2	7	506.677	0.008	0.008	0.042	0.008	205.004	2283.379	0.017	803.349	0.417	5.333
2	NEPH2-30ccc	ccc	D68	2	8	20.000	0.008	0.008	0.042	16.200	20.834	125.336	0.017	131.503	0.417	3.633
2	NEPH2-33ccc	ccc	D50	2	9	135.669	0.008	0.008	0.042	0.227	154.336	486.676	0.017	301.673	0.417	14.134
2	NEPH2-39ccc	ccc	D57	2	10	15.967	0.008	0.008	0.042	12.350	22.000	104.502	0.017	124.336	0.417	3.200
2	NEPH2-29	quenched	D67	2	11	12.700	0.008	0.008	0.042	14.617	16.184	175.004	0.017	121.836	0.417	3.550
2	NEPH2-38	quenched	D84	2	12	10.684	0.008	0.008	0.042	9.650	15.017	127.503	0.017	110.336	0.417	2.467
2	NEPH2-27ccc	ccc	D71	2	13	31.334	0.008	0.008	0.042	18.667	53.501	198.337	0.017	208.338	0.417	5.467
2	NEPH2-28	quenched	D22	2	14	13.767	0.008	0.008	0.042	13.700	17.167	146.336	0.017	123.669	0.417	3.733
2	NEPH2-38ccc	ccc	D89	2	15	122.502	0.008	0.008	0.042	0.973	124.002	408.342	0.017	281.672	0.417	11.650
2	NEPH2-31ccc	ccc	D08	2	16	76.002	0.008	0.008	0.042	15.400	93.002	318.340	0.017	273.339	0.417	11.384
2	Std Soln		std-b2-2	2	17	21.100	0.005	0.005	0.025	3.900	9.990	82.400	0.010	51.800	0.250	0.050
2	NEPH2-35	quenched	D83	2	18	11.900	0.008	0.008	0.042	9.534	16.150	109.002	0.017	112.836	0.417	2.400
2	ARM-1		D75	2	19	19.834	0.008	0.008	0.042	0.333	15.417	39.501	0.017	69.668	0.417	0.083
2	NEPH2-37ccc	ccc	D35	2	20	50.168	0.008	0.008	0.042	21.667	73.001	218.338	0.017	218.338	0.417	8.950

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

Part	Glass ID	Heat Treatment	Laboratory ID	Block	Seq	B (ppm)	Ba (ppm)	Cd (ppm)	Cr (pp)	Fe (ppm)	Li (ppm)	Na (ppm)	Pb (ppm)	Si (ppm)	Th (ppm)	U (ppm)
2	NEPH2-33	quenched	D73	2	21	10.750	0.008	0.008	0.042	13.467	15.134	119.002	0.017	108.169	0.417	2.967
2	NEPH2-32	quenched	D79	2	22	11.017	0.008	0.008	0.042	11.534	15.250	153.170	0.017	112.336	0.417	2.783
2	NEPH2-27	quenched	D24	2	23	10.000	0.008	0.008	0.042	14.917	16.600	136.169	0.017	119.669	0.417	3.933
2	NEPH2-28ccc	ccc	D15	2	24	33.334	0.008	0.008	0.042	23.834	42.334	208.338	0.017	185.004	0.417	5.467
2	NEPH2-34ccc	ccc	D17	2	25	418.342	0.008	0.008	0.042	0.008	245.005	1683.367	0.017	810.016	0.417	6.367
2	NEPH2-32ccc	ccc	D21	2	26	428.342	0.008	0.008	0.042	0.008	213.338	1850.037	0.017	803.349	0.417	6.383
2	NEPH2-40	quenched	D86	2	27	16.834	0.008	0.008	0.042	9.700	14.000	101.502	0.017	103.335	0.417	2.483
2	NEPH2-36	quenched	D34	2	28	12.450	0.008	0.008	0.042	10.000	15.750	102.502	0.017	112.669	0.417	2.567
2	NEPH2-34	quenched	D25	2	29	11.434	0.008	0.008	0.042	10.434	14.900	135.336	0.017	109.336	0.417	2.667
2	EA		D27	2	30	636.668	0.083	0.083	0.417	0.083	186.667	1630.003	0.167	936.669	4.167	0.833
2	NEPH2-37	quenched	D70	2	31	11.434	0.008	0.008	0.042	9.567	14.684	111.002	0.017	107.002	0.417	2.450
2	NEPH2-39	quenched	D55	2	32	10.100	0.008	0.008	0.042	10.384	15.200	95.335	0.017	108.502	0.417	2.300
2	Std Soln		std-b2-3	2	33	20.400	0.005	0.005	0.025	4.110	9.810	79.300	0.010	51.000	0.250	0.050
2	Std Soln		std-b-3-1	3	1	21.200	0.005	0.005	0.025	3.900	9.740	81.800	0.010	52.000	0.250	0.050
2	NEPH2-36	quenched	D91	3	2	10.450	0.008	0.008	0.042	10.834	15.017	101.335	0.017	111.836	0.417	2.883
2	NEPH2-37	quenched	D42	3	3	10.034	0.008	0.008	0.042	8.734	15.000	115.502	0.017	109.669	0.417	2.333
2	NEPH2-29ccc	ccc	D48	3	4	500.010	0.008	0.008	0.042	0.008	203.337	2283.379	0.017	800.016	0.417	5.233
2	NEPH2-40	quenched	D33	3	5	16.167	0.008	0.008	0.042	9.034	14.450	104.169	0.017	106.835	0.417	2.333
2	blank		D72	3	6	0.932	0.008	0.008	0.042	0.008	1.152	0.083	0.017	0.008	0.417	0.083
2	NEPH2-32	quenched	D85	3	7	11.350	0.008	0.008	0.042	12.350	15.534	157.336	0.017	117.002	0.417	2.933
2	NEPH2-39	quenched	D11	3	8	9.484	0.008	0.008	0.042	9.900	14.784	93.669	0.017	108.002	0.417	2.350
2	NEPH2-38	quenched	D66	3	9	9.850	0.008	0.008	0.042	10.217	14.650	127.003	0.017	110.669	0.417	2.283
2	NEPH2-32ccc	ccc	D61	3	10	433.342	0.008	0.008	0.042	0.008	211.671	1883.371	0.017	803.349	0.417	5.933
2	NEPH2-34ccc	ccc	D77	3	11	423.342	0.008	0.008	0.042	0.008	243.338	1683.367	0.017	811.683	0.417	6.050
2	NEPH2-31ccc	ccc	D43	3	12	79.168	0.008	0.008	0.042	15.384	91.335	316.673	0.017	273.339	0.417	11.334
2	NEPH2-39ccc	ccc	D46	3	13	16.000	0.008	0.008	0.042	12.834	21.667	105.002	0.017	126.669	0.417	3.150
2	NEPH2-33ccc	ccc	D64	3	14	128.503	0.008	0.008	0.042	0.528	150.003	468.343	0.017	320.006	0.417	14.684
2	ARM-1		D90	3	15	23.000	0.008	0.008	0.042	0.008	15.617	41.334	0.017	72.168	0.417	0.083
2	NEPH2-36ccc	ccc	D30	3	16	15.150	0.008	0.008	0.042	12.284	22.167	114.169	0.017	128.503	0.417	3.383
2	Std Soln		std-b3-2	3	17	20.200	0.005	0.005	0.025	4.020	9.690	80.800	0.010	51.300	0.250	0.050
2	NEPH2-38ccc	ccc	D28	3	18	121.002	0.008	0.008	0.042	1.497	121.836	410.008	0.017	281.672	0.417	11.250

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

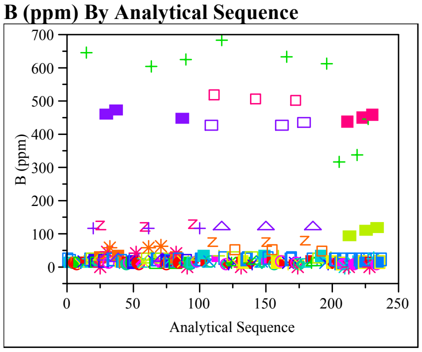
Part	Glass ID	Heat Treatment	Laboratory ID	Block	Seq	B (ppm)	Ba (ppm)	Cd (ppm)	Cr (pp)	Fe (ppm)	Li (ppm)	Na (ppm)	Pb (ppm)	Si (ppm)	Th (ppm)	U (ppm)
2	NEPH2-30ccc	ccc	D47	3	19	14.434	0.008	0.008	0.042	16.200	19.500	120.669	0.017	125.336	0.417	3.567
2	NEPH2-33	quenched	D12	3	20	10.550	0.008	0.008	0.042	9.650	15.000	124.002	0.017	107.669	0.417	2.650
2	NEPH2-40ccc	ccc	D60	3	21	27.667	0.008	0.008	0.042	16.367	44.334	159.503	0.017	170.003	0.417	6.183
2	NEPH2-35ccc	ccc	D18	3	22	12.167	0.008	0.008	0.042	11.550	19.834	114.002	0.017	124.836	0.417	2.750
2	NEPH2-27ccc	ccc	D26	3	23	29.834	0.008	0.008	0.042	18.834	52.001	196.671	0.017	201.671	0.417	5.583
2	NEPH2-37ccc	ccc	D41	3	24	48.668	0.008	0.008	0.042	20.167	71.835	221.671	0.017	220.004	0.417	8.984
2	NEPH2-34	quenched	D13	3	25	10.600	0.008	0.008	0.042	11.550	14.567	139.169	0.017	108.836	0.417	2.667
2	NEPH2-29	quenched	D82	3	26	11.184	0.008	0.008	0.042	14.184	15.417	173.337	0.017	116.669	0.417	3.450
2	EA		D65	3	27	613.335	0.083	0.083	0.417	0.083	185.000	1666.670	0.167	935.002	4.167	0.833
2	NEPH2-35	quenched	D39	3	28	10.567	0.008	0.008	0.042	9.767	15.750	111.836	0.017	110.669	0.417	2.167
2	NEPH2-31	quenched	D62	3	29	10.784	0.008	0.008	0.042	11.717	16.050	139.169	0.017	116.169	0.417	2.700
2	NEPH2-28ccc	ccc	D23	3	30	31.834	0.008	0.008	0.042	23.834	41.501	205.004	0.017	191.671	0.417	5.700
2	NEPH2-27	quenched	D80	3	31	9.867	0.008	0.008	0.042	16.267	16.417	140.169	0.017	118.502	0.417	3.900
2	NEPH2-28	quenched	D29	3	32	12.717	0.008	0.008	0.042	17.500	17.334	150.670	0.017	124.002	0.417	3.183
2	NEPH2-30	quenched	D88	3	33	10.200	0.008	0.008	0.042	16.834	17.000	125.836	0.017	120.002	0.417	3.317
2	Std Soln		std-b3-3	3	34	19.400	0.005	0.005	0.025	3.990	9.620	81.700	0.010	51.100	0.250	0.050
3	Std Soln		STD-B1-1	1	1	19.300	0.050	0.050	0.050	3.990	9.650	86.700	0.100	48.600	0.050	0.050
3	ARM-1		E06	1	2	14.484	0.083	0.083	0.083	0.285	14.050	41.334	0.167	63.168	0.083	0.083
3	EA		E03	1	3	316.667	0.833	0.833	0.833	4.333	119.334	1075.002	1.667	623.335	0.833	0.833
3	NEPH2-35	quenched	E01	1	4	7.900	0.083	0.083	0.083	11.450	15.417	159.170	0.167	113.336	0.083	2.383
3	NEPH2-33	quenched	E12	1	5	7.583	0.083	0.083	0.083	10.400	16.634	128.503	0.167	114.669	0.083	2.233
3	Std Soln		STD-B1-2	1	6	18.400	0.050	0.050	0.050	4.040	9.730	88.600	0.100	49.500	0.050	0.050
3	NEPH2-34	quenched	E25	1	7	9.434	0.083	0.083	0.083	9.467	15.467	143.670	0.167	110.002	0.083	2.083
3	NEPH2-33ccc	ccc	E24	1	8	0.083	0.083	0.083	0.083	12.184	24.500	140.669	0.167	124.502	0.083	2.433
3	NEPH2-35ccc	ccc	E05	1	9	433.342	0.083	0.083	0.083	10.584	220.004	1908.372	0.167	878.351	0.083	26.501
3	NEPH2-34ccc	ccc	E21	1	10	92.002	0.083	0.083	0.083	0.033	129.336	506.677	0.167	290.006	0.083	13.350
3	blank		E22	1	11	0.083	0.083	0.083	0.083	0.033	0.833	0.663	0.167	0.167	0.083	0.083
3	Std Soln		STD-B-1-3	1	12	18.400	0.050	0.050	0.050	4.100	9.670	88.000	0.100	50.000	0.050	0.050
3	Std Soln		STD-B2-1	2	1	20.600	0.050	0.050	0.050	4.050	9.890	86.000	0.100	48.100	0.050	0.050
3	NEPH2-33ccc	ccc	E19	2	2	14.067	0.083	0.083	0.083	17.000	30.001	138.503	0.167	116.502	0.083	2.750
3	NEPH2-34	quenched	E13	2	3	10.417	0.083	0.083	0.083	9.000	15.834	141.503	0.167	104.835	0.083	2.367

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

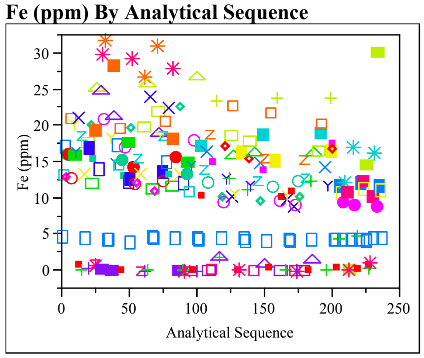
Part	Glass ID	Heat Treatment	Laboratory ID	Block	Seq	B (ppm)	Ba (ppm)	Cd (ppm)	Cr (pp)	Fe (ppm)	Li (ppm)	Na (ppm)	Pb (ppm)	Si (ppm)	Th (ppm)	U (ppm)
3	EA		E02	2	4	338.334	0.833	0.833	0.833	4.783	124.834	1096.669	1.667	603.335	0.833	0.833
3	ARM-1		E11	2	5	17.834	0.083	0.083	0.083	0.033	14.550	41.501	0.167	62.001	0.083	0.083
3	Std Soln		STD-B2-2	2	6	19.800	0.050	0.050	0.050	4.040	9.910	86.200	0.100	48.200	0.050	0.050
3	NEPH2-35	quenched	E14	2	7	11.567	0.083	0.083	0.083	11.700	15.634	155.836	0.167	108.002	0.083	2.650
3	NEPH2-35ccc	ccc	E20	2	8	448.342	0.083	0.083	0.083	12.217	223.338	1873.371	0.167	840.017	0.083	23.334
3	NEPH2-33	quenched	E04	2	9	11.284	0.083	0.083	0.083	10.950	16.834	126.669	0.167	111.669	0.083	2.717
3	NEPH2-34ccc	ccc	E23	2	10	111.836	0.083	0.083	0.083	14.550	128.336	478.343	0.167	283.339	0.083	13.750
3	Std Soln		STDB2-3	2	11	19.800	0.050	0.050	0.050	4.090	9.950	85.900	0.100	48.600	0.050	0.050
3	Std Soln		STD-B3-1	3	1	20.000	0.050	0.050	0.050	3.850	9.630	86.300	0.100	47.500	0.050	0.050
3	EA		E18	3	2	446.668	0.833	0.833	0.833	0.333	135.667	1330.003	1.667	658.335	0.833	0.833
3	ARM-1		E09	3	3	18.834	0.083	0.083	0.083	0.707	14.384	42.334	0.167	62.335	0.083	0.083
3	blank		E10	3	4	0.083	0.083	0.083	0.083	1.042	0.833	1.198	0.167	0.167	0.083	0.083
3	NEPH2-35ccc	ccc	E08	3	5	455.009	0.083	0.083	0.083	10.117	221.671	1860.037	0.167	848.350	0.083	21.834
3	Std Soln		STD-B3-2	3	6	20.500	0.050	0.050	0.050	4.150	9.820	85.300	0.100	48.800	0.050	0.050
3	NEPH2-33ccc	ccc	E17	3	7	26.167	0.083	0.083	0.083	16.234	26.501	144.003	0.167	129.836	0.083	3.983
3	NEPH2-34ccc	ccc	E26	3	8	118.169	0.083	0.083	0.083	30.001	127.836	498.343	0.167	311.673	0.083	13.984
3	NEPH2-34	quenched	E15	3	9	10.884	0.083	0.083	0.083	8.934	15.600	141.670	0.167	106.669	0.083	2.600
3	NEPH2-35	quenched	E07	3	10	10.967	0.083	0.083	0.083	11.367	15.200	155.836	0.167	108.169	0.083	2.667
3	NEPH2-33	quenched	E16	3	11	11.450	0.083	0.083	0.083	10.834	17.000	130.003	0.167	114.836	0.083	2.800
3	Std Soln		STD-B3-3	3	12	20.000	0.050	0.050	0.050	4.130	9.770	84.500	0.100	48.500	0.050	0.050

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

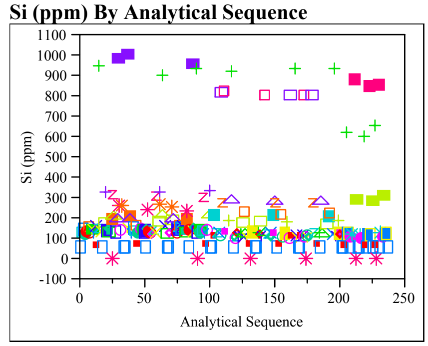
B (ppm) By Analytical Sequence



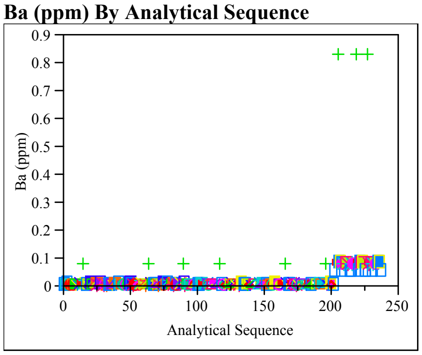
Fe (ppm) By Analytical Sequence



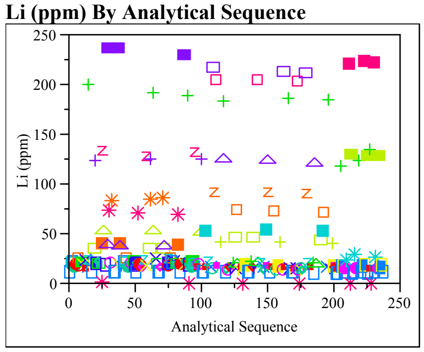
Si (ppm) By Analytical Sequence



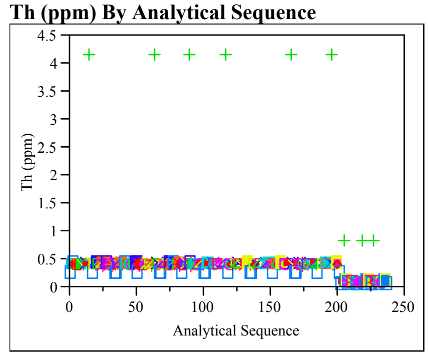
Ba (ppm) By Analytical Sequence



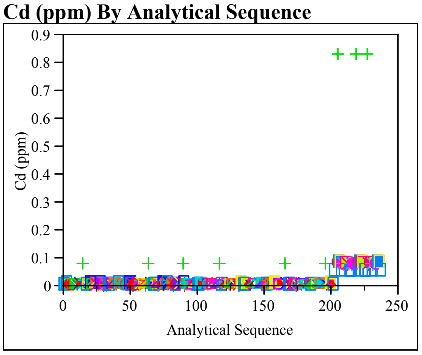
Li (ppm) By Analytical Sequence



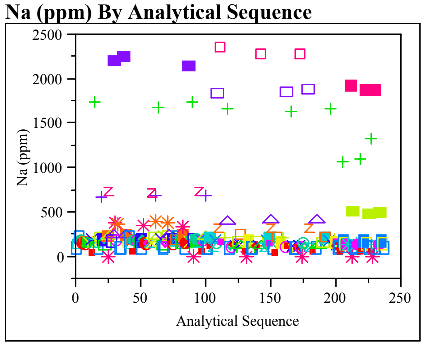
Th (ppm) By Analytical Sequence



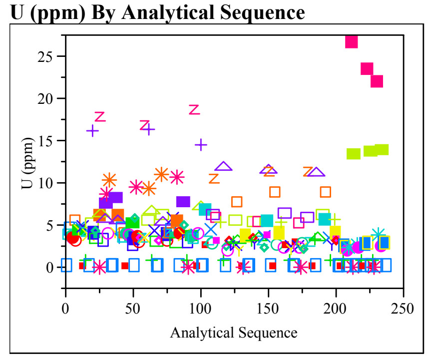
Cd (ppm) By Analytical Sequence



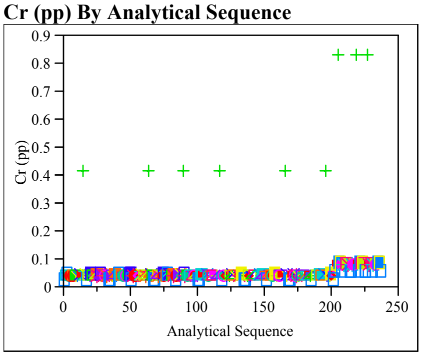
Na (ppm) By Analytical Sequence



U (ppm) By Analytical Sequence



Cr (pp) By Analytical Sequence



Pb (ppm) By Analytical Sequence

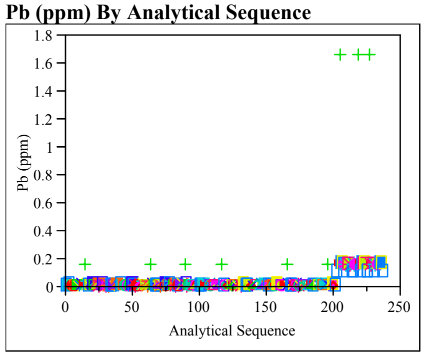
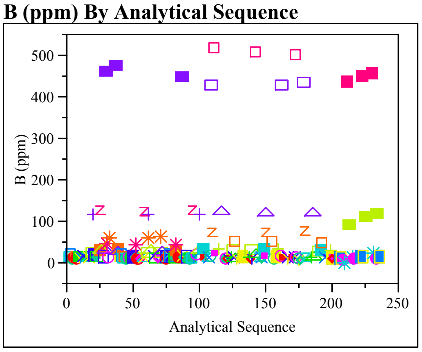
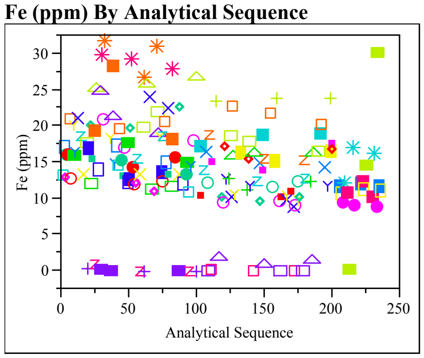


Exhibit D2. Laboratory PCT Measurements in Analytical Sequence for Study Glasses

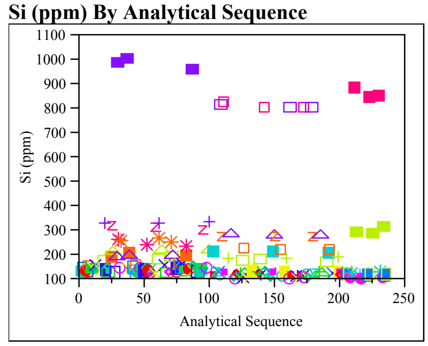
B (ppm) By Analytical Sequence



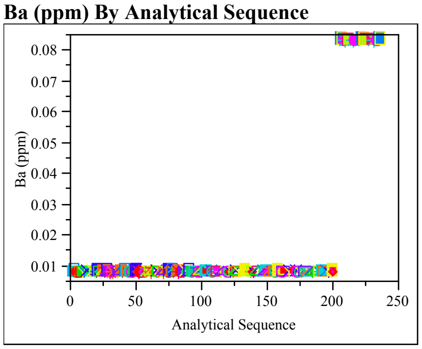
Fe (ppm) By Analytical Sequence



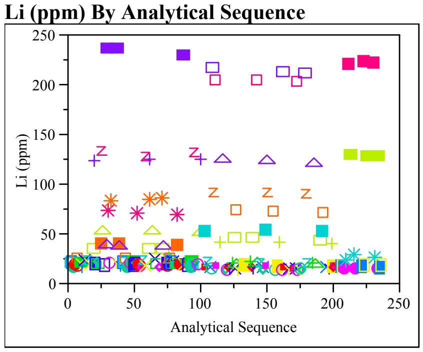
Si (ppm) By Analytical Sequence



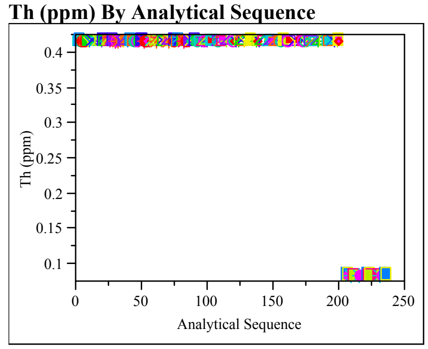
Ba (ppm) By Analytical Sequence



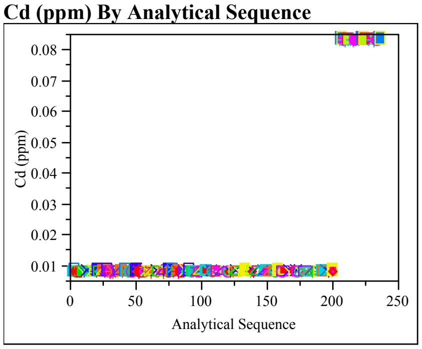
Li (ppm) By Analytical Sequence



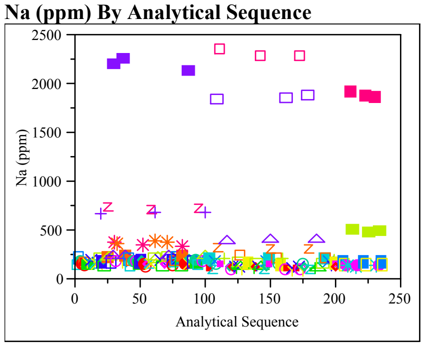
Th (ppm) By Analytical Sequence



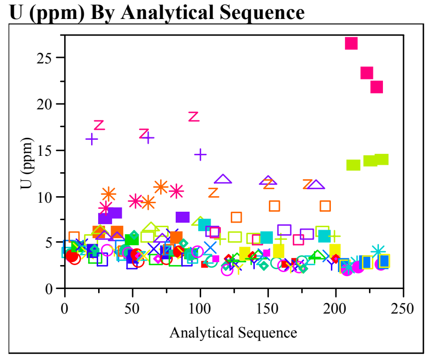
Cd (ppm) By Analytical Sequence



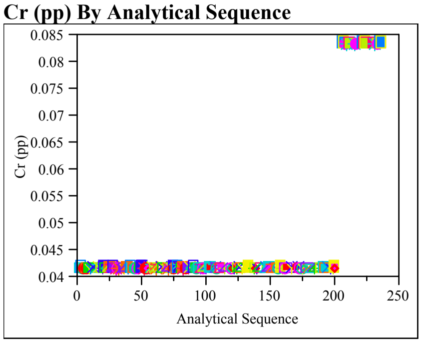
Na (ppm) By Analytical Sequence



U (ppm) By Analytical Sequence



Cr (pp) By Analytical Sequence



Pb (ppm) By Analytical Sequence

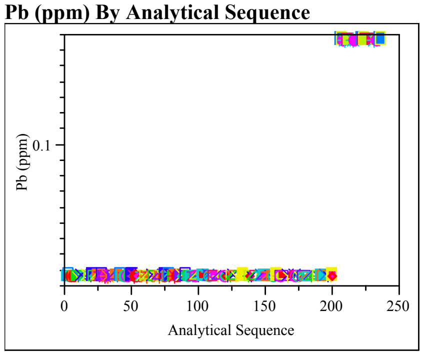
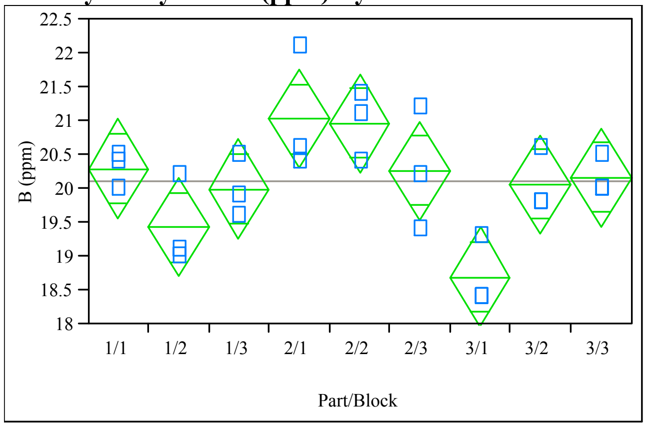


Exhibit D3. Measurements of the Multi-Element Solution Standard by Set and ICP Block

Oneway Analysis of B (ppm) By Part/Block



Oneway Anova

Summary of Fit

Rsquare	0.656193
Adj Rsquare	0.50339
Root Mean Square Error	0.599073
Mean of Response	20.1037
Observations (or Sum Wgts)	27

Analysis of Variance

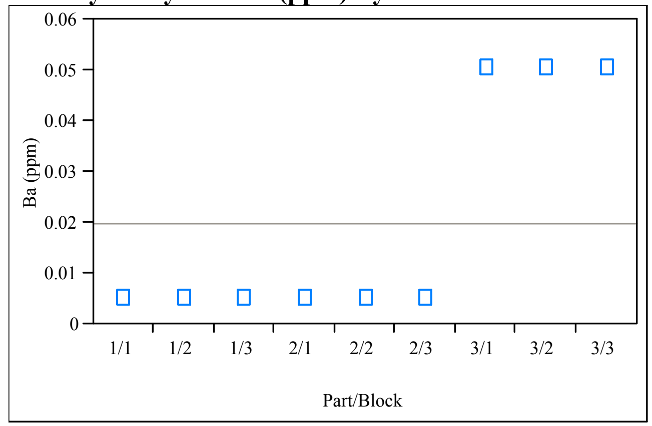
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Part/Block	8	12.329630	1.54120	4.2944	0.0049
Error	18	6.460000	0.35889		
C. Total	26	18.789630			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1/1	3	20.3000	0.34588	19.573	21.027
1/2	3	19.4333	0.34588	18.707	20.160
1/3	3	20.0000	0.34588	19.273	20.727
2/1	3	21.0333	0.34588	20.307	21.760
2/2	3	20.9667	0.34588	20.240	21.693
2/3	3	20.2667	0.34588	19.540	20.993
3/1	3	18.7000	0.34588	17.973	19.427
3/2	3	20.0667	0.34588	19.340	20.793
3/3	3	20.1667	0.34588	19.440	20.893

Std Error uses a pooled estimate of error variance

Oneway Analysis of Ba (ppm) By Part/Block



Oneway Anova

Summary of Fit

Rsquare	1
Adj Rsquare	1
Root Mean Square Error	.
Mean of Response	0.02
Observations (or Sum Wgts)	27

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Part/Block	8	0.0121500	0.00152	-3.94e15	-1.0000
Error	18	-6.939e-18	-3.9e-19		
C. Total	26	0.0121500			

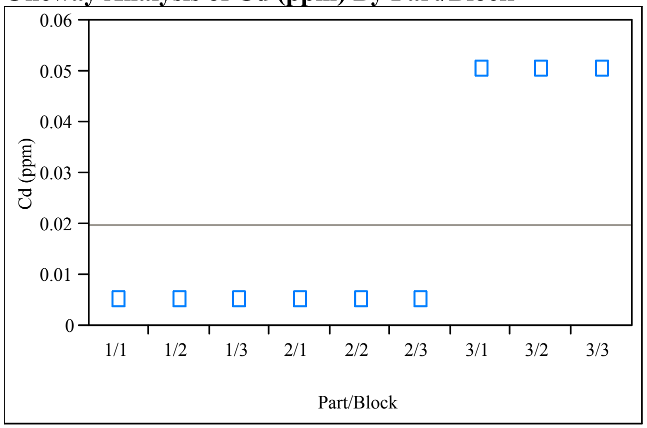
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1/1	3	0.005000	.	.	.
1/2	3	0.005000	.	.	.
1/3	3	0.005000	.	.	.
2/1	3	0.005000	.	.	.
2/2	3	0.005000	.	.	.
2/3	3	0.005000	.	.	.
3/1	3	0.050000	.	.	.
3/2	3	0.050000	.	.	.
3/3	3	0.050000	.	.	.

Std Error uses a pooled estimate of error variance

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

Oneway Analysis of Cd (ppm) By Part/Block



Oneway Anova

Summary of Fit

Rsquare	1
Adj Rsquare	1
Root Mean Square Error	.
Mean of Response	0.02
Observations (or Sum Wgts)	27

Analysis of Variance

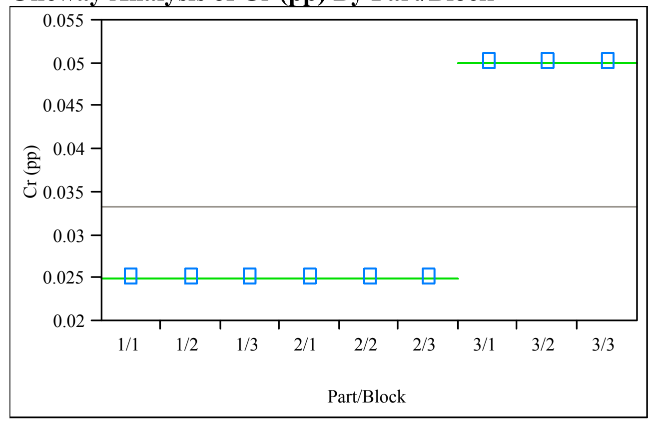
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Part/Block	8	0.0121500	0.00152	-3.94e15	-1.0000
Error	18	-6.939e-18	-3.9e-19		
C. Total	26	0.0121500			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1/1	3	0.005000	.	.	.
1/2	3	0.005000	.	.	.
1/3	3	0.005000	.	.	.
2/1	3	0.005000	.	.	.
2/2	3	0.005000	.	.	.
2/3	3	0.005000	.	.	.
3/1	3	0.050000	.	.	.
3/2	3	0.050000	.	.	.
3/3	3	0.050000	.	.	.

Std Error uses a pooled estimate of error variance

Oneway Analysis of Cr (pp) By Part/Block



Oneway Anova

Summary of Fit

Rsquare	1
Adj Rsquare	1
Root Mean Square Error	0
Mean of Response	0.033333
Observations (or Sum Wgts)	27

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Part/Block	8	0.00375000	0.000469	.	.
Error	18	0.00000000	0.000000		
C. Total	26	0.00375000			

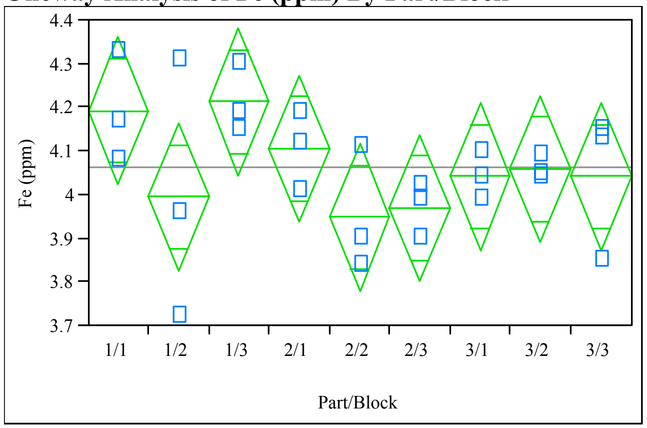
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1/1	3	0.025000	0	0.02500	0.02500
1/2	3	0.025000	0	0.02500	0.02500
1/3	3	0.025000	0	0.02500	0.02500
2/1	3	0.025000	0	0.02500	0.02500
2/2	3	0.025000	0	0.02500	0.02500
2/3	3	0.025000	0	0.02500	0.02500
3/1	3	0.050000	0	0.05000	0.05000
3/2	3	0.050000	0	0.05000	0.05000
3/3	3	0.050000	0	0.05000	0.05000

Std Error uses a pooled estimate of error variance

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

Oneway Analysis of Fe (ppm) By Part/Block



Oneway Anova

Summary of Fit

Rsquare	0.369585
Adj Rsquare	0.089401
Root Mean Square Error	0.139124
Mean of Response	4.064074
Observations (or Sum Wgts)	27

Analysis of Variance

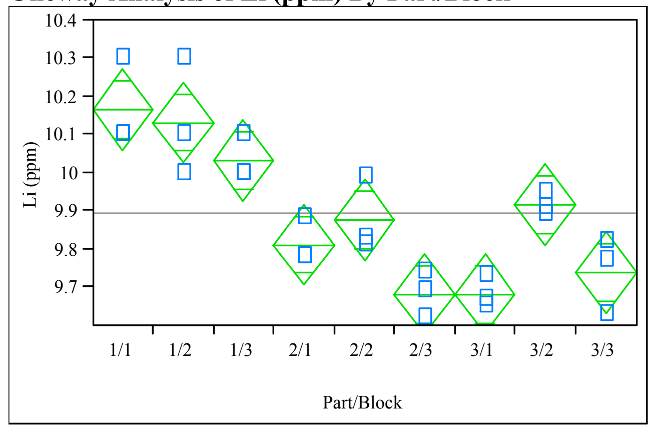
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Part/Block	8	0.20425185	0.025531	1.3191	0.2957
Error	18	0.34840000	0.019356		
C. Total	26	0.55265185			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1/1	3	4.19333	0.08032	4.0246	4.3621
1/2	3	3.99667	0.08032	3.8279	4.1654
1/3	3	4.21333	0.08032	4.0446	4.3821
2/1	3	4.10667	0.08032	3.9379	4.2754
2/2	3	3.95000	0.08032	3.7812	4.1188
2/3	3	3.97000	0.08032	3.8012	4.1388
3/1	3	4.04333	0.08032	3.8746	4.2121
3/2	3	4.06000	0.08032	3.8912	4.2288
3/3	3	4.04333	0.08032	3.8746	4.2121

Std Error uses a pooled estimate of error variance

Oneway Analysis of Li (ppm) By Part/Block



Oneway Anova

Summary of Fit

Rsquare	0.854696
Adj Rsquare	0.790117
Root Mean Square Error	0.087602
Mean of Response	9.894074
Observations (or Sum Wgts)	27

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Part/Block	8	0.81251852	0.101565	13.2348	<.0001
Error	18	0.13813333	0.007674		
C. Total	26	0.95065185			

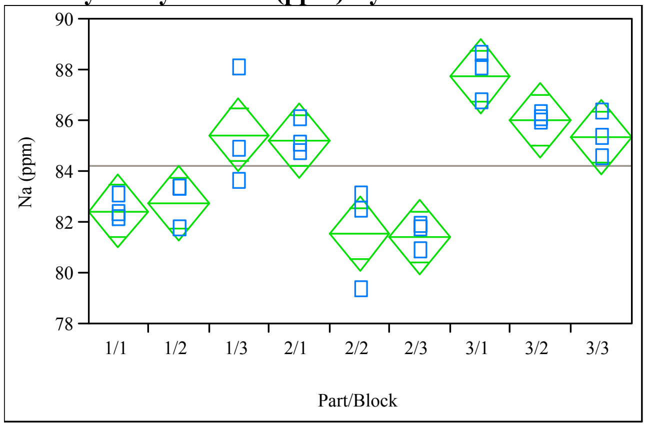
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1/1	3	10.1667	0.05058	10.060	10.273
1/2	3	10.1333	0.05058	10.027	10.240
1/3	3	10.0333	0.05058	9.927	10.140
2/1	3	9.8133	0.05058	9.707	9.920
2/2	3	9.8767	0.05058	9.770	9.983
2/3	3	9.6833	0.05058	9.577	9.790
3/1	3	9.6833	0.05058	9.577	9.790
3/2	3	9.9167	0.05058	9.810	10.023
3/3	3	9.7400	0.05058	9.634	9.846

Std Error uses a pooled estimate of error variance

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

Oneway Analysis of Na (ppm) By Part/Block



Oneway Anova

Summary of Fit

Rsquare	0.82396
Adj Rsquare	0.74572
Root Mean Square Error	1.189771
Mean of Response	84.23333
Observations (or Sum Wgts)	27

Analysis of Variance

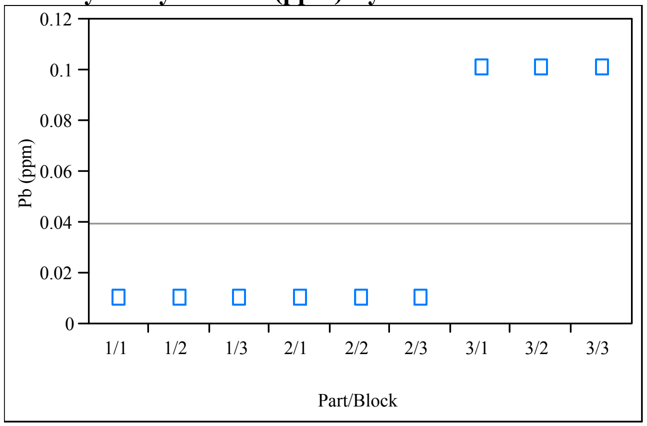
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Part/Block	8	119.26000	14.9075	10.5312	<.0001
Error	18	25.48000	1.4156		
C. Total	26	144.74000			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1/1	3	82.4667	0.68691	81.024	83.910
1/2	3	82.7667	0.68691	81.324	84.210
1/3	3	85.4667	0.68691	84.024	86.910
2/1	3	85.2333	0.68691	83.790	86.676
2/2	3	81.5667	0.68691	80.124	83.010
2/3	3	81.4333	0.68691	79.990	82.876
3/1	3	87.7667	0.68691	86.324	89.210
3/2	3	86.0333	0.68691	84.590	87.476
3/3	3	85.3667	0.68691	83.924	86.810

Std Error uses a pooled estimate of error variance

Oneway Analysis of Pb (ppm) By Part/Block



Oneway Anova

Summary of Fit

Rsquare	1
Adj Rsquare	1
Root Mean Square Error	.
Mean of Response	0.04
Observations (or Sum Wgts)	27

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Part/Block	8	0.0486000	0.00608	-3.94e15	-1.0000
Error	18	-2.776e-17	-1.5e-18		
C. Total	26	0.0486000			

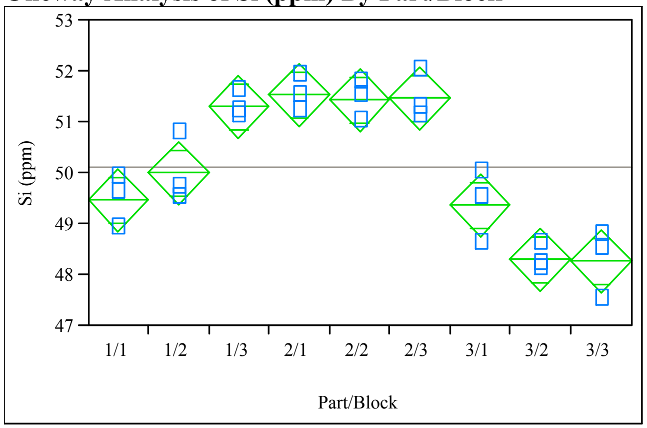
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1/1	3	0.010000	.	.	.
1/2	3	0.010000	.	.	.
1/3	3	0.010000	.	.	.
2/1	3	0.010000	.	.	.
2/2	3	0.010000	.	.	.
2/3	3	0.010000	.	.	.
3/1	3	0.100000	.	.	.
3/2	3	0.100000	.	.	.
3/3	3	0.100000	.	.	.

Std Error uses a pooled estimate of error variance

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

Oneway Analysis of Si (ppm) By Part/Block



Oneway Anova

Summary of Fit

Rsquare	0.902853
Adj Rsquare	0.859676
Root Mean Square Error	0.51316
Mean of Response	50.12593
Observations (or Sum Wgts)	27

Analysis of Variance

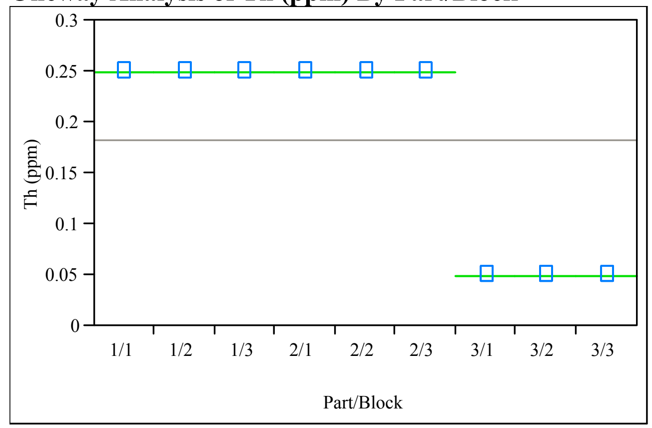
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Part/Block	8	44.051852	5.50648	20.9107	<.0001
Error	18	4.740000	0.26333		
C. Total	26	48.791852			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1/1	3	49.4667	0.29627	48.844	50.089
1/2	3	50.0000	0.29627	49.378	50.622
1/3	3	51.3000	0.29627	50.678	51.922
2/1	3	51.5333	0.29627	50.911	52.156
2/2	3	51.4333	0.29627	50.811	52.056
2/3	3	51.4667	0.29627	50.844	52.089
3/1	3	49.3667	0.29627	48.744	49.989
3/2	3	48.3000	0.29627	47.678	48.922
3/3	3	48.2667	0.29627	47.644	48.889

Std Error uses a pooled estimate of error variance

Oneway Analysis of Th (ppm) By Part/Block



Oneway Anova

Summary of Fit

Rsquare	1
Adj Rsquare	1
Root Mean Square Error	0
Mean of Response	0.183333
Observations (or Sum Wgts)	27

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Part/Block	8	0.24000000	0.030000	.	.
Error	18	0.00000000	0.000000		
C. Total	26	0.24000000			

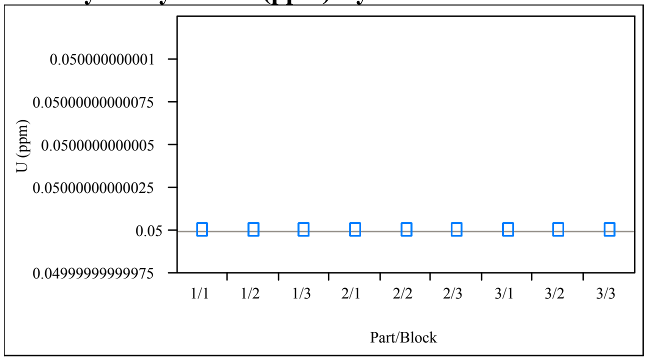
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1/1	3	0.250000	0	0.25000	0.25000
1/2	3	0.250000	0	0.25000	0.25000
1/3	3	0.250000	0	0.25000	0.25000
2/1	3	0.250000	0	0.25000	0.25000
2/2	3	0.250000	0	0.25000	0.25000
2/3	3	0.250000	0	0.25000	0.25000
3/1	3	0.050000	0	0.05000	0.05000
3/2	3	0.050000	0	0.05000	0.05000
3/3	3	0.050000	0	0.05000	0.05000

Std Error uses a pooled estimate of error variance

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

Oneway Analysis of U (ppm) By Part/Block



Oneway Anova

Summary of Fit

Rsquare	.
Adj Rsquare	.
Root Mean Square Error	.
Mean of Response	0.05
Observations (or Sum Wgts)	27

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Part/Block	8	1.3e-33	1.625e-34	-2.2500	-1.0000
Error	18	-1.3e-33	-7.22e-35		
C. Total	26	0			

Means for Oneway Anova

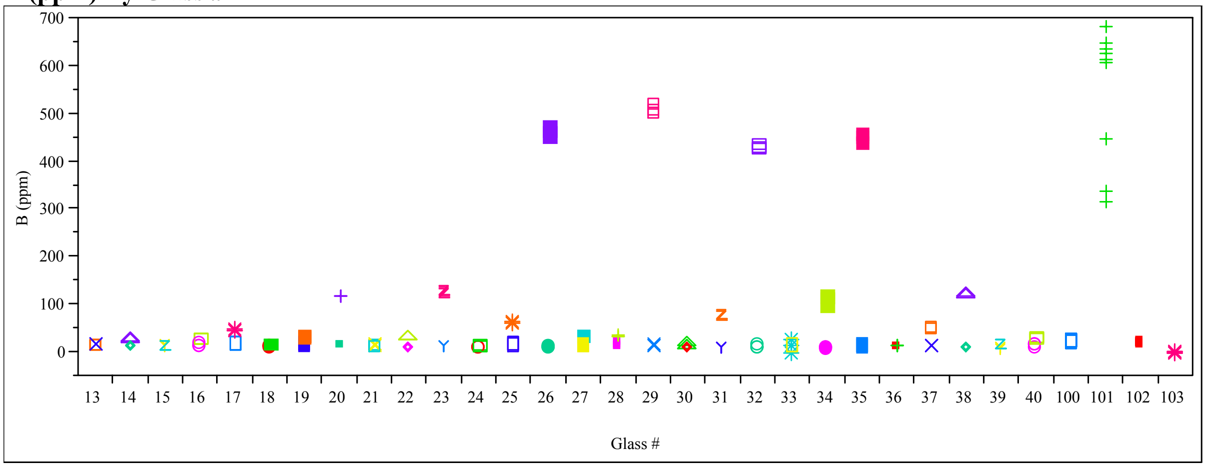
Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1/1	3	0.050000	.	.	.
1/2	3	0.050000	.	.	.
1/3	3	0.050000	.	.	.
2/1	3	0.050000	.	.	.
2/2	3	0.050000	.	.	.
2/3	3	0.050000	.	.	.
3/1	3	0.050000	.	.	.
3/2	3	0.050000	.	.	.
3/3	3	0.050000	.	.	.

Std Error uses a pooled estimate of error variance

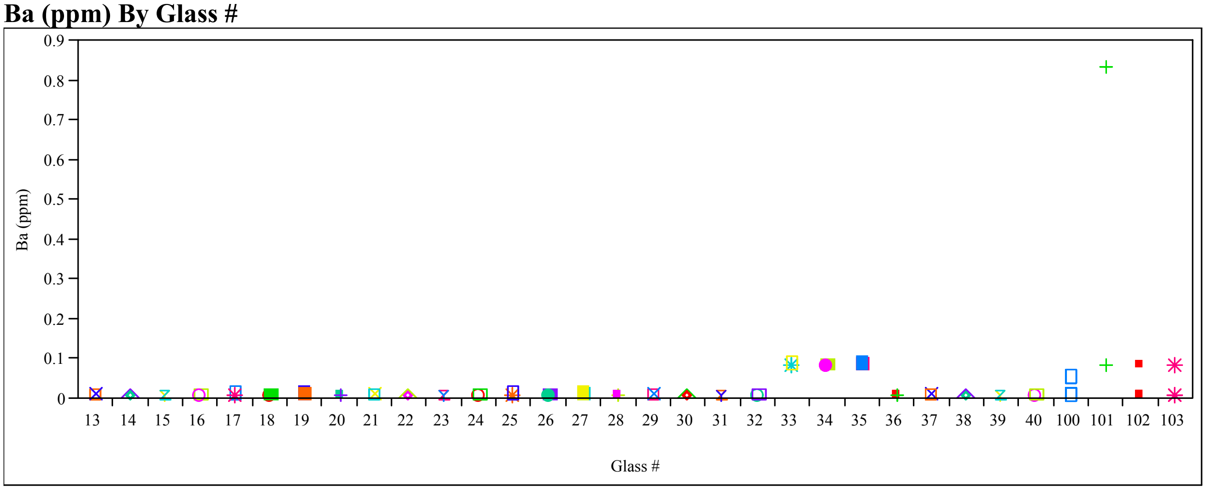
Exhibit D4. Laboratory PCT Measurements by Glass Number for Study Glasses and Standards

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

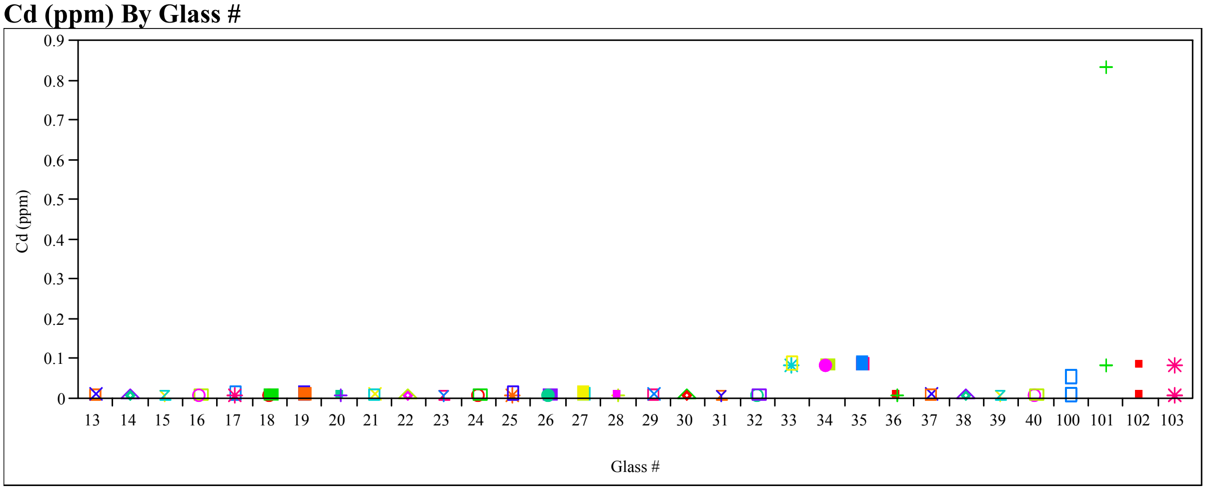
B (ppm) By Glass #



Ba (ppm) By Glass #



Cd (ppm) By Glass #

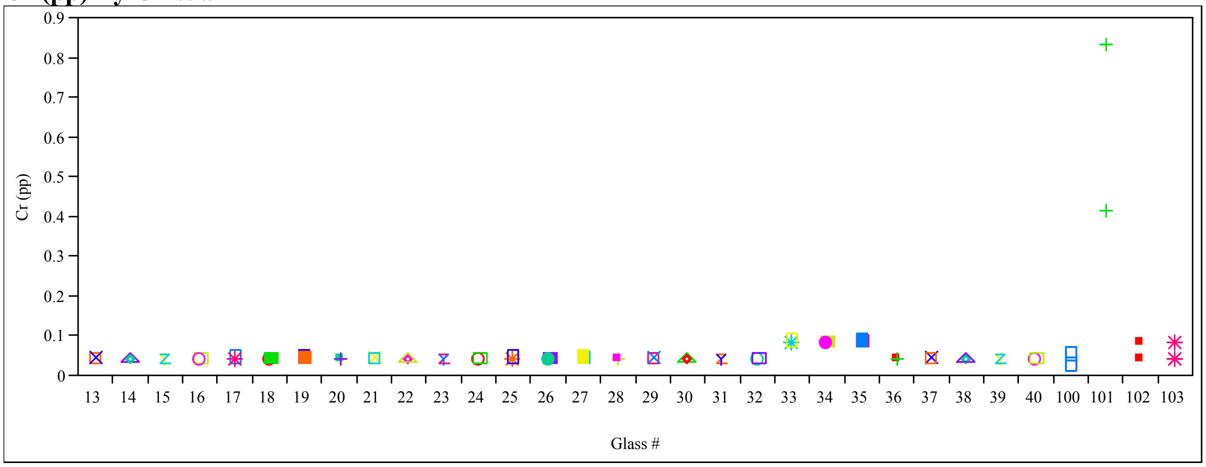


Excluded Rows 18

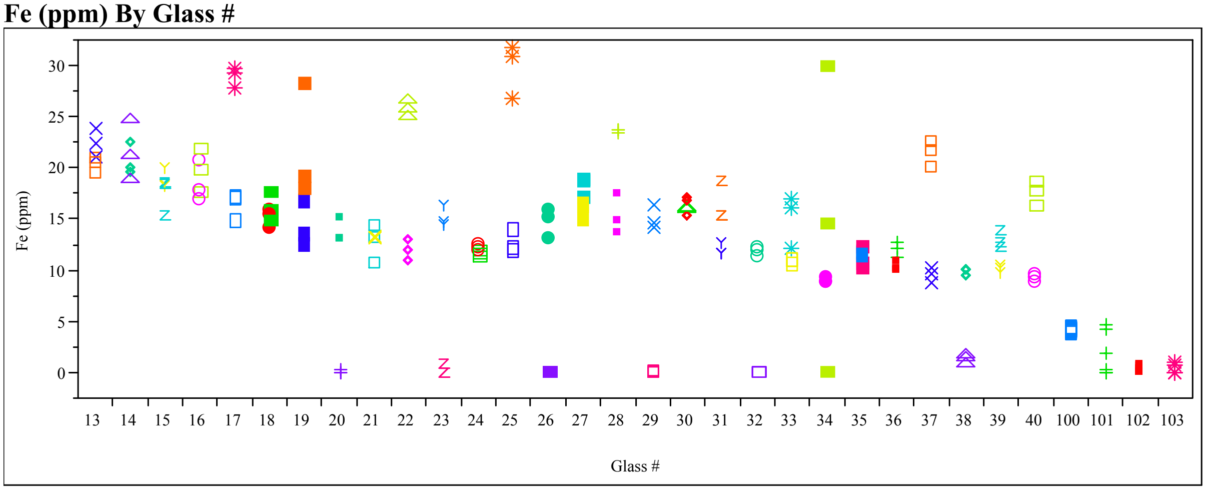
Exhibit D4. Laboratory PCT Measurements by Glass Number for Study Glasses and Standards

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

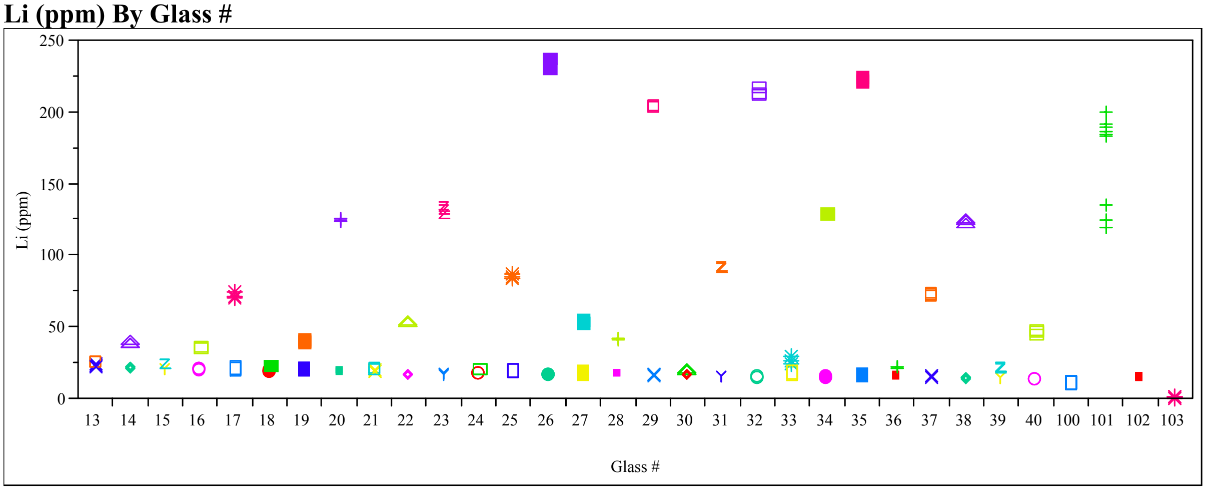
Cr (pp) By Glass



Fe (ppm) By Glass



Li (ppm) By Glass

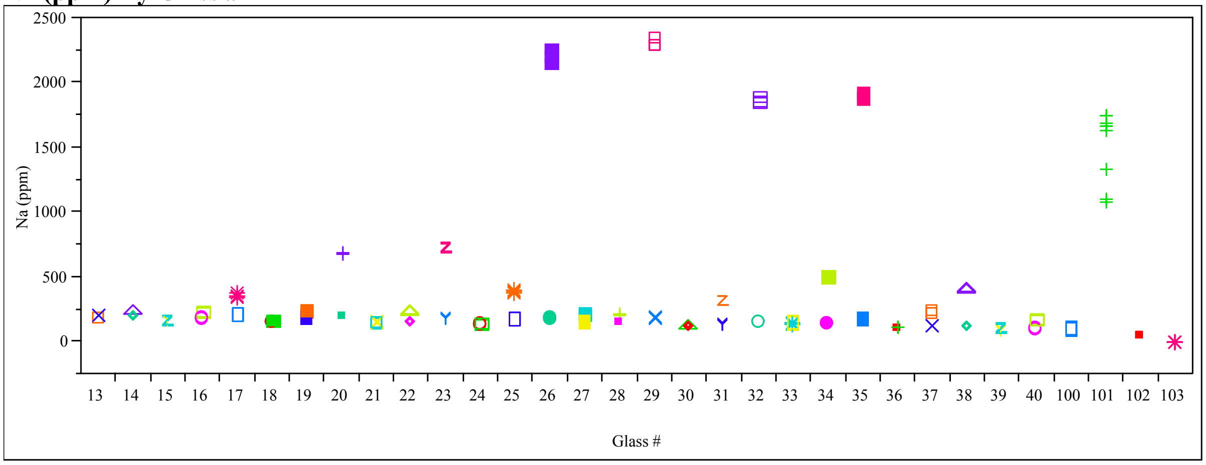


Excluded Rows 18

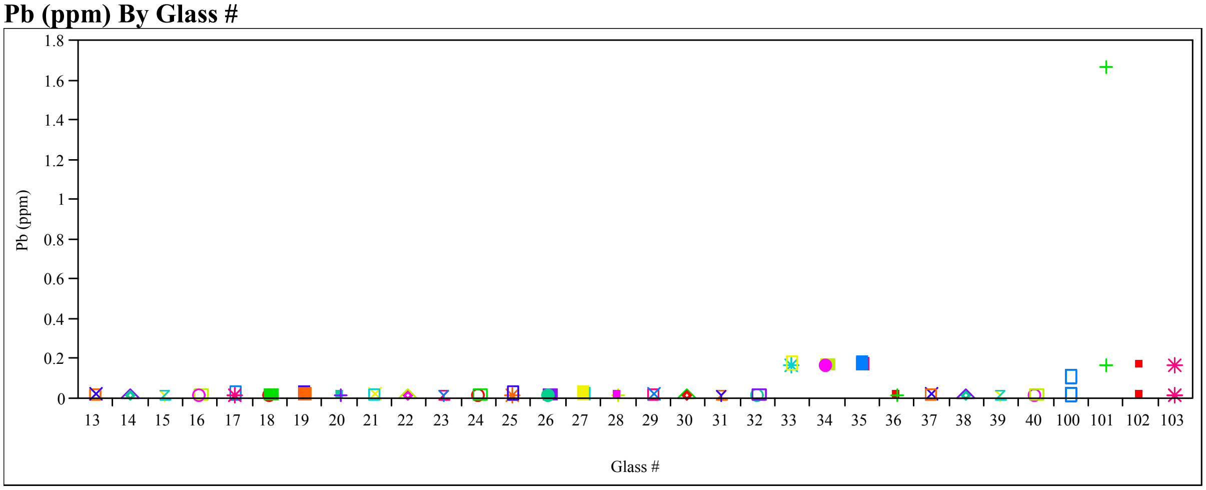
Exhibit D4. Laboratory PCT Measurements by Glass Number for Study Glasses and Standards

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

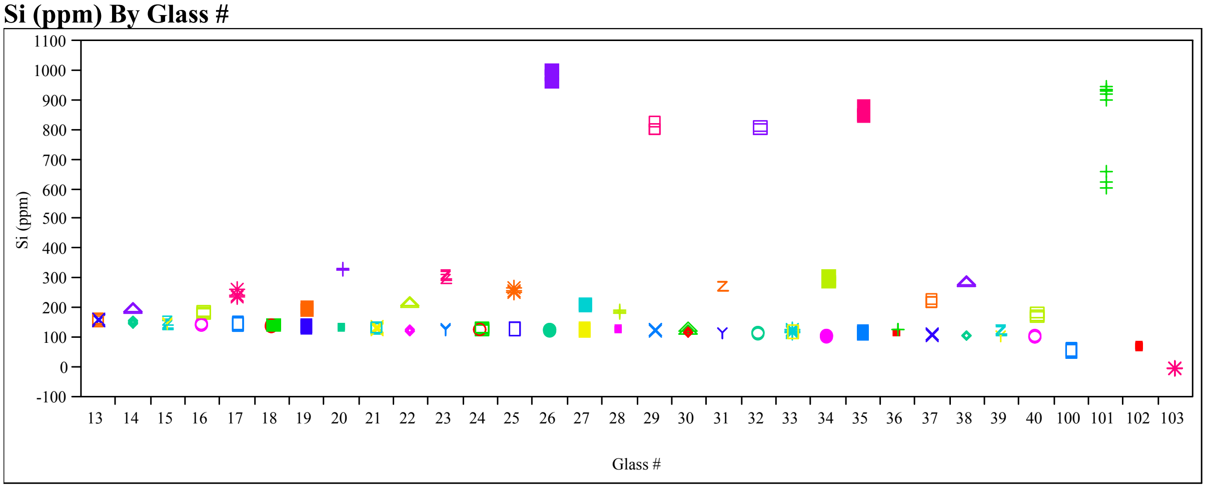
Na (ppm) By Glass #



Pb (ppm) By Glass #



Si (ppm) By Glass #

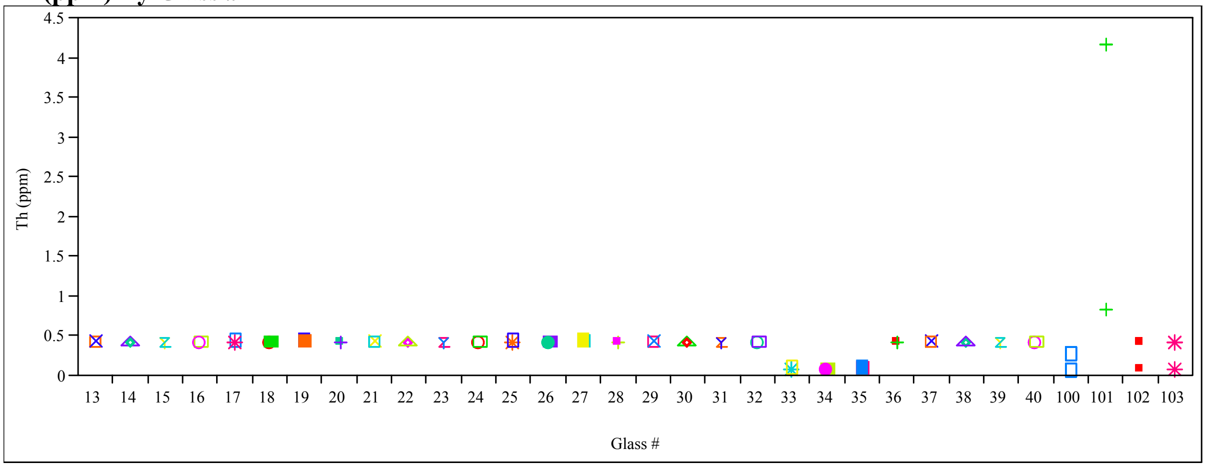


Excluded Rows 18

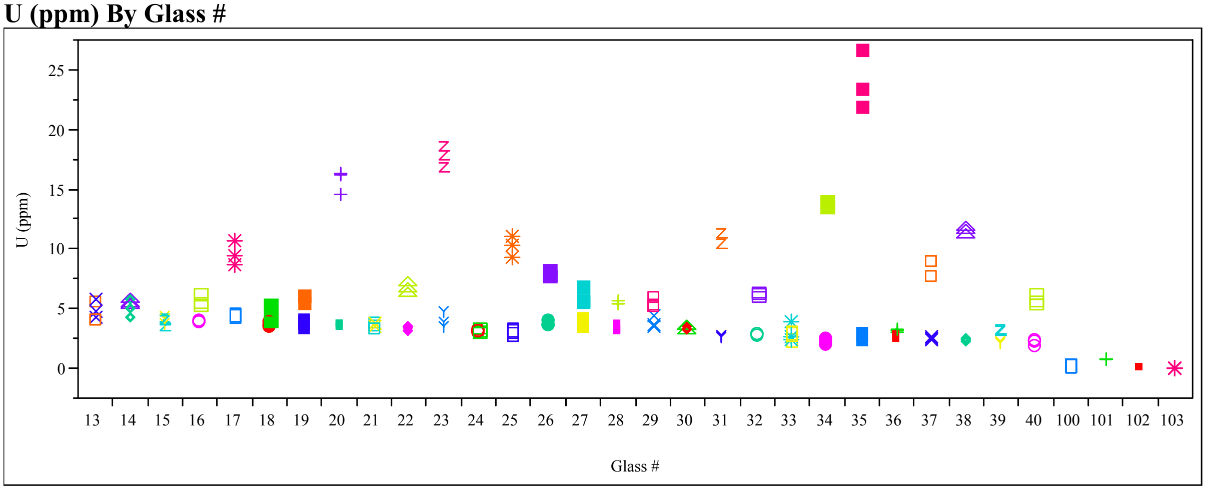
Exhibit D4. Laboratory PCT Measurements by Glass Number for Study Glasses and Standards

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

Th (ppm) By Glass #



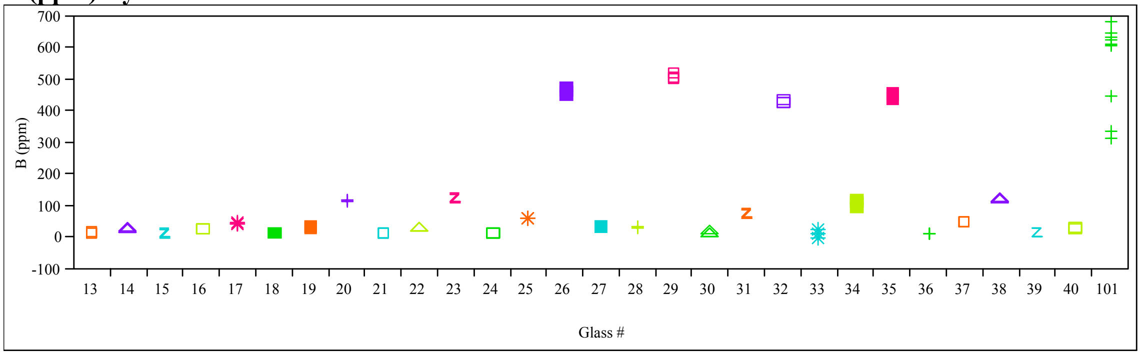
U (ppm) By Glass #



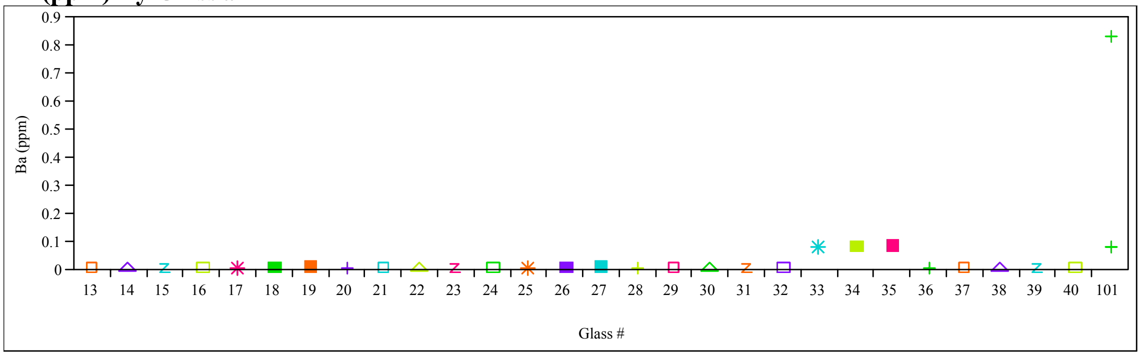
Excluded Rows 18

Exhibit D5. Laboratory PCT Measurements by Glass Number for ccc Study Glasses and EA (101)

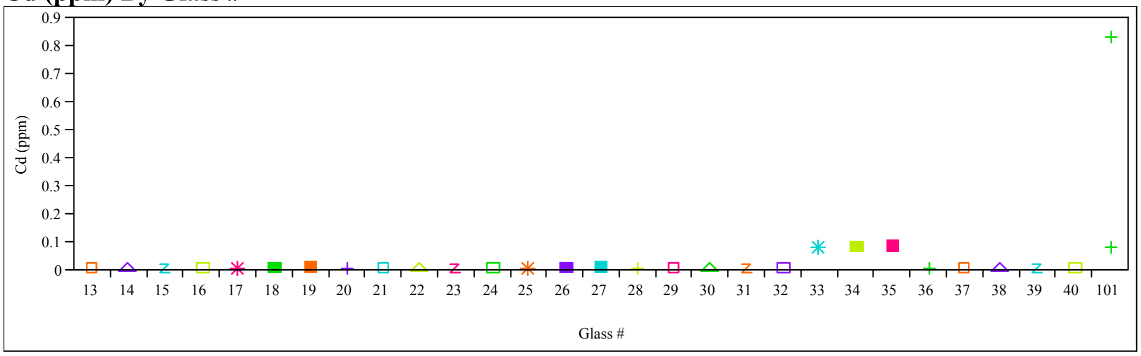
B (ppm) By Glass #



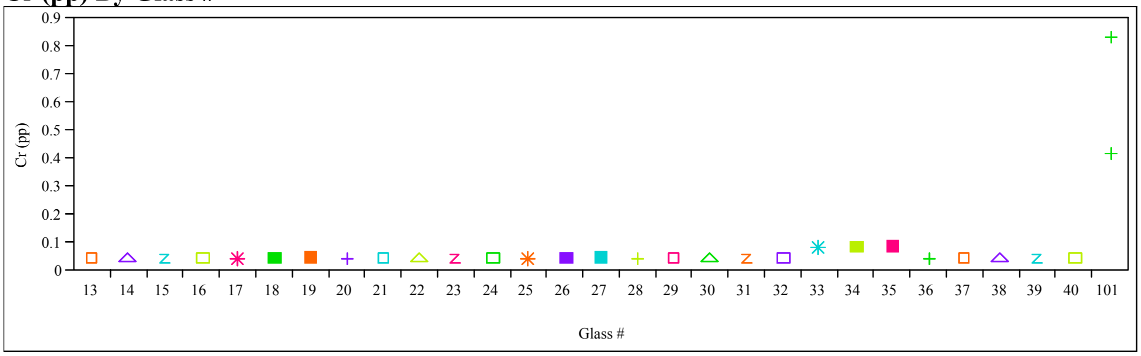
Ba (ppm) By Glass #



Cd (ppm) By Glass #



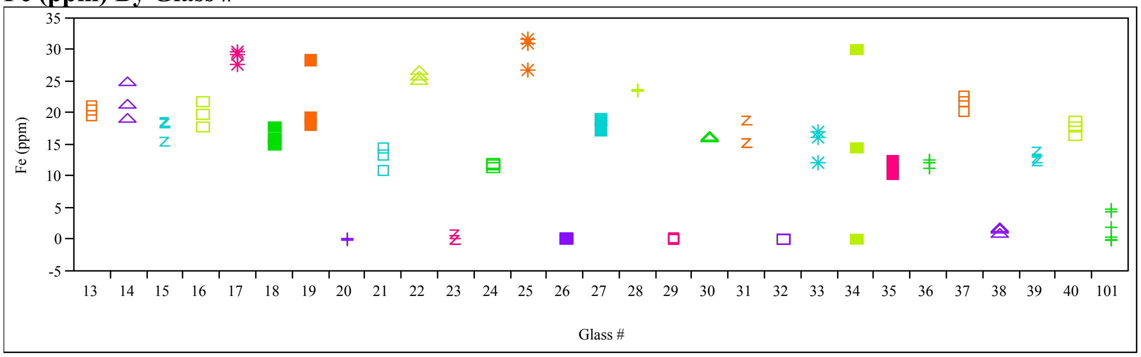
Cr (pp) By Glass #



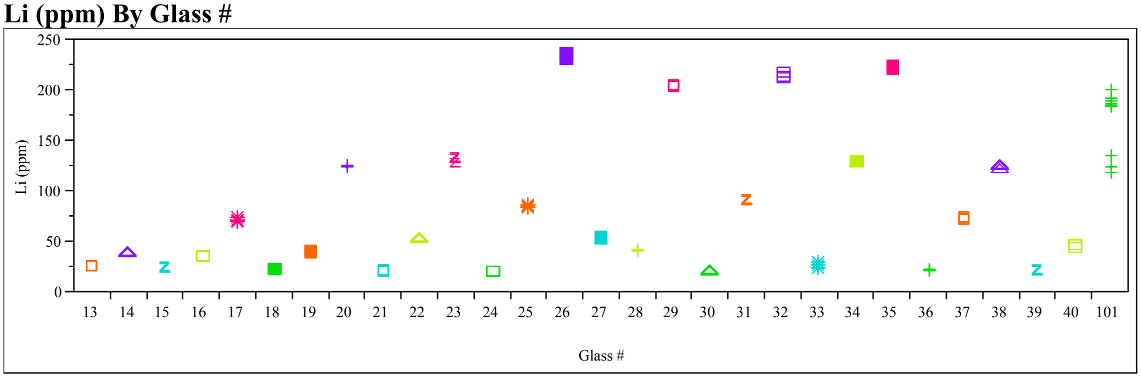
Excluded Rows 9

Exhibit D5. Laboratory PCT Measurements by Glass Number for ccc Study Glasses and EA (101)

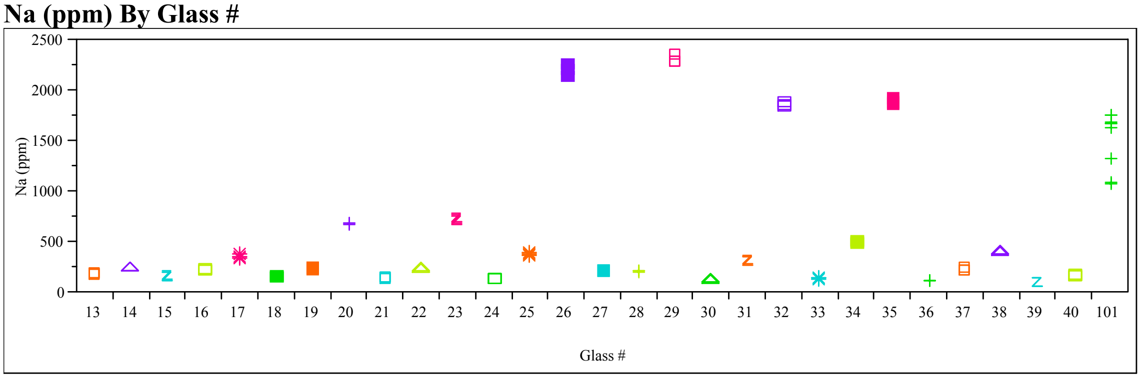
Fe (ppm) By Glass



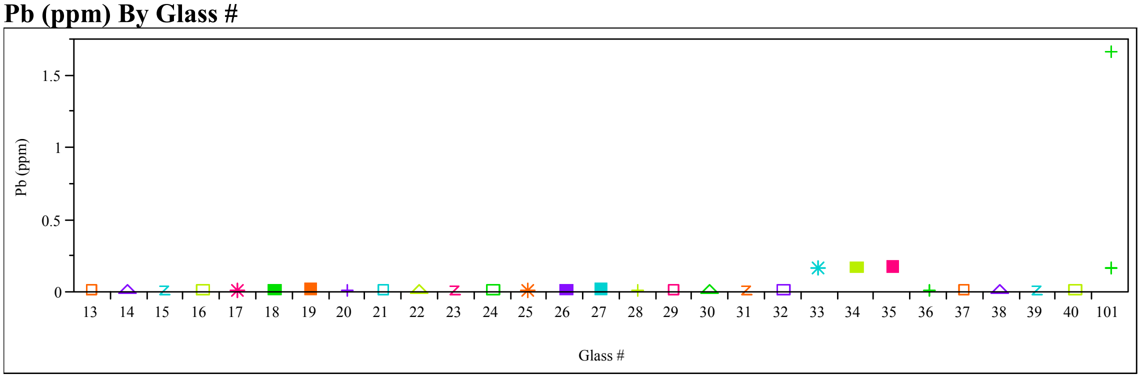
Li (ppm) By Glass



Na (ppm) By Glass



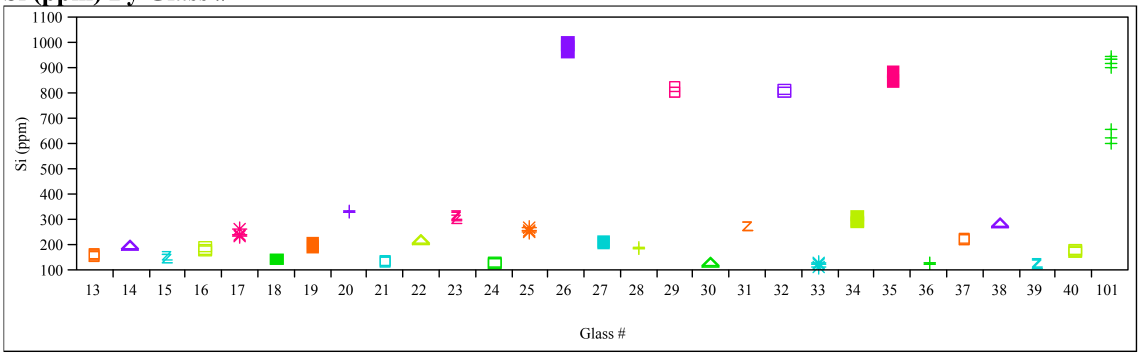
Pb (ppm) By Glass



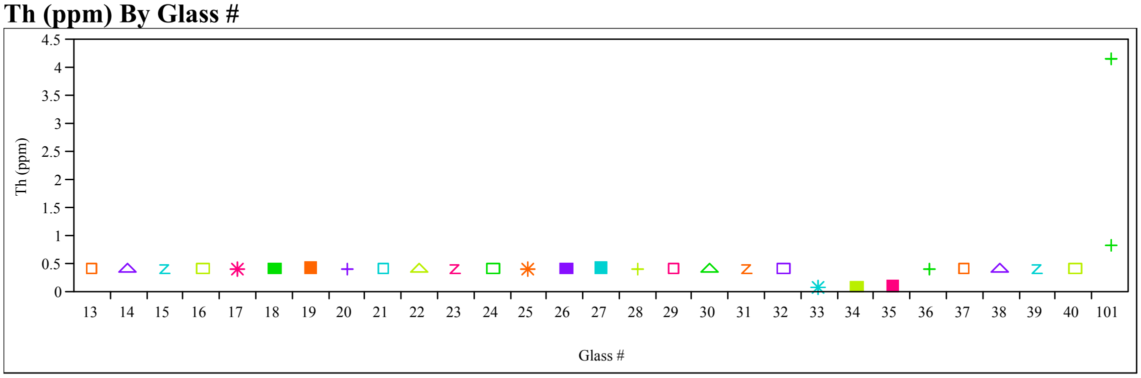
Excluded Rows 9

Exhibit D5. Laboratory PCT Measurements by Glass Number for ccc Study Glasses and EA (101)

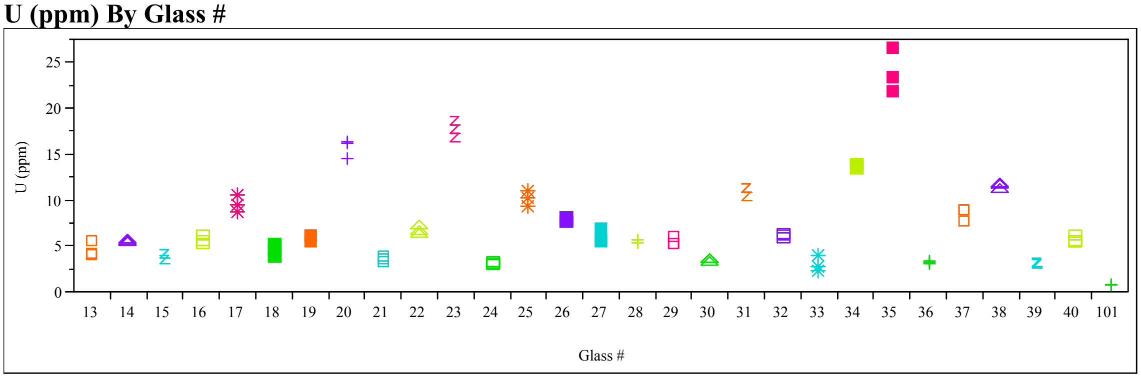
Si (ppm) By Glass



Th (ppm) By Glass



U (ppm) By Glass



Excluded Rows 9

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

Multivariate 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	0.9806	0.9694	0.9778
log NL[Li (g/L)]	0.9806	1.0000	0.9348	0.9522
log NL[Na (g/L)]	0.9694	0.9348	1.0000	0.9871
log NL[Si (g/L)]	0.9778	0.9522	0.9871	1.0000

Scatterplot Matrix

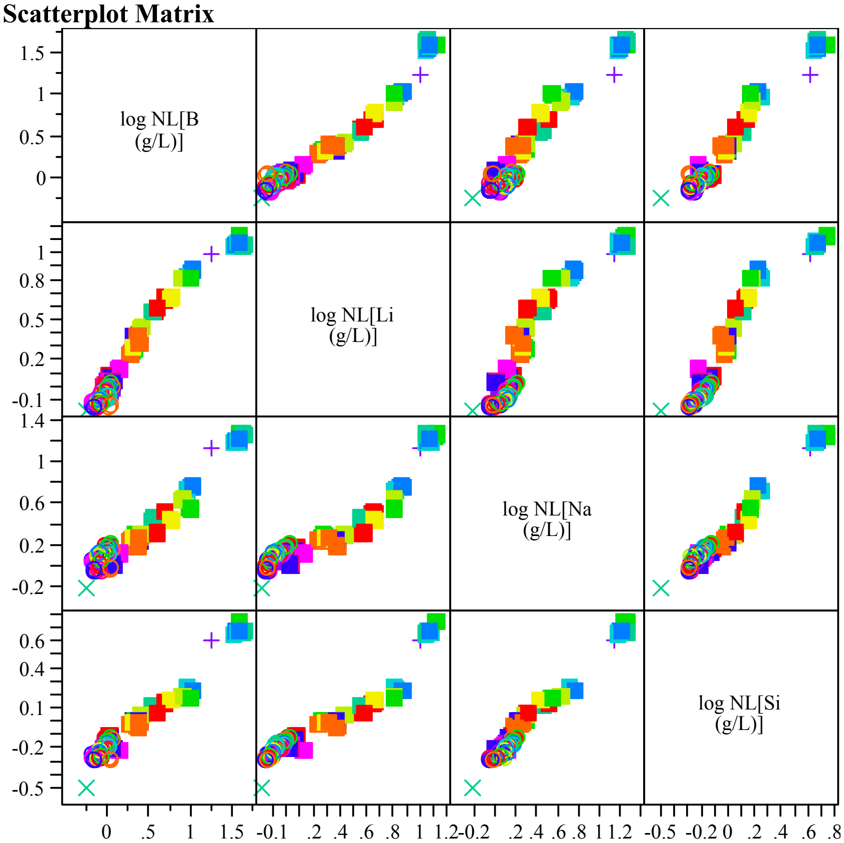
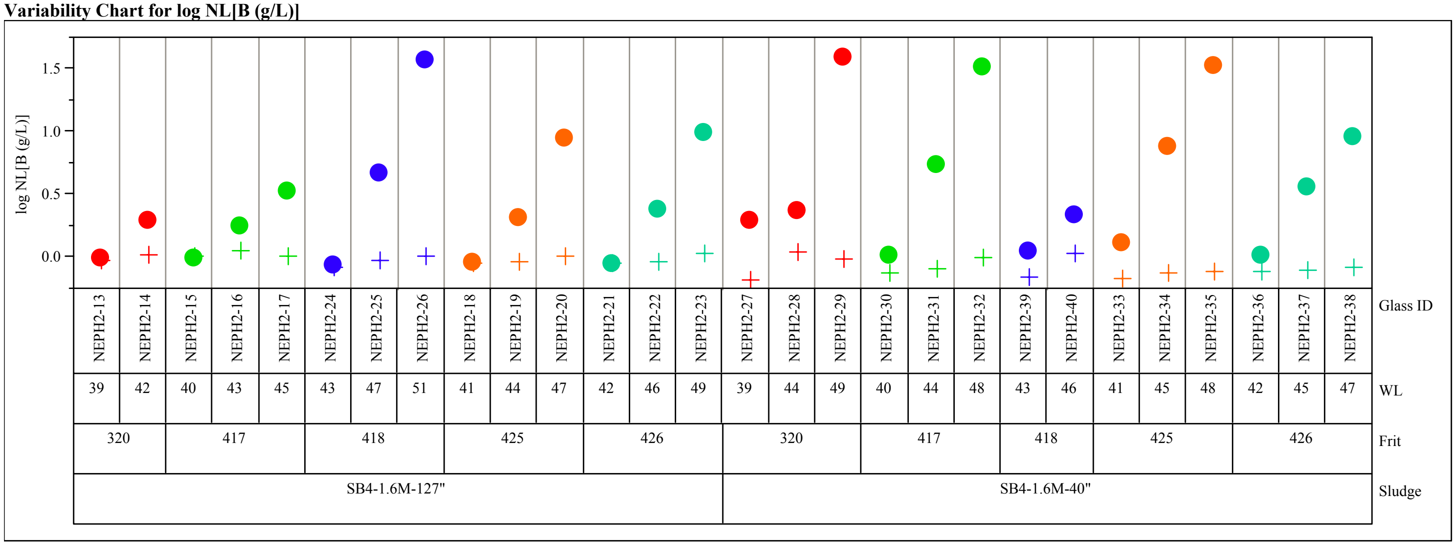


Exhibit D7. Effects of Heat Treatment for Study Glasses Using Targeted Compositions

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



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

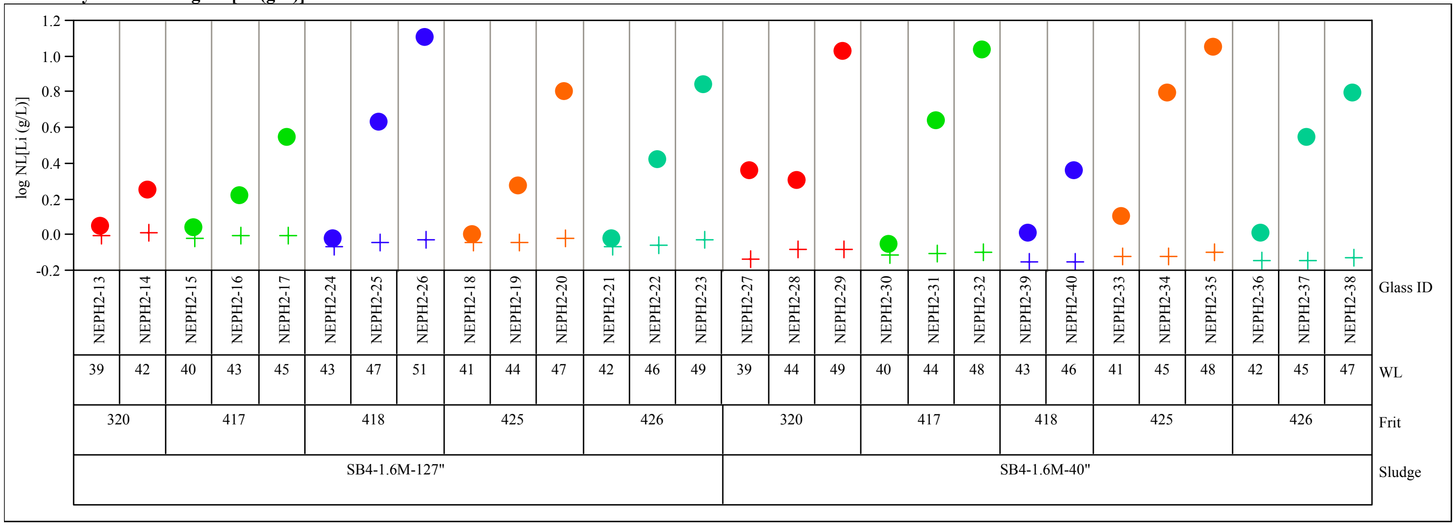
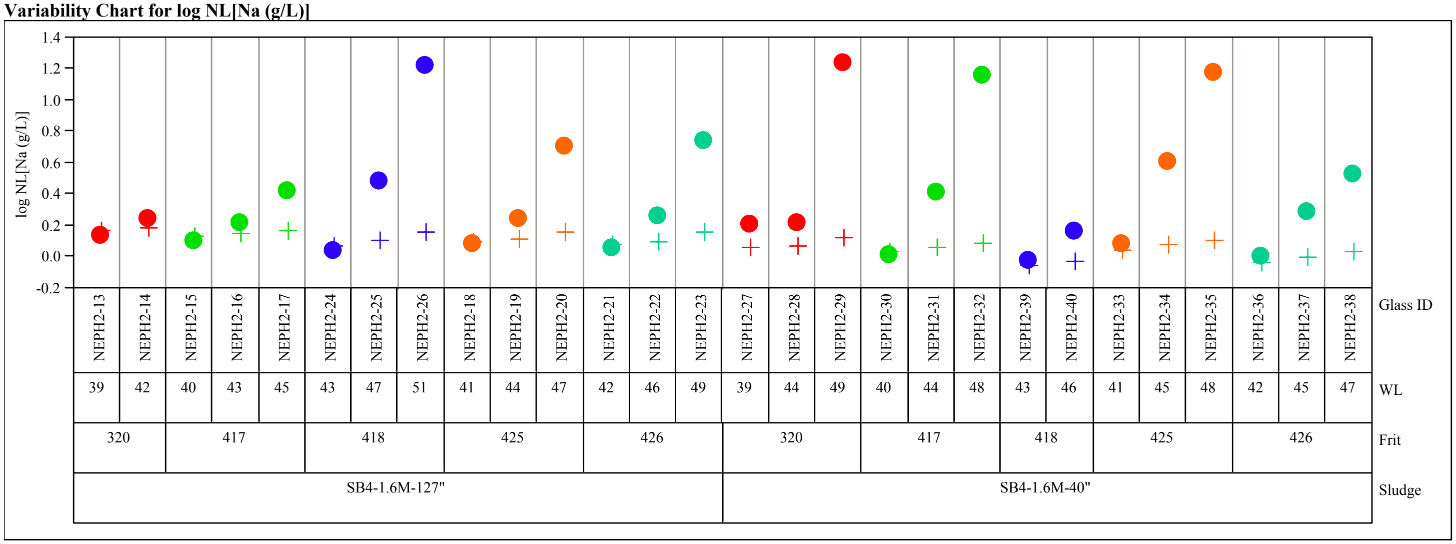


Exhibit D7. Effects of Heat Treatment for Study Glasses Using Targeted Compositions

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



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

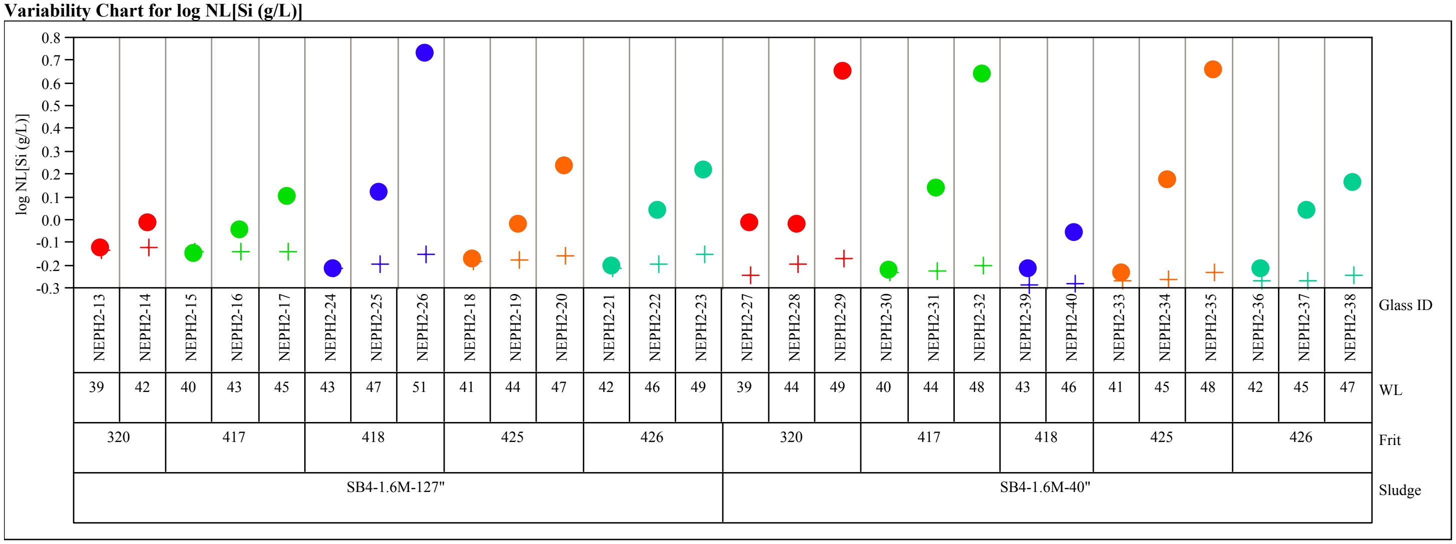
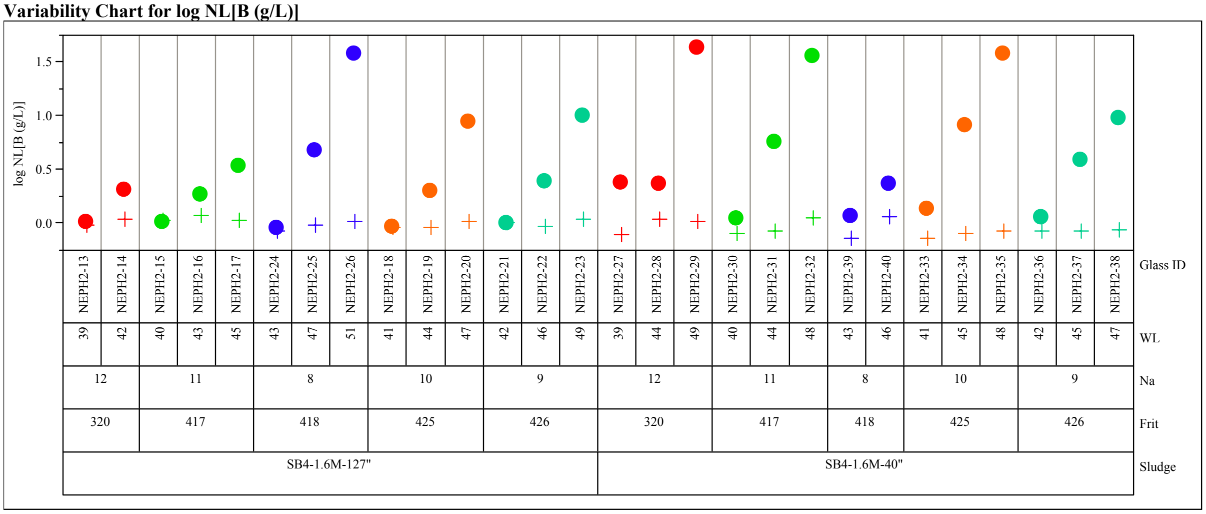
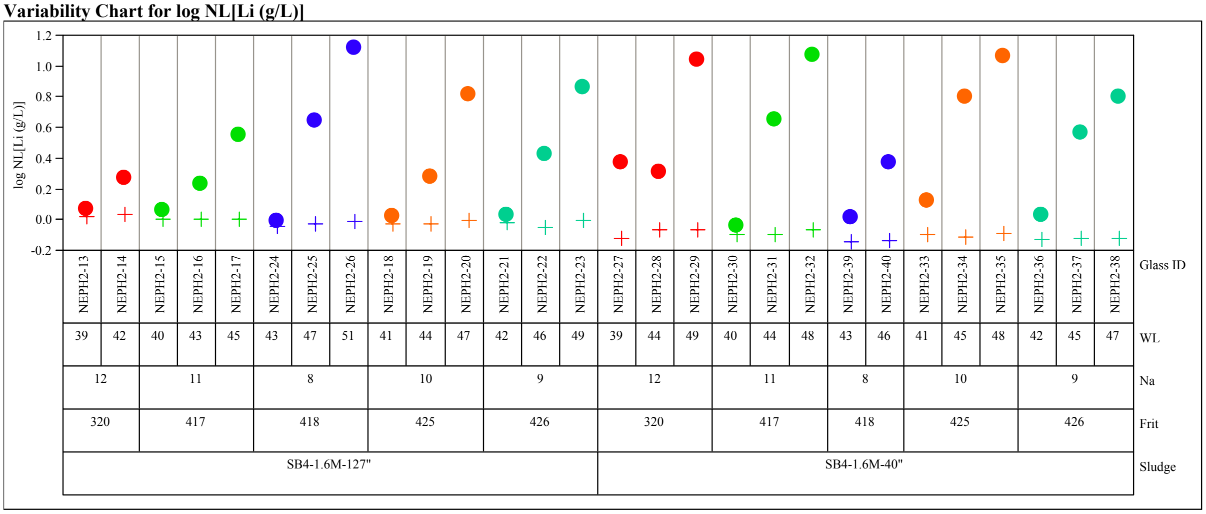


Exhibit D8. Effects of Heat Treatment for Study Glasses Using Measured Compositions

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



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



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

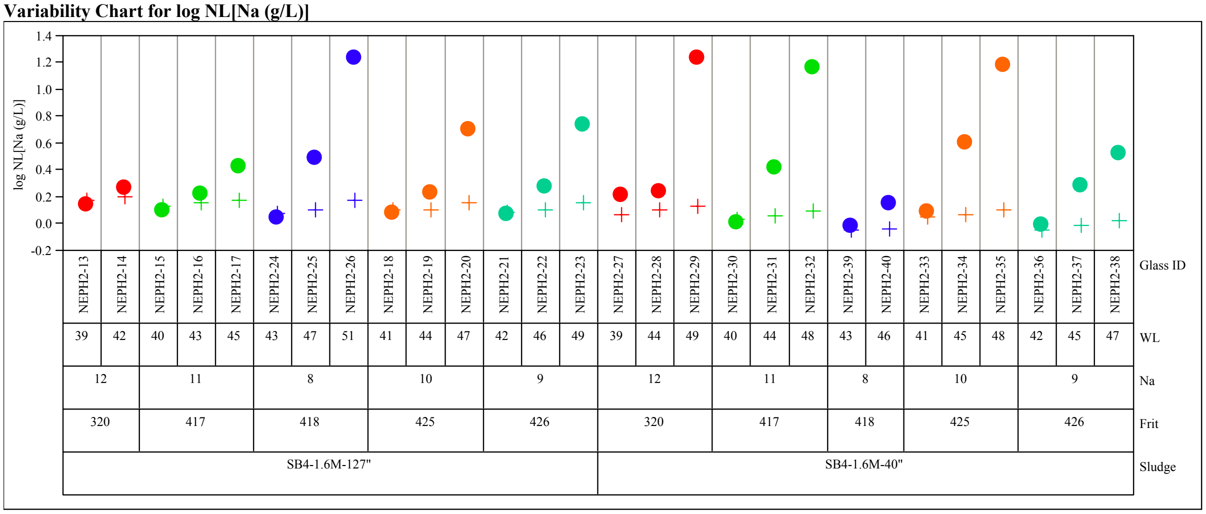


Exhibit D8. Effects of Heat Treatment for Study Glasses Using Measured Compositions

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

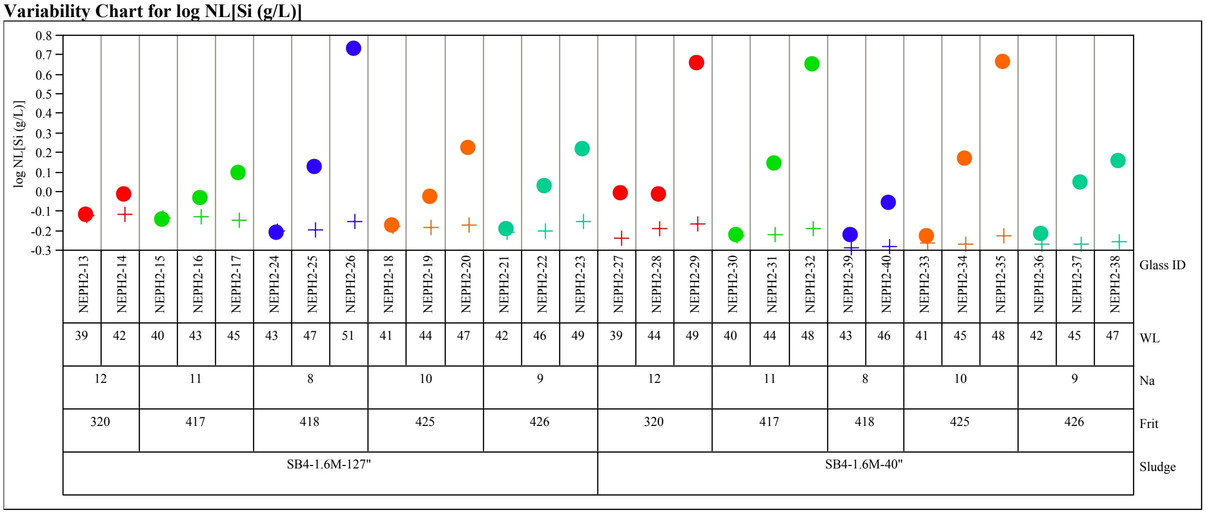
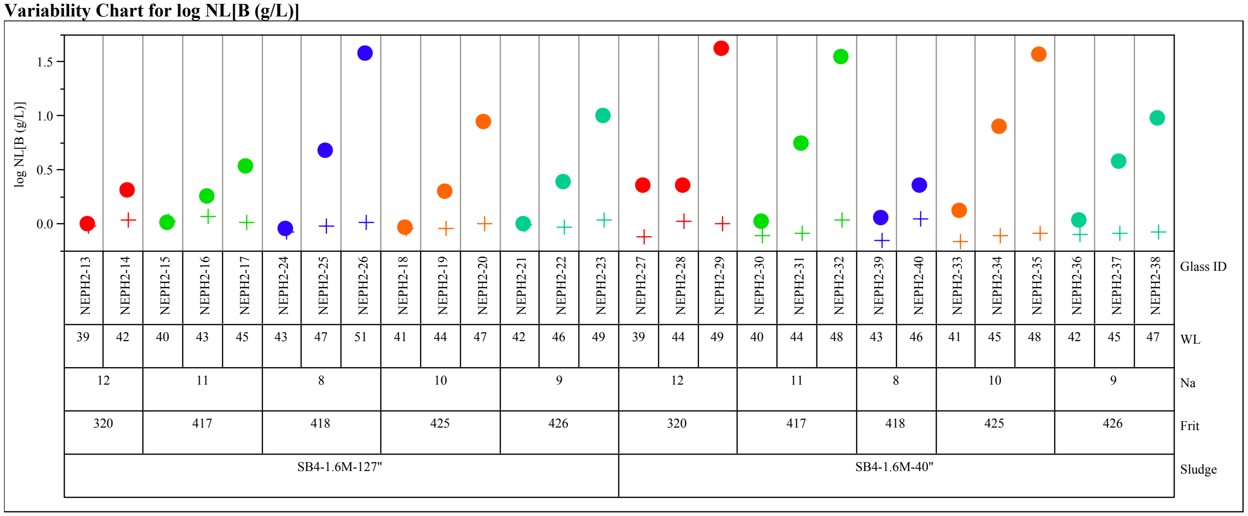


Exhibit D9. Effects of Heat Treatment for Study Glasses Using Measured-Bias Corrected Compositions

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



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

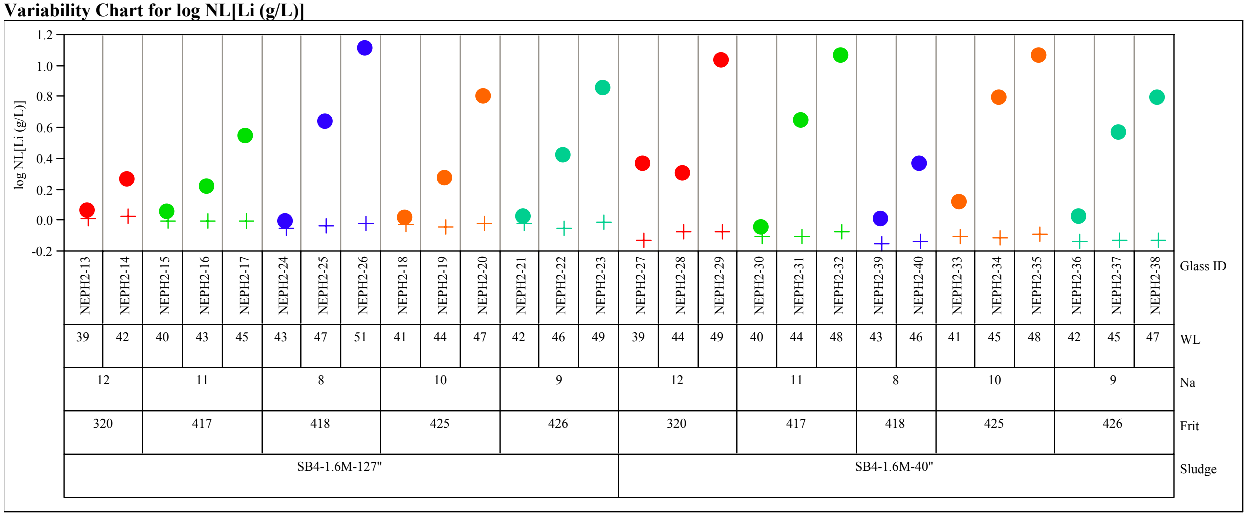
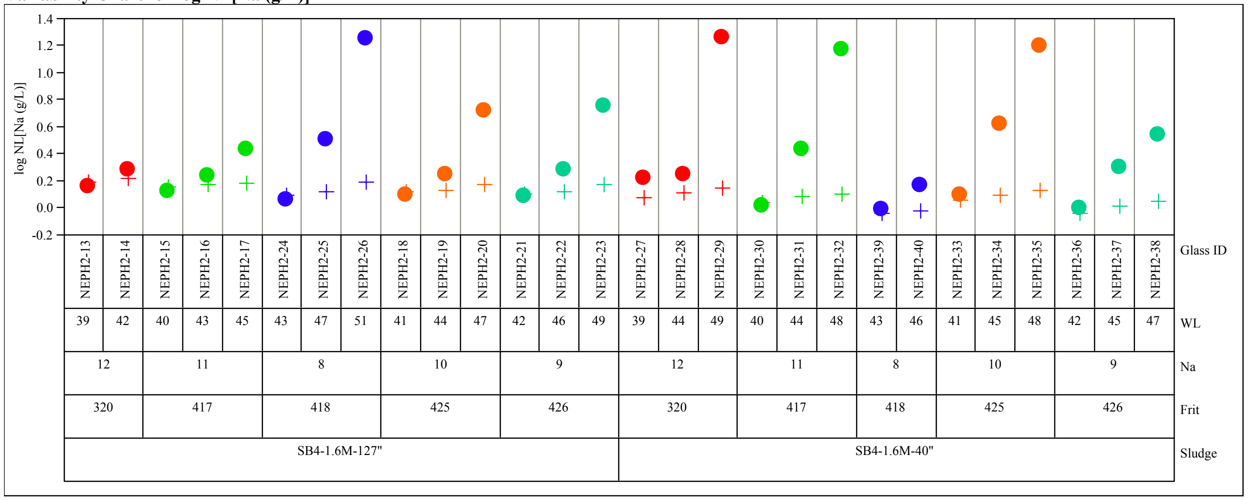


Exhibit D9. Effects of Heat Treatment for Study Glasses Using Measured-Bias Corrected Compositions

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



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

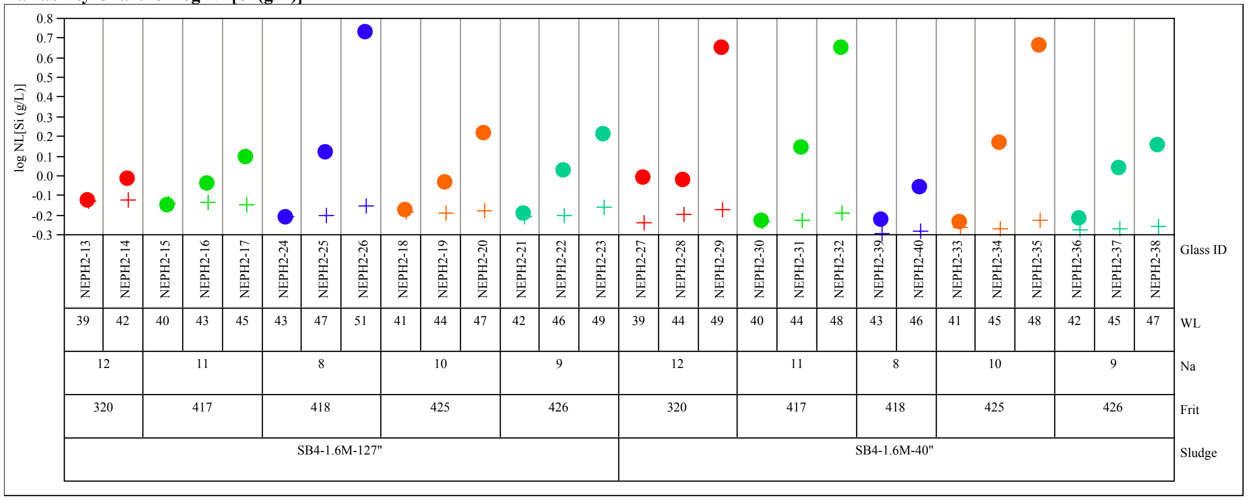
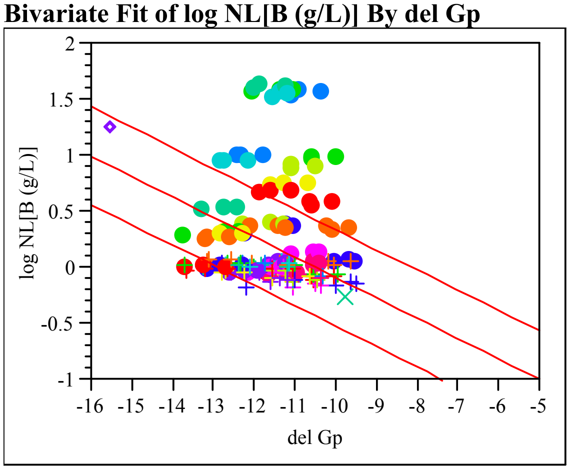
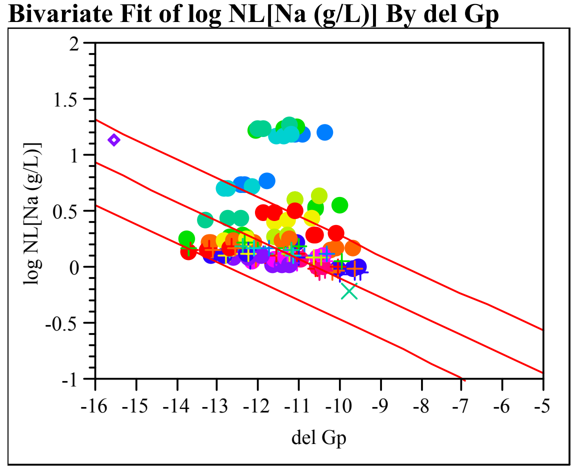


Exhibit D10. del Gp (ΔG_p) Predictions versus Common Logarithm Normalized Leachate (log NL[.]) for B, Li, Na, and Si Over All Compositional Views and Heat Treatments

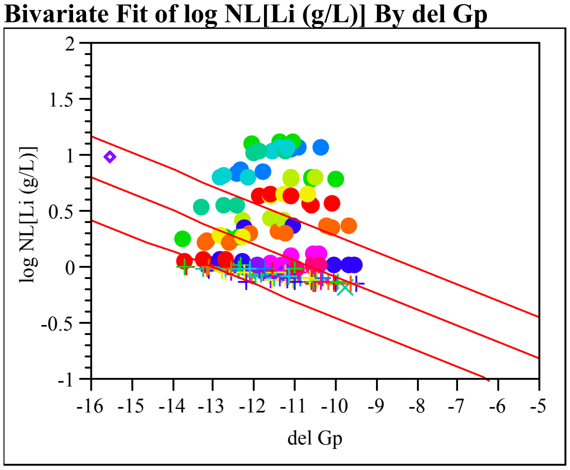
Bivariate Fit of log NL[B (g/L)] By del Gp



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

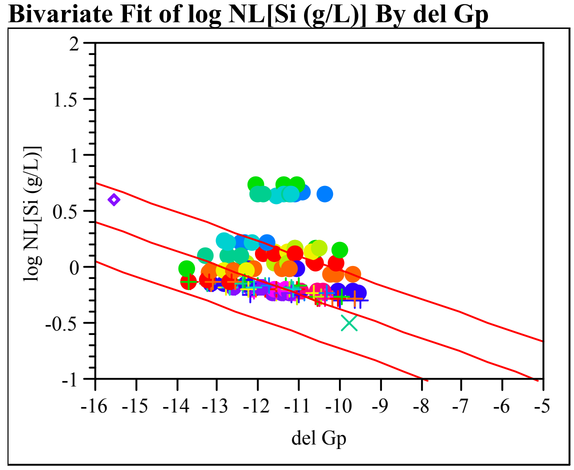
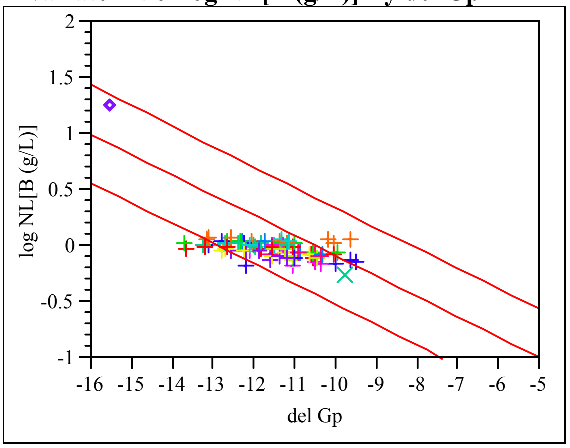
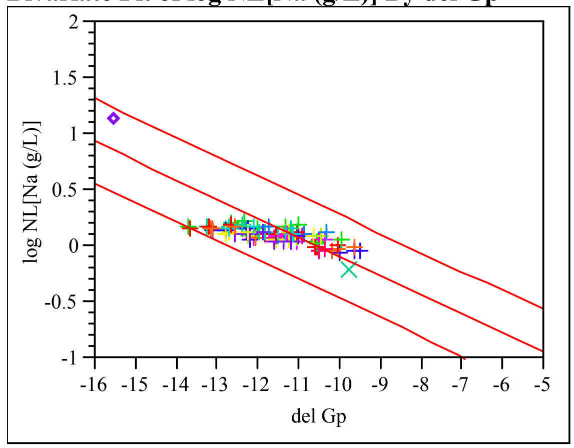


Exhibit D11. del Gp (ΔG_p) Predictions versus Common Logarithm Normalized Leachate (log NL[.]) for B, Li, Na, and Si Over All Compositional Views for Quenched Glasses

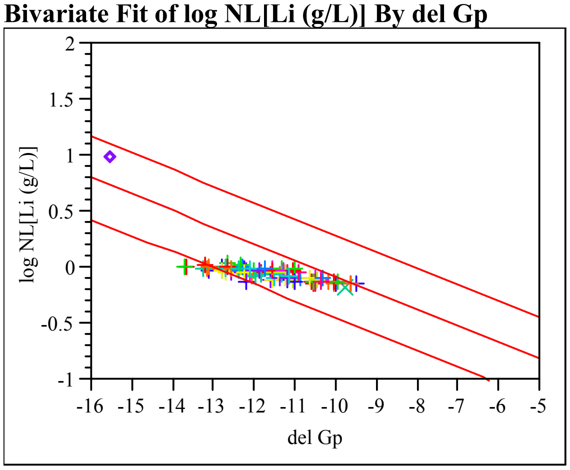
Bivariate Fit of log NL[B (g/L)] By del Gp



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

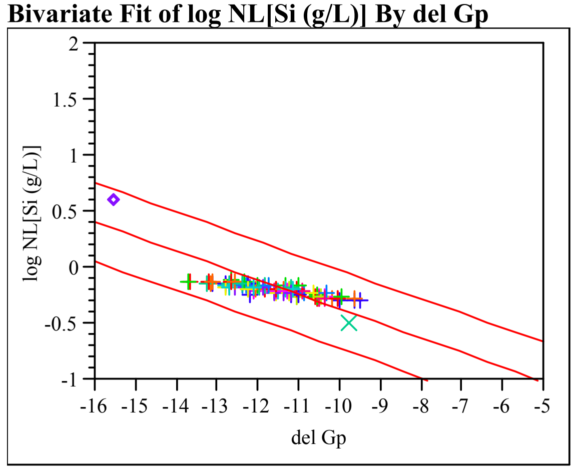
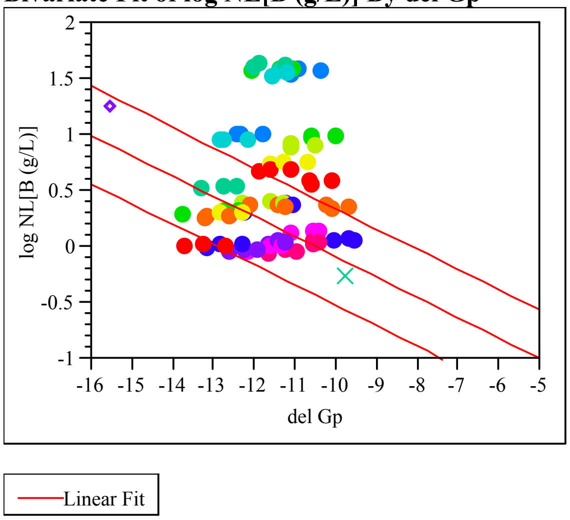
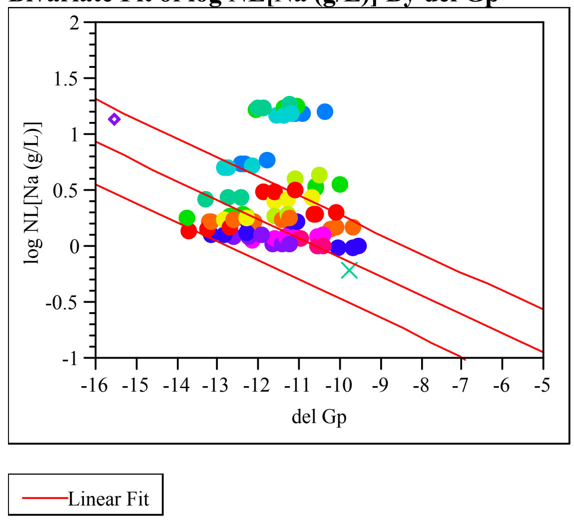


Exhibit D12. del Gp (ΔG_p) Predictions versus Common Logarithm Normalized Leachate (log NL[.]) for B, Li, Na, and Si Over All Compositional Views for ccc Glasses

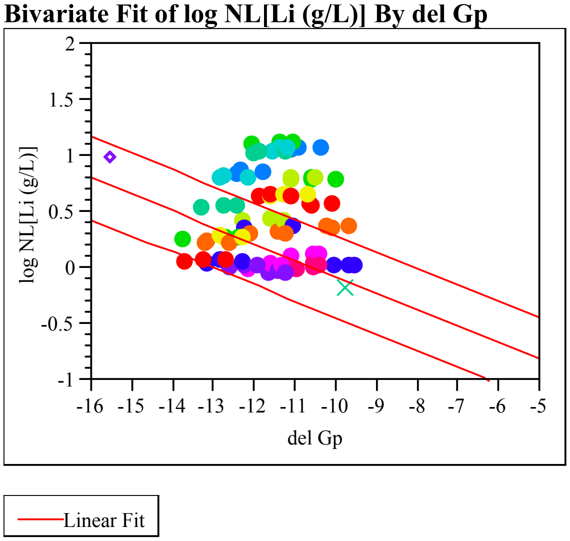
Bivariate Fit of log NL[B (g/L)] By del Gp



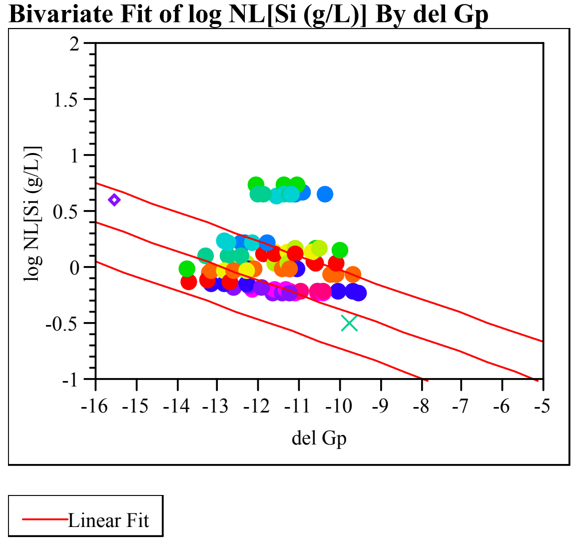
Bivariate Fit of log NL[Na (g/L)] By del Gp



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



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



Distribution:

J.E. Marra, SRNL
R.E. Edwards, SRNL
E. W. Holtzscheiter, SRNL
D. A. Crowley, 999-W
S. L. Marra, 999-W
T. B. Calloway, 999-W
N. E. Bibler, SRNL
C.M. Jantzen, SRNL
J. R. Harbour, 773-42A
G. G. Wicks, SRNL
R. C. Tuckfield, 773-42A
T. B. Edwards, 773-42A
K.M. Fox, SRNL
C. C. Herman, 773-42A
M. E. Smith, 773-42A
M. E. Stone, 999-W
D. H. Miller, 999-W
M.J. Barnes, 999-W
M. S. Miller, 704-S
J. E. Occhipinti, 704-S
R. M. Hoeppel, 704-27S
B. A. Davis, 704-27S
P.M. Patel, 704-27S
H. H. Elder, 766-H
J. F. Iaukea, 704-30S
J. W. Ray, 704-S
M. A. Rios-Armstrong, 766-H
W. B. Van-Pelt, 704-S
H.B. Shah, 766-H