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SB3 PHASE 2 VARIABILITY STUDY:

The Impact of REDOX on Durability for the Frit 418 – SB2/3 System

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Table of Contents

List of Tables

List of Figures

Executive Summary

The objective of this report was to assess the applicability (or predictability) of the ΔG_p model and the acceptability of the resulting glasses to the Frit 418 – Sludge Batch 2/3 (SB2/3) compositional region with and without the Reduction/Oxidation (REDOX) term activated in the model. A limited test matrix was developed to supplement existing data generated by previous variability studies (SB2 and SB3 separately) within the composition region of interest. Based on the results of this study, it was demonstrated that the current model is applicable (i.e., the durability response was predicted by the model for all study glasses) to the Frit 418 – SB2/3 composition region. The results also indicate that acceptable glasses (in terms of their normalized boron release) can be produced within this compositional region. In addition, there is no evidence that the activation of the REDOX term in the Product Composition Control System (PCCS) is warranted for the Frit 418 – SB2/3 system. In fact, the data show that activation could lead to extremely conservative decisions with respect to Slurry Mix Evaporator (SME) acceptability for this frit/sludge system.

1.0 Introduction

Approximately 130M L of sludge/supernate high-level radioactive waste (HLW) is currently stored in underground carbon steel tanks at the Savannah River Site (SRS) in Aiken, South Carolina. The Defense Waste Processing Facility (DWPF) began immobilizing these wastes in borosilicate glass in 1996. Currently, the radioactive glass is being produced as a “sludge-only” composition by combining washed high-level sludge with glass frit and melting. The molten glass is poured into stainless steel canisters that will eventually be disposed of in a permanent geological repository.

In this report, predictability is based on the 95% two-sided confidence interval for an individual Product Consistency Test (PCT) (ASTM 2002) response as generated by the Thermodynamic Energy Reaction Model (THERMO™) ΔG_P model (Jantzen et al. 1995). This definition is consistent with that used in recent variability studies (e.g., Harbour et al. 2000; Herman et al. 2001). A comparison is made of the actual leaching performance as determined by the PCT and the prediction limits for an individual glass generated by the THERMO™ model. The durability of a glass is considered predictable if its PCT response is within the 95% confidence interval.

The term “acceptable” (in reference to a PCT response) is defined as glasses whose log normalized boron release (log NL [B]) is less than 1.0 g/L (or NL [B] < 10 g/L). This is consistent with the limit used by Edwards and Brown (1998) to set the sum-of-alkali and Al_2O_3 criteria for relaxing the homogeneity constraint from the Measurement Acceptability Region (MAR) to the Property Acceptability Region (PAR) for Tank 42. This definition is considered to be conservative relative to the Environmental Assessment (EA) glass as reported by Jantzen et al. (1993) with uncertainties considered.

DWPF is currently processing Sludge Batch 2 (SB2) using Frit 320. Prior to acceptance and processing of SB2 in DWPF, the waste qualification process was completed as required. One phase of this process was a glass variability study as directed by the DWPF Glass Product Control Program (Plodinec et al. 1995). In general, the objective of a variability study is to determine if the durability – ΔG_P (preliminary glass dissolution estimator based on free energy of hydration expressed in kcal/mol) correlation currently utilized by DWPF applies to the projected compositional region for the sludge batch to be processed. Two variability studies (Harbour et al. (2000) and Herman et al. (2001)) were performed to assess the applicability (or predictability) of the ΔG_P model and to confirm that SB2 would produce an acceptable glass via the Product Composition Control System (PCCS). The results from these variability studies demonstrated that acceptable (durable) glass could be produced with either Frit 200 or Frit 320 and the measured releases were predictable (or at least conservative) by the durability model.

In support of the qualification process for Sludge Batch 3 (SB3), Herman, Peeler, and Edwards (2002) indicated that the SB3 variability study might be performed in two phases. The first phase (referred to as Phase 1) was based on a bounding composition region that used the latest Tank 7 compositional estimates or projections, candidate frit compositions, and a waste loading interval of interest (Peeler et al. 2003). The Phase 1 study was considered to be “global” in nature with respect to providing an assessment of the applicability of ΔG_P and acceptability of the glasses over a bounding compositional region. Typically, variability studies are compositionally focused on a specific frit coupled with a known sludge composition over a waste loading range of interest. In Phase 1, a “global” approach was pursued since the washing and/or blending strategy was still in question and a frit recommendation had not been made. Therefore, various candidate frits were used with different sludge compositional views representing possible washing scenarios. The experimental results demonstrated applicability (or conservatism) of the ΔG_P model for each of the 42 SB3 Phase 1 test matrix glasses (Peeler et al. 2003).

Since the completion of the SB3 Phase 1 study, significant changes to the blending strategy have resulted in a new baseline flowsheet. The new flowsheet blends SB3 with some remaining fraction of SB2 (this blend strategy is referred to as SB2/3 throughout this report). The new strategy also accounts for the lower anticipated levels of oxalate and higher concentrations of other sodium salts. Given individual variability studies were completed for SB2 and SB3, the question as to whether a variability study for the SB2/3 blend is required surfaces. More specifically, the applicability of the ΔG_P model for each individual system has been demonstrated but given the possibility of a frit change for SB2/3 (in an effort to improve melt rate or waste throughput) the model's applicability for the SB2/3 flowsheet when coupled with this new frit is an open issue. The need for additional data or a subsequent variability study to demonstrate model applicability relies to a large extent on the overlap between the individual compositional regions covered in Phase 1 and the region expected to be covered by the Frit 418 – SB2/3 system. Frit 418 has been recommended and is being purchased for the SB2/3 blend based on assessments performed by Peeler and Edwards (2003a, 2003b, 2003c, and 2003d), Lorier (2003), and Smith et al. (2003).

As previously mentioned, the decision as to the need for a specific SB2/3 variability study depended on whether sufficient data existed within the anticipated compositional region for the Frit 418 – SB2/3 region. Obviously, the data generated during the specific Frit 320/SB2 and more "global" SB3 variability studies were of interest, but data from other studies within the anticipated region could not be excluded from consideration. That is, numerous studies have been performed to assess the impact of glass composition on the durability response as measured by the PCT (ASTM 2002). The results of these studies could be (and were) included in the assessment to determine if additional data were needed. More specifically, a compiled database was generated as a result of a parallel DWPF effort (Peeler and Edwards 2003e) which has resulted in the compilation of a significant amount of compositional – property information. Once the Frit 418 – SB2/3 compositional region was defined, the database was screened for glasses within this region. An assessment was made as to whether sufficient data existed from which a technical decision could be made with respect to the need for an additional study. The conclusion or recommendation from this assessment could have been one of three options: 1) that sufficient data existed that provides ample coverage of the anticipated compositional region warranting a decision of no additional data needed; 2) that there are no existing glasses within the anticipated region, thus requiring a full variability study to demonstrate applicability of the durability model and/or acceptability of the Frit 418 – SB2/3 glasses; or 3) there was only partial coverage of the compositional region with existing data. This last outcome resulted in a limited study to fill in compositional gaps or address other technical issues. The pathforward or decision with respect to additional data needs was based not only on compositional coverage or overlap, but also the degree to which the impact of Reduction/Oxidation (REDOX) on durability could be assessed within this compositional region. This latter issue was addressed for the Frit 320/SB2 system (Peeler and Edwards 2003f and 2003g) as well as the SB3 variability study (Peeler et al. 2003) to ensure that as higher alkali systems are targeted, the predicted impact of REDOX on durability does not compromise product quality.

In this report, an assessment of the compositional overlap between the projected Frit 418 – SB2/3 region and existing data is made. The objective of the assessment was to determine if additional data were needed (partial or full) to demonstrate the applicability of the durability model for this region.

Objectives for this task are specified in Section 2.0. The strategy or approach used to make a determination regarding the need for additional data is summarized in Section 3.0. Section 4.0 describes the experimental approach used to fabricate and test glasses. Section 5.0 provides a detailed discussion of the results with particular emphasis placed on the applicability of the durability model, the acceptability of the glasses, and the impact of REDOX on durability. A summary and recommendations are provided in Sections 6.0 and 7.0, respectively.

2.0 Objective

The overall objective of the variability study is to demonstrate the applicability of the ΔG_p model to the Frit 418 – SB2/3 compositional region with REDOX activated as well as the acceptability of glasses in terms of their PCT response, and to supplement previous studies. This objective will be met using one of the following methods:

(1) Existing data within the anticipated compositional region will be shown not only to provide sufficient compositional coverage, but it will also demonstrate the applicability of the durability models and the acceptability of the glasses with respect to product quality, OR

(2) Additional data will be generated to fill in compositional gaps. This may be accomplished by a full or partial variability study pending on the degree of compositional overlap between the projected region of interest and the existing dataset to be used.

Given the application of RW-0333P Quality Assurance (QA) requirements to this task, any existing data that is used to support decisions regarding the applicability of the model or the need for additional data will meet the stated requirements. This work has been prepared to address technical issues identified in a TTR (Rios-Armstrong 2002) and in accordance with the Task Technical and Quality Assurance Plan (Herman, Peeler, and Edwards 2002).

3.0 The Strategy or Approach

In Section 1.0, the question was asked: "Is a variability study required for the Frit 418 – SB2/3 system?" To address this issue, one must first define the compositional region of interest for the Frit 418 – SB2/3 system. Secondly, an assessment of previously generated data is needed to assess compositional coverage and/or overlap between the existing data and the anticipated compositional region of interest. Existing data used in this assessment will have been developed under the required QA requirements (RW-0333P) as stated by Rios-Armstrong (2002). If adequate data are available to cover the anticipated composition region, a decision may be made not to proceed with a specific variability study for the Frit 418 – SB2/3 system. If no data lie within the composition region of interest or the data provide limited coverage, performing a full or partial variability study may be required to fill in compositional data gaps or address other outstanding issues (e.g., the impact of REDOX on durability).

3.1 Defining the Composition Region of Interest

Three primary inputs are required to develop a glass compositional region of interest: (1) sludge or waste stream composition(s), (2) frit composition, and (3) waste loading (WL) interval of interest. The WL interval of interest is 25 – 60%. With respect to the sludge composition, Lilliston and Elder provided revised compositional estimates based on the Tank 51 Qualification sample results and updated projections of when SB2 and SB3 may be combined.[1] Four estimates were provided based on two targeted SB3 wash endpoints (1.23M and 1.24M Na^+) and two blending options in terms of timing (175 and 200 canisters[2]). The elemental concentrations provided were converted to an oxide basis (by multiplying by the appropriate gravimetric factor), and these data are presented in Table 3-1.

It should be noted that anions were not reported by Lilliston and Elder as part of the calcined elemental concentrations – only as part of the supernate information.

The information provided by Lilliston and Elder was used by Peeler and Edwards (2003d) to assess projected operating windows and the robustness of candidate frit compositions through Nominal and Variation Stage assessments. In support of the Variation Stage assessment, a ±7.5% compositional variation was applied to the average compositional estimate over the four sludge options to gain insight into the robustness of candidate frits. More specifically, an average SB2/3 composition was computed based on all four nominal sludge options. Using this average composition, a ±7.5% variation was applied to each major oxide as well as the "Others" component (i.e., the group of minor oxides). The minimum and maximum values for each major oxide were then assessed to ensure that they bounded the nominal values for each of the four sludges. The minimum and maximum values for each major component were used to bound the sludge compositional region of interest. JMP Version 5 (SAS Institute 2002) was used to generate 1803 extreme vertices and a centroid (for a total of 1804 sludge compositions) for this region.

[1] Personal communication with G.R. Lilliston via email dated 8/18/03. Appendix A provides the data transmitted in the personal communication (elemental wt%, calcine basis).

[2] This assumes that an additional 175 or 200 canisters will be produced with SB2 prior to blending with SB3, based on a start date of May 1, 2003. It does not represent a total number of canisters produced from SB2.

Table 3-1. Projected SB2/3 Compositions (oxide basis, wt%).

Oxide	SB2/3 1.23M 175 cans	SB2/3 1.24M 175 cans	SB2/3 1.23M 200 cans	SB2/3 1.24M 200 cans
Al_2O_3	15.334	15.325	15.409	15.400
BaO	0.149	0.149	0.147	0.146
CaO	2.947	2.945	2.928	2.927
Ce_2O_3	0.240	0.240	0.236	0.236
Cr_2O_3	0.245	0.245	0.242	0.242
CuO	0.082	0.082	0.079	0.079
Fe_2O_3	32.544	32.525	32.406	32.387
K_2O	0.938	0.937	0.957	0.956
La_2O_3	0.123	0.123	0.121	0.121
MgO	3.565	3.563	3.569	3.567
MnO	6.660	6.656	6.732	6.728
Na_2O	21.318	21.364	21.282	21.328
NiO	1.820	1.819	1.826	1.825
PbO	0.145	0.145	0.140	0.140
SiO_2	2.841	2.839	2.879	2.877
ThO_2	0.034	0.034	0.032	0.032
TiO_2	0.025	0.025	0.026	0.026
U_3O_8	10.256	10.250	10.287	10.281
ZnO	0.156	0.156	0.150	0.150
ZrO_2	0.258	0.258	0.244	0.244
Total	99.680	99.680	99.693	99.693

Model-based assessments performed by Peeler and Edwards (2003d) indicated that the use of Frit 418 (nominal composition provided in Table 3-2) with the four individual streams provided operational windows from 25 – 45% WL (at the MAR). Once compositional uncertainty was applied to the average sludge, the Variation Stage assessment indicated an operational window from 25 – 40% WL over which all EVs could be processed. Based on the assessments performed by Peeler and Edwards (2003d) as well as melt rate assessments (Lorier 2003, Smith et al. 2003), Frit 418 is the recommended frit for SB2/3.

Table 3-2. Nominal Composition (in wt%) of Frit 418.

Oxide	Frit 418
B_2O_3	8
Li_2O	8
Na_2O	8
SiO_2	76
Total	100

3.2 Review of Existing Data

Coupling the 1803 SB2/3 EVs and centroid compositions with Frit 418 over the WL interval of interest (25 – 60%), a multi-dimensional composition region was defined. Table 3-3 summarizes the compositional envelope of interest through the use of minimum and maximum values for each oxide in glass. These minimum and maximum values were then used to search the compiled database for existing glasses within the region of interest. That is, a series of "if/then" statements coded into JMP was used to review each of the > 10,000 rows of composition information contained in the compiled database. If a glass fell within the minimum and maximum oxide ranges of interest, it was retained as part of the matrix from which the decision regarding additional data needs would be made. The results of this search identified 31 glasses that are listed in Table 3-4 (including a general description of each glass). It is interesting to note (but not surprising) that the majority of the 31 glasses come from studies that involved SB2 or SB3. Although Frit 418 was not specifically used in these previous studies, the resulting glasses fall within the compositional region defined by the Frit 418 – SB2/3 system given the adjustments made to the frit composition used for each study. In addition, the studies generating the 31 glasses were conducted under RW-0333P requirements; therefore, all 31 glasses could be used in support of the decision regarding additional data needs.

Table 3-3. Minimum and Maximum Oxide Values Defining the Glass Compositional Region of Interest (oxide basis, wt%).

Oxide	Minimum	Maximum
Al_2O_3	3.554	9.912
B_2O_3	3.200	6.000
BaO	0.034	0.095
CaO	0.679	1.894
Ce_2O_3	0.055	0.153
Cr_2O_3	0.056	0.157
CuO	0.019	0.052
Fe_2O_3	7.508	20.940
K_2O	0.081	0.238
La_2O_3	0.028	0.079
Li_2O	3.200	6.000
MgO	0.825	2.300
MnO	1.548	4.318
Na_2O	10.931	16.953
NiO	0.422	1.176
PbO	0.033	0.092
SiO_2	31.987	57.768
ThO_2	0.008	0.021
TiO_2	0.006	0.017
U_3O_8	2.375	6.623
ZnO	0.035	0.099
ZrO_2	0.058	0.162
Others	0.332	0.927

Table 3-4. Thirty-One Glasses Identified from Compiled Database.

Glass ID	Reference	General Description
HLC-SB2-320	Cozzi et al. (2002)	Frit 320/SB2 qualification glass
NS06	Herman et al. (2001)	SB2 centroid at 40% WL
NS15	Herman et al. (2001)	SB2 EV at 32.5% WL
NS18	Herman et al. (2001)	SB2 EV at 40% WL
NS19	Herman et al. (2001)	SB2 EV at 40% WL
NS20	Herman et al. (2001)	SB2 EV at 40% WL
NS21	Herman et al. (2001)	SB2 EV at 40% WL
SB3-5	Peeler et al. (2003)	Frit 202, SB3 25% wash, 31% WL
SB3-6	Peeler et al. (2003)	Frit 202, SB3 25% wash, 38% WL
SB3-11	Peeler et al. (2003)	Frit 202, SB3 50% wash, 29% WL
SB3-12	Peeler et al. (2003)	Frit 202, SB3 50% wash, 46% WL
SB3-15	Peeler et al. (2003)	Frit 202, SB3 Decant #5, 33% WL
SB3-16	Peeler et al. (2003)	Frit 202, SB3 Decant #5, 37% WL
SB3-29	Peeler et al. (2003)	Frit 202, SB3 Decant #9, 29% WL
SB3-30	Peeler et al. (2003)	Frit 202, SB3 Decant #9,45% WL
VS-1	Peeler and Edwards (2003g)	Frit 320, SB2 EV, 35% WL, redox 0.0
VS-2	Peeler and Edwards (2003g)	Frit 320, SB2 EV, 35% WL, redox 0.2
VS-16	Peeler and Edwards (2003g)	Frit 320, SB2 EV, 35% WL, redox 0.33
VS-5	Peeler and Edwards (2003g)	Frit 320, SB2 centroid, 28% WL, redox 0.0
VS-6	Peeler and Edwards (2003g)	Frit 320, SB2 centroid, 34% WL, redox 0.0
VS-7	Peeler and Edwards (2003g)	Frit 320, SB2 centroid, 34% WL, redox 0.2
VS-8	Peeler and Edwards (2003g)	Frit 320, SB2 centroid, 34% WL, redox 0.33
VS-9	Peeler and Edwards (2003g)	Frit 320, SB2 centroid, 40% WL, redox 0.2
VS-10	Peeler and Edwards (2003g)	Frit 320, SB2 centroid, 40% WL, redox 0.2
VS-11	Peeler and Edwards (2003g)	Frit 320, SB2 centroid, 40% WL, redox 0.2
VS-12	Peeler and Edwards (2003g)	Frit 320, SB2 EV, 38% WL, redox 0.33
VS-13	Peeler and Edwards (2003g)	Frit 320, SB2 EV, 38% WL, redox 0.33
VS-17	Peeler and Edwards (2003g)	Frit 320, SB2 EV, 38% WL, redox 0.33
Rchwl-01	Peeler and Edwards (2003h)	Frit 165, SB3 OL EV, 38.1% WL
Rchwl-02	Peeler and Edwards (2003h)	Frit 165, SB4 OL EV, 41.6% WL
tk40-03	Peeler and Edwards (2003h)	Frit 320, Tank 40, 39.1% WL

3.3 Effects of Colinearity

It should be noted that the use of the minimum and maximum values (see Table 3-3) to identify the 31 glasses within the compositional region of interest did not enforce the colinearity of the components of the Frit 418 – SB2/3 system. More specifically, use of the minimum and maximum values may have allowed a glass composition to be retained in which the contributions of certain components of the frit and/or sludge would misrepresent the inherent structure of the oxides in the Frit 418 – SB2/3 system in terms of waste loading. For example, one of the 31 glasses may have a B_2O_3 concentration indicative of a 35% WL Frit 418 glass while the SiO_2 concentration represents a 45% WL. The lack of enforcing this colinearity does not compromise the use of the 31 glasses with respect to the decision regarding additional data needs, but it is an issue that will be considered. Figures 3-1 and 3-2 demonstrate the concept of colinearity and its potential impact on the additional data need decision.

Figure 3-1 is a plot of the B_2O_3 versus Al_2O_3 concentrations for the thirty-one glasses (shown as the red boxes). The region shaded in gray represents the projected compositional region of the Frit 418 – SB2/3 (EV-based) system over a WL interval of 25 – 60% in terms of B_2O_3 versus Al_2O_3. As shown, the majority of the 31 glasses lie within the compositional region of interest based on this single composition view – but other glasses do not. Although not shown in this report, other single component plots were developed and reviewed which also suggest that although the majority of the 31 glasses are contained within the anticipated region, not all glasses fall within the specific Frit 418 – SB2/3 region of interest.

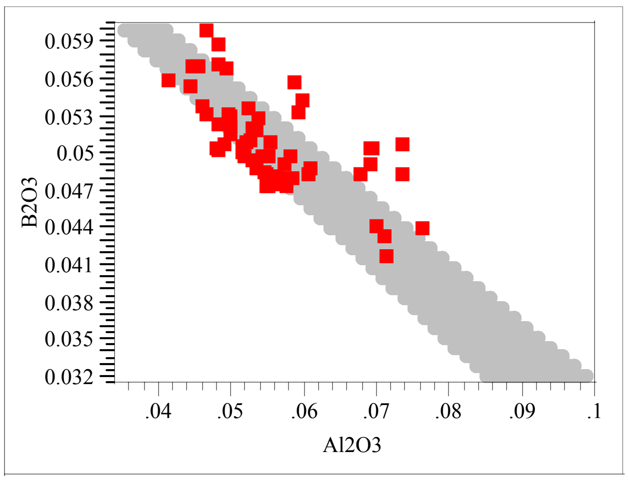


Figure 3-1. B_2O_3 Versus Al_2O_3 for the 31 Database Glasses Compared to the Anticipated Frit 418 – SB2/3 Composition Region.

Figure 3-2 is perhaps a "worst-case" scenario or example of the effect that failing to enforce colinearity has on the selection process. In the figure, various sludge components are ratioed (Fe/Al vs U/Ca) and compared to the ratios expected for the specific Frit 418 – EV-based system (region shaded gray). The results suggest that none of the 31 glasses lie within the compositional region of interest based on this view.

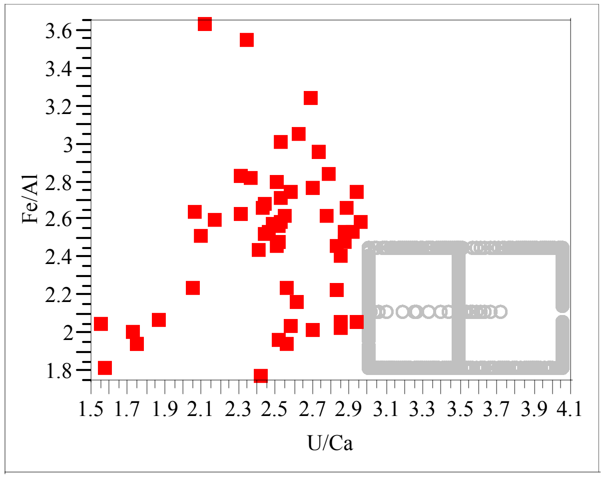


Figure 3-2. Fe/Al vs. U/Ca Concentrations for the 31 Database Glasses Compared to the Anticipated Composition Region.

Although the results of
Figure 3-2 could be viewed as highly discouraging, the 31 glasses can be viewed as providing supportive data for the decision making process. Figure 3-3 demonstrates this concept. The "global" region represents the compositional bounds defined by the minimum and maximum oxide values shown in Table 3-3. Again, those values may not represent actual combinations of the Frit 418 – SB2/3 system due to colinearity of the components being ignored. However, this region does bracket the anticipated region of interest. The "box" shown in Figure 3-3 labeled as "EVs" represents the compositional region that would be generated by the Frit 418 – SB2/3 system (with variation associated with the SB2/3 sludge) with colinearity activated over a WL interval of 25 – 60%. (The "box" parallels the gray shaded region in Figures 3-1 and 3-2). The red points within the "box" represent a series of Frit 418 – SB2/3 glasses that are based on the nominal sludge composition coupled with Frit 418 at WLs of 25 – 45% in 5% increments. These five points represent the anticipated interval over which acceptable glasses would be made based on the model-based assessments at the MAR (see Section 3.1 or Peeler and Edwards (2003d) for more details).

With respect to the decision regarding the need for additional data, the issue essentially depends on the degree of compositional coverage and on the extent that other technical issues (such as the impacts of redox on durability) are adequately addressed. Given that the applicability of the model and the acceptability of the 31 glasses in terms of their PCT response have been previously demonstrated, the authors feel that these glasses provide coverage in the "global" region that surrounds the expected and more well-defined Frit 418 – SB2/3 system. In addition, given certain combinations of individual oxides or ratios of the oxides fall within the region of interest (see Figure 3-1), there is a slight risk due to the partial coverage of the EV region defined in Figure 3-3. Specifically, all of the colinearities of the components were not satisfied in the compiled database search. Additional coverage within the specific region of interest would lower this risk and provide additional data to demonstrate the applicability of the model and acceptability of the glasses within the specific region of interest. Therefore, the decision was made to fabricate and test a limited set of glasses (specific to the Frit 418 – SB2/3 system) to fill in the composition region of interest. The results of this limited set coupled with the 31 existing data points provide a sound technical basis for the objectives of this study.

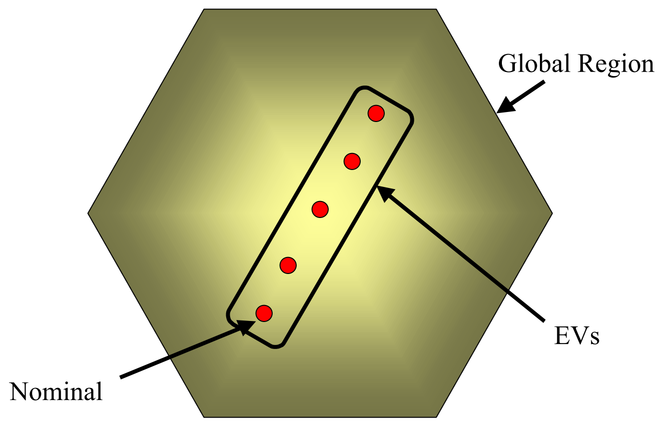


Figure 3-3. Conceptual View of Composition Overlap.

To fill in the compositional gap, twelve glasses were identified based on a nominal SB2/3 composition (i.e., the SB2/3 1.23M 175-canister option) and Frit 418.[3] In addition to filling in compositional gaps, these twelve glasses provide insight into the impacts of REDOX on durability for this system. It should be noted that approximately one-third of the 31 glasses had a targeted REDOX of 0.2 or 0.33. Therefore, not only will the twelve glasses provide compositional coverage, but additional insight into the effects of REDOX on durability will be addressed as well. The intent of the REDOX assessment was to ensure that the REDOX term in PCCS associated with the durability model should remain dormant (i.e., not activated) given potential conservatism of the ΔG_i value associated with FeO. Peeler and Edwards (2003f) have shown that for the Frit 320/SB2 system the application of the ΔG_i value associated with FeO, without consideration of potential composition interactions (i.e., Al_2O_3), can lead to extremely conservative decisions during the SME acceptability process.

Table 3-5 summarizes the targeted compositions of the twelve Frit 418 – SB2/3 glasses. These glasses spanned a WL interval of 30 – 45% (in 5% increments) which was primarily based on the Nominal Stage assessment performed by Peeler and Edwards (2003d). There are four "base" glasses that target four different WLs. At each WL, a REDOX of 0.0 (fully oxidized), 0.2, and 0.33 was targeted. The resulting test matrix has three glasses at each WL (varying in REDOX) for a total of twelve glasses.

[3] It should be noted that although the 1.23M, 175 canister option was selected as the compositional basis for SB2/3, there is essentially very little (or no practical) difference in the nominal compositions of the four projections provided by Lilliston and Elder (see Table 3-1).

Table 3-5. Target Compositions (oxide, wt%) of SB2/3 Glasses.

ID	SB2/3-1	SB2/3-2	SB2/3-3	SB2/3-4	SB2/3-5	SB2/3-6	SB2/3-7	SB2/3-8	SB2/3-9	SB2/3-10	SB2/3-11	SB2/3-12
WL	**30**			**35**			**40**			**45**		
Redox	**0**	**0.2**	**0.33**	**0**	**0.2**	**0.33**	**0**	**0.2**	**0.33**	**0**	**0.2**	**0.33**
Al_2O_3	4.615	4.615	4.615	5.384	5.384	5.384	6.154	6.154	6.154	6.923	6.923	6.923
B_2O_3	5.600	5.600	5.600	5.200	5.200	5.200	4.800	4.800	4.800	4.400	4.400	4.400
BaO	0.045	0.045	0.045	0.052	0.052	0.052	0.060	0.060	0.060	0.067	0.067	0.067
CaO	0.887	0.887	0.887	1.035	1.035	1.035	1.182	1.182	1.182	1.330	1.330	1.330
Ce_2O_3	0.072	0.072	0.072	0.084	0.084	0.084	0.096	0.096	0.096	0.108	0.108	0.108
Cr_2O_3	0.074	0.074	0.074	0.086	0.086	0.086	0.098	0.098	0.098	0.111	0.111	0.111
CuO	0.025	0.025	0.025	0.029	0.029	0.029	0.033	0.033	0.033	0.037	0.037	0.037
Cs_2O	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
FeO	0.000	1.763	2.908	0.000	2.056	3.393	0.000	2.350	3.878	0.000	2.644	4.363
Fe_2O_3	9.794	7.835	6.562	11.427	9.141	7.656	13.059	10.447	8.750	14.692	11.753	9.843
K_2O	0.282	0.282	0.282	0.329	0.329	0.329	0.376	0.376	0.376	0.423	0.423	0.423
La_2O_3	0.037	0.037	0.037	0.043	0.043	0.043	0.050	0.050	0.050	0.056	0.056	0.056
Li_2O	5.600	5.600	5.600	5.200	5.200	5.200	4.800	4.800	4.800	4.400	4.400	4.400
MgO	1.073	1.073	1.073	1.252	1.252	1.252	1.430	1.430	1.430	1.609	1.609	1.609
MnO	2.005	2.005	2.005	2.339	2.339	2.339	2.673	2.673	2.673	3.007	3.007	3.007
MoO_3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Na_2O	12.016	12.016	12.016	12.685	12.685	12.685	13.354	13.354	13.354	14.024	14.024	14.024
NiO	0.548	0.548	0.548	0.639	0.639	0.639	0.730	0.730	0.730	0.822	0.822	0.822
P_2O_5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
PbO	0.043	0.043	0.043	0.051	0.051	0.051	0.058	0.058	0.058	0.065	0.065	0.065
SiO_2	54.055	54.055	54.055	50.397	50.397	50.397	46.740	46.740	46.740	43.082	43.082	43.082
ThO_2	0.010	0.010	0.010	0.012	0.012	0.012	0.014	0.014	0.014	0.015	0.015	0.015
TiO_2	0.008	0.008	0.008	0.009	0.009	0.009	0.010	0.010	0.010	0.012	0.012	0.012
U_3O_8	3.087	3.087	3.087	3.601	3.601	3.601	4.116	4.116	4.116	4.630	4.630	4.630
ZnO	0.047	0.047	0.047	0.055	0.055	0.055	0.062	0.062	0.062	0.070	0.070	0.070
ZrO_2	0.08	0.08	0.08	0.09	0.09	0.09	0.10	0.10	0.10	0.12	0.12	0.12
Total	100.000	99.804	99.676	100.000	99.771	99.622	100.000	99.738	99.568	100.000	99.706	99.514

Table 3-6 summarizes the primary predicted properties of each glass (based on targeted compositions and REDOX values) as well as assessment of "SME acceptability" at the MAR. In general, as WL increases liquidus temperature (T_L) predictions increase and viscosity predictions decrease. It is noted that the T_L and viscosity predictions for the three glasses within each WL group are equivalent given the absence of a REDOX term in each of the models. However, the current durability model does have an associated REDOX term which drives a specific glass composition toward more negative ΔG_P values as the glass becomes more reduced. This is demonstrated in the predicted ΔG_P values for SB2/3-1 through SB2/3-3 – all three glasses targeting the same composition with the exception of REDOX. The ΔG_P values range from –10.792 to –11.950 kcal/mol. Although the glasses are predicted to become less durable as REDOX increases, the glasses still are acceptable based on the SME acceptability criteria. This is not the case for SB2/3-6, -9, -11, and -12. As WL increases, more total Fe is introduced into the glass from the sludge. As REDOX is increased, the propensity of the ΔG_i value to result in an unacceptable decision regarding durability increases (consistent with theory). This same trend was observed in the Frit 320/SB2 study, but the measured PCT responses indicated that the glasses were very acceptable, thus causing some concerns over the direct applicability of the FeO ΔG_i value without consideration of other possible interactive effects (i.e., Al_2O_3). The results of this study will provide additional insight into the effect of REDOX on durability as measured by the PCT.

Table 3-6. MAR Based Assessment of 12 Glasses.

Glass ID	Comp View	Target WL	REDOX View	Failed at the MAR[(a)]	ΔG_p	T_L (°C)	η (P)
SB2/3-1	target	30	0.0	-	-10.792	833.5	59.72
SB2/3-2	target	30	0.2	-	-11.494	833.5	59.72
SB2/3-3	target	30	0.33	-	-11.950	833.5	59.72
SB2/3-4	target	35	0.0	-	-11.030	898.2	47.36
SB2/3-5	target	35	0.2	-	-11.849	898.2	47.36
SB2/3-6	target	35	0.33	ΔG_P	-12.381	898.2	47.36
SB2/3-7	target	40	0.0	-	-11.267	956.4	36.22
SB2/3-8	target	40	0.2	-	-12.203	956.4	36.22
SB2/3-9	target	40	0.33	ΔG_P	-12.811	956.4	36.22
SB2/3-10	target	45	0.0	-	-11.505	1009.4	26.47
SB2/3-11	target	45	0.2	ΔG_P	-12.558	1009.4	26.47
SB2/3-12	target	45	0.33	ΔG_P	-13.242	1009.4	26.47

(a) MAR assessment performed with the REDOX term activated.

4.0 Experimental

4.1 Glass Fabrication

Each glass was prepared from the proper proportions of reagent-grade metal oxides, carbonates, H_3BO_3, and salts in 150-g batches using SRTC technical procedure “Glass Batching” (SRTC 2002a). FeO and Fe_2O_3 were batched in the ratio to produce the targeted REDOX value for a particular glass. Batch sheets were filled out as the materials were weighed. Once batched, the glasses were melted using SRTC technical procedure “Glass Melting” (SRTC 2002b). In general, the raw materials were thoroughly mixed and placed into a 95% Platinum/5% Gold 250-mL crucible. The batch was subsequently 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. During the entire melting process, the furnace was purged with nitrogen flowing at approximately 10 scfm to maintain the targeted REDOX value of the glass.[4] A vertical tube furnace was used for this study to provide a controlled temperature and atmosphere for the glasses. The small working space limited the melting to one glass at a time. A schematic of the melting set up is shown in Figure 4-1.

Approximately 140 g of glass was removed (poured) from the crucible while ~10 g remained in the crucible along the walls. The pour patty was used as a sampling stock for the various property measurements (i.e., chemical composition, REDOX and durability).

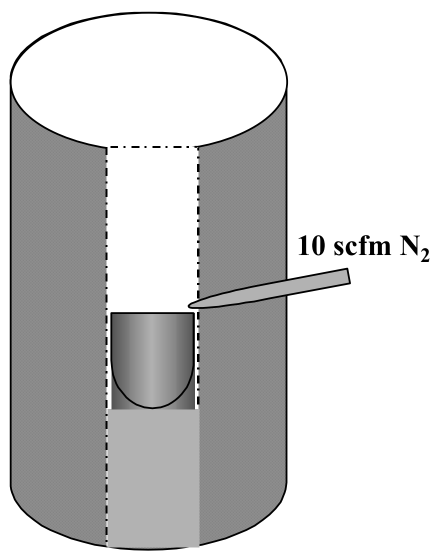


Figure 4-1. Schematic of furnace used to melt glasses and maintain REDOX.

[4] For the SB2/3 glasses targeting a redox of 0.0 (fully oxidized), the source of Fe was Fe_2O_3 and the melts were performed under fully oxidizing conditions.

4.2 Property Measurements

This section provides a general discussion of the analysis of chemical compositions and the PCTs for the SB2/3 glasses.

4.2.1 Chemical Composition Analysis

To confirm that the "as-fabricated" glasses corresponded to the defined target compositions, a representative sample from each SB2/3 glass pour patty was submitted to the SRTC Mobile Laboratory (SRTC-ML) for chemical analysis. Edwards (see Appendix B) provided an analytical plan that accompanied these samples. This plan identified the cations to be analyzed and the dissolution techniques (i.e., sodium peroxide fusion [PF] and lithium-metaborate [LM]) to be used. Each glass was prepared in duplicate for each cation dissolution technique (PF and LM). Concentrations (as mass %) for the cations of interest were measured by inductively coupled plasma – atomic emission spectroscopy (ICP – AES). The analytical plan was developed in such a way as to provide the opportunity to evaluate potential sources of error. Glass standards were intermittently run to assess the performance of the ICP – AES over the course of these analyses and for potential bias-correction needs.

4.2.2 Product Consistency Test (PCT)

The PCT was performed in triplicate on each SB2/3 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 were the Environmental Assessment (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. Fifteen milliliters of Type I American Society for Testing and Materials (ASTM) water were added to 1.5 g of glass in stainless steel vessels. The vessels were closed, sealed, and placed in an oven at 90 ± 2°C where the samples were maintained for 7 days. The resulting solutions (once cooled) were sampled (filtered and acidified), labeled (according to the analytical plan), and analyzed. Edwards provided an analytical plan for the SRTC-ML analysis (see Appendix C). The overall philosophy of the plan 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 SB2/3 glasses. Normalized release rates were calculated based on targeted, measured, and bias-corrected compositions using the average of the logs of the leachate concentrations.

To bound the effects of thermal history on the product performance, approximately 25 g of select SB2/3 glasses (i.e., glasses targeting a REDOX of 0.0) were 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. This terminology will be used in this report to differentiate samples from different cooling regimes (quenched versus ccc). PCTs were conducted in triplicate for these glasses and were included in the analytical plan (see Appendix C).

4.2.3 Reduction/Oxidation (REDOX)

REDOX for select SB2/3 glasses was determined using SRTC technical procedure "Determining Fe^{2+}/Fe^{3+} and Fe^{2+}/Fe_{total} Using the HP8452A Diode Array Spectrometer " (SRTC 2002c). In general, each glass was pulverized and dissolved in a sulfuric-hydrofluoric acid mixture containing ammonium vanadate (which preserves the Fe^{2+} content). Boric acid was then added to destroy iron-fluoride complexes making the Fe^{2+} available for complexation with ferrozine. Absorbance measurements for the Fe^{2+} content followed the addition of a pH 5 buffer and ferrozine reagent to form the magenta-colored ferrous-ferrozine complex. Following the addition of ascorbic acid to reduce the Fe^{3+} to Fe^{2+}, a second absorbance measurement allowed for the determination of the total Fe.

4.2.4 X-Ray Diffraction Analysis

Although visual observations for crystallization were performed and documented, representative samples for all "as-fabricated" (or quenched) and ccc SB2/3 glasses were submitted to the SRTC Analytical Development Section (ADS) for X-ray diffraction (XRD) analysis. Samples were run under conditions allowing an approximately 1.0 vol% detection limit. That is, if crystals (or undissolved solids) are present at 1.0 vol% (or greater), the diffractometer will not only be capable of detecting these crystals but will also allow a qualitative measure (i.e., determine the type of crystal[s] present). Otherwise, a characteristic high background devoid of crystalline spectral lines indicates that the glass product is amorphous.

5.0 Results

5.1 Homogeneity

Table 5-1 summarizes the visual and XRD results for the quenched and ccc SB2/3 glasses. The use of "homogeneous" (for both visual and XRD results) indicates that the sample appeared to be a single-phase system (i.e., glass with no evidence of crystallization at the associated detection limits). XRD patterns for each SB2/3 glass are shown in Appendix D.

Table 5-1. Visual and XRD Results for the SB2/3 Glasses.

Glass	Heat Treatment	Target WL	Target REDOX	Visual	XRD
SB2/3-1	Quenched	30	0.0	Homogeneous	Homogeneous
SB2/3-2	Quenched	30	0.2	Homogeneous	Homogeneous
SB2/3-3	Quenched	30	0.33	Homogeneous	Homogeneous
SB2/3-4	Quenched	35	0.0	Homogeneous	Homogeneous
SB2/3-5	Quenched	35	0.2	Homogeneous	Homogeneous
SB2/3-6	Quenched	35	0.33	Homogeneous	Homogeneous
SB2/3-7	Quenched	40	0.0	Homogeneous	Homogeneous
SB2/3-8	Quenched	40	0.2	Homogeneous	Homogeneous
SB2/3-9	Quenched	40	0.33	Homogeneous	Homogeneous
SB2/3-10	Quenched	45	0.0	Homogeneous	Homogeneous
SB2/3-11	Quenched	45	0.2	Surface Crystals	Trevorite
SB2/3-12	Quenched	45	0.33	Surface Crystals	Trevorite
SB2/3-1	CCC	30	0.0	Homogeneous	Homogeneous
SB2/3-4	CCC	35	0.0	Homogeneous	Homogeneous
SB2/3-7	CCC	40	0.0	Homogeneous	Homogeneous
SB2/3-10	CCC	45	0.0	Crystals	Trevorite

With the exception of SB2/3-11 and SB2/3-12, all of the quenched glasses were homogeneous based on both visual and XRD analysis. Trevorite ($NiFe_2O_4$) was detected in SB2/3-11 and SB2/3-12 both targeting 45% WL. As WL increases, the propensity for devitrification increases. Therefore it is not surprising that the higher WL glasses contained trevorite. It should be noted that the devitrification observed was surface crystallization and does not affect the T_L. Trevorite was also observed in the ccc version of SB2/3-10 – the fully oxidized version targeting 45% WL. Although the ΔG_P model was developed to be applied to a homogeneous glass (DWPF Waste Qualification Report [WQR] [Plodinec et al. 1995] and THERMO™ [Jantzen et al. 1995]), application to inhomogeneous glasses does have potential (and technical) merit, given that the impact of the developing secondary phase(s) is minimal to the overall performance (Peeler et al. 2002). In Section 5.4.8, the assessment of the durability model's applicability will utilize all glasses with the recognition that the use of SB2/3-11 and SB2/3-12 may not be warranted.

5.2 Assessment of REDOX: Targeted vs. Measured

All glasses for this variability study were batched with FeO and/or Fe_2O_3 in the ratio to produce the targeted REDOX value for a particular glass. Of the twelve glasses studied, eight were fabricated under reducing conditions to target REDOX values of 0.2 or 0.33 (see Table 3-5). Table 5-2 summarizes the target and measured REDOX values for each SB2/3 glass.

Table 5-2. Target vs. Measured REDOX Values for the SB2/3 Glasses.

Glass	Target	Measured Sample #1	Measured Sample #2	Measured Average	% Difference
SB2/3-01	0	0.049	0.049	0.049	-
SB2/3-02	0.2	0.211	0.235	0.223	11.5%
SB2/3-03	0.33	0.324	0.317	0.321	-2.7%
SB2/3-04	0	0.061	0.064	0.063	-
SB2/3-05	0.2	0.207	0.204	0.206	3.0%
SB2/3-06	0.33	0.321	0.318	0.320	-3.0%
SB2/3-07	0	0.038	0.045	0.042	-
SB2/3-08	0.2	0.137	0.131	0.134	-33.0%
SB2/3-09	0.33	0.280	0.289	0.285	-13.6%
SB2/3-10	0	0.040	0.042	0.041	-
SB2/3-11	0.2	0.189	0.184	0.187	-6.5%
SB2/3-12	0.33	0.257	0.289	0.273	-17.3%
EA	0.18	0.182	0.187	0.185	2.8%

The SB2/3 glasses with a targeted REDOX of 0.0 (all Fe_2O_3 and melted under fully oxidized conditions) were measured for REDOX along with the other glasses. All measured average values of REDOX for those glasses were slightly greater than 0.0, but the values were within the detection limit and there is no technical reason to believe that these glasses were not fully oxidized. Figure 5-1 shows the measured (average) REDOX data as compared to the targeted values graphically. The 45° line in Figure 5-1 represents REDOX values where the target would be identical to the measured. For the most reduced glasses (i.e., those with a targeted REDOX of 0.33), the data all fall slightly below the diagonal line. For those glasses with a targeted REDOX of 0.2, the measured values fall above as well as below the diagonal. The inference is that the experimental technique used was not as successful in maintaining the targeted partitioning of Fe^{2+} to Fe^{3+} for the most reduced glasses as for those targeting a REDOX of 0.2. Thus, the fabrication process may have resulted in slightly more oxidizing glasses than anticipated for those targeting a REDOX of 0.33. The percent differences between targeted and measured average REDOX values are also provided in Table 5-2. The largest percent difference is a miss of 33% low for SB2/3-08, a glass in the same waste loading group as SB2/3-7 and SB2/3-9 (40% WL). The results of the compositional analysis (see Table E.4 of Appendix E) suggest that the target composition was obtained. The low value (or more oxidized than targeted) may have resulted from "oxidation" during the melting process as the N_2 purge may not have been effective in maintaining the batched redox state for that specific glass. Regardless, subsequent analyses of the effects of REDOX on durability will use both measured and targeted REDOX values.

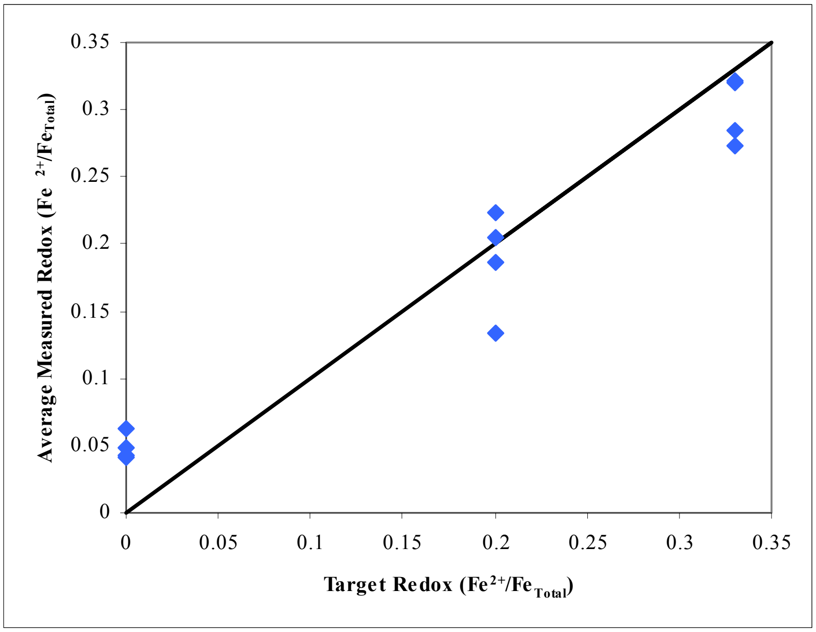
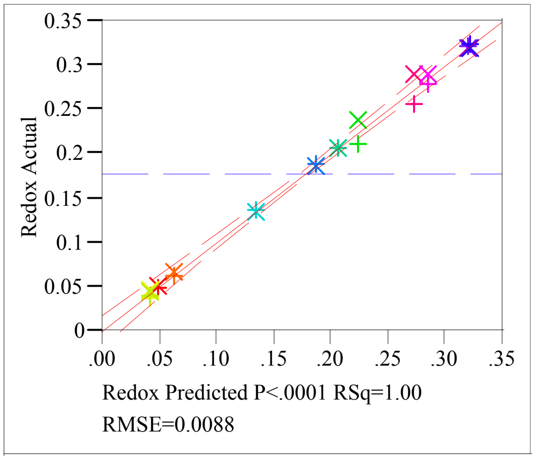


Figure 5-1. Measured (Average) vs. Targeted REDOX Values.

Figure 5-2 provides the results of a statistical analysis of the repeatability of these 24 measurements across the 12 glasses. The root mean squared error for these REDOX data is ~0.009 and this value estimates the standard deviation of the random error associated with the REDOX measurement process. This suggests that using the current analytical procedures, one can expect an acceptable random uncertainty associated with the repeatability of the REDOX measurements.



Summary of Fit

Rsquare	0.996492
RSquare Adj	0.993276
Root Mean Square Error	0.008829
Mean of Response	0.178375
Observations (or Sum Wgts)	24

Analysis of Variance

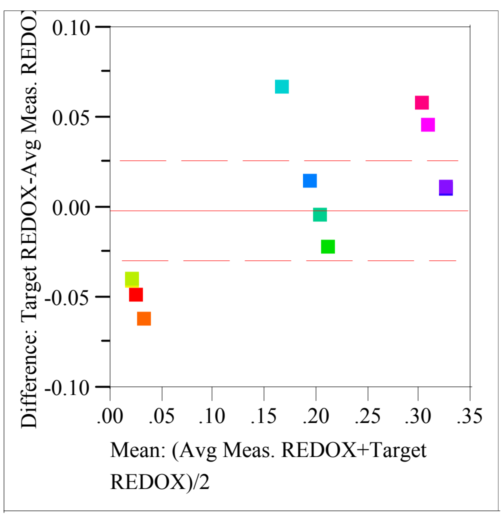
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	11	0.26573212	0.024157	309.8766
Error	12	0.00093550	0.000078	Prob > F
C. Total	23	0.26666762		<.0001

Effect Tests

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F	
Glass	11	11	0.26573212	309.8766	<.0001	

Figure 5-2. Statistical Analysis of Repeatability of REDOX Measurements Across SB2/3 Glasses.

Figure 5-3 provides the results of a statistical (paired) comparison between the (average) measured and targeted REDOX values for these twelve study glasses. The results suggest that on average the measured REDOX values are 0.002 higher than targeted but that this difference is not statistically significant at the 5% significance level. The results from the batching and fabrication used to target the REDOX of the glasses and from the analytical procedures used to measure the REDOX of the glasses indicate that the objectives of this study associated with working with reduced glasses have been met.



Target REDOX	0.17667		t-Ratio	-0.13778
Avg Meas. REDOX	0.17838		DF	11
Mean Difference	-0.0017		Prob > |t|	0.8929
Std Error	0.0124		Prob > t	0.5535
Upper95%	0.02558		Prob < t	0.4465
Lower95%	-0.029			
N	12			
Correlation	0.97337			

Figure 5-3. Average REDOX Measurements as Compared to Target.

5.3 A Statistical Review of the Chemical Composition Measurements

In this section, the measured versus targeted compositions of the twelve SB2/3 variability study (VS) glasses (SB2/3-01 through SB2/3-12) are presented and compared. The targeted compositions for these glasses are provided in Table E.1 of Appendix E (also shown in Table 3-5). A sum of oxides column is provided in this table. Notice that for the reduced glasses this sum is slightly smaller than 100% due to batching process (as discussed earlier). Chemical composition measurements for these glasses were conducted by the SRTC-ML following the analytical plan provided in Appendix B. Two dissolution methods were utilized in measuring these chemical compositions: samples prepared by LM dissolution were used to measure elemental concentrations of aluminum (Al), barium (Ba), calcium (Ca), cerium (Ce), chromium (Cr), copper (Cu), potassium (K), lanthanum (La), magnesium (Mg), manganese (Mn), sodium (Na), nickel (Ni), lead (Pb), silicon (Si), thorium (Th), titanium (Ti), zinc (Zn), and zirconium (Zr) while samples from glasses prepared by PF dissolution were used to measure elemental concentrations of boron (B), iron (Fe), lithium (Li), silicon (Si), and uranium (U). Notice that silicon is measured by both methods, while all of the other analytes are measured by only one. For each study glass, measurements were obtained from samples prepared in duplicate by each of these dissolution methods. All of the prepared samples were analyzed (twice for each element of interest) by ICP-AES (with the instrumentation being re-calibrated between the duplicate analyses).

Table E.2 in Appendix E provides the elemental concentration measurements derived from the samples prepared using LM, and Table E.3 in Appendix E 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 SRTC-ML analytical plan along with the study glasses are also provided in these two tables. The measured values for a check standard (used and reported by the SRTC-ML) are also listed in these tables; these values are not included in the subsequent analyses.

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 SRTC-ML was reduced to half of that detection limit as the oxide concentration was determined.

In the sections that follow, the analytical sequence of the measurements is 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.

5.3.1 Measurements in Analytical Sequence

Exhibit E.1 in Appendix E provides plots of the measurements generated by the SRTC-ML for samples prepared using the LM method. These plots are in analytical sequence with different symbols and colors being used to represent each of the study and standard glasses. Similar plots for samples prepared using the PF method are provided in Exhibit E.2 in Appendix E. These plots include all of the measurement data from Tables E.2 and E.3 except for the check standards. 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.

5.3.2 Batch 1 and Uranium Standard Results

In this section, the SRTC-ML measurements of the chemical compositions of the Batch 1 and uranium standard (U_{std}) glasses are reviewed. These measurements are investigated across the ICP analytical blocks, and the results are used to bias correct the measurements for the SB2/3 glasses.

Exhibit E.3 in Appendix E provides statistical analyses of the Batch 1 and U_{std} results generated by the LM prep method by analytical 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 these statistical tests for the Batch 1 standard may be summarized as follows: the Cr_2O_3 and Na_2O measurements indicate a significant ICP calibration effect on these averages at the 5% significance level. For the U_{std}, the K_2O measurements indicate a significant ICP calibration effect on these 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, and several of the oxides yield average measurements that are significantly lower (e.g., Al_2O_3, BaO, CuO, MnO, NiO, TiO_2, and ZrO_2) or higher (e.g., CaO, K_2O, and Na_2O) for one (or more frequently, both) of the standard glasses.

Exhibit E.4 in Appendix E provides a similar set of analyses for the measurements derived from samples prepared via the PF method. In this exhibit, the Fe_2O_3 and SiO_2 measurements for Batch 1 indicate a significant ICP calibration effect on these averages at the 5% significance level while the measurements for Li_2O, SiO_2, and U_3O_8 for U_{std} show a significant ICP calibration effect on these 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, and several of the oxides yield average measurements that are significantly lower (e.g., B_2O_3, Li_2O, SiO_2, and U_3O_8) for one or both of the standard glasses.

The results suggest that it may be helpful to bias correct the oxide measurements of the SB2/3 glasses for the effect of the ICP calibration on each of the analytical blocks. The basis for this bias correction is presented as part of Exhibits E.3 and E.4 – the average measurement for Batch 1 for each ICP block for Al_2O_3, B_2O_3, BaO, CaO, Cr_2O_3, CuO, Fe_2O_3, Li_2O, MgO, MnO, Na_2O, NiO, SiO_2, and TiO_2 and the average measurement for U_{std} for each ICP 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, 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 i^{th} oxide for Batch 1 (or for U_{std} if uranium). The averages and reference values are provided in Exhibits E.3 and E.4. 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, 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, 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, ThO_2, ZnO, and ZrO_2 values (i.e., once again, no bias correction was performed for this group of oxides).

5.3.3 Composition Measurements by Glass Number

Exhibits E.5 and E.6 in Appendix E provide plots of the oxide concentration measurements by Glass ID # (including both Batch 1, labeled as glass number 100 and U_{std}, labeled as glass number 101) for the measured and bias-corrected (bc) values for the LM and PF preparation methods, respectively. Different symbols and colors are used to represent the different glasses. These plots show the individual measurements across the duplicates of each preparation method and the two ICP calibrations. A review of the plots presented in these exhibits reveals the repeatability of the four individual, oxide values for each glass. No problems are evident in these plots.

More detailed discussions of the average, measured chemical compositions of the SB2/3 glasses are provided in the sections that follow.

5.3.4 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. For SiO_2, there was an additional step. The average measurement derived by LM was averaged with the average measurement derived by PF to represent the SiO_2 for each of the glasses. These determinations were conducted for both the measured and the bias-corrected data. A sum of oxides was also computed for each glass based upon both the measured and bias-corrected values. Exhibit E.7 in Appendix E 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 E.7 are offered: For nearly every SB2/3 glass the measured Al_2O_3 values and measured CaO values are greater than their respective targeted concentrations. For Fe_2O_3, MgO, and NiO the measured values for most of the study glasses fell below their respective targets for these oxides.

Table E.4 in Appendix E 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 # 101) glasses. All of the sums of oxides (both measured and bias-corrected) for the study glasses fall within the interval of 95 to 105 wt%.

Entries in Table E.4 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. However, these differences are not seen as being of practical concern.

5.4 A Statistical Review of the PCT Measurements

The SB2/3 glasses, after being batched and fabricated, were subjected to the 7-day PCT to assess their durabilities. More specifically, Method A of the PCT (ASTM C1285-2002 [ASTM 2002]) was used for these measurements. Durability is the critical product quality metric for DWPF glass variability studies. The PCTs were conducted in triplicate for each of the study glasses, which were all cooled by quenching and for select glasses additionally by ccc (Marra and Jantzen (1993)) during their fabrication. In addition, PCTs were conducted in triplicate for samples of the EA glass and for samples of the ARM glass. Blanks (samples consisting only of ASTM Type I water) were also submitted for the PCT.

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

Table F.1 in Appendix F provides the elemental leachate concentration measurements determined by the SRTC-ML for the solution samples generated by the PCTs. Measurements of an additional check standard utilized by the SRTC-ML are also included in this table. One of the quality control checkpoints for the PCT procedure is solution-weight loss over the course of the 7-day test. None of these PCT results indicated a solution-weight loss problem. Any measurement in Table F.1 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 F.1 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 F.2 in Appendix F provides the resulting measurements.

One of the important objectives of this study is the investigation of the effects of REDOX on PCTs. The SB2/3 glasses may be grouped by elemental composition with the glasses in the same group having a common (targeted) elemental composition but with different targeted REDOX values. 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 measurement process, the measurements for each glass are reviewed, comparisons are made between the results for the two heat treatments (quenched and ccc), plots are provided that explore the effects of REDOX on the PCTs for these glasses, the PCTs are normalized using the compositions (targeted, measured, and bias-corrected) presented in Table E.4, and the normalized PCTs are compared to durability predictions for these compositions generated from the current DWPF models (Jantzen et al. 1995).

5.4.1 Measurements in Analytical Sequence

Exhibits F.1 and F.2 in Appendix F provide plots of the leachate (ppm) concentrations in analytical sequence as generated by the SRTC-ML for all of the data and for only the study glasses, respectively. A different color is used for each glass (please see Exhibit F.4 for glass/color designations) with a small, solid square used to represent a fully oxidized glass, a plus being used to represent a glass with a targeted redox of 0.2, and an "x" for a targeted redox of 0.33. No problems are seen in these plots.

5.4.2 Results for the Samples of the Multi-Element Solution Standard

Exhibit F.3 in Appendix F provides analyses of the SRTC-ML measurements of the samples of the multi-element solution standard by ICP analytical (or calibration) block. An ANOVA investigating for statistically significant differences among the block averages for these samples for each element of interest is included in these exhibits. These results indicate a statistically significant (at the 5% level) difference among the Al, Fe, Li, and Na average measurements over these blocks. However, no bias correction of the PCT results for the study glasses was conducted. This approach was taken since the triplicate PCTs for a single study glass were placed in different ICP blocks. Averaging the ppm's for each set of triplicates helps to minimize the impact of the ICP effects.

Table 5-3 summarizes the average measurements and the reference values for the 4 primary elements of interest. The results indicate consistent and accurate measurements from the SRTC-ML processes used to conduct these analyses.

Table 5-3. Results from Samples of the Multi-Element Solution Standard.

Analytical Block	Avg B (ppm)	Avg Li (ppm)	Avg Na (ppm)	Avg Si (ppm)
1	20.41	10.20	84.33	47.79
2	19.95	9.56	81.64	48.49
3	20.19	9.58	80.70	48.23
Grand Average	20.19	9.78	82.22	48.17
Reference Value	20	10	81	50
% difference	0.93%	-2.21%	1.51%	-3.66%

5.4.3 Measurements by Glass Number

Exhibits F.4 and F.5 in Appendix F provide plots of the leachate concentrations for each type of submitted sample: the study glasses and the standards (the check standard, the multi-element solution standard, ARM, and blanks) with and without EA, respectively. 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. None of the values have been excluded from the calculations that follow, however.

5.4.4 Common Glass Groups Covering a Range of REDOX Values

Exhibit F.6 in Appendix F provides a closer look at the effect of REDOX on the PCTs for the SB2/3 glasses. This exhibit provides an analysis of the common log of the measurements for each of the four primary analytes versus targeted REDOX for each REDOX group. In this report, a REDOX group is defined as a set of three glasses having a common targeted, elemental composition (same WL), but varying in REDOX (0, 0.2, or 0.33). The symbols used in these plots are the same as those used earlier: a small, solid square used to represent a fully oxidized glass, a plus being used to represent a glass with a targeted redox of 0.2, and an "x" for a targeted redox of 0.33. The analysis investigates for a statistically significant trend in the common logarithm of the PCT leachate concentrations due to REDOX. At an approximate 5% significance level, the Na and Si values of Group 1 and all of the analytes for Groups 3 and 4 indicate a statistically significant trend in the PCT response due to REDOX. The practical importance of this trend will be investigated relative to the ΔG_P model in Sections 5.4.6 through 5.4.9.

5.4.5 Effects of Heat Treatments

Exhibit F.7 in Appendix F provides a look at the effect of heat treatment on the PCTs for the SB2/3 glasses. Four glasses – SB2/3-01, SB2/3-04, SB2/3-07, and SB2/3-10, were subjected to both quenched and ccc heat treatments. The common logs of the leachates concentrations for the 4 key analytes (B, Li, Na, and Si) for these two heat treatments were investigated for each of the 4 glasses. The only statistically significant (at the 5% significance level) difference between the two heat treatments is in the log(Na) values for SB2/3-10. Thus, there is no indication of an effect of practical concern between the results for the two heat treatments in these data.

5.4.6 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 F.2 of Appendix F);

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

3) Normalize using measured composition (preferred method) – 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***

3) Normalize using target composition – 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***

3) Normalize using measured bias-corrected composition – 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 F.8 in Appendix F 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) 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 for most of the pairs of the elements; the smallest correlation (93.77%) is between Na and Li for the measured data.

Table 5-4 summarizes the normalized PCTs for the glasses of this study. The targeted redox for each of the study glasses is also shown in this table.

Table 5-4. Normalized PCTs by Glass ID/Compositional View (Shaded by REDOX Group)

(Q – Quenched; ccc – Centerline Canister Cooled)

			Results from Study and Standard Glasses							
Glass ID	Targeted REDOX	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	-	see (Jantzen et al. 1995)	-0.1719	-0.1910	-0.1725	-0.5055	0.67	0.64	0.67	0.31
EA	-	see (Jantzen et al. 1995)	1.2589	0.9614	1.1312	0.5894	18.15	9.15	13.53	3.88
SB2/3-01	0	Meas. bc-Q	-0.0729	-0.0375	-0.0106	-0.2503	0.85	0.92	0.98	0.56
SB2/3-01	0	Measured-Q	-0.0579	-0.0271	-0.0290	-0.2483	0.88	0.94	0.94	0.56
SB2/3-01	0	Targeted-Q	-0.0717	-0.0379	-0.0153	-0.2540	0.85	0.92	0.97	0.56
SB2/3-01ccc	0	Meas. bc -ccc	-0.0597	-0.0101	-0.0233	-0.2371	0.87	0.98	0.95	0.58
SB2/3-01ccc	0	Measured-ccc	-0.0447	0.0004	-0.0417	-0.2351	0.90	1.00	0.91	0.58
SB2/3-01ccc	0	Targeted-ccc	-0.0584	-0.0104	-0.0279	-0.2408	0.87	0.98	0.94	0.57
SB2/3-02	0.2	Meas. bc-Q	-0.0401	-0.0147	-0.0029	-0.2388	0.91	0.97	0.99	0.58
SB2/3-02	0.2	Measured-Q	-0.0341	-0.0072	-0.0213	-0.2390	0.92	0.98	0.95	0.58
SB2/3-02	0.2	Targeted-Q	-0.0537	-0.0166	0.0015	-0.2412	0.88	0.96	1.00	0.57
SB2/3-03	0.33	Meas. bc-Q	-0.0263	0.0014	0.0152	-0.2293	0.94	1.00	1.04	0.59
SB2/3-03	0.33	Measured-Q	-0.0113	0.0118	-0.0032	-0.2273	0.97	1.03	0.99	0.59
SB2/3-03	0.33	Targeted-Q	-0.0355	0.0006	0.0148	-0.2389	0.92	1.00	1.03	0.58
SB2/3-04	0	Meas. bc-Q	-0.0100	-0.0058	0.0424	-0.2182	0.98	0.99	1.10	0.61
SB2/3-04	0	Measured-Q	-0.0039	0.0018	0.0240	-0.2183	0.99	1.00	1.06	0.60
SB2/3-04	0	Targeted-Q	-0.0080	0.0013	0.0418	-0.2180	0.98	1.00	1.10	0.61
SB2/3-04ccc	0	Meas. bc -ccc	-0.0117	0.0072	0.0130	-0.2201	0.97	1.02	1.03	0.60
SB2/3-04ccc	0	Measured-ccc	-0.0056	0.0147	-0.0054	-0.2202	0.99	1.03	0.99	0.60
SB2/3-04ccc	0	Targeted-ccc	-0.0096	0.0142	0.0125	-0.2199	0.98	1.03	1.03	0.60
SB2/3-05	0.2	Meas. bc-Q	0.0403	0.0249	0.0544	-0.2106	1.10	1.06	1.13	0.62
SB2/3-05	0.2	Measured-Q	0.0464	0.0325	0.0482	-0.2090	1.11	1.08	1.12	0.62
SB2/3-05	0.2	Targeted-Q	0.0143	0.0211	0.0560	-0.2107	1.03	1.05	1.14	0.62
SB2/3-06	0.33	Meas. bc-Q	0.0170	0.0119	0.0484	-0.2060	1.04	1.03	1.12	0.62
SB2/3-06	0.33	Measured-Q	0.0320	0.0223	0.0422	-0.2023	1.08	1.05	1.10	0.63
SB2/3-06	0.33	Targeted-Q	0.0246	0.0173	0.0527	-0.2120	1.06	1.04	1.13	0.61
SB2/3-07	0	Meas. bc-Q	0.0306	-0.0032	0.0510	-0.2244	1.07	0.99	1.12	0.60
SB2/3-07	0	Measured-Q	0.0456	0.0072	0.0448	-0.2206	1.11	1.02	1.11	0.60
SB2/3-07	0	Targeted-Q	0.0152	-0.0060	0.0553	-0.2264	1.04	0.99	1.14	0.59
SB2/3-07ccc	0	Meas. bc -ccc	0.0306	0.0044	0.0260	-0.2212	1.07	1.01	1.06	0.60
SB2/3-07ccc	0	Measured-ccc	0.0456	0.0148	0.0198	-0.2175	1.11	1.03	1.05	0.61
SB2/3-07ccc	0	Targeted-ccc	0.0152	0.0015	0.0302	-0.2232	1.04	1.00	1.07	0.60
SB2/3-08	0.2	Meas. bc-Q	0.0744	0.0252	0.0786	-0.1987	1.19	1.06	1.20	0.63
SB2/3-08	0.2	Measured-Q	0.0894	0.0356	0.0724	-0.1950	1.23	1.09	1.18	0.64
SB2/3-08	0.2	Targeted-Q	0.0590	0.0313	0.0840	-0.2027	1.15	1.07	1.21	0.63
SB2/3-09	0.33	Meas. bc-Q	0.0939	0.0490	0.0975	-0.1819	1.24	1.12	1.25	0.66
SB2/3-09	0.33	Measured-Q	0.1090	0.0594	0.0913	-0.1782	1.29	1.15	1.23	0.66
SB2/3-09	0.33	Targeted-Q	0.0754	0.0531	0.1072	-0.1882	1.19	1.13	1.28	0.65
SB2/3-10	0	Meas. bc-Q	0.1435	0.0482	0.1283	-0.1778	1.39	1.12	1.34	0.66
SB2/3-10	0	Measured-Q	0.1495	0.0558	0.1100	-0.1779	1.41	1.14	1.29	0.66
SB2/3-10	0	Targeted-Q	0.1211	0.0528	0.1242	-0.1788	1.32	1.13	1.33	0.66
SB2/3-10ccc	0	Meas. bc-ccc	0.1136	0.0589	0.0973	-0.1779	1.30	1.15	1.25	0.66
SB2/3-10ccc	0	Measured-ccc	0.1197	0.0665	0.0790	-0.1780	1.32	1.17	1.20	0.66
SB2/3-10ccc	0	Targeted-ccc	0.0913	0.0636	0.0932	-0.1789	1.23	1.16	1.24	0.66
SB2/3-11	0.2	Meas. bc-Q	0.1547	0.0723	0.1397	-0.1682	1.43	1.18	1.38	0.68
SB2/3-11	0.2	Measured-Q	0.1608	0.0798	0.1213	-0.1683	1.45	1.20	1.32	0.68
SB2/3-11	0.2	Targeted-Q	0.1482	0.0801	0.1406	-0.1651	1.41	1.20	1.38	0.68
SB2/3-12	0.33	Meas. bc-Q	0.1703	0.1056	0.1756	-0.1469	1.48	1.28	1.50	0.71
SB2/3-12	0.33	Measured-Q	0.1764	0.1131	0.1694	-0.1453	1.50	1.30	1.48	0.72
SB2/3-12	0.33	Targeted-Q	0.1720	0.1150	0.1796	-0.1448	1.49	1.30	1.51	0.72

5.4.7 Acceptability of the Study Glasses

As seen in Table 5-4, the durabilities for the SB2/3 glasses are much better than those of EA (this is indicated for a glass by its normalized leachate being smaller than that of EA). The most durable glass is SB2/3-01 with a NL [B] of 0.85 g/L (based on targeted and measured-bc compositions) while the least durable glass is SB2/3-12 with a NL [B] of 1.5 g/L (based on the measured composition). Therefore, in terms of "acceptability", the results indicate that all SB2/3 glasses produced are very acceptable glasses with respect to durability as defined by PCT.

In general, the transition from most durable to least durable follows both theory and predictions. More specifically, as the WL and/or REDOX increases, predictions indicate that durability will be negatively impacted. One issue to be assessed is the magnitude of the REDOX impact on durability (i.e., is the ΔG_i value for FeO warranted in this system?). As shown in Table 3-6, four (SB2/3-6, -9, -11, and -12) of the twelve glasses are not acceptable from a MAR assessment (all four failing the ΔG_P criterion). The NL [B] for these glasses (based on targeted compositions) are 1.06, 1.19, 1.41, and 1.49 g/L, respectively. As previously described, the general trend is that as WL increases or REDOX increases (SB2/3-11 versus SB2/3-12), the measured durability decreases – consistent with theory. However, the magnitude of that impact is minimal and is of little practical concern. For example, consider the 35% WL series which includes SB2/3-4, -5, and -6 (varying in REDOX from fully oxidized to 0.33). The NL [B] for this series of glasses transitions from 0.98 to 1.06 g/L (a difference of 0.08 g/L). Once again, the model prediction of the impact of REDOX on durability appears to be extremely conservative (SB2/3-6 is not processable based on the MAR assessment even though its measured release is 1.06 g/L).

Since the greatest impact of REDOX on durability would be at the highest WL and more reduced glasses, the 45% WL series is of interest. The NL [B]'s for this series range from 1.32 g/L (for SB2/3-10, redox of 0.0) to 1.49 g/L (for SB2/3-12, redox of 0.33). Again, the difference between the fully oxidized version and the most reduced version is only 0.17 g/L – insignificant from a practical viewpoint. Given the model-based decisions regarding the unacceptability of the two reduced glasses in this series (SB2/3-11 and SB2/3-12), the results indicate that the model is once again conservative and does not account for interactive effects that may minimize the theoretical impact of REDOX on durability.

5.4.8 Predictability of the ΔG_P model

Predictability has historically been (and is currently being) based on the 95% two-sided confidence interval (CI) for an individual PCT response as generated by the ΔG_P model (Jantzen et al. 1995). More specifically, a glass falling within the 95% CI is considered "predictable" by the ΔG_P model. However, the ability of the model to predict the PCT response is not a full and direct reflection on the ultimate decision to process a particular composition. The decision to process (i.e., to transfer the SME batch to the Melter Feed Tank (MFT) and ultimately the melter) is judged by the relationship of the measured SME products' predicted ΔG_P to the SME acceptability ΔG_P criterion at the MAR. The use of the term "processable" in this report indicates that the predicted ΔG_P value satisfies the SME acceptability criterion and would be a candidate for melter processing assuming all other constraints are satisfied.

Exhibit F.9 in Appendix F 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 (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.

Figure 5-4 provides an enhanced plot of the results for the SB2/3 glasses. In this plot all compositional views from this study are shown and the plot is modified with the PCT results from the glass warehouse for the 31 glasses found to bound the region of interest for SB2/3 blend. The open circles represent the results from the compiled database while the crosses (quenched) and open squares (ccc) represent the SB2/3 glass results. The EA (solid circle) and ARM (open diamond) results from this SB2/3 study are also shown on this plot.

In terms of predictability, all of the SB2/3 glasses (when considering both quenched and ccc) are predictable (i.e., lie within the upper and lower 95% confidence interval). In fact, the model appears to be conservative for all of the glasses with the measured releases falling below the prediction line (solid line in Figure 5-4). It should be noted that the glasses containing Trevorite are also predictable suggesting the formation of spinels had little impact on the measured response rendering the model applicable.

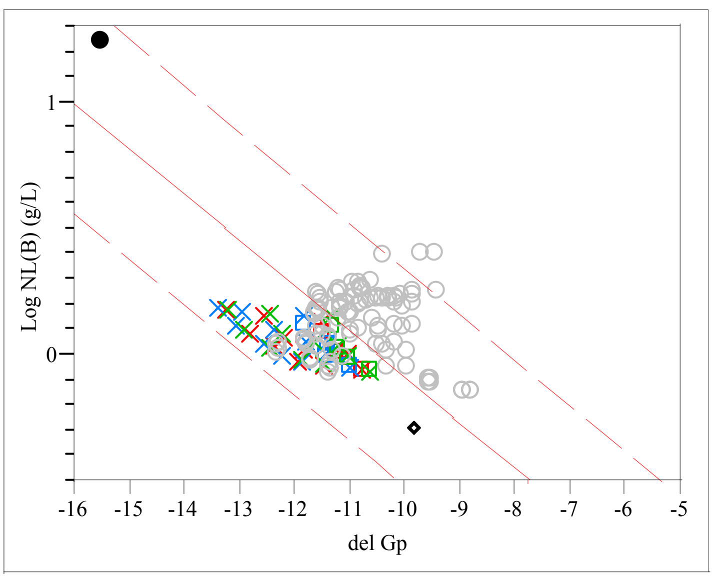


Figure 5-4. Log NL[B (g/L)] for SB2/3 VS Glasses and Results from Compiled Database.

5.4.9 Predicted versus Measured PCTs without Accounting for REDOX

Exhibit F.10 in Appendix F provides plots of the DWPF models that relate the logarithm of the normalized PCT (for each element of interest) to the linear function of a free energy of hydration, ΔG_p, without accounting for REDOX. That is, the glasses are assumed to be fully oxidized in this exhibit, which shows each REDOX group separately. All compositional views, as well as both heat treatments where available, are shown in the plots of this exhibit. Note that for each

REDOX group, the log normalized PCT releases fall within the uncertainties of the ΔG_p model, suggesting that the adjustments in the ΔG_p values to account for REDOX in this glass compositional region may be overly conservative.

To investigate this more fully, the glasses of this variability study were assessed against the PCCS MAR criteria. In this assessment, the targeted, measured, and measured bias-corrected compositional views were considered. Also, the targeted and measured REDOX values were considered. Finally, an assessment was conducted with the REDOX of the glasses not considered. The results of this assessment are provided in Table 5-5.

The results from Table 5-5 suggest that if REDOX were turned on for PCCS some of the SB2/3 glasses would not meet the MAR criteria. That is, the ΔG_p model predictions for these glasses would not be acceptable. However, the PCTs have been measured for these glasses and they have been found to be much better than that of EA. Thus, turning REDOX on in PCCS for the anticipated SB2/3 blend with Frit 418 appears to be overly conservative and could unnecessarily restrict the DWPF's operation in processing this sludge/frit system.

Table 5-5. MAR Assessment of SB2/3 Glasses.

Glass ID	Comp View	REDOX View	Failed at the MAR	ΔG_p	T_L (°C)	η (P)
SB2/3-01	target	target	-	-10.792	833.5	59.72
SB2/3-02	target	target	-	-11.494	833.5	59.72
SB2/3-03	target	target	-	-11.950	833.5	59.72
SB2/3-04	target	target	-	-11.030	898.2	47.36
SB2/3-05	target	target	-	-11.849	898.2	47.36
SB2/3-06	target	target	Del Gp	-12.381	898.2	47.36
SB2/3-07	target	target	-	-11.267	956.4	36.22
SB2/3-08	target	target	-	-12.203	956.4	36.22
SB2/3-09	target	target	Del Gp	-12.811	956.4	36.22
SB2/3-10	target	target	-	-11.505	1009.4	26.47
SB2/3-11	target	target	Del Gp	-12.558	1009.4	26.47
SB2/3-12	target	target	Del Gp	-13.242	1009.4	26.47
SB2/3-01	measured	target	-	-11.004	823.1	58.48
SB2/3-02	measured	target	-	-11.867	818.8	58.24
SB2/3-03	measured	target	-	-12.241	824.0	54.99
SB2/3-04	measured	target	-	-11.461	874.8	46.55
SB2/3-05	measured	target	-	-11.820	878.1	51.85
SB2/3-06	measured	target	Del Gp	-12.586	890.3	43.95
SB2/3-07	measured	target	-	-11.393	935.7	36.78
SB2/3-08	measured	target	Del Gp	-12.399	933.4	35.45
SB2/3-09	measured	target	Del Gp	-13.078	934.0	34.11
SB2/3-10	measured	target	-	-11.826	979.9	27.07
SB2/3-11	measured	target	Del Gp	-12.988	980.6	26.33
SB2/3-12	measured	target	Del Gp	-13.405	974.2	26.82
SB2/3-01	meas bc	target	-	-10.631	838.0	60.84
SB2/3-02	meas bc	target	-	-11.464	831.1	61.06
SB2/3-03	meas bc	target	-	-11.875	838.9	57.30
SB2/3-04	meas bc	target	-	-11.031	888.4	49.30
SB2/3-05	meas bc	target	-	-11.675	885.5	53.22
SB2/3-06	meas bc	target	Del Gp	-12.475	900.3	44.77
SB2/3-07	meas bc	target	-	-11.238	946.2	37.79
SB2/3-08	meas bc	target	-	-12.254	943.9	36.41
SB2/3-09	meas bc	target	Del Gp	-12.938	944.6	35.05
SB2/3-10	meas bc	target	-	-11.324	995.7	29.50
SB2/3-11	meas bc	target	Del Gp	-12.472	996.4	28.71
SB2/3-12	meas bc	target	Del Gp	-13.217	982.3	27.99
SB2/3-01	target	measured	-	-10.964	833.5	59.72
SB2/3-02	target	measured	-	-11.575	833.5	59.72
SB2/3-03	target	measured	-	-11.917	833.5	59.72
SB2/3-04	target	measured	-	-11.286	898.2	47.36
SB2/3-05	target	measured	-	-11.871	898.2	47.36
SB2/3-06	target	measured	-	-12.338	898.2	47.36
SB2/3-07	target	measured	-	-11.461	956.4	36.22
SB2/3-08	target	measured	-	-11.894	956.4	36.22
SB2/3-09	target	measured	Del Gp	-12.598	956.4	36.22
SB2/3-10	target	measured	-	-11.721	1009.4	26.47
SB2/3-11	target	measured	Del Gp	-12.487	1009.4	26.47
SB2/3-12	target	measured	Del Gp	-12.942	1009.4	26.47
SB2/3-01	measured	measured	-	-11.170	823.1	58.48
SB2/3-02	measured	measured	-	-11.945	818.8	58.24
SB2/3-03	Measured	measured	-	-12.208	824.0	54.99
SB2/3-04	Measured	measured	-	-11.704	874.8	46.55
SB2/3-05	Measured	Measured	-	-11.840	878.1	51.85
SB2/3-06	Measured	Measured	Del Gp	-12.544	890.3	43.95
SB2/3-07	Measured	Measured	-	-11.578	935.7	36.78
SB2/3-08	Measured	Measured	-	-12.109	933.4	35.45
SB2/3-09	Measured	Measured	Del Gp	-12.876	934.0	34.11
SB2/3-10	Measured	Measured	-	-12.027	979.9	27.07
SB2/3-11	Measured	Measured	Del Gp	-12.919	980.6	26.33
SB2/3-12	Measured	Measured	Del Gp	-13.121	974.2	26.82
SB2/3-01	meas bc	Measured	-	-10.799	838.0	60.84
SB2/3-02	meas bc	Measured	-	-11.542	831.1	61.06
SB2/3-03	meas bc	Measured	-	-11.841	838.9	57.30
SB2/3-04	meas bc	Measured	-	-11.273	888.4	49.30
SB2/3-05	meas bc	Measured	-	-11.695	885.5	53.22
SB2/3-06	meas bc	Measured	Del Gp	-12.432	900.3	44.77
SB2/3-07	meas bc	measured	-	-11.425	946.2	37.79
SB2/3-08	meas bc	measured	-	-11.961	943.9	36.41
SB2/3-09	meas bc	measured	Del Gp	-12.733	944.6	35.05
SB2/3-10	meas bc	measured	-	-11.524	995.7	29.50
SB2/3-11	meas bc	measured	Del Gp	-12.404	996.4	28.71
SB2/3-12	meas bc	measured	Del Gp	-12.935	982.3	27.99
SB2/3-01	Target	not considered	-	-10.792	833.5	59.72
SB2/3-02	Target	not considered	-	-10.792	833.5	59.72
SB2/3-03	Target	not considered	-	-10.792	833.5	59.72
SB2/3-04	Target	not considered	-	-11.030	898.2	47.36
SB2/3-05	Target	not considered	-	-11.030	898.2	47.36
SB2/3-06	Target	not considered	-	-11.030	898.2	47.36
SB2/3-07	Target	not considered	-	-11.267	956.4	36.22
SB2/3-08	Target	not considered	-	-11.267	956.4	36.22
SB2/3-09	Target	not considered	-	-11.267	956.4	36.22
SB2/3-10	Target	not considered	-	-11.505	1009.4	26.47
SB2/3-11	Target	not considered	-	-11.505	1009.4	26.47
SB2/3-12	Target	not considered	-	-11.505	1009.4	26.47
SB2/3-01	Measured	not considered	-	-11.004	823.1	58.48
SB2/3-02	Measured	not considered	-	-11.182	818.8	58.24
SB2/3-03	Measured	not considered	-	-11.084	824.0	54.99
SB2/3-04	Measured	not considered	-	-11.461	874.8	46.55
SB2/3-05	Measured	not considered	-	-11.079	878.1	51.85
SB2/3-06	Measured	not considered	-	-11.259	890.3	43.95
SB2/3-07	Measured	not considered	-	-11.393	935.7	36.78
SB2/3-08	Measured	not considered	-	-11.520	933.4	35.45
SB2/3-09	Measured	not considered	-	-11.607	934.0	34.11
SB2/3-10	Measured	not considered	-	-11.826	979.9	27.07
SB2/3-11	Measured	not considered	-	-11.974	980.6	26.33
SB2/3-12	Measured	not considered	-	-11.762	974.2	26.82
SB2/3-01	meas bc	not considered	-	-10.631	838.0	60.84
SB2/3-02	meas bc	not considered	-	-10.783	831.1	61.06
SB2/3-03	meas bc	not considered	-	-10.705	838.9	57.30
SB2/3-04	meas bc	not considered	-	-11.031	888.4	49.30
SB2/3-05	meas bc	not considered	-	-10.939	885.5	53.22
SB2/3-06	meas bc	not considered	-	-11.134	900.3	44.77
SB2/3-07	meas bc	not considered	-	-11.238	946.2	37.79
SB2/3-08	meas bc	not considered	-	-11.366	943.9	36.41
SB2/3-09	meas bc	not considered	-	-11.451	944.6	35.05
SB2/3-10	meas bc	not considered	-	-11.324	995.7	29.50
SB2/3-11	meas bc	not considered	-	-11.464	996.4	28.71
SB2/3-12	meas bc	not considered	-	-11.583	982.3	27.99

6.0 Summary

The overall objective of this variability study was to demonstrate the applicability of the ΔG_p model to the Frit 418 – SB2/3 compositional region with and without the REDOX activated as well as the acceptability of glasses in terms of their PCT response. A compositional assessment indicated only partial coverage of the projected Frit 418 – SB2/3 region with existing (and qualified) data. Therefore, to fill in compositional gaps and provide more insight into the effect of REDOX on durability, a limited test matrix was developed to supplement existing data.

Based on the results of this study, it was demonstrated that the current model is applicable (i.e., the durability responses were predicted by the model for all study glasses). The results also indicated that acceptable glasses (in terms of their normalized boron release) can be produced within this compositional region. In addition, there is no evidence that the activation of the REDOX term in the PCCS is warranted for the Frit 418 – SB2/3 system. In fact, the data show that activation could lead to extremely conservative decisions with respect to SME acceptability for this frit/sludge system.

This summary is supported by the following specific observations:

(1) The durabilities for the SB2/3 glasses are much better than those of EA. The most durable glass is SB2/3-01 with a NL [B] of 0.85 g/L (based on targeted and measured-bc compositions) while the least durable glass is SB2/3-12 with a NL [B] of 1.5 g/L (based on the measured composition). Therefore, in terms of "acceptability", the results indicate that all SB2/3 glasses produced are very acceptable glasses with respect to durability as defined by PCT. It should be noted that the NL [B] for EA is 16.695 g/L (Jantzen et al. 1993).

(2) In terms of predictability, all of the SB2/3 glasses (when considering both quenched and ccc) are predictable (i.e., lie within the upper and lower 95% confidence interval). In fact, the model appears to be conservative for all of the glasses with the measured releases falling below the prediction line.

(3) In general, the transition from most durable to least durable follows both theory and predictions. More specifically, as the WL and/or REDOX increases, predictions indicate that durability will be negatively impacted. However, the primary concern was the assessment of the magnitude of the REDOX impact on durability (i.e., is the ΔG_i value for FeO warranted in this system?). For each REDOX group, the log normalized PCT releases fall within the uncertainties of the ΔG_p model, suggesting that the adjustments in the ΔG_p values to account for REDOX in this glass compositional region may be overly conservative. Given the model-based decisions regarding the unacceptability of the select Frit 418 – SB2/3 glasses, the results indicate that the model is once again conservative and does not account for interactive effects that may minimize the theoretical impact of REDOX on durability.

7.0 Recommendation

Based on the results and observations of this study, the following recommendation is made:

- Perform SME acceptability decisions for the Frit 418 – SB2/3 system assuming a fully oxidized flowsheet (i.e., do not activate the REDOX knob on PCCS).

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Appendix A

Nominal SB2/3 Compositional Projections
(Personal Communications with G.R. Lilliston)

Table A.1 Elemental Concentrations for Tank 51-Based SB2/3 Options.[5]

	Elemental Weight % in Calcined Washed Sludge			
	Calcine for SB2/3 Combo			
	sb3_allNO2withPu 1.67exSB2a.xls	sb3_noNO2withPu 1.67exSB2a.xls	sb3_allNO2withPu 1.67exSB2a.xls	sb3_noNO2withPu 1.67exSB2a.xls
	1.23 M Na; 175 Cans Produced from Batch 2	1.24 M Na; 175 Cans Produced from Batch 2	1.23 M Na; 200 Cans Produced from Batch 2	1.24 M Na; 200 Cans Produced from Batch 2
Al	8.115629591	8.110875837	8.155072516	8.150321394
B	0	0	0	0
Ba	0.133826698	0.133748309	0.131261611	0.131185138
Ca	2.105990597	2.104757006	2.092956781	2.09173743
Ce	0.205100428	0.20498029	0.201401249	0.201283914
Cr	0.16766371	0.167565501	0.1657469	0.165650336
Cs	0	0	0	0
Cu	0.065565888	0.065527482	0.063001102	0.062964397
Fe	22.76271702	22.74938369	22.66608954	22.65288435
K	0.778102356	0.77764658	0.794194678	0.793731983
La	0.097225215	0.097168265	0.095040426	0.094985056
Li	0	0	0	0
Mg	2.149806393	2.148547138	2.152661813	2.151407679
Mn	5.158274242	5.155252768	5.214018776	5.210981104
Mo	0	0	0	0
Na	15.81421125	15.84840151	15.78798695	15.82200828
Nb	0	0	0	0
Ni	1.430345399	1.42950757	1.43530071	1.434464508
Pb	0.134471143	0.134392376	0.130320165	0.130244241
Si	1.327973549	1.327195685	1.345552843	1.344768928
Th	0.029543479	0.029526174	0.027907457	0.027891198
Ti	0.015259293	0.015250355	0.015771585	0.015762396
U	8.697595732	8.692501089	8.723887036	8.718804525
Y	0	0	0	0
Zn	0.125215453	0.125142108	0.12022102	0.120150979
Zr	0.197390649	0.197275027	0.187138292	0.187029266

[5] Personal communication with G.R. Lilliston via email dated 8/18/03.

Appendix B

Chemical Composition Analytical Plan

WESTINGHOUSE SAVANNAH RIVER COMPANY
INTEROFFICE MEMORANDUM

SRT-SCS-2003-00039

October 15, 2003

To: T. H. Lorier, 999-W

cc:
R. A. Baker, 773-42A
S. L. Marra, 999-W (es)
D. K. Peeler, 999-W
I. A. Reamer, 773-A
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: 10/20/2003

R. C. Tuckfield, Manager
Statistical Consulting Section — Date: 10/20/03

An Analytical Plan for Measuring the Chemical Compositions of Glasses for the SB2-SB3 Variability Study (U)

1.0 EXECUTIVE SUMMARY

A series of studies is being conducted by the Savannah River Technology Center (SRTC) for the Defense Waste Processing Facility (DWPF) that involves investigating issues anticipated for the processing of a blend of Sludge Batch 2 (SB2) and Sludge Batch 3 (SB3). One of the issues arising during these investigations is the necessity of a variability study to demonstrate applicability of the durability models over the compositional region anticipated for the SB2/SB3 blend. Another issue is the potential impact of REDOX on DWPF's compositional operating window for the blend. To address these issues, a variability study has been initiated to complement the results available from previous studies. A small number (12) of glasses has been selected for batching and testing to support this effort; eight (8) of these glasses are to be fabricated under reducing conditions to target REDOX values of 0.2 or 0.33.

The chemical compositions of the 12 glasses from this study are to be determined by the Savannah River Technology Center – Mobile Laboratory (SRTC-ML). This memorandum provides an analytical plan to direct and support these measurements at the SRTC-ML. REDOX is to be measured on these glasses using standard measurement techniques.

2.0 INTRODUCTION

A series of studies [1] is being conducted by the Savannah River Technology Center (SRTC) as directed [2] by the Defense Waste Processing Facility (DWPF) that involves investigating issues anticipated for the processing of a blend of Sludge Batch 2 (SB2) and Sludge Batch 3 (SB3). One of the issues arising during these investigations is the necessity of a variability study to demonstrate applicability of the durability models over the compositional region anticipated for the SB2/SB3 blend. Another issue is the potential impact of REDOX on DWPF's compositional operating window for this blend. To address these issues, a variability study has been initiated to complement the results available from previous studies. A small number (12) of glasses has been selected for batching and testing to support this effort; eight (8) of these glasses are to be fabricated under reducing conditions to target REDOX values of 0.2 or 0.33.

The chemical compositions of the 12 glasses from this study are to be determined by the Savannah River Technology Center – Mobile Laboratory (SRTC-ML). This memorandum, which is in coordination with the Analytical Study Plan [3], is intended to support these measurements at the SRTC-ML. REDOX is to be measured on these glasses using standard measurement techniques.

3.0 ANALYTICAL PLAN

The analytical procedures used by the SRTC-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 (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 aluminum (Al), barium (Ba), calcium (Ca), cerium (Ce), chromium (Cr), copper (Cu), potassium (K), lanthanum (La), magnesium (Mg), manganese (Mn), sodium (Na), nickel (Ni), lead (Pb), thorium (Th), titanium (Ti), uranium (U), zinc (Zn), and zirconium (Zr) concentrations. Samples prepared by PF are to be measured for boron (B), iron (Fe), lithium (Li), and silicon (Si). Samples dissolved by either of these two 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 and may be below 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 SRTC-ML to determine the cation concentrations for the submitted glass samples primarily involve the dissolution step in the preparation of the sample and the calibrations of the ICP-AES.

Samples of two standard glasses 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) [4] and a glass containing uranium (a uranium standard denoted by UST) are included in this analytical plan. The reference compositions of these glasses are provided in Table 1. These standards will be referred to using the short identifier provided in Table 1 in the remainder of this memo.

Table 1: Oxide Compositions of WCP Batch 1 (BCH) and Uranium Standard (UST) Glasses (wt%).

Oxide/ Anion	BCH (wt%)	UST (wt%)
Al_2O_3	4.877	4.1
B_2O_3	7.777	9.209
BaO	0.151	0.00
CaO	1.220	1.301
CdO	0.00	0.00
Cl	0.00	0.00
Cr_2O_3	0.107	0.00
Cs_2O	0.060	0.00
CuO	0.399	0.00
F	0.00	0.00
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
MoO_3	0.00	0.00
Na_2O	9.003	11.795
Nd_2O_3	0.147	0.00
NiO	0.751	1.12
P_2O_5	0.00	0.00
PbO	0.00	0.00
RuO_2	0.0214	0.00
SiO_2	50.22	45.353
SnO_2	0.00	0.00
SO_3	0.00	0.00
TiO_2	0.677	1.049
U_3O_8	0.00	2.406
ZrO_2	0.098	0.00
Sum of Oxides	99.2484	99.687

Each glass sample submitted to the SRTC-ML will be prepared in duplicate by the LM and PF dissolution methods. Each sample prepared using LM or PF 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, A01 through A12, for the 12 glasses batched for this variability study. The table provides a naming convention that is to be used in analyzing the glasses and reporting the measurements of their compositions.[6] This labeling scheme will also be used for the glasses submitted for REDOX analyses.

6 Renaming these samples helps to ensure that they will be processed as blind samples within the SRTC-ML. Table 2 is not shown in its entirety in those copies going to the SRTC-ML.

Table 2: Glass Identifiers to Establish Blind Samples for the SRTC-ML

Glass ID	Sample ID	Glass ID	Sample ID
SB2/3-01	A06	SB2/3-07	A10
SB2/3-02	A12	SB2/3-08	A03
SB2/3-03	A09	SB2/3-09	A04
SB2/3-04	A01	SB2/3-10	A11
SB2/3-05	A05	SB2/3-11	A07
SB2/3-06	A08	SB2/3-12	A02

3.1 PREPARATION OF THE SAMPLES

Each of the 12 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 $12 \cdot 2 \cdot 2 = 48$, not including the samples of the BCH and UST glass standards that are to be prepared.

Tables 3a-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.

Table 3a: LM (Lithium Metaborate) Preparation Block

LM Block
A12LM1
A04LM1
A02LM1
A08LM1
A12LM2
A02LM2
A08LM2
A10LM1
A01LM1
A09LM1
A03LM1
A04LM2
A09LM2
A05LM1
A07LM1
A01LM2
A11LM1
A10LM2
A05LM2
A03LM2
A06LM1
A11LM2
A07LM2
A06LM2

Table 3b: PF (Peroxide Fusion) Preparation Block

PF Block
A05PF1
A04PF1
A05PF2
A04PF2
A08PF1
A09PF1
A12PF1
A06PF1
A06PF2
A09PF2
A08PF2
A07PF1
A10PF1
A02PF1
A07PF2
A11PF1
A01PF1
A03PF1
A03PF2
A11PF2
A02PF2
A01PF2
A12PF2
A10PF2

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 4a and 4b, respectively. The cations to be measured are specified in the header of each of these tables. In these tables, the sample identifiers for the 12 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) ICP-AES calibration group. The identifiers for the BCH and UST samples have been modified to indicate that each of these prepared samples is to be read 3 times (mirrored in the corresponding suffix of 1, 2, or 3) per calibration block.

Tables 4a and 4b: ICP-AES Blocks & Calibration Groups for the Glass Samples By Preparation Method

Table 4a: LM Preparation Method
(Used to Measure Elemental Al, Ba, Ca, Ce, Cr, Cu, K, La, Mg, Mn, Na, Ni, Pb, Th, Ti, U, Zn, & Zr)

ICP-AES Block 1		ICP-AES Block 2	
Calibration 1	**Calibration 2**	**Calibration 1**	**Calibration 2**
BCHLM111	BCHLM121	BCHLM211	BCHLM221
USTLM111	USTLM121	USTLM211	USTLM221
A09LM21	A11LM12	A10LM11	A03LM12
A07LM11	A12LM12	A03LM11	A08LM22
A06LM11	A09LM12	A04LM11	A03LM22
A09LM11	A11LM22	A05LM11	A04LM12
A06LM21	A12LM22	A08LM11	A05LM12
A12LM11	A07LM22	A05LM21	A10LM12
BCHLM112	BCHLM122	BCHLM212	BCHLM222
USTLM112	USTLM122	USTLM212	USTLM222
A01LM11	A07LM12	A08LM21	A08LM12
A11LM11	A01LM12	A04LM21	A02LM12
A11LM21	A06LM22	A02LM11	A04LM22
A12LM21	A09LM22	A02LM21	A02LM22
A01LM21	A06LM12	A10LM21	A10LM22
A07LM21	A01LM22	A03LM21	A05LM22
BCHLM113	BCHLM123	BCHLM213	BCHLM223
USTLM113	USTLM123	USTLM213	USTLM223

Table 4b: PF Preparation Method
(Used to Measure Elemental B, Fe, Li, & Si)

ICP-AES Block 1		ICP-AES Block 2	
Calibration 1	**Calibration 2**	**Calibration 1**	**Calibration 2**
BCHPF111	BCHPF121	BCHPF211	BCHPF221
USTPF111	USTPF121	USTPF211	USTPF221
A08PF11	A08PF22	A12PF11	A01PF22
A09PF21	A08PF12	A07PF21	A02PF22
A08PF21	A04PF12	A02PF11	A05PF12
A04PF21	A03PF22	A11PF21	A05PF22
A09PF11	A03PF12	A05PF11	A07PF12
A03PF11	A10PF22	A12PF21	A12PF12
BCHPF112	BCHPF122	BCHPF212	BCHPF222
USTPF112	USTPF122	USTPF212	USTPF222
A06PF11	A06PF22	A01PF21	A02PF12
A04PF11	A09PF22	A05PF21	A01PF12
A10PF11	A04PF22	A02PF21	A07PF22
A06PF21	A06PF12	A01PF11	A12PF22
A03PF21	A10PF12	A07PF11	A11PF12
A10PF21	A09PF12	A11PF11	A11PF22
BCHPF113	BCHPF123	BCHPF213	BCHPF223
USTPF113	USTPF123	USTPF213	USTPF223

4.0 CONCLUDING COMMENTS

In summary, this analytical plan identifies two preparation blocks in Tables 3a-3b and several ICP-AES calibration blocks in Tables 4a – 4b for use by the SRTC-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 re-calibrated and the block of samples 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 SRTC-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] Herman, C. C., D. K. Peeler, and T. B. Edwards, "Task Technical/Quality Assurance Plan: Sludge Batch 3 Variability Studies with Simulants," WSRC-RP-2002-00386, Revision 0, July 11, 2002.

[2] Rios-Armstrong, M. A., "Sludge Batch 3 Variability Studies with Simulants," HLW/DWPF/TTR-02-0027, 2002.

[3] Peeler, D. K., C. C. Herman, and T. B. Edwards, "Analytical Study Plan: Sludge Batch 3 Variability Studies with Simulants," WSRC-RP-2002-00394, Revision 0, July 11, 2002.

[4] 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, Rev. 1, Volume 2, Table B.1, pp. B.9, 1995.

Appendix C

PCT Analytical Plan

SRS
savannah river site

WESTINGHOUSE SAVANNAH RIVER COMPANY
INTEROFFICE MEMORANDUM

SRT-SCS-2003-00040

October 22, 2003

To: T. H. Lorier, 999-W

cc: R. A. Baker, 773-42A
D. R. Best, 786-1A (wo)
S. L. Marra, 999-W (es)
D. K. Peeler, 999-W
I. A. Reamer, 773-A
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 — 10/24/2003 Date

R. C. Tuckfield, Manager
Statistical Consulting Section — 10/24/03 Date

An Analytical Plan for Measuring PCT Solutions from the Glasses for the SB2-SB3 Variability Study (U)

1.0 EXECUTIVE SUMMARY

A series of studies is being conducted by the Savannah River Technology Center (SRTC) for the Defense Waste Processing Facility (DWPF) that involves investigating issues anticipated for the processing of a blend of Sludge Batch 2 (SB2) and Sludge Batch 3 (SB3). One such issue is the necessity of a variability study to demonstrate applicability of the durability models over the compositional region anticipated for the SB2/SB3 blend. Another issue is the potential impact of REDOX on DWPF's compositional operating window for the blend. To address these issues, a variability study has been initiated to complement the results available from previous studies.

A small number (12) of glass compositions were selected for batching and testing to support this effort; eight (8) of these glasses were fabricated under reducing conditions to target REDOX values of 0.2 or 0.33. Two heat treatments were utilized during the fabrication of these glasses. All 12 glasses were quenched (i.e., rapidly cooled). In addition, the 4 fully oxidized glasses (i.e., those with a targeted REDOX of 0) were cooled in accordance with the centerline-canister-cooling regime.

These 16 (12 quenched and 4 centerline-canister-cooled) study glasses are to be subjected to the Product Consistency Test, or PCT. The durabilities of the study glasses are to be measured in triplicate using the PCT, the requirements of which are described in ASTM C1285-97 (Method A).

The Savannah River Technology Center-Mobile Laboratory (SRTC-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 SRTC-ML to follow in measuring the compositions of the leachate solutions resulting from the PCT procedures for the glasses.

2.0 INTRODUCTION

A series of studies [1] is being conducted by the Savannah River Technology Center (SRTC) as directed [2] by the Defense Waste Processing Facility (DWPF) that involves investigating issues anticipated for the processing of a blend of Sludge Batch 2 (SB2) and Sludge Batch 3 (SB3). One such issue is the necessity of a variability study to demonstrate applicability of the durability models over the compositional region anticipated for the SB2/SB3 blend. Another issue is the potential impact of REDOX on DWPF's compositional operating window for this blend. To address these issues, a variability study has been initiated to complement the results available from previous studies.

A small number (12) of glass compositions were selected for batching and testing to support this effort; eight (8) of these glasses were fabricated under reducing conditions to target REDOX values of 0.2 or 0.33. Two heat treatments were utilized during the fabrication of these glasses. All 12 glasses were quenched (i.e., rapidly cooled). In addition, the 4 fully oxidized glasses (i.e., those with a targeted REDOX of 0) were cooled in accordance with the centerline-canister-cooling regime.

These 16 glasses (12 quenched and 4 centerline-canister-cooled) are to be subjected to the Product Consistency Test, or PCT. The durabilities of the glasses are to be measured in triplicate using the PCT, the requirements of which are described in ASTM C1285-97 (Method A) [3]. The identifiers for the study glasses are presented in Table 1. Note that the centerline-canister-cooled glasses are denoted by a "ccc" suffix.

Table 1: Identifiers for the Study Glasses

SB2/3-01	SB2/3-07	SB2/3-01-ccc
SB2/3-02	SB2/3-08	SB2/3-04-ccc
SB2/3-03	SB2/3-09	SB2/3-07-ccc
SB2/3-04	SB2/3-10	SB2/3-10-ccc
SB2/3-05	SB2/3-11	
SB2/3-06	SB2/3-12	

This memorandum is in support of the Analytical Study Plan [4] and provides an analytical plan for the Savannah River Technology Center's Mobile Laboratory (SRTC-ML) to follow in measuring the compositions of the PCT leachate solutions for these glasses.

3.0 DISCUSSION

The study glasses are to be subjected to the PCT in triplicate. In addition to those for the 16 study glasses, triplicate PCTs are to be conducted on a sample of the Approved Reference Material (ARM) 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 56 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 SRTC-ML. The

EA leachates will be further diluted (1:10 v:v) with deionized water prior to submission to the SRTC-ML in order to prevent problems with the nebulizer.

Table 2 presents identifying codes, P01 through P56, for the individual solutions required for the PCTs of the study glasses and of the standards (EA, ARM, and blanks). This provides a naming convention that is to be used by the SRTC-ML in analyzing the solutions and reporting the relevant concentration measurements.[7]

Table 2: Identifiers for the PCT Solutions

Original Sample	Solution Identifier	Original Sample	Solution Identifier	Original Sample	Solution Identifier
SB2/3-01	P41	SB2/3-08	P27	SB2/3-07ccc	P55
SB2/3-01	P18	SB2/3-08	P56	SB2/3-07ccc	P07
SB2/3-01	P53	SB2/3-08	P10	SB2/3-07ccc	P21
SB2/3-02	P19	SB2/3-09	P40	SB2/3-10ccc	P39
SB2/3-02	P49	SB2/3-09	P47	SB2/3-10ccc	P03
SB2/3-02	P06	SB2/3-09	P32	SB2/3-10ccc	P34
SB2/3-03	P12	SB2/3-10	P31	ARM	P52
SB2/3-03	P22	SB2/3-10	P46	ARM	P37
SB2/3-03	P24	SB2/3-10	P20	ARM	P17
SB2/3-04	P38	SB2/3-11	P48	EA	P50
SB2/3-04	P45	SB2/3-11	P08	EA	P54
SB2/3-04	P02	SB2/3-11	P35	EA	P25
SB2/3-05	P36	SB2/3-12	P26	blank	P11
SB2/3-05	P42	SB2/3-12	P01	blank	P28
SB2/3-05	P13	SB2/3-12	P33		
SB2/3-06	P09	SB2/3-01ccc	P23		
SB2/3-06	P51	SB2/3-01ccc	P43		
SB2/3-06	P04	SB2/3-01ccc	P05		
SB2/3-07	P14	SB2/3-04ccc	P15		
SB2/3-07	P30	SB2/3-04ccc	P44		
SB2/3-07	P29	SB2/3-04ccc	P16		

4.0 ANALYTICAL PLAN

The analytical plan for the SRTC-ML is provided in this section. Each of the solution samples submitted to the SRTC-ML is to be analyzed only once for each of the following: aluminum, (Al), boron (B), iron (Fe), lithium (Li), sodium (Na), silicon (Si), and uranium (U). The measurements are to be made in parts per million (ppm). The analytical procedure used by the SRTC-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 SRTC-ML in Table 3. Each block requires a different calibration of the ICP-AES.

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

Table 3: ICP-AES Calibration Blocks for Leachate Measurements

Block 1	Block 2	Block 3
std-b1-1	std-b2-1	std-b3-1
P15	P56	P35
P23	P44	P53
P19	P42	P21
P14	P46	P16
P48	P03	P02
P38	P54	P04
P52	P43	P32
P50	P22	P17
P12	P37	P33
std-b1-2	std-b2-2	std-b3-2
P09	P51	P05
P26	P08	P06
P11	P18	P24
P31	P28	P29
P39	P07	P25
P40	P45	P20
P41	P47	P13
P27	P30	P10
P55	P49	P34
P36	P01	std-b3-3
std-b1-3	std-b2-3	

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 SRTC-ML to use in conducting the aluminum, (Al), boron (B), iron (Fe), lithium (Li), sodium (Na), silicon (Si), and uranium (U) concentration measurements for this PCT study. The sequencing of the activities associated with each of the steps in the analytical procedure has been randomized. The size of the blocks was selected so that 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 SRTC-ML to include any calibration check standards and/or other standards that are part of their standard operating procedures.

6.0 REFERENCES

[1] Herman, C. C., D. K. Peeler, and T. B. Edwards, "Task Technical/Quality Assurance Plan: Sludge Batch 3 Variability Studies with Simulants," WSRC-RP-2002-00386, Revision 0, July 11, 2002.

[2] Rios-Armstrong, M. A., "Sludge Batch 3 Variability Studies with Simulants," HLW/DWPF/TTR-02-0027, 2002.

[3] ASTM C1285-97, "Standard Test Methods for Determining Chemical Durability of Nuclear Waste Glasses: The Product Consistency Test (PCT)," 1997.

[4] Peeler, D. K., C. C. Herman, and T. B. Edwards, "Analytical Study Plan: Sludge Batch 3 Variability Studies with Simulants," WSRC-RP-2002-00394, Revision 0, July 11, 2002.

Appendix D

XRD Patterns

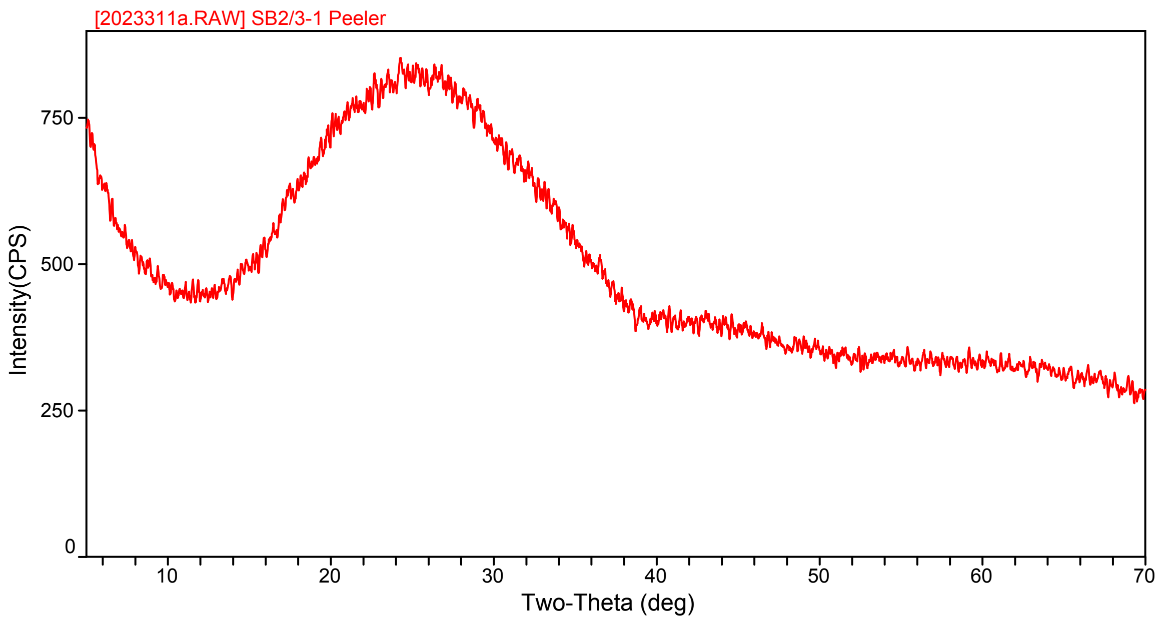


Figure D-1. XRD Pattern for SB2/3-01 Quenched.

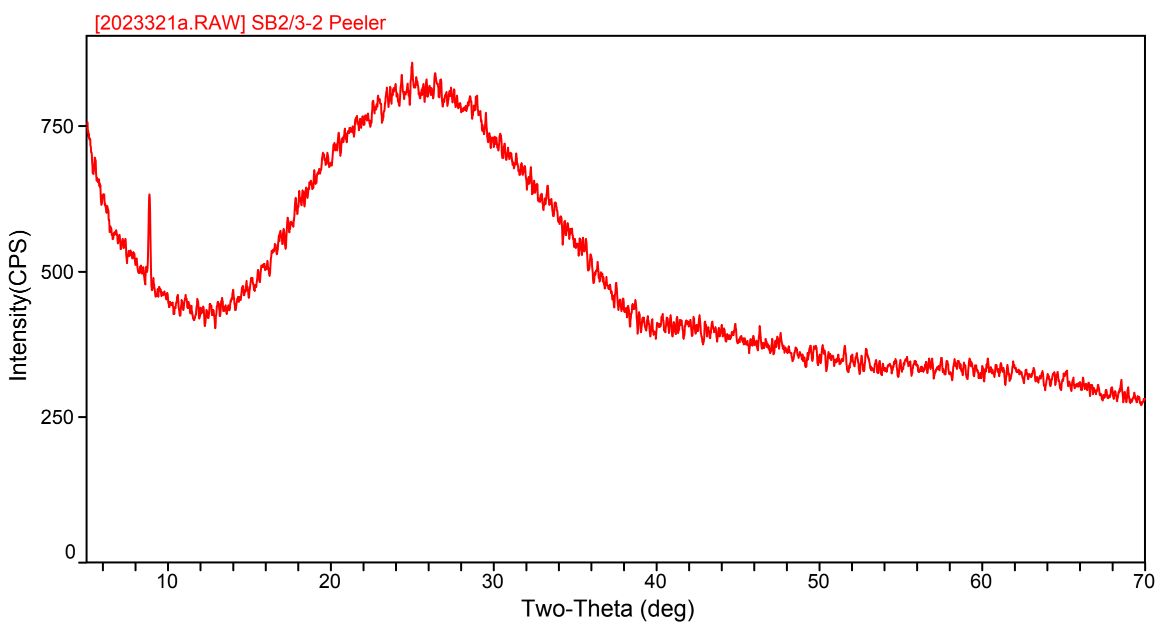


Figure D-2. XRD Pattern for SB2/3-02 Quenched.

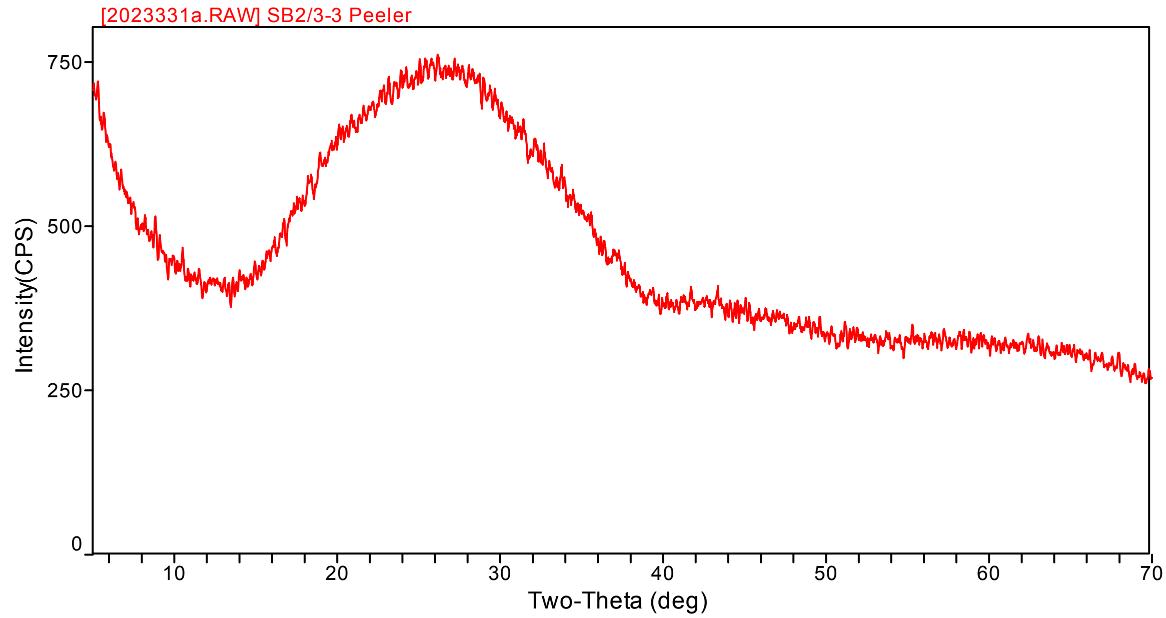


Figure D-3. XRD Pattern for SB2/3-03 Quenched.

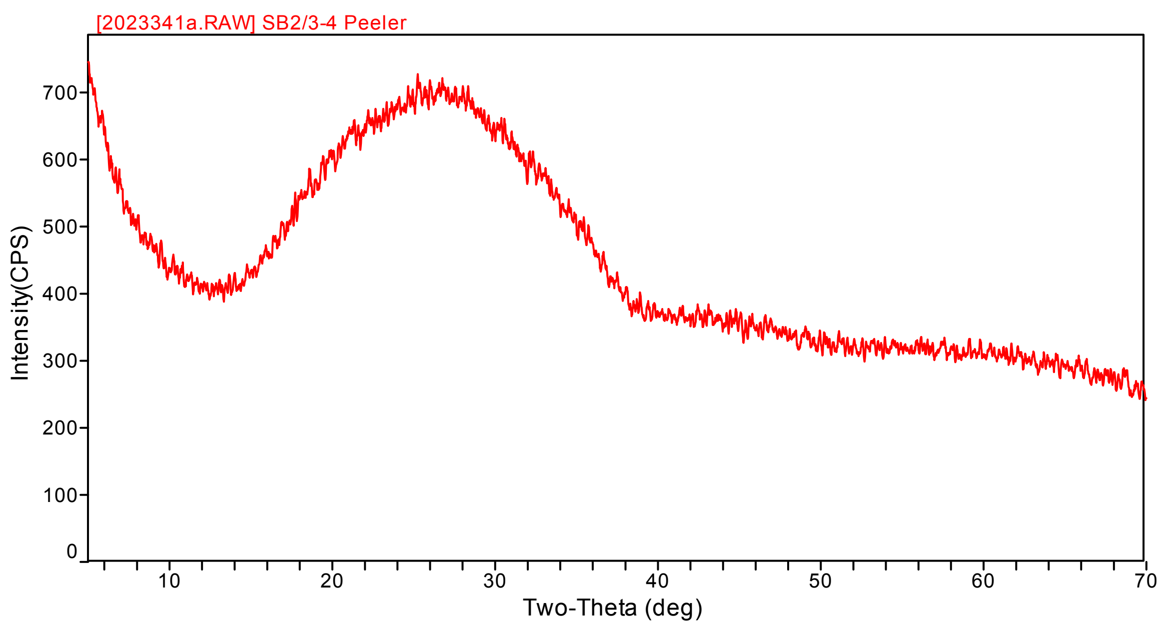


Figure D-4. XRD Pattern for SB2/3-04 Quenched.

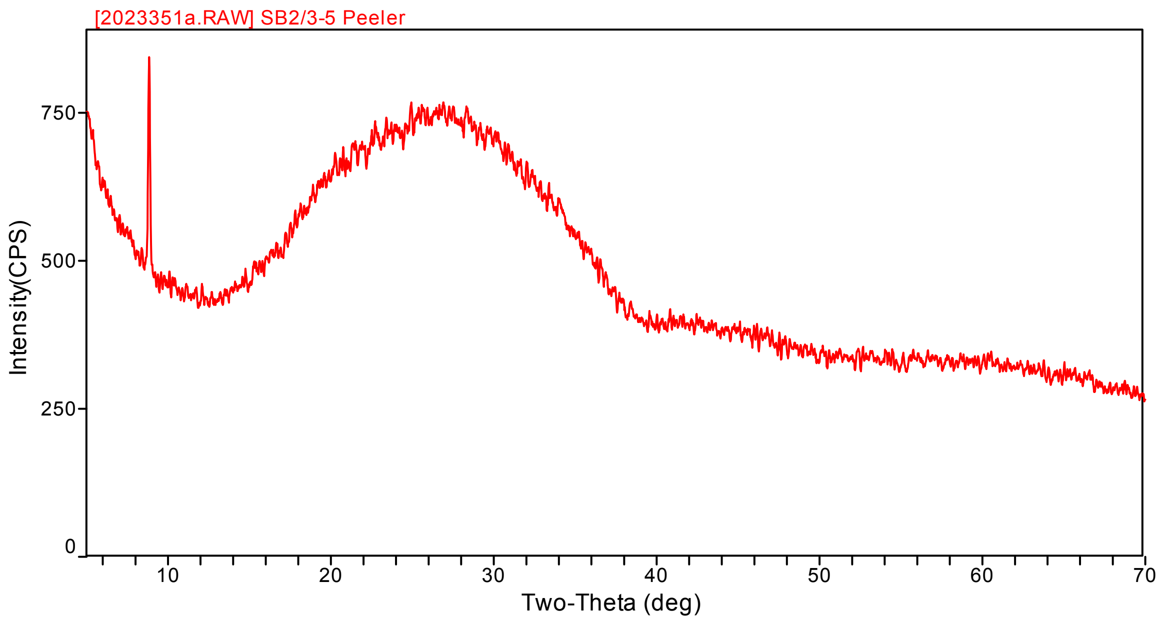


Figure D-5. XRD Pattern for SB2/3-05 Quenched.

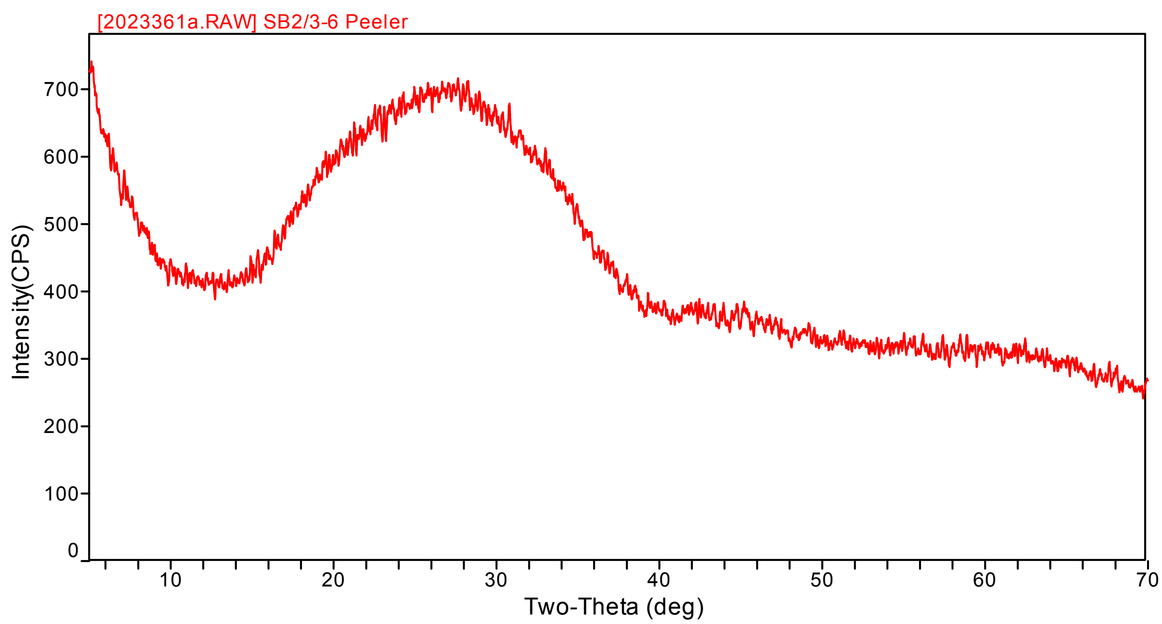


Figure D-6. XRD Pattern for SB2/3-06 Quenched.

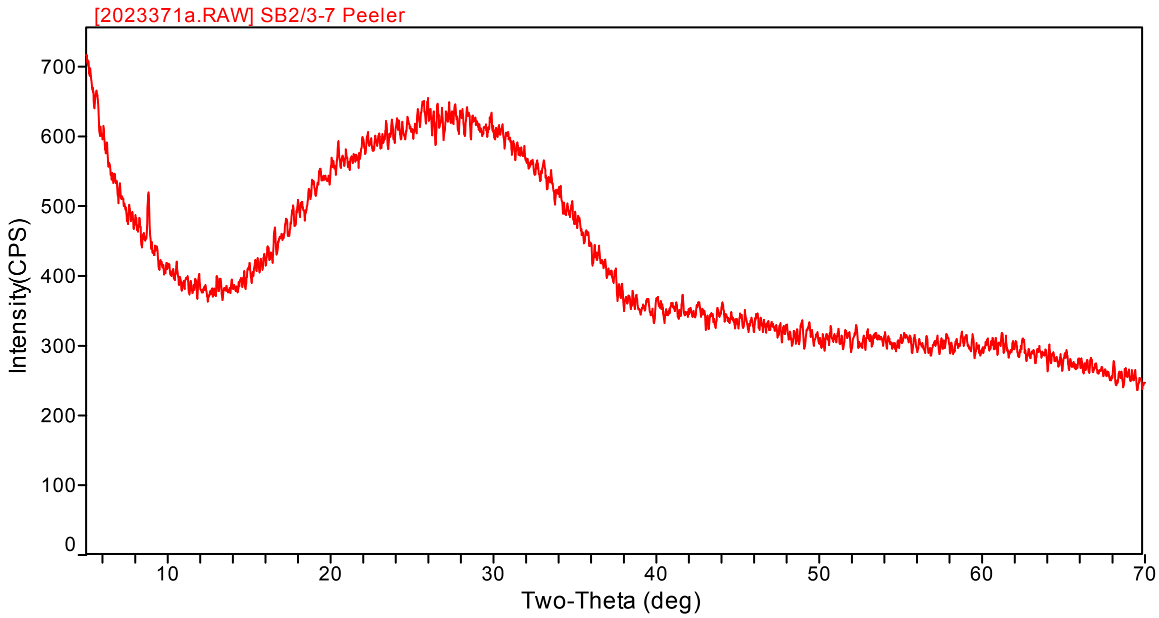


Figure D-7. XRD Pattern for SB2/3-07 Quenched.

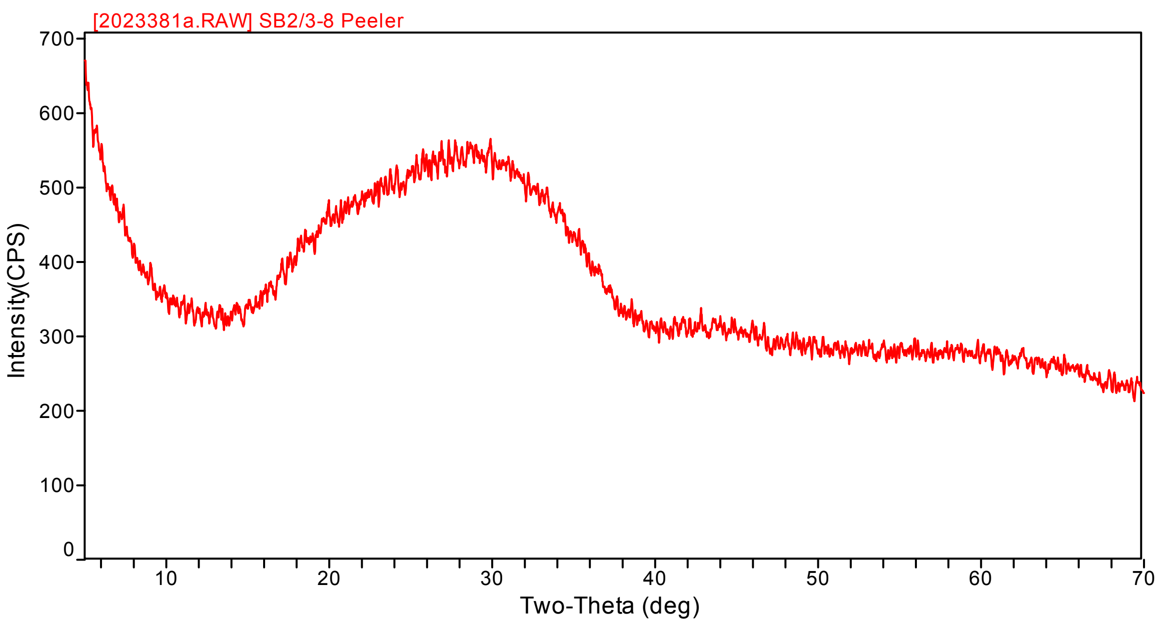


Figure D-8. XRD Pattern for SB2/3-08 Quenched.

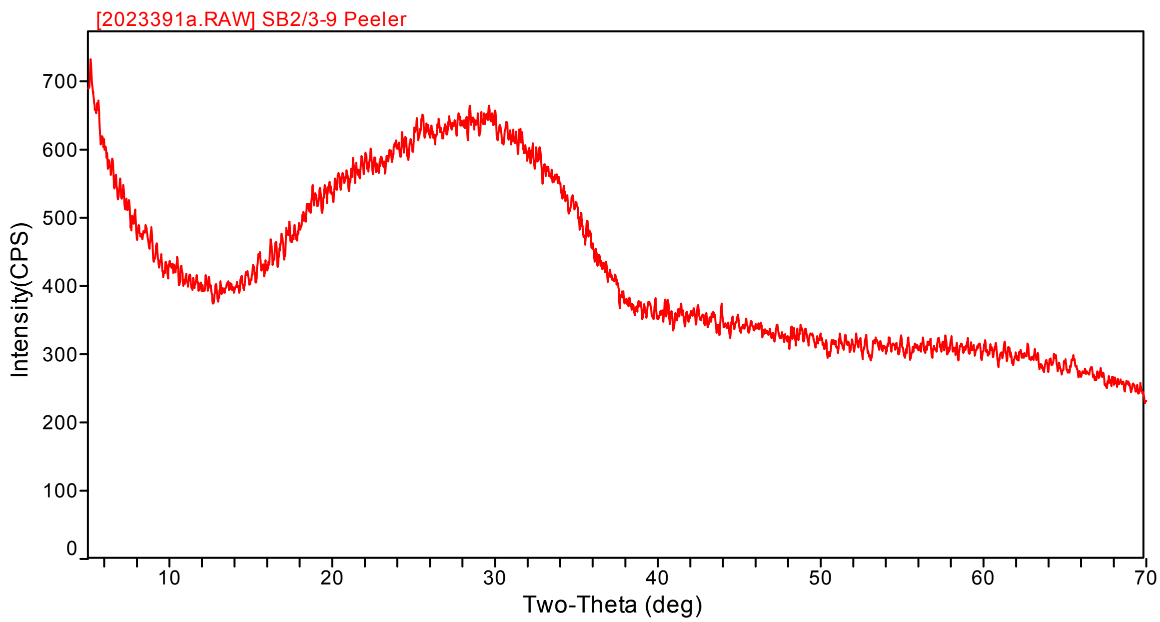


Figure D-9. XRD Pattern for SB2/3-09 Quenched.

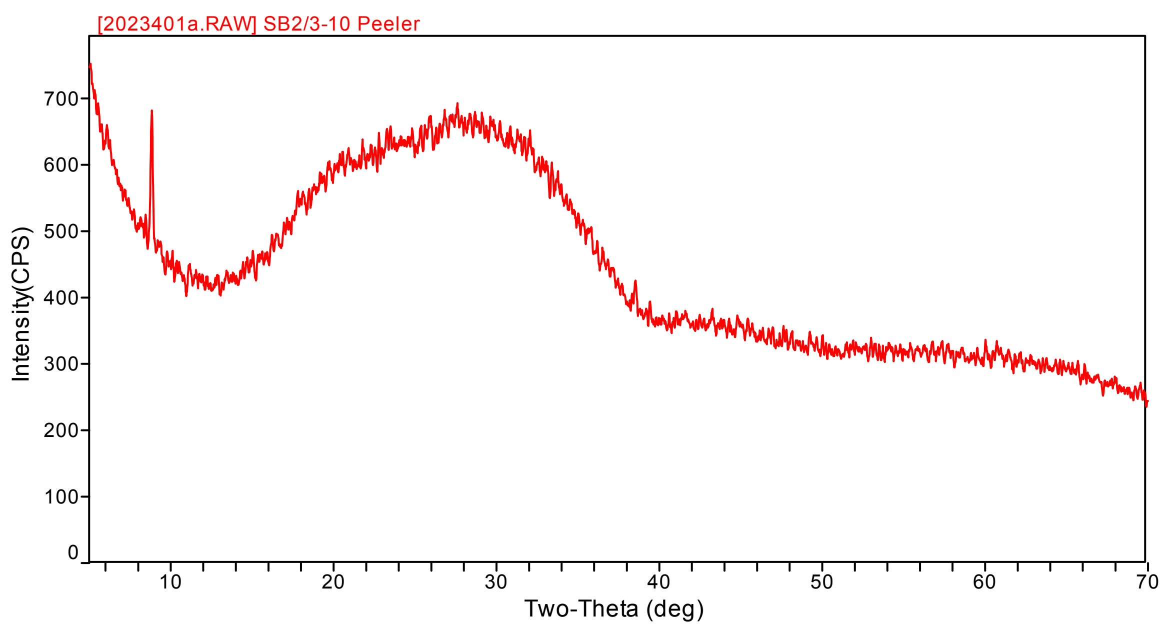


Figure D-10. XRD Pattern for SB2/3-10 Quenched.

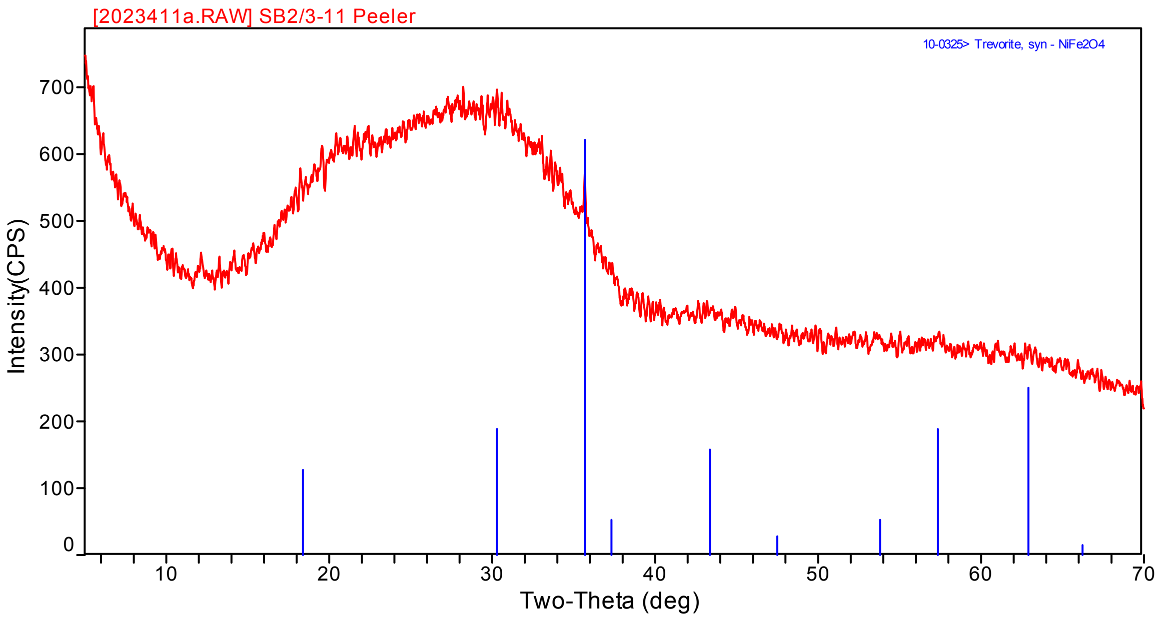


Figure D-11. XRD Pattern for SB2/3-11 Quenched.

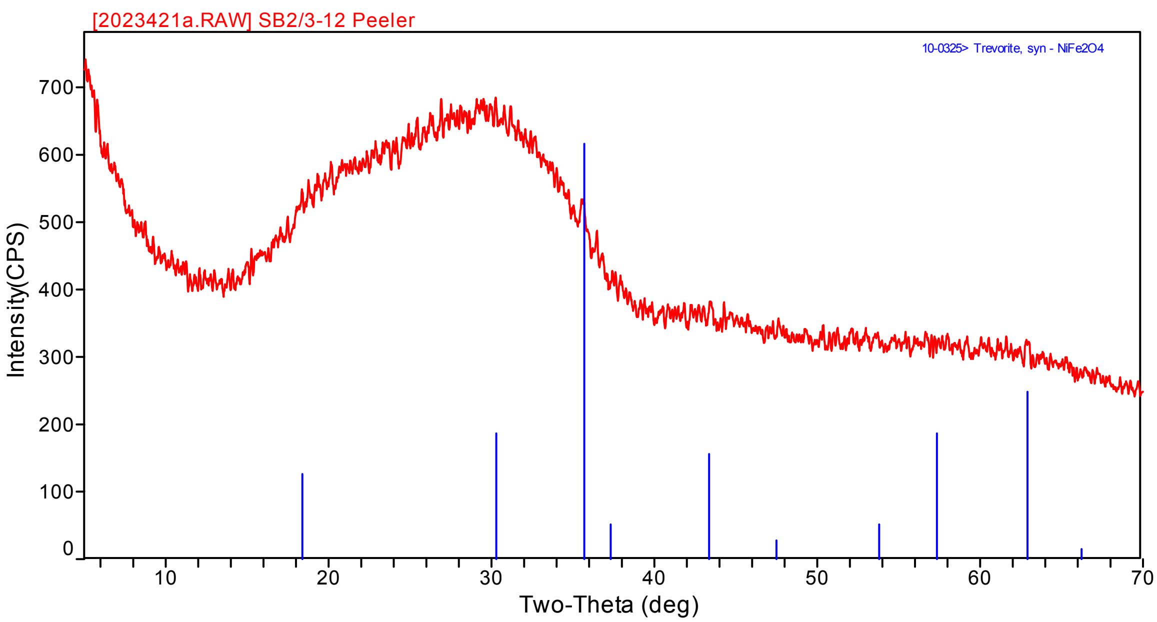


Figure D-12. XRD Pattern for SB2/3-12 Quenched.

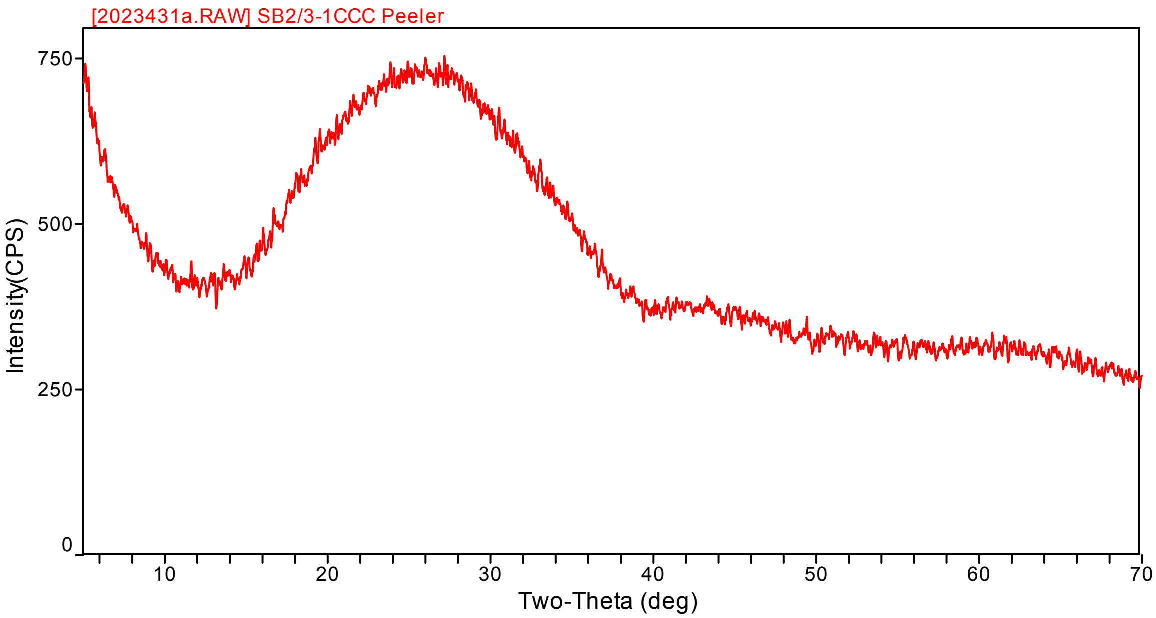


Figure D-13. XRD Pattern for SB2/3-01 CCC.

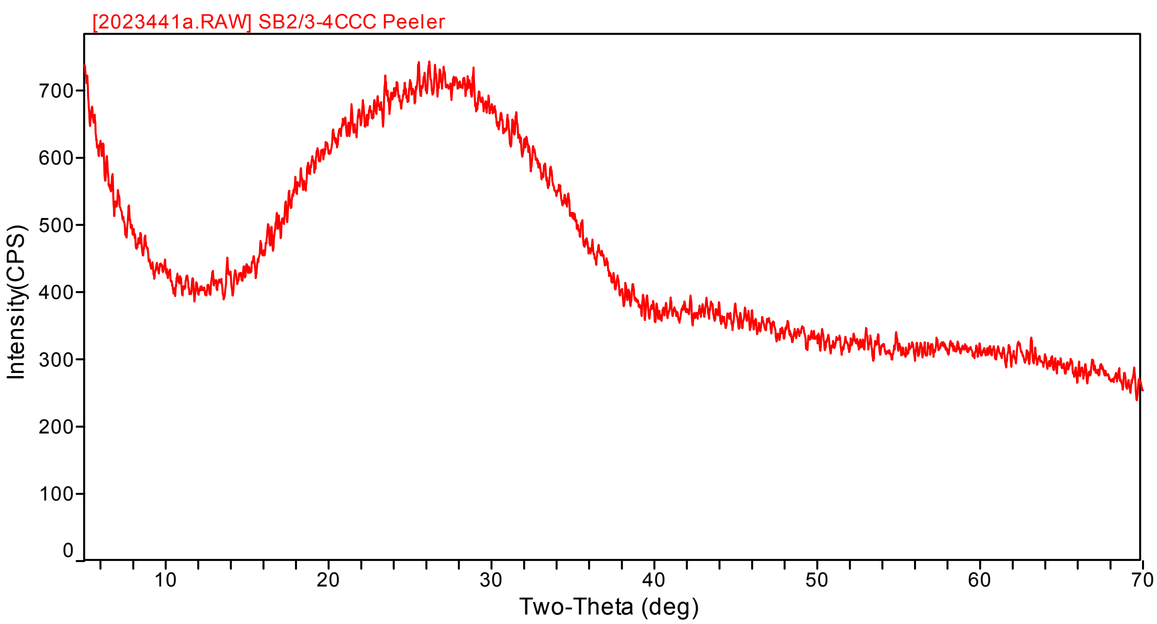


Figure D-14. XRD Pattern for SB2/3-04 CCC.

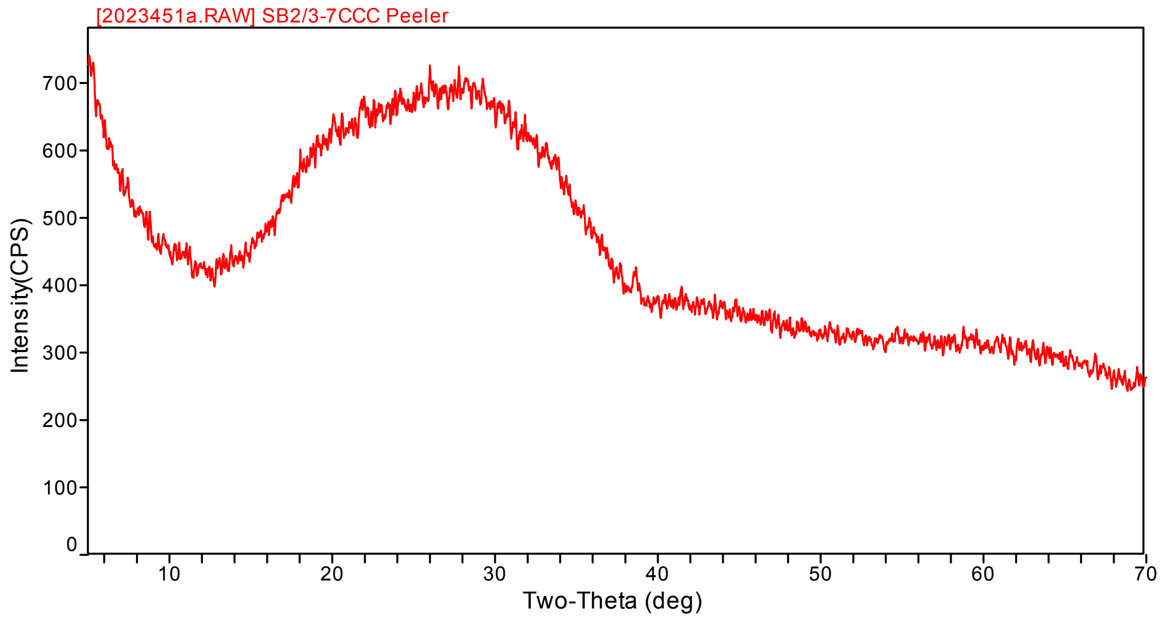


Figure D-15. XRD Pattern for SB2/3-07 CCC.

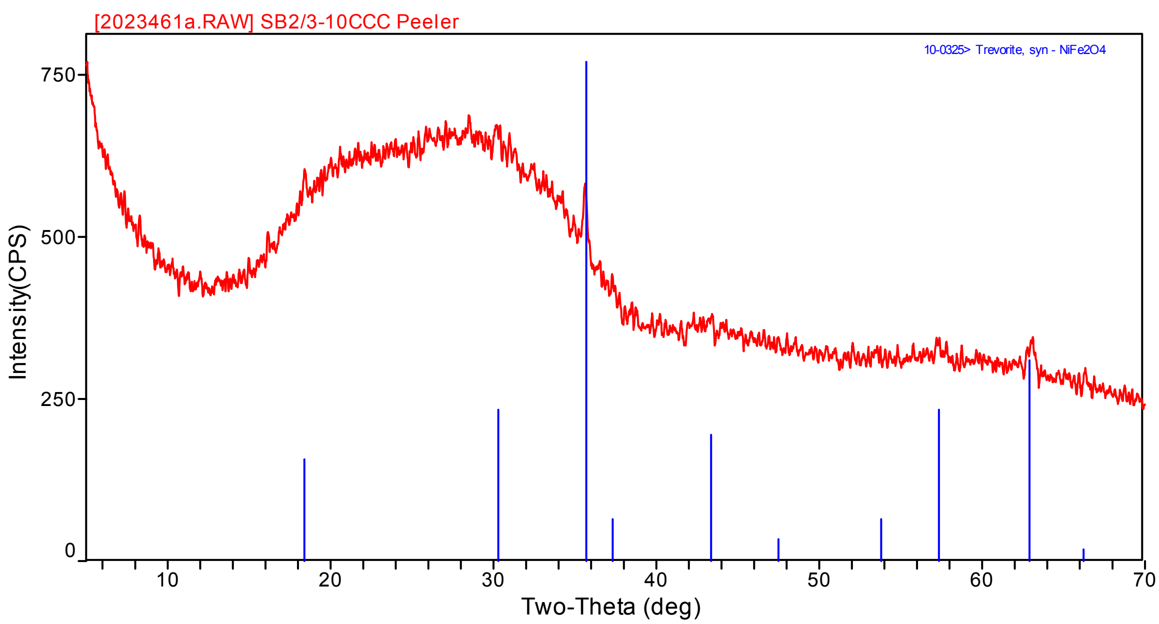


Figure D-16. XRD Pattern for SB2/3-10 CCC.

Appendix E

Tables and Exhibits Supporting the Analysis of the Chemical Composition Measurements of the SB2/3 VS Glasses

Table E.1: Targeted Oxide Concentrations (as wt%'s) for the SB2/3 Variability Study Glasses

Glass ID	Al2O3	B2O3	BaO	CaO	Ce2O3	Cr2O3	CuO	FeO	Fe2O3	K2O	La2O3	Li2O	MgO	MnO	Na2O	NiO	PbO	SiO2	ThO2	TiO2	U3O8	ZnO	ZrO2	Total
SB2/3-1	4.615	5.600	0.045	0.887	0.072	0.074	0.025	0.000	9.794	0.282	0.037	5.600	1.073	2.005	12.016	0.548	0.043	54.055	0.010	0.008	3.087	0.047	0.078	100.000
SB2/3-2	4.615	5.600	0.045	0.887	0.072	0.074	0.025	1.763	7.835	0.282	0.037	5.600	1.073	2.005	12.016	0.548	0.043	54.055	0.010	0.008	3.087	0.047	0.078	99.804
SB2/3-3	4.615	5.600	0.045	0.887	0.072	0.074	0.025	2.908	6.562	0.282	0.037	5.600	1.073	2.005	12.016	0.548	0.043	54.055	0.010	0.008	3.087	0.047	0.078	99.676
SB2/3-4	5.384	5.200	0.052	1.035	0.084	0.086	0.029	0.000	11.427	0.329	0.043	5.200	1.252	2.339	12.685	0.639	0.051	50.397	0.012	0.009	3.601	0.055	0.091	100.000
SB2/3-5	5.384	5.200	0.052	1.035	0.084	0.086	0.029	2.056	9.141	0.329	0.043	5.200	1.252	2.339	12.685	0.639	0.051	50.397	0.012	0.009	3.601	0.055	0.091	99.771
SB2/3-6	5.384	5.200	0.052	1.035	0.084	0.086	0.029	3.393	7.656	0.329	0.043	5.200	1.252	2.339	12.685	0.639	0.051	50.397	0.012	0.009	3.601	0.055	0.091	99.622
SB2/3-7	6.154	4.800	0.060	1.182	0.096	0.098	0.033	0.000	13.059	0.376	0.050	4.800	1.430	2.673	13.354	0.730	0.058	46.740	0.014	0.010	4.116	0.062	0.104	100.000
SB2/3-8	6.154	4.800	0.060	1.182	0.096	0.098	0.033	2.350	10.447	0.376	0.050	4.800	1.430	2.673	13.354	0.730	0.058	46.740	0.014	0.010	4.116	0.062	0.104	99.738
SB2/3-9	6.154	4.800	0.060	1.182	0.096	0.098	0.033	3.878	8.750	0.376	0.050	4.800	1.430	2.673	13.354	0.730	0.058	46.740	0.014	0.010	4.116	0.062	0.104	99.568
SB2/3-10	6.923	4.400	0.067	1.330	0.108	0.111	0.037	0.000	14.692	0.423	0.056	4.400	1.609	3.007	14.024	0.822	0.065	43.082	0.015	0.012	4.630	0.070	0.117	100.000
SB2/3-11	6.923	4.400	0.067	1.330	0.108	0.111	0.037	2.644	11.753	0.423	0.056	4.400	1.609	3.007	14.024	0.822	0.065	43.082	0.015	0.012	4.630	0.070	0.117	99.706
SB2/3-12	6.923	4.400	0.067	1.330	0.108	0.111	0.037	4.363	9.843	0.423	0.056	4.400	1.609	3.007	14.024	0.822	0.065	43.082	0.015	0.012	4.630	0.070	0.117	99.514

Table E.2: Measured Elemental Concentrations (wt%) for Samples Prepared Using Lithium Metaborate

Glass ID	SRTC-ML ID	Block	Sub-Block	Analytical Sequence	Al	Ba	Ca	Ce	Cr	Cu	K	La	Mg	Mn	Na	Ni	Pb	Si	Th	Ti	Zn	Zr
Soln Std	CKSTD	1	1	1	4.97	5.10	5.16	4.95	5.09	4.99	5.41	5.04	5.21	5.18	5.10	5.05	5.10	5.03	5.00	5.08	5.22	5.00
Batch 1	BCHLM111	1	1	2	2.54	0.130	0.917	<0.010	0.072	0.307	2.83	<0.010	0.873	1.34	6.88	0.561	<0.020	23.7	<0.030	0.397	<0.005	0.063
U std	USTLM111	1	1	3	2.12	<0.010	0.990	<0.010	0.166	0.009	2.69	<0.010	0.712	2.09	8.85	0.776	<0.020	21.1	<0.030	0.555	<0.005	<0.001
SB2/3-03	A09LM21	1	1	4	2.58	0.036	0.691	0.060	0.042	0.023	0.257	0.027	0.622	1.56	9.40	0.38	0.039	24.9	0.056	0.003	0.031	0.048
SB2/3-11	A07LM11	1	1	5	3.85	0.055	1.04	0.083	0.073	0.034	0.383	0.039	0.943	2.34	11.0	0.577	0.059	20.4	0.089	0.004	0.054	0.074
SB2/3-01	A06LM11	1	1	6	2.57	0.034	0.679	0.057	0.054	0.036	0.256	0.026	0.617	1.53	9.44	0.392	0.036	25.3	0.057	0.001	0.032	0.053
SB2/3-03	A09LM11	1	1	7	2.62	0.037	0.691	0.060	0.043	0.023	0.257	0.027	0.624	1.58	9.42	0.383	0.045	25.2	0.056	0.002	0.031	0.051
SB2/3-01	A06LM21	1	1	8	2.53	0.034	0.664	0.056	0.055	0.034	0.241	0.026	0.630	1.58	9.29	0.407	0.037	25.5	0.054	0.002	0.032	0.054
SB2/3-02	A12LM11	1	1	9	2.59	0.037	0.681	0.057	0.051	0.025	0.249	0.026	0.626	1.57	9.58	0.393	0.042	25.7	0.050	0.002	0.041	0.053
Batch 1	BCHLM112	1	1	10	2.54	0.128	0.913	<0.010	0.072	0.307	2.85	<0.010	0.867	1.34	7.08	0.560	<0.020	24.2	<0.030	0.394	<0.005	0.062
U std	USTLM112	1	1	11	2.13	<0.010	0.997	<0.010	0.164	0.009	2.72	<0.010	0.700	2.06	9.25	0.771	<0.020	21.4	<0.030	0.549	<0.005	<0.001
Soln Std	CKSTD	1	1	12	5.01	5.10	5.19	4.88	5.08	5	5.54	5.02	5.17	5.16	5.27	5.10	5.12	5.16	4.87	5.04	5.28	4.94
SB2/3-04	A01LM11	1	1	13	2.99	0.051	0.788	0.039	0.063	0.029	0.306	0.029	0.727	1.82	9.96	0.460	0.050	23.9	0.067	0.002	0.042	0.062
SB2/3-10	A11LM11	1	1	14	3.85	0.053	1.03	0.079	0.082	0.035	0.417	0.040	0.885	2.18	11.0	0.551	0.066	20.4	0.079	0.003	0.050	0.074
SB2/3-10	A11LM21	1	1	15	3.76	0.052	1.01	0.078	0.083	0.034	0.393	0.040	0.899	2.22	10.8	0.572	0.068	20.0	0.086	0.003	0.048	0.072
SB2/3-02	A12LM21	1	1	16	2.59	0.037	0.694	0.057	0.049	0.025	0.255	0.026	0.625	1.56	9.70	0.386	0.043	25.5	0.051	0.002	0.035	0.052
SB2/3-04	A01LM21	1	1	17	2.99	0.051	0.783	0.041	0.056	0.031	0.304	0.027	0.731	1.84	9.97	0.464	0.048	23.8	0.060	0.002	0.041	0.062
SB2/3-11	A07LM21	1	1	18	3.86	0.053	1.05	0.079	0.079	0.034	0.416	0.036	0.900	2.23	11.2	0.541	0.056	20.3	0.083	0.003	0.052	0.069
Batch 1	BCHLM113	1	1	19	2.55	0.123	0.917	<0.010	0.070	0.308	2.91	<0.010	0.830	1.30	7.16	0.545	<0.020	23.8	<0.030	0.388	<0.005	0.061
U std	USTLM113	1	1	20	2.12	<0.010	0.999	<0.010	0.160	0.009	2.76	<0.010	0.678	2.03	9.31	0.750	<0.020	21.1	<0.030	0.543	<0.005	<0.001
Soln Std	CKSTD	1	1	21	5	5.15	5.16	4.85	5.10	5.03	5.53	5.02	5.16	5.22	5.34	5.08	5.16	5.11	4.87	5.04	5.33	4.91
Soln Std	CKSTD	1	2	1	4.97	5.02	5.14	4.99	5.05	4.93	5.40	5.01	5.17	5.17	5.12	5.01	5.00	5.09	4.99	5.06	5.13	5.00
Batch 1	BCHLM121	1	2	2	2.51	0.125	0.909	<0.010	0.075	0.304	2.82	<0.010	0.858	1.33	6.89	0.552	<0.020	23.6	<0.030	0.395	<0.005	0.063
U std	USTLM121	1	2	3	2.09	<0.010	0.984	<0.010	0.162	0.009	2.66	<0.010	0.688	2.02	8.89	0.744	<0.020	20.8	<0.030	0.548	<0.005	<0.001
SB2/3-10	A11LM12	1	2	4	3.79	0.051	1.03	0.081	0.084	0.035	0.404	0.042	0.875	2.14	10.6	0.539	0.063	19.9	0.083	0.005	0.047	0.073
SB2/3-02	A12LM12	1	2	5	2.54	0.035	0.676	0.059	0.055	0.025	0.240	0.029	0.614	1.54	9.09	0.382	0.036	24.9	0.053	0.003	0.034	0.053
SB2/3-03	A09LM12	1	2	6	2.6	0.035	0.687	0.061	0.046	0.023	0.250	0.030	0.610	1.55	9.16	0.372	0.037	24.7	0.056	0.003	0.029	0.051
SB2/3-10	A11LM22	1	2	7	3.71	0.052	1.00	0.080	0.085	0.034	0.381	0.043	0.893	2.17	10.6	0.559	0.062	19.8	0.089	0.004	0.045	0.072
SB2/3-02	A12LM22	1	2	8	2.57	0.035	0.691	0.059	0.053	0.025	0.245	0.028	0.619	1.55	9.21	0.381	0.038	24.9	0.052	0.003	0.032	0.053
SB2/3-11	A07LM22	1	2	9	3.8	0.051	1.04	0.081	0.083	0.034	0.396	0.039	0.895	2.22	10.7	0.532	0.051	20.1	0.089	0.004	0.049	0.070
Batch 1	BCHLM122	1	2	10	2.51	0.123	0.910	<0.010	0.073	0.303	2.84	<0.010	0.831	1.30	6.89	0.537	<0.020	23.3	<0.030	0.390	<0.005	0.061
U std	USTLM122	1	2	11	2.07	<0.010	0.971	<0.010	0.163	0.009	2.62	<0.010	0.693	2.05	8.88	0.746	<0.020	20.7	<0.030	0.547	<0.005	<0.001
Soln Std	CKSTD	1	2	12	4.95	4.95	5.14	4.94	4.98	4.94	5.41	4.93	5.07	5.10	5.08	4.94	4.89	5.00	4.98	5.00	5.05	4.94
SB2/3-11	A07LM12	1	2	13	3.75	0.052	1.02	0.083	0.075	0.034	0.378	0.041	0.913	2.23	10.6	0.550	0.051	19.9	0.090	0.005	0.048	0.074
SB2/3-04	A01LM12	1	2	14	2.96	0.048	0.789	0.041	0.064	0.029	0.299	0.030	0.703	1.78	9.68	0.441	0.046	23.3	0.065	0.003	0.037	0.062
SB2/3-01	A06LM22	1	2	15	2.49	0.033	0.657	0.057	0.057	0.034	0.233	0.029	0.617	1.54	9.06	0.398	0.035	24.9	0.056	0.003	0.030	0.054
SB2/3-03	A09LM22	1	2	16	2.59	0.035	0.691	0.061	0.045	0.023	0.252	0.029	0.608	1.53	9.18	0.374	0.034	24.3	0.057	0.004	0.027	0.048

Table E.2: Measured Elemental Concentrations (wt%) for Samples Prepared Using Lithium Metaborate *(continued)*

Glass ID	SRTC-ML ID	Block	Sub-Block	Analytical Sequence	Al	Ba	Ca	Ce	Cr	Cu	K	La	Mg	Mn	Na	Ni	Pb	Si	Th	Ti	Zn	Zr
SB2/3-01	A06LM12	1	2	17	2.53	0.032	0.674	0.057	0.056	0.036	0.250	0.028	0.598	1.50	9.01	0.379	0.035	24.6	0.053	0.002	0.030	0.052
SB2/3-04	A01LM22	1	2	18	2.96	0.050	0.789	0.040	0.059	0.031	0.293	0.031	0.715	1.80	9.61	0.454	0.048	23.3	0.066	0.003	0.038	0.062
Batch 1	BCHLM122	1	2	19	2.51	0.126	0.902	<0.010	0.074	0.303	2.79	<0.010	0.853	1.32	6.90	0.547	<0.020	23.4	<0.030	0.393	<0.005	0.063
U std	USTLM122	1	2	20	2.09	<0.010	0.990	<0.010	0.162	0.009	2.68	<0.010	0.687	2.02	9.03	0.741	<0.020	20.7	<0.030	0.547	<0.005	<0.001
Soln Std	CKSTD	1	2	21	4.89	4.91	5.11	4.91	4.92	4.85	5.33	4.88	5.05	5.04	5.13	4.89	4.86	5.04	4.94	4.96	5.00	4.91
Soln Std	CKSTD	2	1	1	5	5.09	5.16	5.01	5.07	4.98	5.43	5.04	5.15	5.17	5.08	5.01	5.01	5.07	5.01	5.09	5.13	5.03
Batch 1	BCHLM211	2	1	2	2.54	0.127	0.926	<0.010	0.071	0.306	2.83	<0.010	0.855	1.33	6.82	0.555	<0.020	23.4	<0.030	0.395	<0.005	0.061
U std	USTLM211	2	1	3	2.09	<0.010	0.988	<0.010	0.160	0.004	2.66	<0.010	0.686	2.02	8.88	0.749	<0.020	20.8	<0.030	0.545	<0.005	<0.001
SB2/3-07	A10LM11	2	1	4	3.45	0.045	0.931	0.068	0.064	0.028	0.354	0.035	0.814	2.02	10.3	0.513	0.048	21.9	0.081	0.002	0.038	0.063
SB2/3-08	A03LM11	2	1	5	3.41	0.045	0.921	0.059	0.071	0.029	0.340	0.036	0.807	2.03	10.2	0.501	0.055	21.5	0.080	0.002	0.037	0.061
SB2/3-09	A04LM11	2	1	6	3.45	0.046	0.942	0.069	0.065	0.03	0.347	0.030	0.801	2.03	10.3	0.484	0.052	21.5	0.074	0.003	0.037	0.063
SB2/3-05	A05LM11	2	1	7	3.03	0.040	0.813	0.057	0.069	0.021	0.311	0.028	0.697	1.76	9.74	0.432	0.040	23.1	0.070	0.004	0.027	0.053
SB2/3-06	A08LM11	2	1	8	2.98	0.038	0.807	0.062	0.061	0.023	0.293	0.025	0.706	1.78	9.65	0.438	0.040	22.9	0.064	0.003	0.036	0.056
SB2/3-05	A05LM21	2	1	9	2.94	0.040	0.792	0.057	0.075	0.021	0.288	0.028	0.698	1.75	9.48	0.433	0.044	22.6	0.062	0.004	0.028	0.055
Batch 1	BCHLM212	2	1	10	2.46	0.117	0.904	<0.010	0.068	0.293	2.88	<0.010	0.843	1.28	6.83	0.534	<0.020	23.3	<0.030	0.387	<0.005	0.059
U std	USTLM212	2	1	11	2.09	<0.010	0.987	<0.010	0.158	0.004	2.66	<0.010	0.680	2.03	8.93	0.747	<0.020	20.6	<0.030	0.542	<0.005	<0.001
Soln Std	CKSTD	2	1	12	4.92	4.98	5.18	4.94	4.93	4.96	5.46	4.96	5.02	5.04	5.03	4.97	4.92	5.00	4.92	5.01	5.04	4.96
SB2/3-06	A08LM21	2	1	13	2.96	0.039	0.798	0.063	0.062	0.025	0.280	0.025	0.724	1.83	9.58	0.456	0.045	22.9	0.063	0.003	0.037	0.057
SB2/3-09	A04LM21	2	1	14	3.44	0.045	0.948	0.071	0.072	0.03	0.352	0.030	0.794	2.01	10.3	0.477	0.051	21.6	0.078	0.003	0.038	0.059
SB2/3-12	A02LM11	2	1	15	3.76	0.053	1.01	0.083	0.066	0.029	0.374	0.036	0.902	2.24	10.6	0.546	0.062	20.1	0.086	0.003	0.045	0.071
SB2/3-12	A02LM21	2	1	16	3.78	0.050	1.03	0.080	0.062	0.028	0.400	0.034	0.861	2.14	10.6	0.510	0.056	19.8	0.084	0.002	0.043	0.069
SB2/3-07	A10LM21	2	1	17	3.31	0.043	0.913	0.064	0.061	0.029	0.344	0.033	0.777	1.95	9.99	0.488	0.047	21.0	0.079	0.001	0.036	0.064
SB2/3-08	A03LM21	2	1	18	3.41	0.045	0.927	0.057	0.064	0.029	0.354	0.035	0.794	1.97	10.3	0.485	0.052	21.5	0.083	0.002	0.038	0.060
Batch 1	BCHLM213	2	1	19	2.53	0.124	0.923	<0.010	0.070	0.304	2.84	<0.010	0.847	1.31	6.78	0.546	<0.020	23.7	<0.030	0.392	<0.005	0.061
U std	USTLM213	2	1	20	2.09	<0.010	0.990	<0.010	0.159	0.004	2.69	<0.010	0.684	2.04	8.97	0.749	<0.020	21.2	<0.030	0.544	<0.005	<0.001
Soln Std	CKSTD	2	1	21	4.94	4.89	5.15	4.91	4.92	4.93	5.41	4.93	5.03	5.02	5.04	4.96	4.93	5.19	4.94	4.97	5.03	4.92
Soln Std	CKSTD	2	2	1	4.93	5.08	5.17	4.91	5.01	4.99	5.42	4.97	5.12	5.07	5.17	4.97	5.01	5.09	4.99	5.13	5.11	4.99
Batch 1	BCHLM221	2	2	2	2.48	0.121	0.911	<0.010	0.075	0.298	2.84	<0.010	0.854	1.29	6.77	0.545	<0.020	23.7	<0.030	0.394	<0.005	0.063
U std	USTLM221	2	2	3	2.09	<0.010	0.986	<0.010	0.165	0.008	2.64	<0.010	0.699	2.05	8.82	0.760	<0.020	21.0	<0.030	0.559	<0.005	<0.001
SB2/3-08	A03LM12	2	2	4	3.4	0.046	0.914	0.059	0.076	0.033	0.340	0.045	0.821	2.02	10.1	0.504	0.053	21.7	0.075	<0.001	0.041	0.062
SB2/3-06	A08LM22	2	2	5	2.94	0.040	0.787	0.063	0.066	0.028	0.278	0.034	0.736	1.84	9.62	0.463	0.046	23.2	0.059	0.001	0.041	0.060
SB2/3-08	A03LM22	2	2	6	3.41	0.045	0.921	0.059	0.070	0.034	0.353	0.045	0.808	1.99	10.1	0.490	0.052	21.6	0.080	<0.001	0.042	0.063
SB2/3-09	A04LM12	2	2	7	3.41	0.046	0.932	0.070	0.069	0.034	0.346	0.039	0.809	2.01	10.2	0.484	0.050	21.5	0.074	<0.001	0.041	0.067
SB2/3-05	A05LM12	2	2	8	3.02	0.040	0.816	0.058	0.074	0.025	0.311	0.038	0.704	1.74	9.54	0.434	0.041	23.3	0.063	0.001	0.031	0.056
SB2/3-07	A10LM12	2	2	9	3.43	0.045	0.921	0.069	0.069	0.032	0.352	0.043	0.823	2.00	10.2	0.511	0.047	22.0	0.077	<0.001	0.041	0.068
Batch 1	BCHLM222	2	2	10	2.53	0.125	0.920	<0.010	0.075	0.308	2.87	<0.010	0.861	1.32	6.65	0.553	<0.020	23.4	<0.030	0.400	<0.005	0.062
U std	USTLM222	2	2	11	2.01	<0.010	0.962	<0.010	0.159	0.008	2.68	<0.010	0.691	1.96	8.81	0.732	<0.020	20.9	<0.030	0.548	<0.005	<0.001

Table E.2: Measured Elemental Concentrations (wt%) for Samples Prepared Using Lithium Metaborate *(continued)*

Glass ID	SRTC-ML ID	Block	Sub-Block	Analytical Sequence	Al	Ba	Ca	Ce	Cr	Cu	K	La	Mg	Mn	Na	Ni	Pb	Si	Th	Ti	Zn	Zr
Soln Std	CKSTD	2	2	12	4.94	5.07	5.16	4.91	5.04	4.99	5.39	4.96	5.12	5.09	5.08	4.98	4.99	5.00	4.95	5.12	5.13	5.00
SB2/3-06	A08LM12	2	2	13	3.01	0.040	0.815	0.063	0.066	0.028	0.302	0.034	0.711	1.77	9.71	0.439	0.046	23.0	0.067	0.001	0.040	0.059
SB2/3-12	A02LM12	2	2	14	3.77	0.054	1.01	0.083	0.071	0.033	0.375	0.045	0.919	2.28	10.7	0.552	0.059	20.1	0.087	<0.001	0.049	0.075
SB2/3-09	A04LM22	2	2	15	3.42	0.046	0.937	0.070	0.076	0.033	0.346	0.040	0.810	2.00	10.3	0.485	0.050	21.4	0.075	<0.001	0.042	0.063
SB2/3-12	A02LM22	2	2	16	3.77	0.050	1.03	0.081	0.066	0.031	0.400	0.044	0.863	2.11	10.7	0.512	0.055	19.9	0.084	<0.001	0.046	0.072
SB2/3-07	A10LM22	2	2	17	3.29	0.043	0.910	0.066	0.065	0.033	0.343	0.042	0.783	1.92	10.1	0.487	0.044	21.0	0.073	<0.001	0.039	0.066
SB2/3-05	A05LM22	2	2	18	2.96	0.040	0.802	0.058	0.080	0.024	0.295	0.037	0.706	1.74	9.57	0.443	0.043	23.1	0.067	0.001	0.031	0.058
Batch 1	BCHLM223	2	2	19	2.53	0.125	0.925	<0.010	0.073	0.307	2.84	<0.010	0.848	1.30	6.80	0.549	<0.020	23.4	<0.030	0.395	<0.005	0.062
U std	USTLM223	2	2	20	2.09	<0.010	0.989	<0.010	0.163	0.008	2.66	<0.010	0.692	2.01	8.88	0.750	<0.020	20.7	<0.030	0.551	<0.005	<0.001
Soln Std	CKSTD	2	2	21	4.92	4.99	5.16	4.86	4.96	4.93	5.44	4.91	5.08	5.00	5.11	4.94	4.98	4.98	4.90	5.07	5.07	4.97

Table E.3: Measured Elemental Concentrations (wt%) for Samples Prepared Using Peroxide Fusion

Glass ID	SRTC-ML ID	Block	Sub-Block	Analytical Sequence	B	Fe	Li	Si	U
Soln Std	CKSTD	1	1	1	5.07	5.08	4.90	4.99	4.94
Batch 1	BCHPF111	1	1	2	2.47	8.52	2.03	22.9	<0.200
U std	USTPF111	1	1	3	2.78	8.73	1.37	20.3	1.93
SB2/3-06	A08PF11	1	1	4	1.60	7.75	2.37	22.8	2.96
SB2/3-03	A09PF21	1	1	5	1.64	6.75	2.52	24.2	2.50
SB2/3-06	A08PF21	1	1	6	1.54	7.79	2.36	22.9	2.96
SB2/3-09	A04PF21	1	1	7	1.34	8.55	2.18	21	3.24
SB2/3-03	A09PF11	1	1	8	1.61	6.76	2.51	24.1	2.54
SB2/3-08	A03PF11	1	1	9	1.39	8.55	2.18	21.2	3.34
Batch 1	BCHPF112	1	1	10	2.22	8.7	2.00	22.7	<0.200
U std	USTPF112	1	1	11	2.65	8.86	1.36	20.2	1.90
Soln Std	CKSTD	1	1	12	4.81	4.85	4.90	4.86	4.79
SB2/3-01	A06PF11	1	1	13	1.72	6.48	2.52	24.5	2.50
SB2/3-09	A04PF11	1	1	14	1.40	8.76	2.18	21	3.30
SB2/3-07	A10PF11	1	1	15	1.41	8.74	2.13	21.6	3.42
SB2/3-01	A06PF21	1	1	16	1.61	6.65	2.52	24.7	2.45
SB2/3-08	A03PF21	1	1	17	1.38	8.66	2.21	21.4	3.33
SB2/3-07	A10PF21	1	1	18	1.37	8.67	2.17	21.6	3.32
Batch 1	BCHPF113	1	1	19	2.22	8.96	1.98	23	<0.200
U std	USTPF113	1	1	20	2.65	9.15	1.35	20.4	1.87
Soln Std	CKSTD	1	1	21	5.04	5.18	4.90	4.99	4.87
Soln Std	CKSTD	1	2	1	5.17	5.09	4.96	5.02	4.97
Batch 1	BCHPF121	1	2	2	2.57	9.1	2.02	23.3	<0.200
U std	USTPF121	1	2	3	2.86	9.31	1.40	21	2.01
SB2/3-06	A08PF22	1	2	4	1.62	7.85	2.42	23.2	3.04
SB2/3-06	A08PF12	1	2	5	1.59	8.01	2.40	23.4	3.10
SB2/3-09	A04PF12	1	2	6	1.42	8.93	2.21	21.5	3.45
SB2/3-08	A03PF22	1	2	7	1.40	8.58	2.22	21.4	3.44
SB2/3-08	A03PF12	1	2	8	1.39	8.53	2.22	21.4	3.44
SB2/3-07	A10PF22	1	2	9	1.37	8.57	2.20	21.6	3.42
Batch 1	BCHPF122	1	2	10	2.24	8.97	2.01	23.1	<0.200
U std	USTPF122	1	2	11	2.71	9.12	1.39	20.7	2.01
Soln Std	CKSTD	1	2	12	5.06	5.1	4.96	5.03	5.02
SB2/3-01	A06PF22	1	2	13	1.77	6.73	2.57	25.1	2.59
SB2/3-03	A09PF22	1	2	14	1.68	6.95	2.57	24.9	2.62
SB2/3-09	A04PF22	1	2	15	1.36	8.57	2.22	21.3	3.36
SB2/3-01	A06PF12	1	2	16	1.64	6.63	2.54	24.9	2.58
SB2/3-07	A10PF12	1	2	17	1.41	8.85	2.15	21.8	3.56
SB2/3-03	A09PF12	1	2	18	1.65	6.92	2.54	24.5	2.64
Batch 1	BCHPF122	1	2	19	2.28	9.06	2.01	23.4	<0.200
U std	USTPF122	1	2	20	2.67	9.12	1.37	20.7	2.00
Soln Std	CKSTD	1	2	21	5.05	5.23	4.95	5.09	5.06
Soln Std	CKSTD	2	1	1	5.16	5.05	4.97	5.01	5.03
Batch 1	BCHPF211	2	1	2	2.60	8.97	2.01	23.3	<0.200
U std	USTPF211	2	1	3	2.87	9.07	1.38	20.6	2.02
SB2/3-02	A12PF11	2	1	4	1.75	6.64	2.53	24.9	2.59
SB2/3-11	A07PF21	2	1	5	1.37	9.86	2.02	20.4	3.96
SB2/3-12	A02PF11	2	1	6	1.33	9.58	2.04	20.3	3.81
SB2/3-10	A11PF21	2	1	7	1.29	9.57	2.02	20.3	3.88
SB2/3-05	A05PF11	2	1	8	1.44	7.04	2.29	24.3	2.87
SB2/3-02	A12PF21	2	1	9	1.64	6.79	2.56	25.4	2.56
Batch 1	BCHPF212	2	1	10	2.31	9.27	2.02	23.6	<0.200
U std	USTPF212	2	1	11	2.74	9.38	1.38	20.9	2.03
Soln Std	CKSTD	2	1	12	5.05	5.27	5.00	5.07	5.03
SB2/3-04	A01PF21	2	1	13	1.66	7.59	2.41	23.6	3.03
SB2/3-05	A05PF21	2	1	14	1.59	7.57	2.42	23.7	3.02
SB2/3-12	A02PF21	2	1	15	1.35	10.1	2.07	20.7	3.90
SB2/3-04	A01PF11	2	1	16	1.57	7.82	2.44	24	3.07

Table E.3: Measured Elemental Concentrations (wt%) for Samples Prepared Using Peroxide Fusion *(continued)*

Glass ID	SRTC-ML ID	Block	Sub-Block	Analytical Sequence	B	Fe	Li	Si	U
SB2/3-11	A07PF11	2	1	17	1.32	10	2.07	20.7	3.91
SB2/3-10	A11PF11	2	1	18	1.31	9.86	2.04	20.4	3.89
Batch 1	BCHPF213	2	1	19	2.31	9.32	2.03	23.7	<0.200
U std	USTPF213	2	1	20	2.76	9.43	1.39	21	2.05
Soln Std	CKSTD	2	1	21	5.15	5.34	5.05	5.14	5.12
Soln Std	CKSTD	2	2	1	5.19	5.13	4.97	5.03	5.04
Batch 1	BCHPF221	2	2	2	2.56	8.89	2.02	23.1	<0.200
U std	USTPF221	2	2	3	2.81	9.06	1.38	20.5	1.96
SB2/3-04	A01PF22	2	2	4	1.58	7.37	2.39	23.3	2.97
SB2/3-12	A02PF22	2	2	5	1.33	9.73	2.05	20.3	3.84
SB2/3-05	A05PF12	2	2	6	1.45	6.99	2.29	24.3	2.87
SB2/3-05	A05PF22	2	2	7	1.52	7.3	2.41	23.3	3.03
SB2/3-11	A07PF12	2	2	8	1.30	9.8	2.05	20.2	3.88
SB2/3-02	A12PF12	2	2	9	1.61	6.63	2.53	24.6	2.51
Batch 1	BCHFP222	2	2	10	2.27	8.93	2.03	23.2	<0.200
U std	USTPF222	2	2	11	2.70	9.04	1.38	20.5	1.96
Soln Std	CKSTD	2	2	12	5.09	5.11	5.01	5.02	5.09
SB2/3-12	A02PF12	2	2	13	1.40	9.47	2.05	20.1	3.77
SB2/3-04	A01PF12	2	2	14	1.59	7.54	2.41	23.4	2.99
SB2/3-11	A07PF22	2	2	15	1.32	9.9	2.04	20.3	3.94
SB2/3-02	A12PF22	2	2	16	1.65	6.68	2.56	25.2	2.55
SB2/3-10	A11PF12	2	2	17	1.26	9.45	2.03	20	3.88
SB2/3-10	A11PF22	2	2	18	1.26	9.48	2.03	20	3.83
Batch 1	BCHPF223	2	2	19	2.24	8.82	2.02	22.9	<0.200
U std	USTPF223	2	2	20	2.67	8.97	1.39	20.4	1.99
Soln Std	CKSTD	2	2	21	4.94	5	4.97	4.98	5.03

Table E.4: Average Measured and Bias-Corrected Chemical Compositions Versus Targeted Compositions by Oxide by Variability Study (VS) Glass Number

(100-Batch 1; 101-U std)

VS Glass #	VS Glass ID	Oxide	Measured (wt%)	Measured Bias-Corrected (wt%)	Targeted (wt%)	Diff of Measured	Diff of Meas BC	% Diff of Measured	% Diff of Meas BC
1	SB2/3-01	Al2O3	4.7804	4.8834	4.6152	0.1652	0.2682	3.58%	5.81%
1	SB2/3-01	B2O3	5.4255	5.6162	5.6000	-0.1745	0.0162	-3.12%	0.29%
1	SB2/3-01	BaO	0.0371	0.0399	0.0450	-0.0079	-0.0051	-17.50%	-11.34%
1	SB2/3-01	CaO	0.9354	0.8949	0.8868	0.0486	0.0081	5.48%	0.92%
1	SB2/3-01	Ce2O3	0.0665	0.0665	0.0723	-0.0058	-0.0058	-8.06%	-8.06%
1	SB2/3-01	Cr2O3	0.0811	0.0817	0.0738	0.0073	0.0079	9.92%	10.74%
1	SB2/3-01	CuO	0.0438	0.0457	0.0246	0.0192	0.0211	78.10%	85.93%
1	SB2/3-01	Fe2O3	9.4682	9.5712	9.7940	-0.3258	-0.2228	-3.33%	-2.27%
1	SB2/3-01	K2O	0.2951	0.2870	0.2823	0.0128	0.0047	4.54%	1.66%
1	SB2/3-01	La2O3	0.0320	0.0320	0.0372	-0.0052	-0.0052	-14.09%	-14.09%
1	SB2/3-01	Li2O	5.4630	5.5959	5.6000	-0.1370	-0.0041	-2.45%	-0.07%
1	SB2/3-01	MgO	1.0206	1.0251	1.0728	-0.0522	-0.0477	-4.87%	-4.45%
1	SB2/3-01	MnO	1.9852	2.0078	2.0046	-0.0194	0.0032	-0.97%	0.16%
1	SB2/3-01	Na2O	12.4016	11.8882	12.0158	0.3858	-0.1276	3.21%	-1.06%
1	SB2/3-01	NiO	0.5014	0.5376	0.5478	-0.0464	-0.0102	-8.48%	-1.85%
1	SB2/3-01	PbO	0.0385	0.0385	0.0435	-0.0050	-0.0050	-11.47%	-11.47%
1	SB2/3-01	SiO2	53.3488	53.6004	54.0550	-0.7062	-0.4546	-1.31%	-0.84%
1	SB2/3-01	ThO2	0.0626	0.0626	0.0102	0.0524	0.0524	513.58%	513.58%
1	SB2/3-01	TiO2	0.0033	0.0034	0.0078	-0.0045	-0.0044	-57.23%	-55.81%
1	SB2/3-01	U3O8	2.9834	3.1168	3.0870	-0.1036	0.0298	-3.36%	0.96%
1	SB2/3-01	ZnO	0.0386	0.0386	0.0468	-0.0082	-0.0082	-17.55%	-17.55%
1	SB2/3-01	ZrO2	0.0719	0.0719	0.0777	-0.0058	-0.0058	-7.43%	-7.43%
1	SB2/3-01	Sum of Oxides	99.0840	99.5053	100.0001	-0.9162	-0.4948	-0.92%	-0.49%
2	SB2/3-02	Al2O3	4.8607	4.9655	4.6152	0.2456	0.3503	5.32%	7.59%
2	SB2/3-02	B2O3	5.3531	5.4281	5.6000	-0.2469	-0.1719	-4.41%	-3.07%
2	SB2/3-02	BaO	0.0402	0.0432	0.0450	-0.0048	-0.0018	-10.68%	-4.02%
2	SB2/3-02	CaO	0.9592	0.9177	0.8868	0.0724	0.0309	8.16%	3.48%
2	SB2/3-02	Ce2O3	0.0679	0.0679	0.0723	-0.0044	-0.0044	-6.04%	-6.04%
2	SB2/3-02	Cr2O3	0.0760	0.0765	0.0738	0.0022	0.0027	2.99%	3.71%
2	SB2/3-02	CuO	0.0313	0.0327	0.0246	0.0067	0.0081	27.22%	32.81%
2	SB2/3-02	Fe2O3	9.5575	9.5034	9.7940	-0.2365	-0.2906	-2.41%	-2.97%
2	SB2/3-02	K2O	0.2978	0.2896	0.2823	0.0155	0.0073	5.50%	2.59%
2	SB2/3-02	La2O3	0.0320	0.0320	0.0372	-0.0052	-0.0052	-14.09%	-14.09%
2	SB2/3-02	Li2O	5.4791	5.5755	5.6000	-0.1209	-0.0245	-2.16%	-0.44%
2	SB2/3-02	MgO	1.0297	1.0343	1.0728	-0.0431	-0.0385	-4.02%	-3.59%
2	SB2/3-02	MnO	2.0078	2.0307	2.0046	0.0032	0.0261	0.16%	1.30%
2	SB2/3-02	Na2O	12.6645	12.1391	12.0158	0.6487	0.1234	5.40%	1.03%
2	SB2/3-02	NiO	0.4905	0.5261	0.5478	-0.0572	-0.0217	-10.45%	-3.97%
2	SB2/3-02	PbO	0.0428	0.0428	0.0435	-0.0007	-0.0007	-1.57%	-1.57%
2	SB2/3-02	SiO2	53.7767	53.7592	54.0550	-0.2783	-0.2958	-0.51%	-0.55%
2	SB2/3-02	ThO2	0.0586	0.0586	0.0102	0.0484	0.0484	474.53%	474.53%
2	SB2/3-02	TiO2	0.0042	0.0043	0.0078	-0.0036	-0.0035	-46.54%	-44.76%
2	SB2/3-02	U3O8	3.0099	3.0684	3.0870	-0.0771	-0.0186	-2.50%	-0.60%
2	SB2/3-02	ZnO	0.0442	0.0442	0.0468	-0.0026	-0.0026	-5.58%	-5.58%
2	SB2/3-02	ZrO2	0.0713	0.0713	0.0777	-0.0064	-0.0064	-8.29%	-8.29%
2	SB2/3-02	Sum of Oxides	99.9550	99.7110	100.0001	-0.0452	-0.2891	-0.05%	-0.29%
3	SB2/3-03	Al2O3	4.9080	5.0139	4.6152	0.2928	0.3987	6.34%	8.64%
3	SB2/3-03	B2O3	5.2967	5.4828	5.6000	-0.3033	-0.1172	-5.42%	-2.09%
3	SB2/3-03	BaO	0.0399	0.0429	0.0450	-0.0051	-0.0021	-11.30%	-4.68%
3	SB2/3-03	CaO	0.9654	0.9237	0.8868	0.0787	0.0369	8.87%	4.16%
3	SB2/3-03	Ce2O3	0.0709	0.0709	0.0723	-0.0014	-0.0014	-1.99%	-1.99%
3	SB2/3-03	Cr2O3	0.0643	0.0648	0.0738	-0.0095	-0.0090	-12.86%	-12.24%
3	SB2/3-03	CuO	0.0288	0.0301	0.0246	0.0042	0.0055	17.04%	22.18%
3	SB2/3-03	Fe2O3	9.7863	9.8920	9.7940	-0.0077	0.0980	-0.08%	1.00%
3	SB2/3-03	K2O	0.3060	0.2975	0.2823	0.0237	0.0152	8.38%	5.40%

Table E.4: Average Measured and Bias-Corrected Chemical Compositions Versus Targeted Compositions by Oxide by Variability Study (VS) Glass Number

(100-Batch 1; 101-U std)

VS Glass #	VS Glass ID	Oxide	Measured (wt%)	Measured Bias-Corrected (wt%)	Targeted (wt%)	Diff of Measured	Diff of Meas BC	% Diff of Measured	% Diff of Meas BC
3	SB2/3-03	La2O3	0.0331	0.0331	0.0372	-0.0041	-0.0041	-10.94%	-10.94%
3	SB2/3-03	Li2O	5.4576	5.5904	5.6000	-0.1424	-0.0096	-2.54%	-0.17%
3	SB2/3-03	MgO	1.0214	1.0259	1.0728	-0.0514	-0.0469	-4.79%	-4.37%
3	SB2/3-03	MnO	2.0078	2.0307	2.0046	0.0032	0.0261	0.16%	1.30%
3	SB2/3-03	Na2O	12.5229	12.0051	12.0158	0.5072	-0.0106	4.22%	-0.09%
3	SB2/3-03	NiO	0.4801	0.5148	0.5478	-0.0677	-0.0330	-12.37%	-6.02%
3	SB2/3-03	PbO	0.0417	0.0417	0.0435	-0.0018	-0.0018	-4.04%	-4.04%
3	SB2/3-03	SiO2	52.6268	52.8737	54.0550	-1.4282	-1.1813	-2.64%	-2.19%
3	SB2/3-03	ThO2	0.0640	0.0640	0.0102	0.0538	0.0538	527.52%	527.52%
3	SB2/3-03	TiO2	0.0050	0.0052	0.0078	-0.0028	-0.0026	-35.85%	-33.71%
3	SB2/3-03	U3O8	3.0364	3.1722	3.0870	-0.0506	0.0852	-1.64%	2.76%
3	SB2/3-03	ZnO	0.0367	0.0367	0.0468	-0.0101	-0.0101	-21.53%	-21.53%
3	SB2/3-03	ZrO2	0.0669	0.0669	0.0777	-0.0108	-0.0108	-13.94%	-13.94%
3	SB2/3-03	Sum of Oxides	98.8668	99.2790	100.0001	-1.1334	-0.7211	-1.13%	-0.72%
4	SB2/3-04	Al2O3	5.6213	5.7424	5.3844	0.2369	0.3581	4.40%	6.65%
4	SB2/3-04	B2O3	5.1518	5.2246	5.2000	-0.0482	0.0246	-0.93%	0.47%
4	SB2/3-04	BaO	0.0558	0.0600	0.0525	0.0033	0.0075	6.33%	14.28%
4	SB2/3-04	CaO	1.1015	1.0539	1.0346	0.0669	0.0193	6.47%	1.87%
4	SB2/3-04	Ce2O3	0.0471	0.0471	0.0843	-0.0372	-0.0372	-44.11%	-44.11%
4	SB2/3-04	Cr2O3	0.0884	0.0891	0.0861	0.0023	0.0030	2.70%	3.47%
4	SB2/3-04	CuO	0.0376	0.0392	0.0287	0.0089	0.0105	30.85%	36.60%
4	SB2/3-04	Fe2O3	10.8371	10.7735	11.4270	-0.5899	-0.6535	-5.16%	-5.72%
4	SB2/3-04	K2O	0.3620	0.3520	0.3293	0.0326	0.0227	9.91%	6.88%
4	SB2/3-04	La2O3	0.0343	0.0343	0.0434	-0.0091	-0.0091	-20.96%	-20.96%
4	SB2/3-04	Li2O	5.1939	5.2853	5.2000	-0.0061	0.0853	-0.12%	1.64%
4	SB2/3-04	MgO	1.1922	1.1974	1.2516	-0.0594	-0.0542	-4.75%	-4.33%
4	SB2/3-04	MnO	2.3371	2.3637	2.3387	-0.0016	0.0250	-0.07%	1.07%
4	SB2/3-04	Na2O	13.2171	12.6702	12.6851	0.5321	-0.0149	4.19%	-0.12%
4	SB2/3-04	NiO	0.5787	0.6205	0.6391	-0.0604	-0.0186	-9.46%	-2.91%
4	SB2/3-04	PbO	0.0517	0.0517	0.0507	0.0010	0.0010	1.88%	1.88%
4	SB2/3-04	SiO2	50.4340	50.4188	50.3970	0.0370	0.0218	0.07%	0.04%
4	SB2/3-04	ThO2	0.0734	0.0734	0.0119	0.0615	0.0615	516.76%	516.76%
4	SB2/3-04	TiO2	0.0042	0.0043	0.0091	-0.0049	-0.0048	-54.18%	-52.65%
4	SB2/3-04	U3O8	3.5553	3.6243	3.6010	-0.0457	0.0233	-1.27%	0.65%
4	SB2/3-04	ZnO	0.0492	0.0492	0.0546	-0.0054	-0.0054	-9.95%	-9.95%
4	SB2/3-04	ZrO2	0.0837	0.0837	0.0906	-0.0069	-0.0069	-7.61%	-7.61%
4	SB2/3-04	Sum of Oxides	100.1074	99.8587	99.9998	0.1076	-0.1411	0.11%	-0.14%
5	SB2/3-05	Al2O3	5.6449	5.8009	5.3844	0.2605	0.4166	4.84%	7.74%
5	SB2/3-05	B2O3	4.8299	4.8981	5.2000	-0.3702	-0.3019	-7.12%	-5.81%
5	SB2/3-05	BaO	0.0447	0.0490	0.0525	-0.0078	-0.0035	-14.93%	-6.59%
5	SB2/3-05	CaO	1.1274	1.0706	1.0346	0.0928	0.0360	8.97%	3.48%
5	SB2/3-05	Ce2O3	0.0673	0.0673	0.0843	-0.0170	-0.0170	-20.15%	-20.15%
5	SB2/3-05	Cr2O3	0.1089	0.1107	0.0861	0.0228	0.0246	26.47%	28.58%
5	SB2/3-05	CuO	0.0285	0.0300	0.0287	-0.0002	0.0013	-0.77%	4.46%
5	SB2/3-05	Fe2O3	10.3296	10.2699	11.4270	-1.0974	-1.1571	-9.60%	-10.13%
5	SB2/3-05	K2O	0.3629	0.3517	0.3293	0.0335	0.0223	10.18%	6.78%
5	SB2/3-05	La2O3	0.0384	0.0384	0.0434	-0.0050	-0.0050	-11.50%	-11.50%
5	SB2/3-05	Li2O	5.0647	5.1538	5.2000	-0.1353	-0.0462	-2.60%	-0.89%
5	SB2/3-05	MgO	1.1627	1.1688	1.2516	-0.0889	-0.0828	-7.10%	-6.61%
5	SB2/3-05	MnO	2.2564	2.3112	2.3387	-0.0823	-0.0274	-3.52%	-1.17%
5	SB2/3-05	Na2O	12.9172	12.7339	12.6851	0.2322	0.0489	1.83%	0.39%
5	SB2/3-05	NiO	0.5542	0.5979	0.6391	-0.0849	-0.0412	-13.29%	-6.44%
5	SB2/3-05	PbO	0.0452	0.0452	0.0507	-0.0055	-0.0055	-10.85%	-10.85%
5	SB2/3-05	SiO2	50.1933	50.3779	50.3970	-0.2037	-0.0191	-0.40%	-0.04%
5	SB2/3-05	ThO2	0.0745	0.0745	0.0119	0.0626	0.0626	526.33%	526.33%

Table E.4: Average Measured and Bias-Corrected Chemical Compositions Versus Targeted Compositions by Oxide by Variability Study (VS) Glass Number

(100-Batch 1; 101-U std)

VS Glass #	VS Glass ID	Oxide	Measured (wt%)	Measured Bias-Corrected (wt%)	Targeted (wt%)	Diff of Measured	Diff of Meas BC	% Diff of Measured	% Diff of Meas BC
5	SB2/3-05	TiO2	0.0042	0.0043	0.0091	-0.0049	-0.0048	-54.18%	-52.59%
5	SB2/3-05	U3O8	3.4757	3.5438	3.6010	-0.1253	-0.0572	-3.48%	-1.59%
5	SB2/3-05	ZnO	0.0364	0.0364	0.0546	-0.0182	-0.0182	-33.31%	-33.31%
5	SB2/3-05	ZrO2	0.0750	0.0750	0.0906	-0.0157	-0.0157	-17.30%	-17.30%
5	SB2/3-05	Sum of Oxides	98.4419	98.8096	99.9998	-1.5579	-1.1903	-1.56%	-1.19%
6	SB2/3-06	Al2O3	5.6165	5.7718	5.3844	0.2322	0.3874	4.31%	7.20%
6	SB2/3-06	B2O3	5.1116	5.2913	5.2000	-0.0884	0.0913	-1.70%	1.76%
6	SB2/3-06	BaO	0.0438	0.0481	0.0525	-0.0087	-0.0044	-16.53%	-8.35%
6	SB2/3-06	CaO	1.1218	1.0653	1.0346	0.0872	0.0307	8.43%	2.97%
6	SB2/3-06	Ce2O3	0.0735	0.0735	0.0843	-0.0109	-0.0109	-12.86%	-12.86%
6	SB2/3-06	Cr2O3	0.0932	0.0947	0.0861	0.0071	0.0086	8.22%	10.02%
6	SB2/3-06	CuO	0.0325	0.0343	0.0287	0.0038	0.0056	13.40%	19.38%
6	SB2/3-06	Fe2O3	11.2231	11.3449	11.4270	-0.2039	-0.0821	-1.78%	-0.72%
6	SB2/3-06	K2O	0.3472	0.3365	0.3293	0.0179	0.0071	5.43%	2.17%
6	SB2/3-06	La2O3	0.0346	0.0346	0.0434	-0.0088	-0.0088	-20.28%	-20.28%
6	SB2/3-06	Li2O	5.1400	5.2651	5.2000	-0.0600	0.0651	-1.15%	1.25%
6	SB2/3-06	MgO	1.1926	1.1988	1.2516	-0.0590	-0.0528	-4.71%	-4.22%
6	SB2/3-06	MnO	2.3306	2.3873	2.3387	-0.0081	0.0486	-0.35%	2.08%
6	SB2/3-06	Na2O	12.9947	12.8107	12.6851	0.3097	0.1256	2.44%	0.99%
6	SB2/3-06	NiO	0.5714	0.6164	0.6391	-0.0677	-0.0226	-10.60%	-3.54%
6	SB2/3-06	PbO	0.0477	0.0477	0.0507	-0.0031	-0.0031	-6.08%	-6.08%
6	SB2/3-06	SiO2	49.2841	49.7119	50.3970	-1.1129	-0.6851	-2.21%	-1.36%
6	SB2/3-06	ThO2	0.0720	0.0720	0.0119	0.0601	0.0601	504.81%	504.81%
6	SB2/3-06	TiO2	0.0033	0.0034	0.0091	-0.0058	-0.0057	-63.34%	-62.10%
6	SB2/3-06	U3O8	3.5553	3.7146	3.6010	-0.0457	0.1136	-1.27%	3.16%
6	SB2/3-06	ZnO	0.0479	0.0479	0.0546	-0.0067	-0.0067	-12.23%	-12.23%
6	SB2/3-06	ZrO2	0.0783	0.0783	0.0906	-0.0123	-0.0123	-13.57%	-13.57%
6	SB2/3-06	Sum of Oxides	99.0159	100.0493	99.9998	-0.9839	0.0495	-0.98%	0.05%
7	SB2/3-07	Al2O3	6.3676	6.5437	6.1536	0.2140	0.3901	3.48%	6.34%
7	SB2/3-07	B2O3	4.4757	4.6336	4.8000	-0.3243	-0.1664	-6.76%	-3.47%
7	SB2/3-07	BaO	0.0491	0.0539	0.0600	-0.0109	-0.0061	-18.12%	-10.09%
7	SB2/3-07	CaO	1.2855	1.2208	1.1824	0.1031	0.0384	8.72%	3.25%
7	SB2/3-07	Ce2O3	0.0782	0.0782	0.0964	-0.0182	-0.0182	-18.90%	-18.90%
7	SB2/3-07	Cr2O3	0.0946	0.0962	0.0984	-0.0038	-0.0022	-3.82%	-2.22%
7	SB2/3-07	CuO	0.0382	0.0402	0.0328	0.0054	0.0074	16.40%	22.54%
7	SB2/3-07	Fe2O3	12.4491	12.5864	13.0590	-0.6099	-0.4726	-4.67%	-3.62%
7	SB2/3-07	K2O	0.4195	0.4065	0.3764	0.0431	0.0301	11.45%	8.01%
7	SB2/3-07	La2O3	0.0449	0.0449	0.0496	-0.0047	-0.0047	-9.56%	-9.56%
7	SB2/3-07	Li2O	4.6556	4.7689	4.8000	-0.1444	-0.0311	-3.01%	-0.65%
7	SB2/3-07	MgO	1.3252	1.3322	1.4304	-0.1052	-0.0982	-7.35%	-6.87%
7	SB2/3-07	MnO	2.5469	2.6088	2.6728	-0.1259	-0.0640	-4.71%	-2.39%
7	SB2/3-07	Na2O	13.6788	13.4849	13.3543	0.3245	0.1306	2.43%	0.98%
7	SB2/3-07	NiO	0.6359	0.6861	0.7304	-0.0945	-0.0443	-12.93%	-6.06%
7	SB2/3-07	PbO	0.0501	0.0501	0.0580	-0.0079	-0.0079	-13.64%	-13.64%
7	SB2/3-07	SiO2	46.1287	46.5317	46.7400	-0.6113	-0.2083	-1.31%	-0.45%
7	SB2/3-07	ThO2	0.0882	0.0882	0.0136	0.0746	0.0746	548.44%	548.44%
7	SB2/3-07	TiO2	0.0017	0.0017	0.0104	-0.0087	-0.0087	-83.96%	-83.42%
7	SB2/3-07	U3O8	4.0447	4.2260	4.1160	-0.0713	0.1100	-1.73%	2.67%
7	SB2/3-07	ZnO	0.0479	0.0479	0.0624	-0.0145	-0.0145	-23.20%	-23.20%
7	SB2/3-07	ZrO2	0.0881	0.0881	0.1036	-0.0155	-0.0155	-14.92%	-14.92%
7	SB2/3-07	Sum of Oxides	98.5943	99.6192	100.0005	-1.4062	-0.3813	-1.41%	-0.38%
8	SB2/3-08	Al2O3	6.4385	6.6165	6.1536	0.2849	0.4629	4.63%	7.52%
8	SB2/3-08	B2O3	4.4757	4.6334	4.8000	-0.3243	-0.1666	-6.76%	-3.47%
8	SB2/3-08	BaO	0.0505	0.0555	0.0600	-0.0095	-0.0045	-15.80%	-7.54%
8	SB2/3-08	CaO	1.2883	1.2234	1.1824	0.1059	0.0410	8.96%	3.47%

Table E.4: Average Measured and Bias-Corrected Chemical Compositions Versus Targeted Compositions by Oxide by Variability Study (VS) Glass Number

(100-Batch 1; 101-U std)

VS Glass #	VS Glass ID	Oxide	Measured (wt%)	Measured Bias-Corrected (wt%)	Targeted (wt%)	Diff of Measured	Diff of Meas BC	% Diff of Measured	% Diff of Meas BC
8	SB2/3-08	Ce2O3	0.0685	0.0685	0.0964	-0.0279	-0.0279	-28.92%	-28.92%
8	SB2/3-08	Cr2O3	0.1027	0.1044	0.0984	0.0043	0.0060	4.35%	6.07%
8	SB2/3-08	CuO	0.0391	0.0412	0.0328	0.0063	0.0084	19.26%	25.55%
8	SB2/3-08	Fe2O3	12.2668	12.4028	13.0590	-0.7922	-0.6562	-6.07%	-5.02%
8	SB2/3-08	K2O	0.4177	0.4048	0.3764	0.0413	0.0284	10.97%	7.54%
8	SB2/3-08	La2O3	0.0472	0.0472	0.0496	-0.0024	-0.0024	-4.83%	-4.83%
8	SB2/3-08	Li2O	4.7525	4.8682	4.8000	-0.0475	0.0682	-0.99%	1.42%
8	SB2/3-08	MgO	1.3389	1.3459	1.4304	-0.0915	-0.0845	-6.40%	-5.91%
8	SB2/3-08	MnO	2.5856	2.6485	2.6728	-0.0872	-0.0243	-3.26%	-0.91%
8	SB2/3-08	Na2O	13.7159	13.5210	13.3543	0.3616	0.1666	2.71%	1.25%
8	SB2/3-08	NiO	0.6299	0.6796	0.7304	-0.1005	-0.0508	-13.76%	-6.95%
8	SB2/3-08	PbO	0.0571	0.0571	0.0580	-0.0009	-0.0009	-1.57%	-1.57%
8	SB2/3-08	SiO2	45.9147	46.3120	46.7400	-0.8253	-0.4280	-1.77%	-0.92%
8	SB2/3-08	ThO2	0.0905	0.0905	0.0136	0.0769	0.0769	565.17%	565.17%
8	SB2/3-08	TiO2	0.0021	0.0022	0.0104	-0.0083	-0.0082	-79.95%	-79.26%
8	SB2/3-08	U3O8	3.9945	4.1739	4.1160	-0.1215	0.0579	-2.95%	1.41%
8	SB2/3-08	ZnO	0.0492	0.0492	0.0624	-0.0132	-0.0132	-21.20%	-21.20%
8	SB2/3-08	ZrO2	0.0831	0.0831	0.1036	-0.0205	-0.0205	-19.81%	-19.81%
8	SB2/3-08	Sum of Oxides	98.4090	99.4287	100.0005	-1.5915	-0.5718	-1.59%	-0.57%
9	SB2/3-09	Al2O3	6.4810	6.6602	6.1536	0.3274	0.5066	5.32%	8.23%
9	SB2/3-09	B2O3	4.4435	4.5999	4.8000	-0.3565	-0.2001	-7.43%	-4.17%
9	SB2/3-09	BaO	0.0511	0.0561	0.0600	-0.0089	-0.0039	-14.87%	-6.52%
9	SB2/3-09	CaO	1.3149	1.2487	1.1824	0.1325	0.0663	11.21%	5.61%
9	SB2/3-09	Ce2O3	0.0820	0.0820	0.0964	-0.0144	-0.0144	-14.95%	-14.95%
9	SB2/3-09	Cr2O3	0.1030	0.1048	0.0984	0.0046	0.0064	4.72%	6.49%
9	SB2/3-09	CuO	0.0397	0.0418	0.0328	0.0069	0.0090	21.17%	27.57%
9	SB2/3-09	Fe2O3	12.4420	12.5780	13.0590	-0.6170	-0.4810	-4.72%	-3.68%
9	SB2/3-09	K2O	0.4189	0.4060	0.3764	0.0425	0.0296	11.29%	7.85%
9	SB2/3-09	La2O3	0.0408	0.0408	0.0496	-0.0088	-0.0088	-17.83%	-17.83%
9	SB2/3-09	Li2O	4.7310	4.8461	4.8000	-0.0690	0.0461	-1.44%	0.96%
9	SB2/3-09	MgO	1.3323	1.3393	1.4304	-0.0981	-0.0911	-6.86%	-6.37%
9	SB2/3-09	MnO	2.5985	2.6617	2.6728	-0.0742	-0.0111	-2.78%	-0.41%
9	SB2/3-09	Na2O	13.8507	13.6542	13.3543	0.4964	0.2998	3.72%	2.25%
9	SB2/3-09	NiO	0.6140	0.6624	0.7304	-0.1164	-0.0680	-15.94%	-9.30%
9	SB2/3-09	PbO	0.0547	0.0547	0.0580	-0.0033	-0.0033	-5.74%	-5.74%
9	SB2/3-09	SiO2	45.6741	46.0671	46.7400	-1.0659	-0.6729	-2.28%	-1.44%
9	SB2/3-09	ThO2	0.0856	0.0856	0.0136	0.0720	0.0720	529.61%	529.61%
9	SB2/3-09	TiO2	0.0029	0.0030	0.0104	-0.0075	-0.0074	-71.93%	-70.94%
9	SB2/3-09	U3O8	3.9356	4.1117	4.1160	-0.1804	-0.0043	-4.38%	-0.10%
9	SB2/3-09	ZnO	0.0492	0.0492	0.0624	-0.0132	-0.0132	-21.20%	-21.20%
9	SB2/3-09	ZrO2	0.0851	0.0851	0.1036	-0.0185	-0.0185	-17.86%	-17.86%
9	SB2/3-09	Sum of Oxides	98.4304	99.4384	100.0005	-1.5701	-0.5621	-1.57%	-0.56%
10	SB2/3-10	Al2O3	7.1376	7.2913	6.9228	0.2148	0.3686	3.10%	5.32%
10	SB2/3-10	B2O3	4.1215	4.1794	4.4000	-0.2785	-0.2206	-6.33%	-5.01%
10	SB2/3-10	BaO	0.0581	0.0624	0.0675	-0.0094	-0.0051	-13.99%	-7.56%
10	SB2/3-10	CaO	1.4237	1.3621	1.3302	0.0935	0.0319	7.03%	2.40%
10	SB2/3-10	Ce2O3	0.0931	0.0931	0.1084	-0.0153	-0.0153	-14.14%	-14.14%
10	SB2/3-10	Cr2O3	0.1220	0.1230	0.1107	0.0113	0.0123	10.25%	11.08%
10	SB2/3-10	CuO	0.0432	0.0451	0.0369	0.0063	0.0082	17.04%	22.18%
10	SB2/3-10	Fe2O3	13.7108	13.6311	14.6920	-0.9812	-1.0609	-6.68%	-7.22%
10	SB2/3-10	K2O	0.4803	0.4671	0.4234	0.0569	0.0437	13.43%	10.31%
10	SB2/3-10	La2O3	0.0484	0.0484	0.0558	-0.0074	-0.0074	-13.30%	-13.30%
10	SB2/3-10	Li2O	4.3704	4.4473	4.4000	-0.0296	0.0473	-0.67%	1.07%
10	SB2/3-10	MgO	1.4724	1.4790	1.6092	-0.1368	-0.1302	-8.50%	-8.09%
10	SB2/3-10	MnO	2.8116	2.8436	3.0069	-0.1953	-0.1633	-6.50%	-5.43%

Table E.4: Average Measured and Bias-Corrected Chemical Compositions Versus Targeted Compositions by Oxide by Variability Study (VS) Glass Number

(100-Batch 1; 101-U std)

VS Glass #	VS Glass ID	Oxide	Measured (wt%)	Measured Bias-Corrected (wt%)	Targeted (wt%)	Diff of Measured	Diff of Meas BC	% Diff of Measured	% Diff of Meas BC
10	SB2/3-10	Na2O	14.4910	13.8917	14.0236	0.4674	-0.1319	3.33%	-0.94%
10	SB2/3-10	NiO	0.7066	0.7577	0.8217	-0.1151	-0.0640	-14.01%	-7.79%
10	SB2/3-10	PbO	0.0697	0.0697	0.0652	0.0045	0.0045	6.90%	6.90%
10	SB2/3-10	SiO2	42.9999	42.9890	43.0820	-0.0821	-0.0930	-0.19%	-0.22%
10	SB2/3-10	ThO2	0.0959	0.0959	0.0153	0.0806	0.0806	526.59%	526.59%
10	SB2/3-10	TiO2	0.0063	0.0065	0.0117	-0.0054	-0.0052	-46.54%	-44.76%
10	SB2/3-10	U3O8	4.5635	4.6526	4.6300	-0.0665	0.0226	-1.44%	0.49%
10	SB2/3-10	ZnO	0.0591	0.0591	0.0702	-0.0111	-0.0111	-15.77%	-15.77%
10	SB2/3-10	ZrO2	0.0983	0.0983	0.1165	-0.0183	-0.0183	-15.68%	-15.68%
10	SB2/3-10	Sum of Oxides	98.9833	98.6934	100.0002	-1.0169	-1.3068	-1.02%	-1.31%
11	SB2/3-11	Al2O3	7.2084	7.3636	6.9228	0.2857	0.4408	4.13%	6.37%
11	SB2/3-11	B2O3	4.2744	4.3346	4.4000	-0.1256	-0.0654	-2.85%	-1.49%
11	SB2/3-11	BaO	0.0589	0.0633	0.0675	-0.0086	-0.0042	-12.75%	-6.23%
11	SB2/3-11	CaO	1.4517	1.3889	1.3302	0.1215	0.0587	9.13%	4.41%
11	SB2/3-11	Ce2O3	0.0955	0.0955	0.1084	-0.0130	-0.0130	-11.98%	-11.98%
11	SB2/3-11	Cr2O3	0.1133	0.1141	0.1107	0.0026	0.0034	2.33%	3.09%
11	SB2/3-11	CuO	0.0426	0.0444	0.0369	0.0057	0.0075	15.34%	20.41%
11	SB2/3-11	Fe2O3	14.1397	14.0597	14.6920	-0.5523	-0.6323	-3.76%	-4.30%
11	SB2/3-11	K2O	0.4737	0.4607	0.4234	0.0503	0.0372	11.87%	8.79%
11	SB2/3-11	La2O3	0.0454	0.0454	0.0558	-0.0104	-0.0104	-18.56%	-18.56%
11	SB2/3-11	Li2O	4.4027	4.4801	4.4000	0.0027	0.0801	0.06%	1.82%
11	SB2/3-11	MgO	1.5134	1.5201	1.6092	-0.0958	-0.0890	-5.95%	-5.53%
11	SB2/3-11	MnO	2.9117	2.9448	3.0069	-0.0952	-0.0621	-3.17%	-2.07%
11	SB2/3-11	Na2O	14.6595	14.0522	14.0236	0.6359	0.0286	4.53%	0.20%
11	SB2/3-11	NiO	0.6999	0.7505	0.8217	-0.1218	-0.0712	-14.83%	-8.67%
11	SB2/3-11	PbO	0.0584	0.0584	0.0652	-0.0068	-0.0068	-10.44%	-10.44%
11	SB2/3-11	SiO2	43.4010	43.3909	43.0820	0.3190	0.3089	0.74%	0.72%
11	SB2/3-11	ThO2	0.0999	0.0999	0.0153	0.0846	0.0846	552.62%	552.62%
11	SB2/3-11	TiO2	0.0067	0.0069	0.0117	-0.0050	-0.0048	-42.97%	-41.08%
11	SB2/3-11	U3O8	4.6254	4.7158	4.6300	-0.0046	0.0858	-0.10%	1.85%
11	SB2/3-11	ZnO	0.0632	0.0632	0.0702	-0.0070	-0.0070	-10.01%	-10.01%
11	SB2/3-11	ZrO2	0.0969	0.0969	0.1165	-0.0196	-0.0196	-16.84%	-16.84%
11	SB2/3-11	Sum of Oxides	100.4423	100.1499	100.0002	0.4421	0.1497	0.44%	0.15%
12	SB2/3-12	Al2O3	7.1234	7.3204	6.9228	0.2006	0.3976	2.90%	5.74%
12	SB2/3-12	B2O3	4.3549	4.4173	4.4000	-0.0451	0.0173	-1.02%	0.39%
12	SB2/3-12	BaO	0.0578	0.0634	0.0675	-0.0097	-0.0041	-14.40%	-6.01%
12	SB2/3-12	CaO	1.4272	1.3553	1.3302	0.0970	0.0251	7.29%	1.89%
12	SB2/3-12	Ce2O3	0.0958	0.0958	0.1084	-0.0127	-0.0127	-11.71%	-11.71%
12	SB2/3-12	Cr2O3	0.0968	0.0984	0.1107	-0.0139	-0.0122	-12.53%	-11.07%
12	SB2/3-12	CuO	0.0379	0.0399	0.0369	0.0010	0.0030	2.62%	8.04%
12	SB2/3-12	Fe2O3	13.8967	13.8160	14.6920	-0.7953	-0.8760	-5.41%	-5.96%
12	SB2/3-12	K2O	0.4665	0.4521	0.4234	0.0430	0.0286	10.16%	6.76%
12	SB2/3-12	La2O3	0.0466	0.0466	0.0558	-0.0092	-0.0092	-16.45%	-16.45%
12	SB2/3-12	Li2O	4.4188	4.4966	4.4000	0.0188	0.0966	0.43%	2.19%
12	SB2/3-12	MgO	1.4695	1.4772	1.6092	-0.1397	-0.1320	-8.68%	-8.20%
12	SB2/3-12	MnO	2.8310	2.8998	3.0069	-0.1759	-0.1071	-5.85%	-3.56%
12	SB2/3-12	Na2O	14.3562	14.1530	14.0236	0.3326	0.1294	2.37%	0.92%
12	SB2/3-12	NiO	0.6744	0.7277	0.8217	-0.1473	-0.0940	-17.92%	-11.44%
12	SB2/3-12	PbO	0.0625	0.0625	0.0652	-0.0028	-0.0028	-4.25%	-4.25%
12	SB2/3-12	SiO2	43.1336	43.2901	43.0820	0.0516	0.2081	0.12%	0.48%
12	SB2/3-12	ThO2	0.0970	0.0970	0.0153	0.0817	0.0817	534.03%	534.03%
12	SB2/3-12	TiO2	0.0025	0.0026	0.0117	-0.0092	-0.0091	-78.62%	-77.87%
12	SB2/3-12	U3O8	4.5163	4.6043	4.6300	-0.1137	-0.0257	-2.45%	-0.55%
12	SB2/3-12	ZnO	0.0569	0.0569	0.0702	-0.0133	-0.0133	-18.87%	-18.87%
12	SB2/3-12	ZrO2	0.0969	0.0969	0.1165	-0.0196	-0.0196	-16.84%	-16.84%

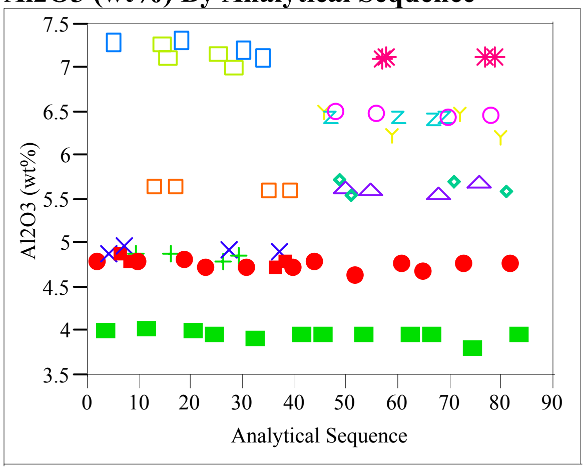
Table E.4: Average Measured and Bias-Corrected Chemical Compositions Versus Targeted Compositions by Oxide by Variability Study (VS) Glass Number

(100-Batch 1; 101-U std)

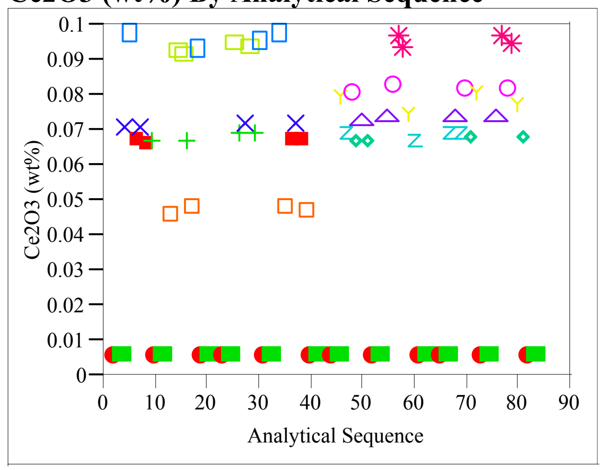
VS Glass #	VS Glass ID	Oxide	Measured (wt%)	Measured Bias-Corrected (wt%)	Targeted (wt%)	Diff of Measured	Diff of Meas BC	% Diff of Measured	% Diff of Meas BC
12	SB2/3-12	Sum of Oxides	99.3193	99.6698	100.0002	-0.6809	-0.3303	-0.68%	-0.33%
100	Batch 1	Al2O3	4.7600	4.8770	4.8770	-0.1170	0.0000	-2.40%	0.00%
100	Batch 1	B2O3	7.5909	7.7770	7.7770	-0.1861	0.0000	-2.39%	0.00%
100	Batch 1	BaO	0.1390	0.1510	0.1510	-0.0120	0.0000	-7.94%	0.00%
100	Batch 1	CaO	1.2799	1.2200	1.2200	0.0599	0.0000	4.91%	0.00%
100	Batch 1	Ce2O3	0.0059	0.0059	0.0000	0.0059	0.0059		
100	Batch 1	Cr2O3	0.1057	0.1070	0.1070	-0.0013	0.0000	-1.19%	0.00%
100	Batch 1	CuO	0.3805	0.3990	0.3990	-0.0185	0.0000	-4.62%	0.00%
100	Batch 1	Fe2O3	12.8089	12.8390	12.8390	-0.0301	0.0000	-0.23%	0.00%
100	Batch 1	K2O	3.4271	3.3270	3.3270	0.1001	0.0000	3.01%	0.00%
100	Batch 1	La2O3	0.0059	0.0059	0.0000	0.0059	0.0059		
100	Batch 1	Li2O	4.3381	4.4290	4.4290	-0.0909	0.0000	-2.05%	0.00%
100	Batch 1	MgO	1.4121	1.4190	1.4190	-0.0069	0.0000	-0.48%	0.00%
100	Batch 1	MnO	1.6958	1.7260	1.7260	-0.0302	0.0000	-1.75%	0.00%
100	Batch 1	Na2O	9.2619	9.0030	9.0030	0.2589	0.0000	2.88%	0.00%
100	Batch 1	NiO	0.6982	0.7510	0.7510	-0.0528	0.0000	-7.03%	0.00%
100	Batch 1	PbO	0.0108	0.0108	0.0000	0.0108	0.0108		
100	Batch 1	SiO2	50.0151	50.2200	50.2200	-0.2049	0.0000	-0.41%	0.00%
100	Batch 1	ThO2	0.0171	0.0171	0.0000	0.0171	0.0171		
100	Batch 1	TiO2	0.6561	0.6770	0.6770	-0.0209	0.0000	-3.09%	0.00%
100	Batch 1	U3O8	0.1179	0.1217	0.0000	0.1179	0.1217		
100	Batch 1	ZnO	0.0031	0.0031	0.0000	0.0031	0.0031		
100	Batch 1	ZrO2	0.0834	0.0834	0.0980	-0.0146	-0.0146	-14.89%	-14.89%
100	Batch 1	Sum of Oxides	98.8133	99.1698	99.0200	-0.2067	0.1498	-0.21%	0.15%
101	U std	Al2O3	3.9491	4.0461	4.1000	-0.1509	-0.0539	-3.68%	-1.32%
101	U std	B2O3	8.8198	9.0365	9.2090	-0.3892	-0.1725	-4.23%	-1.87%
101	U std	BaO	0.0056	0.0061	0.0000	0.0056	0.0061		
101	U std	CaO	1.3797	1.3152	1.3010	0.0787	0.0142	6.05%	1.09%
101	U std	Ce2O3	0.0059	0.0059	0.0000	0.0059	0.0059		
101	U std	Cr2O3	0.2364	0.2394	0.0000	0.2364	0.2394		
101	U std	CuO	0.0094	0.0098	0.0000	0.0094	0.0098		
101	U std	Fe2O3	13.0150	13.0464	13.1960	-0.1810	-0.1496	-1.37%	-1.13%
101	U std	K2O	3.2243	3.1301	2.9990	0.2253	0.1311	7.51%	4.37%
101	U std	La2O3	0.0059	0.0059	0.0000	0.0059	0.0059		
101	U std	Li2O	2.9674	3.0296	3.0570	-0.0896	-0.0274	-2.93%	-0.90%
101	U std	MgO	1.1455	1.1510	1.2100	-0.0645	-0.0590	-5.33%	-4.87%
101	U std	MnO	2.6233	2.6700	2.8920	-0.2687	-0.2220	-9.29%	-7.68%
101	U std	Na2O	12.0758	11.7391	11.7950	0.2808	-0.0559	2.38%	-0.47%
101	U std	NiO	0.9560	1.0283	1.1200	-0.1640	-0.0917	-14.65%	-8.19%
101	U std	PbO	0.0108	0.0108	0.0000	0.0108	0.0108		
101	U std	SiO2	44.4083	44.5906	45.3530	-0.9447	-0.7624	-2.08%	-1.68%
101	U std	ThO2	0.0171	0.0171	0.0000	0.0171	0.0171		
101	U std	TiO2	0.9143	0.9435	1.0490	-0.1347	-0.1055	-12.84%	-10.06%
101	U std	U3O8	2.3319	2.4060	2.4060	-0.0741	0.0000	-3.08%	0.00%
101	U std	ZnO	0.0031	0.0031	0.0000	0.0031	0.0031		
101	U std	ZrO2	0.0007	0.0007	0.0000	0.0007	0.0007		
101	U std	Sum of Oxides	98.1052	98.4310	99.6870	-1.5818	-1.2560	-1.59%	-1.26%

Exhibit E.1: SRTC-ML Measurements for Samples Prepared Using the LM Method

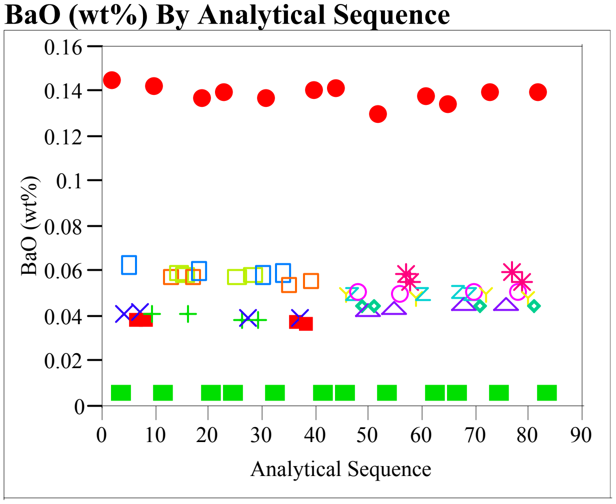
Al2O3 (wt%) By Analytical Sequence



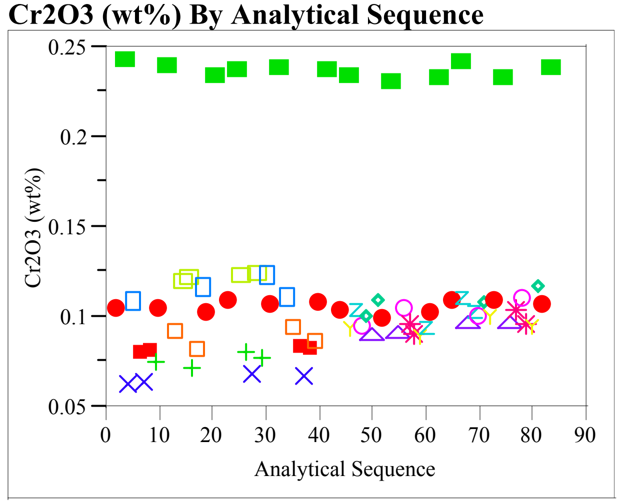
Ce2O3 (wt%) By Analytical Sequence



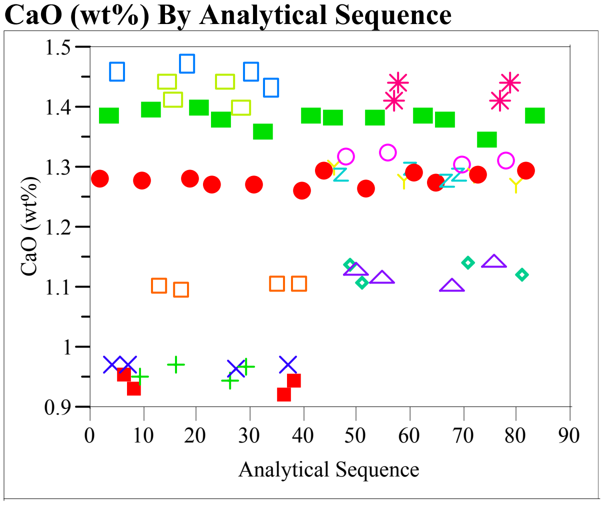
BaO (wt%) By Analytical Sequence



Cr2O3 (wt%) By Analytical Sequence



CaO (wt%) By Analytical Sequence



CuO (wt%) By Analytical Sequence

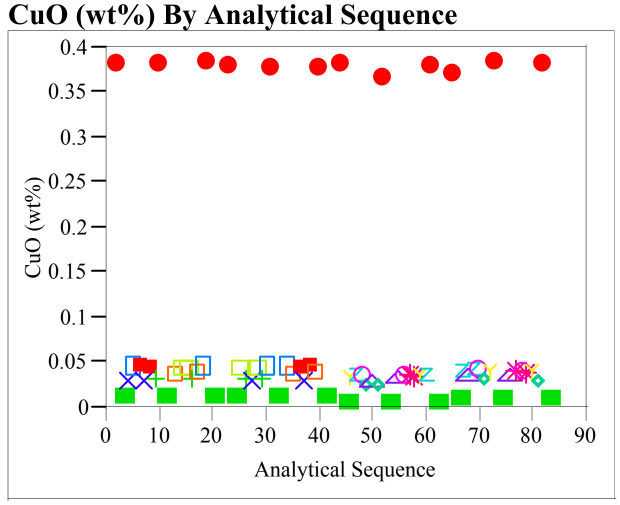
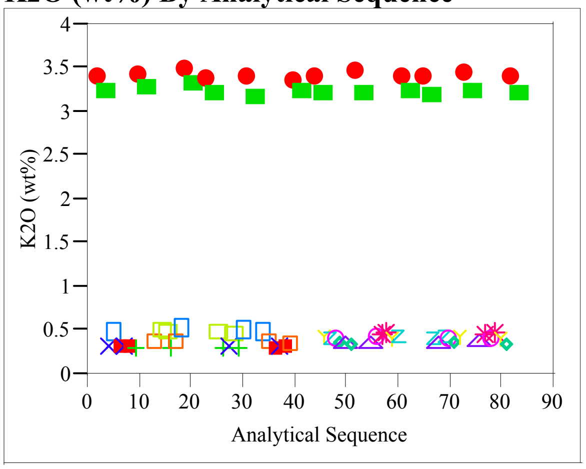
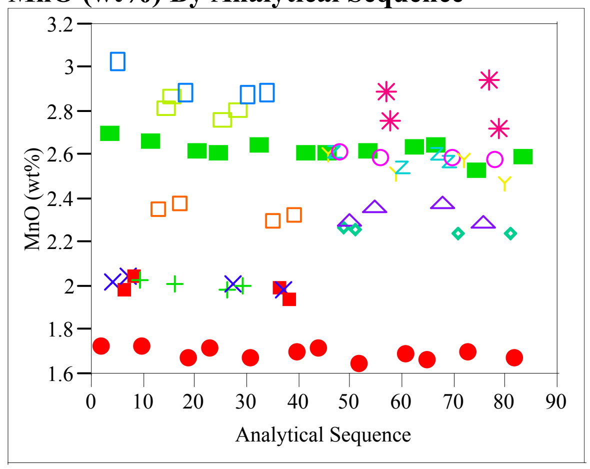


Exhibit E.1: SRTC-ML Measurements for Samples Prepared Using the LM Method *(continued)*

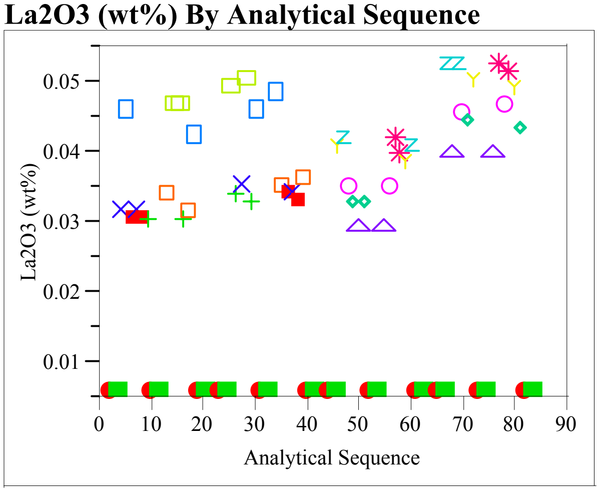
K2O (wt%) By Analytical Sequence



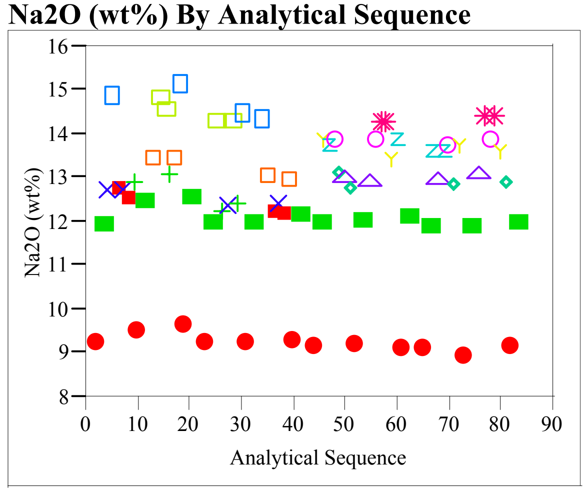
MnO (wt%) By Analytical Sequence



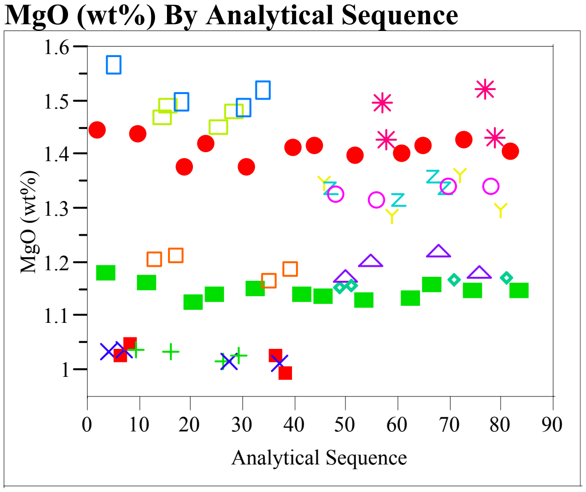
La2O3 (wt%) By Analytical Sequence



Na2O (wt%) By Analytical Sequence



MgO (wt%) By Analytical Sequence



NiO (wt%) By Analytical Sequence

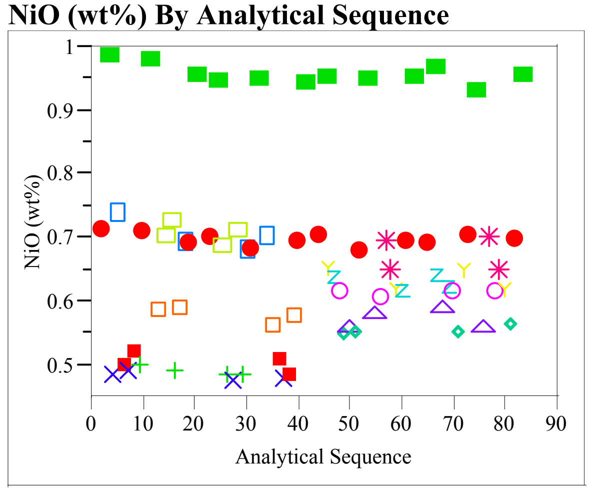
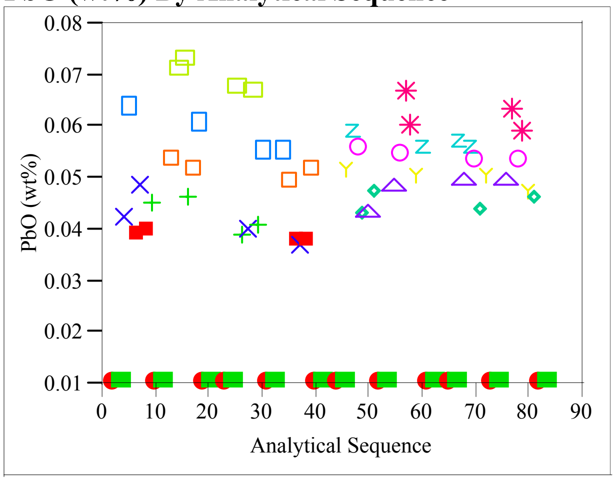
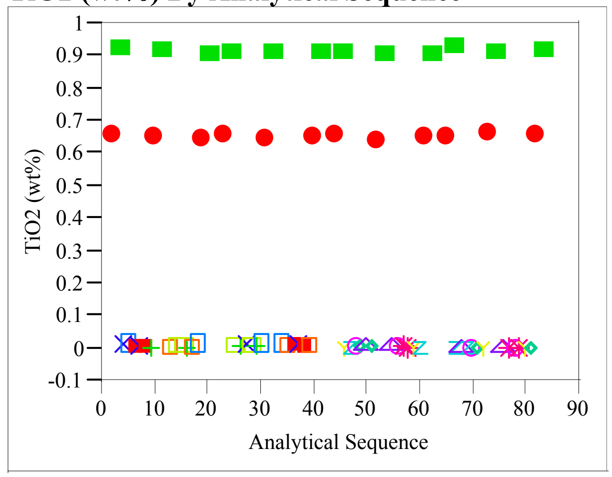


Exhibit E.1: SRTC-ML Measurements for Samples Prepared Using the LM Method *(continued)*

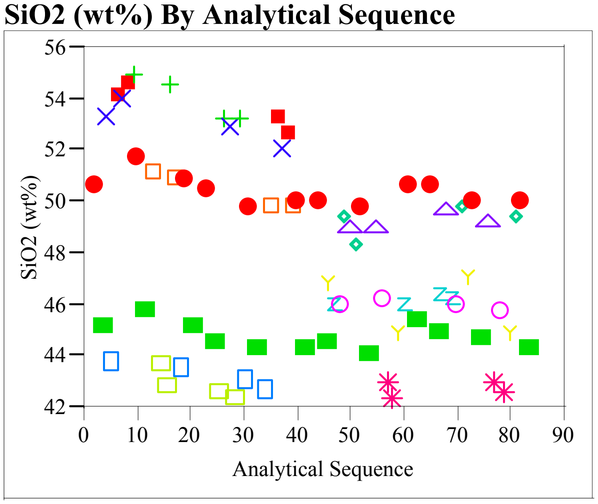
PbO (wt%) By Analytical Sequence



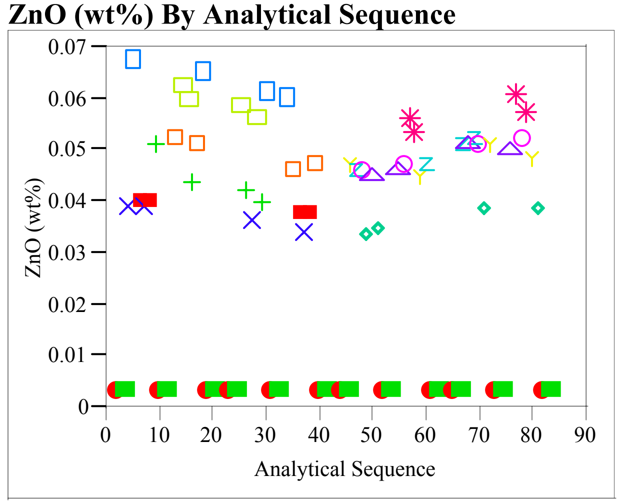
TiO2 (wt%) By Analytical Sequence



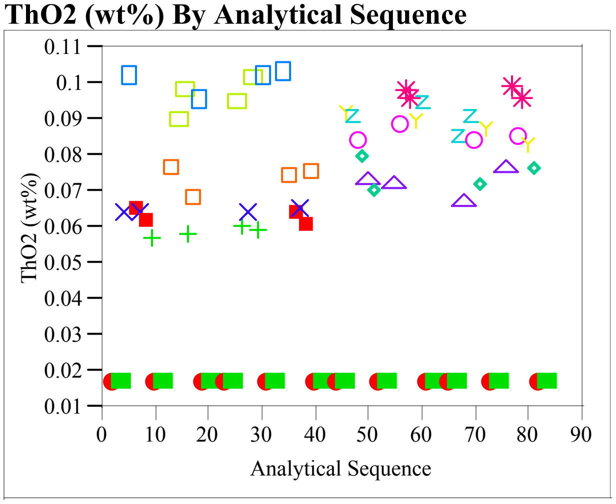
SiO2 (wt%) By Analytical Sequence



ZnO (wt%) By Analytical Sequence



ThO2 (wt%) By Analytical Sequence



ZrO2 (wt%) By Analytical Sequence

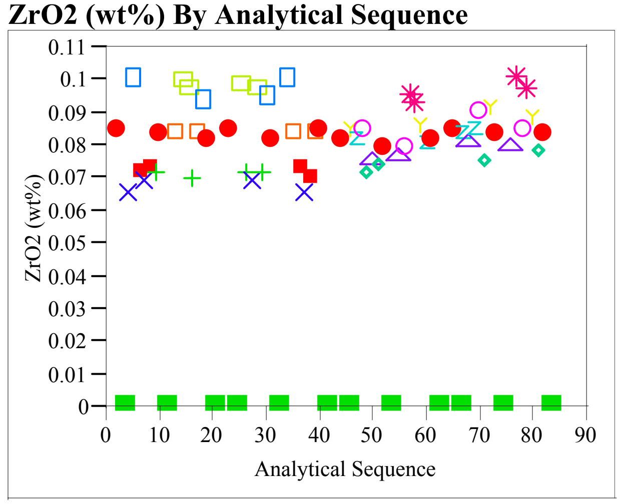
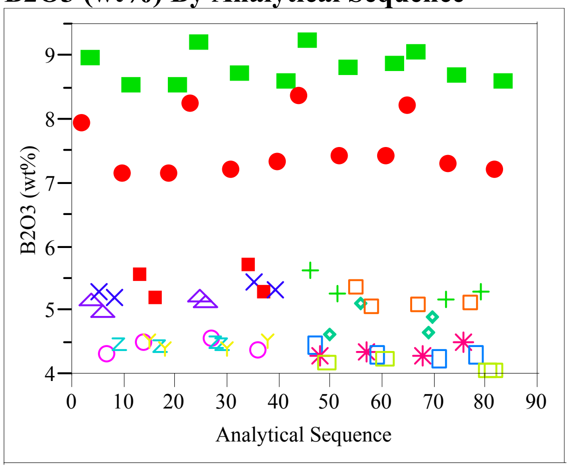
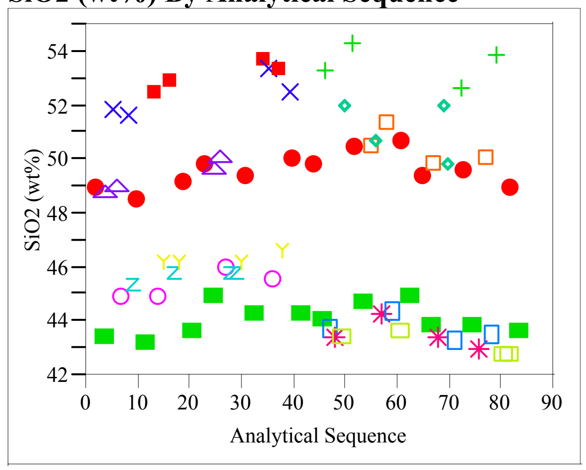


Exhibit E.2: SRTC-ML Measurements for Samples Prepared Using the PF Method

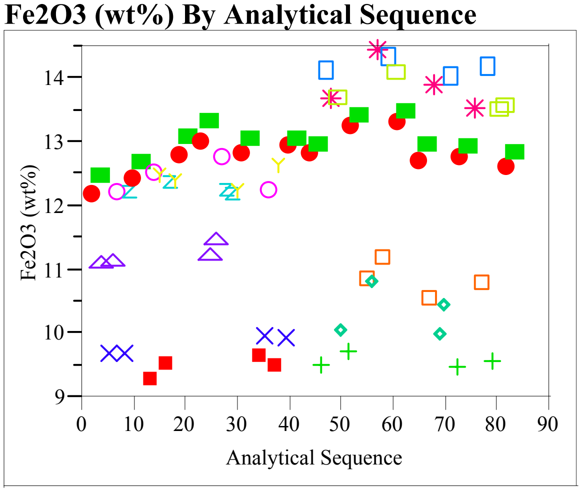
B2O3 (wt%) By Analytical Sequence



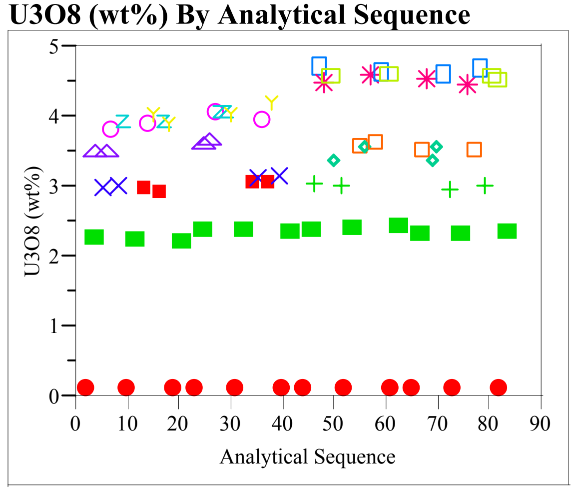
SiO2 (wt%) By Analytical Sequence



Fe2O3 (wt%) By Analytical Sequence



U3O8 (wt%) By Analytical Sequence



Li2O (wt%) By Analytical Sequence

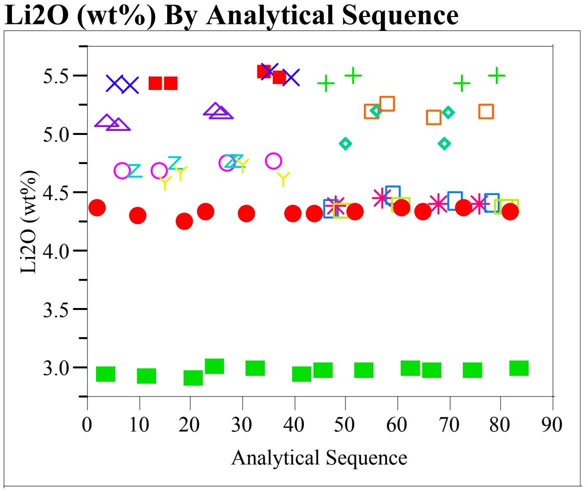
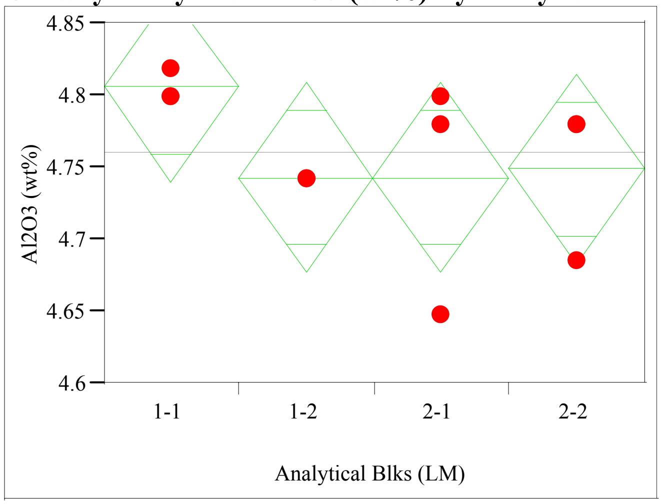


Exhibit E.3: SRTC-ML Measurements by Analytical Block for Samples of the Standard Glasses Prepared Using the LM Method

Batch 1 – Al2O3 reference value 4.877 wt%

Oneway Analysis of Al2O3 (wt%) By Analytical Blks (LM)



Oneway Anova

Summary of Fit

Rsquare	0.298838
Root Mean Square Error	0.049693
Mean of Response	4.759965
Observations (or Sum Wgts)	12

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	3	0.00841975	0.002807	1.1365	0.3910
Error	8	0.01975516	0.002469		
C. Total	11	0.02817491			

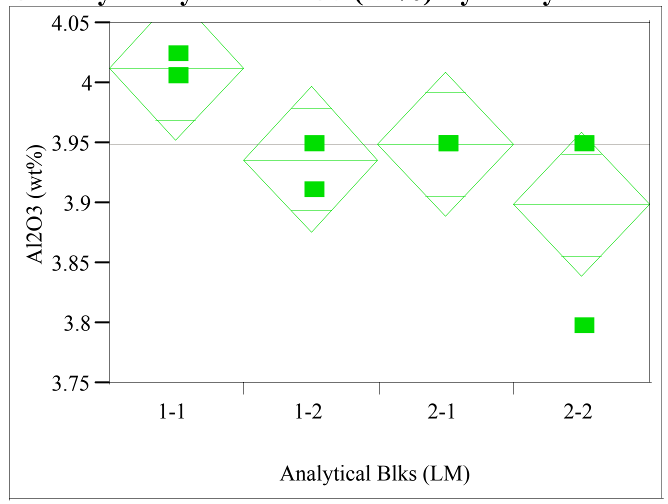
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	4.80563	0.02869	4.7395	4.8718
1-2	3	4.74264	0.02869	4.6765	4.8088
2-1	3	4.74264	0.02869	4.6765	4.8088
2-2	3	4.74894	0.02869	4.6828	4.8151

Std Error uses a pooled estimate of error variance

U std – Al2O3 reference value 4.1 wt%

Oneway Analysis of Al2O3 (wt%) By Analytical Blks (LM)



Oneway Anova

Summary of Fit

Rsquare	0.54902
Root Mean Square Error	0.045309
Mean of Response	3.949055
Observations (or Sum Wgts)	12

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	3	0.01999318	0.006664	3.2464	0.0813
Error	8	0.01642297	0.002053		
C. Total	11	0.03641614			

Means for Oneway Anova

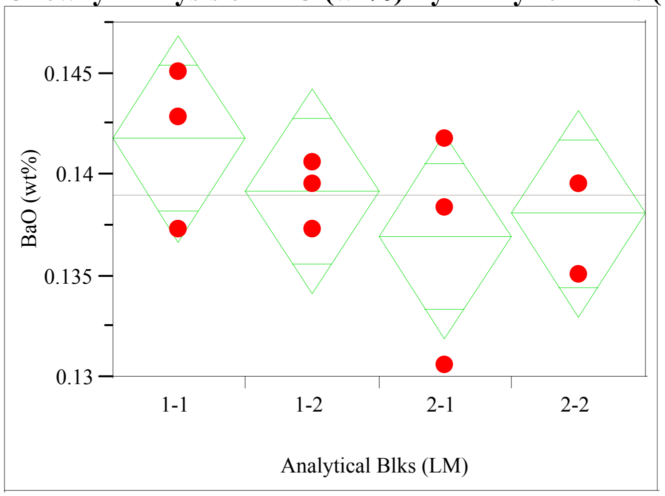
Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	4.01204	0.02616	3.9517	4.0724
1-2	3	3.93646	0.02616	3.8761	3.9968
2-1	3	3.94905	0.02616	3.8887	4.0094
2-2	3	3.89867	0.02616	3.8383	3.9590

Std Error uses a pooled estimate of error variance

Exhibit E.3: SRTC-ML Measurements by Analytical Block for Samples of the Standard Glasses Prepared Using the LM Method *(continued)*

Batch 1 – BaO reference value 0.151 wt%

Oneway Analysis of BaO (wt%) By Analytical Blks (LM)



Oneway Anova

Summary of Fit

Rsquare	0.248
Root Mean Square Error	0.003827
Mean of Response	0.139004
Observations (or Sum Wgts)	12

Analysis of Variance

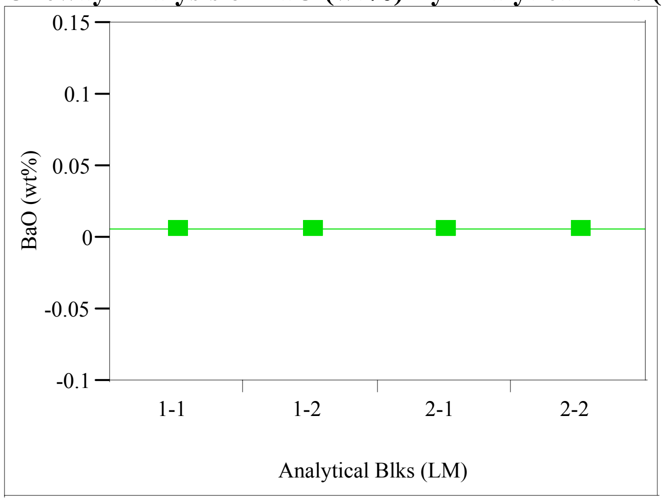
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	3	0.00003864	0.000013	0.8794	0.4913
Error	8	0.00011718	0.000015		
C. Total	11	0.00015582			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.141795	0.00221	0.13670	0.14689
1-2	3	0.139190	0.00221	0.13409	0.14429
2-1	3	0.136957	0.00221	0.13186	0.14205
2-2	3	0.138074	0.00221	0.13298	0.14317

U std – BaO reference value 0 wt%

Oneway Analysis of BaO (wt%) By Analytical Blks (LM)



Oneway Anova

Summary of Fit

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

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	3	0	0	.	.
Error	8	0	0		
C. Total	11	0			

Means for Oneway Anova

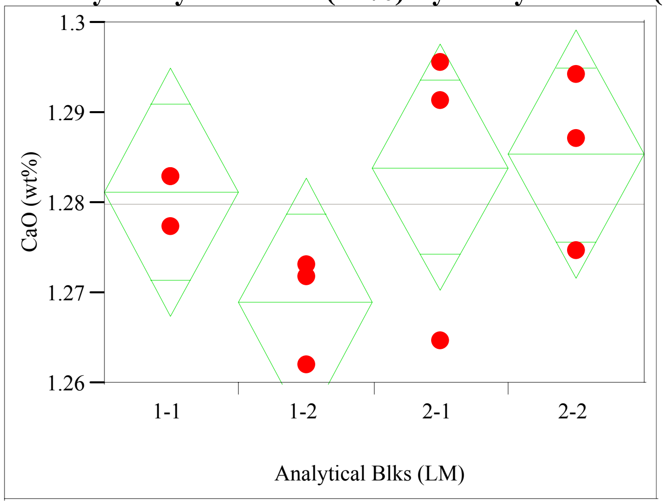
Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.005583	0	0.00558	0.00558
1-2	3	0.005583	0	0.00558	0.00558
2-1	3	0.005583	0	0.00558	0.00558
2-2	3	0.005583	0	0.00558	0.00558

std Error uses a pooled estimate of error variance

Exhibit E.3: SRTC-ML Measurements by Analytical Block for Samples of the Standard Glasses Prepared Using the LM Method *(continued)*

Batch 1 – CaO reference value 1.220 wt%

Oneway Analysis of CaO (wt%) By Analytical Blks (LM)



Oneway Anova

Summary of Fit

Rsquare	0.369415
Root Mean Square Error	0.010306
Mean of Response	1.279918
Observations (or Sum Wgts)	12

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	3	0.00049776	0.000166	1.5622	0.2725
Error	8	0.00084967	0.000106		
C. Total	11	0.00134743			

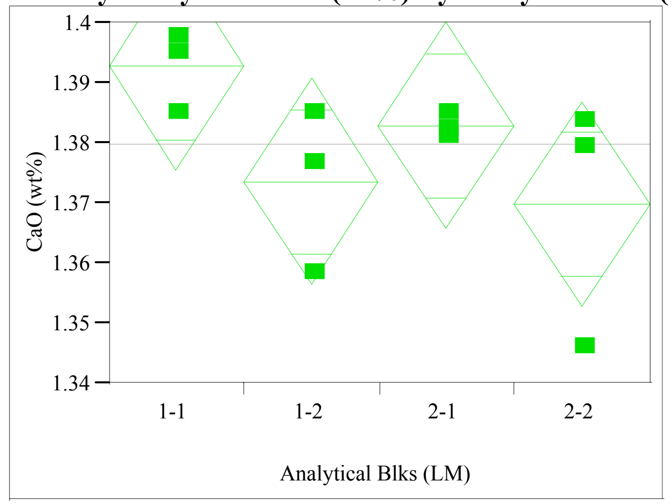
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	1.28120	0.00595	1.2675	1.2949
1-2	3	1.26907	0.00595	1.2554	1.2828
2-1	3	1.28400	0.00595	1.2703	1.2977
2-2	3	1.28540	0.00595	1.2717	1.2991

Std Error uses a pooled estimate of error variance

U std – CaO reference value 1.301 wt%

Oneway Analysis of CaO (wt%) By Analytical Blks (LM)



Oneway Anova

Summary of Fit

Rsquare	0.415688
Root Mean Square Error	0.012862
Mean of Response	1.379728
Observations (or Sum Wgts)	12

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	3	0.00094152	0.000314	1.8971	0.2086
Error	8	0.00132345	0.000165		
C. Total	11	0.00226497			

Means for Oneway Anova

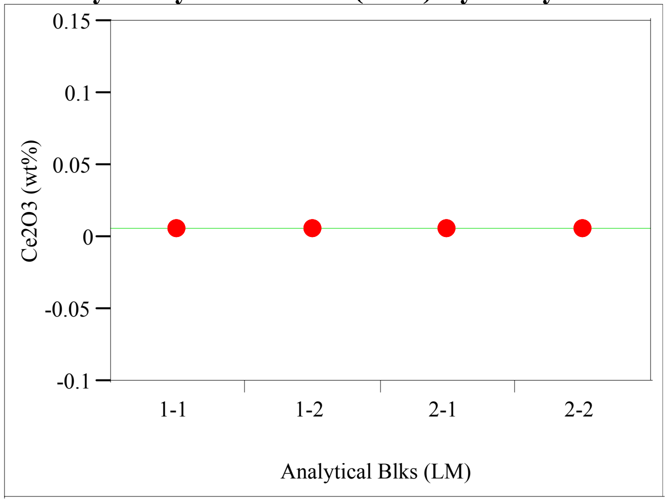
Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	1.39267	0.00743	1.3755	1.4098
1-2	3	1.37355	0.00743	1.3564	1.3907
2-1	3	1.38288	0.00743	1.3658	1.4000
2-2	3	1.36982	0.00743	1.3527	1.3869

Std Error uses a pooled estimate of error variance

Exhibit E.3: SRTC-ML Measurements by Analytical Block for Samples of the Standard Glasses Prepared Using the LM Method *(continued)*

Batch 1 – Ce2O3 reference 0 wt%

Oneway Analysis of Ce2O3 (wt%) By Analytical Blks (LM)



Oneway Anova

Summary of Fit

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

Analysis of Variance

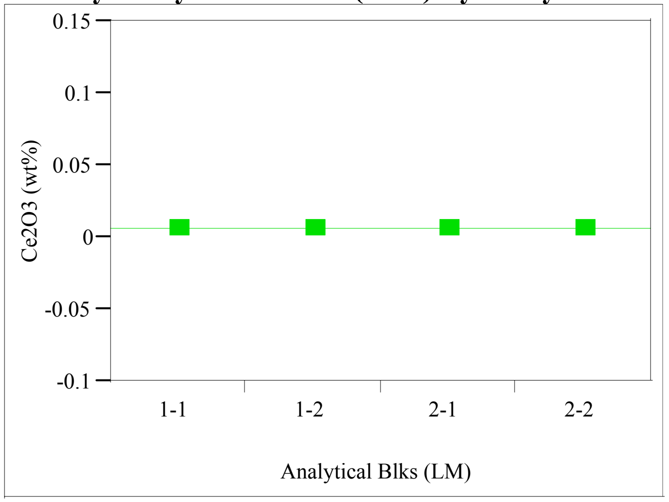
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	3	0	0	.	.
Error	8	0	0		
C. Total	11	0			

Means for Oneway Anova

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

U std – Ce2O3 reference value ~0 wt%

Oneway Analysis of Ce2O3 (wt%) By Analytical Blks (LM)



Oneway Anova

Summary of Fit

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

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	3	0	0	.	.
Error	8	0	0		
C. Total	11	0			

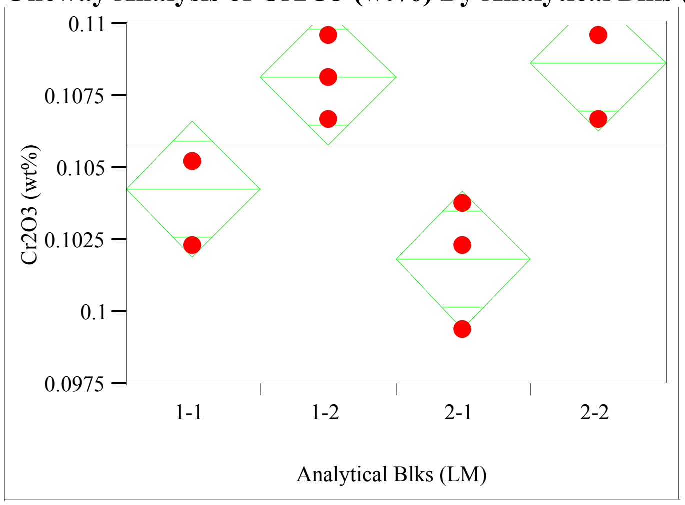
Means for Oneway Anova

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

Exhibit E.3: SRTC-ML Measurements by Analytical Block for Samples of the Standard Glasses Prepared Using the LM Method *(continued)*

Batch 1 – Cr2O3 reference 0.107 wt%

Oneway Analysis of Cr2O3 (wt%) By Analytical Blks (LM)



Oneway Anova

Summary of Fit

Rsquare	0.788235
Root Mean Square Error	0.00179
Mean of Response	0.105722
Observations (or Sum Wgts)	12

Analysis of Variance

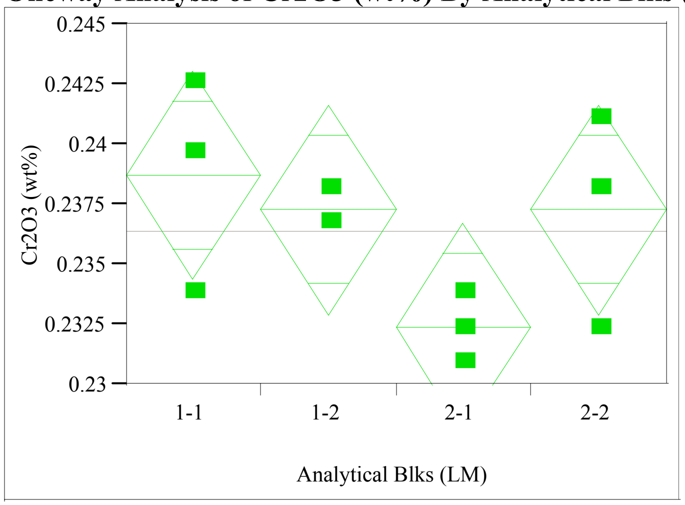
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	3	0.00009542	0.000032	9.9259	0.0045
Error	8	0.00002564	0.000003		
C. Total	11	0.00012106			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.104261	0.00103	0.10188	0.10664
1-2	3	0.108158	0.00103	0.10578	0.11054
2-1	3	0.101825	0.00103	0.09944	0.10421
2-2	3	0.108646	0.00103	0.10626	0.11103

U std – Cr2O3 reference value ~0 wt%

Oneway Analysis of Cr2O3 (wt%) By Analytical Blks (LM)



Oneway Anova

Summary of Fit

Rsquare	0.446367
Root Mean Square Error	0.003268
Mean of Response	0.236414
Observations (or Sum Wgts)	12

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	3	0.00006889	0.000023	2.1500	0.1720
Error	8	0.00008545	0.000011		
C. Total	11	0.00015435			

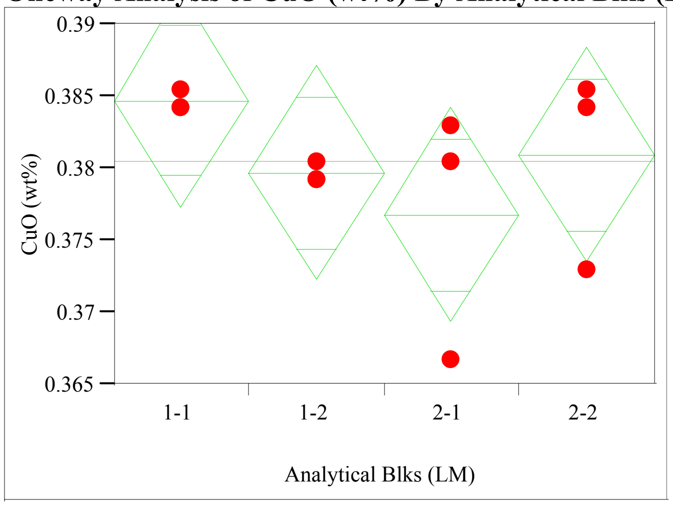
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.238728	0.00189	0.23438	0.24308
1-2	3	0.237266	0.00189	0.23292	0.24162
2-1	3	0.232394	0.00189	0.22804	0.23675
2-2	3	0.237266	0.00189	0.23292	0.24162

Exhibit E.3: SRTC-ML Measurements by Analytical Block for Samples of the Standard Glasses Prepared Using the LM Method *(continued)*

Batch 1 – CuO reference value 0.399 wt%

Oneway Analysis of CuO (wt%) By Analytical Blks (LM)



Oneway Anova

Summary of Fit

Rsquare	0.279279
Root Mean Square Error	0.005598
Mean of Response	0.380547
Observations (or Sum Wgts)	12

Analysis of Variance

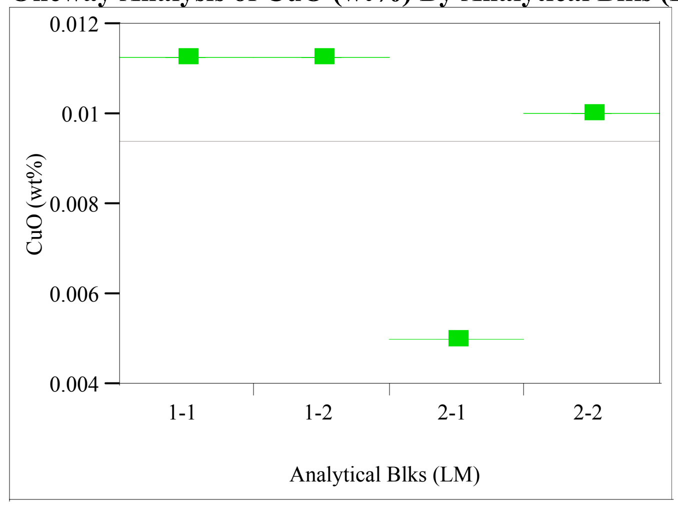
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	3	0.00009715	0.000032	1.0333	0.4282
Error	8	0.00025072	0.000031		
C. Total	11	0.00034787			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.384720	0.00323	0.37727	0.39217
1-2	3	0.379713	0.00323	0.37226	0.38717
2-1	3	0.376792	0.00323	0.36934	0.38425
2-2	3	0.380964	0.00323	0.37351	0.38842

U std – CuO reference value 0 wt%

Oneway Analysis of CuO (wt%) By Analytical Blks (LM)



Oneway Anova

Summary of Fit

Rsquare	1
Root Mean Square Error	4.12e-11
Mean of Response	0.009388
Observations (or Sum Wgts)	12

Analysis of Variance

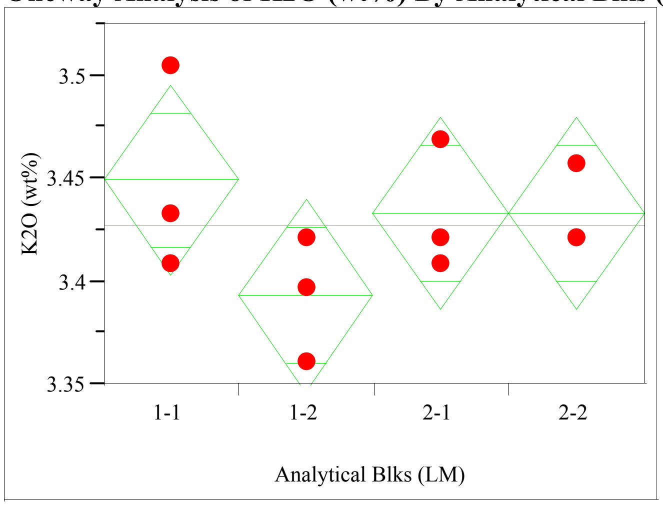
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	3	0.00007992	0.000027	1.572e16	<.0001
Error	8	0.00000000	0.000000		
C. Total	11	0.00007992			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.011266	2.376e-11	0.01127	0.01127
1-2	3	0.011266	2.376e-11	0.01127	0.01127
2-1	3	0.005007	2.376e-11	0.00501	0.00501
2-2	3	0.010014	2.376e-11	0.01001	0.01001

Exhibit E.3: SRTC-ML Measurements by Analytical Block for Samples of the Standard Glasses Prepared Using the LM Method *(continued)*

Batch 1 – K2O reference value 3.327 wt %
Oneway Analysis of K2O (wt%) By Analytical Blks (LM)



Oneway Anova
Summary of Fit

Rsquare	0.346278
Root Mean Square Error	0.034947
Mean of Response	3.427087
Observations (or Sum Wgts)	12

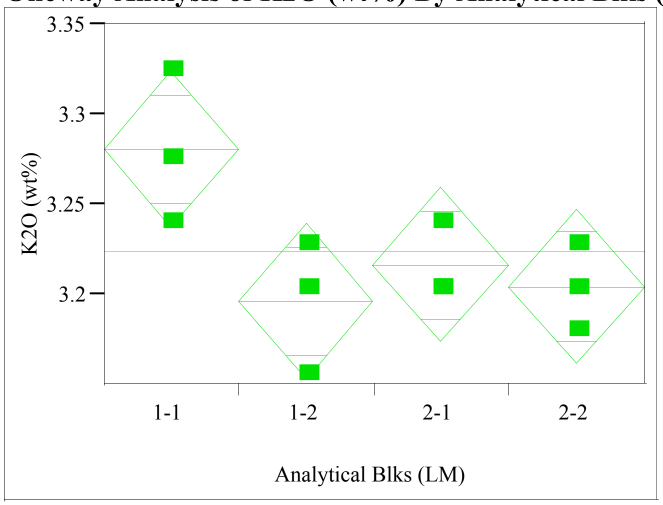
Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	3	0.00517545	0.001725	1.4125	0.3086
Error	8	0.00977048	0.001221		
C. Total	11	0.01494593			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	3.44917	0.02018	3.4026	3.4957
1-2	3	3.39296	0.02018	3.3464	3.4395
2-1	3	3.43311	0.02018	3.3866	3.4796
2-2	3	3.43311	0.02018	3.3866	3.4796

U std – K2O reference value 2.999 wt%
Oneway Analysis of K2O (wt%) By Analytical Blks (LM)



Oneway Anova
Summary of Fit

Rsquare	0.61435
Root Mean Square Error	0.032248
Mean of Response	3.224313
Observations (or Sum Wgts)	12

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	3	0.01325303	0.004418	4.2481	0.0452
Error	8	0.00831942	0.001040		
C. Total	11	0.02157244			

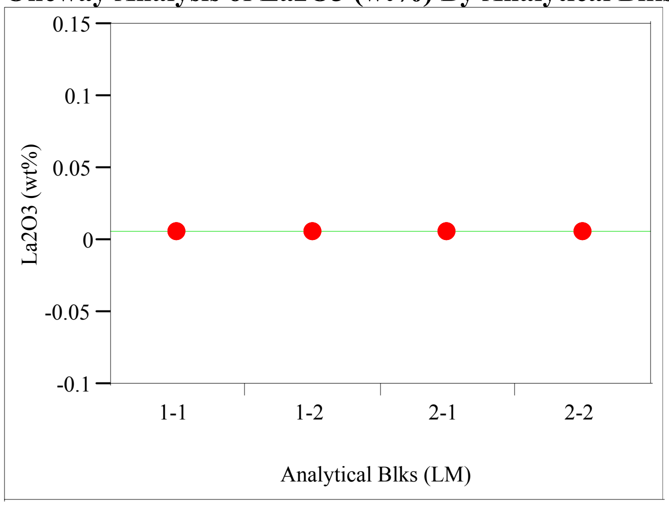
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	3.28053	0.01862	3.2376	3.3235
1-2	3	3.19621	0.01862	3.1533	3.2391
2-1	3	3.21628	0.01862	3.1733	3.2592
2-2	3	3.20424	0.01862	3.1613	3.2472

Exhibit E.3: SRTC-ML Measurements by Analytical Block for Samples of the Standard Glasses Prepared Using the LM Method *(continued)*

Batch 1 – La2O3 reference value 0 wt %

Oneway Analysis of La2O3 (wt%) By Analytical Blks (LM)



Oneway Anova

Summary of Fit

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

Analysis of Variance

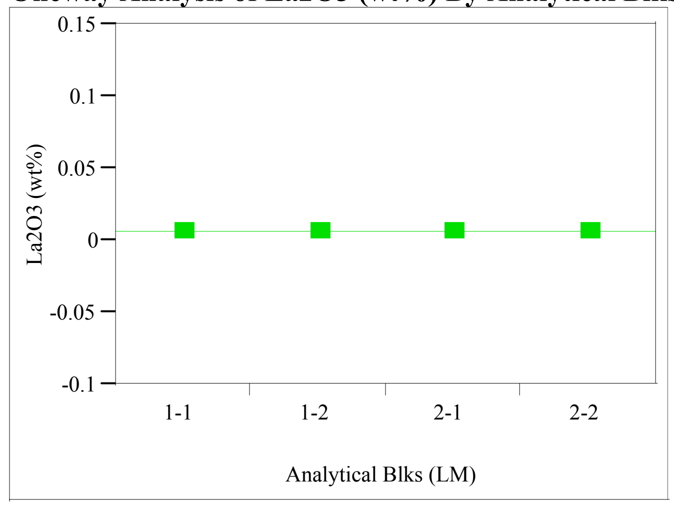
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	3	0	0	.	.
Error	8	0	0		
C. Total	11	0			

Means for Oneway Anova

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

U std – La2O3 reference value 0 wt%

Oneway Analysis of La2O3 (wt%) By Analytical Blks (LM)



Oneway Anova

Summary of Fit

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

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	3	0	0	.	.
Error	8	0	0		
C. Total	11	0			

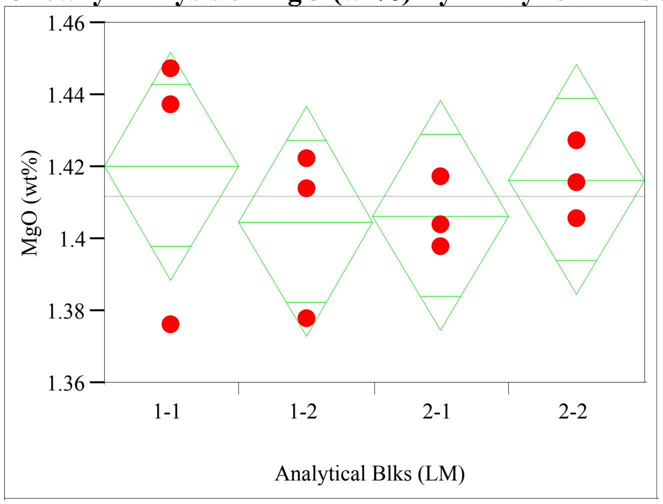
Means for Oneway Anova

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

Exhibit E.3: SRTC-ML Measurements by Analytical Block for Samples of the Standard Glasses Prepared Using the LM Method *(continued)*

Batch 1 – MgO reference value 1.419 wt %

Oneway Analysis of MgO (wt%) By Analytical Blks (LM)



Oneway Anova

Summary of Fit

Rsquare	0.100941
Root Mean Square Error	0.023861
Mean of Response	1.412148
Observations (or Sum Wgts)	12

Analysis of Variance

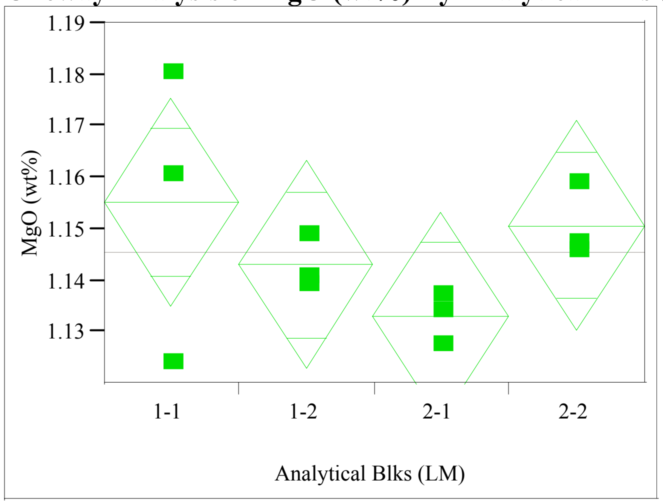
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	3	0.00051137	0.000170	0.2994	0.8251
Error	8	0.00455467	0.000569		
C. Total	11	0.00506604			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	1.42044	0.01378	1.3887	1.4522
1-2	3	1.40496	0.01378	1.3732	1.4367
2-1	3	1.40662	0.01378	1.3749	1.4384
2-2	3	1.41657	0.01378	1.3848	1.4483

U std – MgO reference value 1.21 wt%

Oneway Analysis of MgO (wt%) By Analytical Blks (LM)



Oneway Anova

Summary of Fit

Rsquare	0.314052
Root Mean Square Error	0.015197
Mean of Response	1.145471
Observations (or Sum Wgts)	12

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	3	0.00084587	0.000282	1.2209	0.3634
Error	8	0.00184753	0.000231		
C. Total	11	0.00269339			

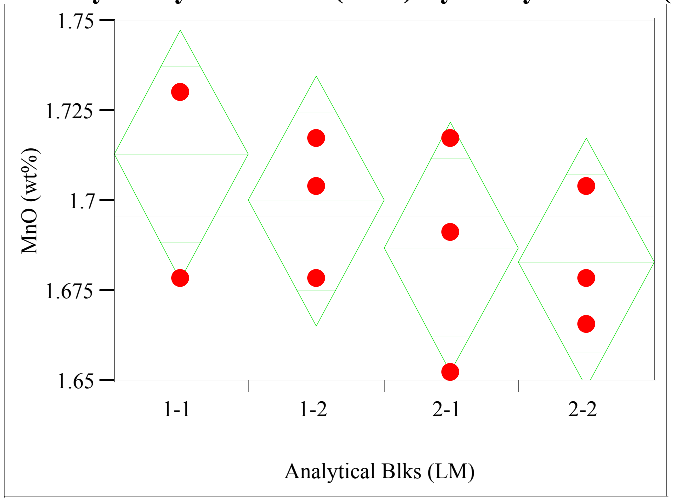
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	1.15514	0.00877	1.1349	1.1754
1-2	3	1.14298	0.00877	1.1228	1.1632
2-1	3	1.13303	0.00877	1.1128	1.1533
2-2	3	1.15072	0.00877	1.1305	1.1710

Exhibit E.3: SRTC-ML Measurements by Analytical Block for Samples of the Standard Glasses Prepared Using the LM Method *(continued)*

Batch 1 – MnO reference value 1.726 wt%

Oneway Analysis of MnO (wt%) By Analytical Blks (LM)



Oneway Anova

Summary of Fit

Rsquare	0.234375
Root Mean Square Error	0.026092
Mean of Response	1.695776
Observations (or Sum Wgts)	12

Analysis of Variance

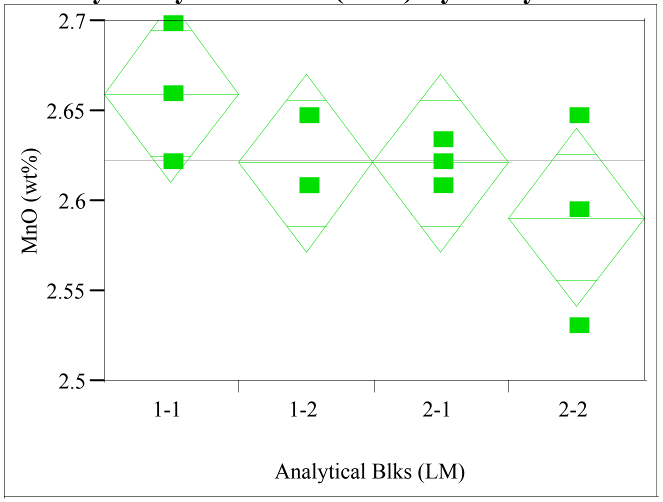
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	3	0.00166720	0.000556	0.8163	0.5201
Error	8	0.00544618	0.000681		
C. Total	11	0.00711338			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	1.71299	0.01506	1.6783	1.7477
1-2	3	1.70008	0.01506	1.6653	1.7348
2-1	3	1.68717	0.01506	1.6524	1.7219
2-2	3	1.68286	0.01506	1.6481	1.7176

U std – MnO reference value 2.892 wt%

Oneway Analysis of MnO (wt%) By Analytical Blks (LM)



Oneway Anova

Summary of Fit

Rsquare	0.392097
Root Mean Square Error	0.037274
Mean of Response	2.623288
Observations (or Sum Wgts)	12

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	3	0.00716895	0.002390	1.7200	0.2398
Error	8	0.01111465	0.001389		
C. Total	11	0.01828360			

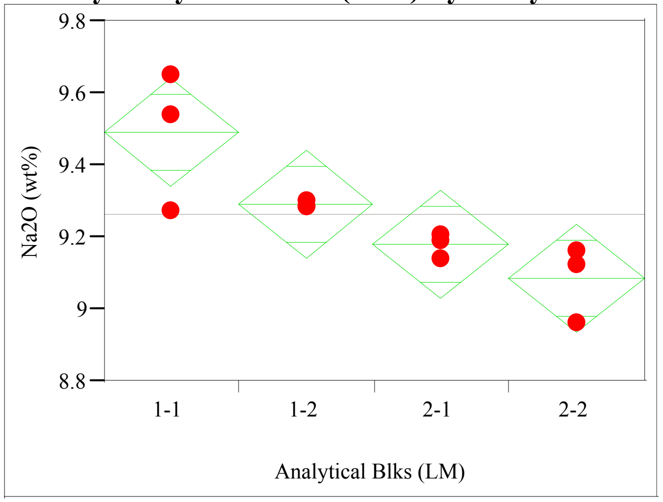
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	2.65987	0.02152	2.6102	2.7095
1-2	3	2.62114	0.02152	2.5715	2.6708
2-1	3	2.62114	0.02152	2.5715	2.6708
2-2	3	2.59101	0.02152	2.5414	2.6406

Exhibit E.3: SRTC-ML Measurements by Analytical Block for Samples of the Standard Glasses Prepared Using the LM Method *(continued)*

Batch 1 – Na2O reference value 9.003 wt%

Oneway Analysis of Na2O (wt%) By Analytical Blks (LM)



Oneway Anova

Summary of Fit

Rsquare	0.729105
Root Mean Square Error	0.112446
Mean of Response	9.261883
Observations (or Sum Wgts)	12

Analysis of Variance

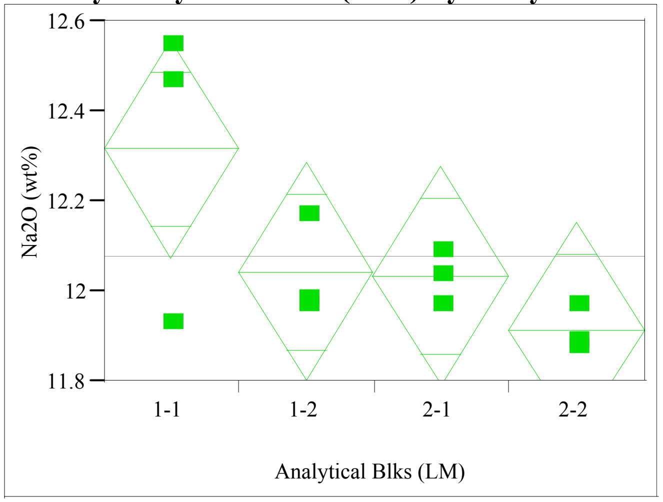
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	3	0.27224761	0.090749	7.1772	0.0117
Error	8	0.10115212	0.012644		
C. Total	11	0.37339973			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	9.48992	0.06492	9.3402	9.6396
1-2	3	9.29221	0.06492	9.1425	9.4419
2-1	3	9.17988	0.06492	9.0302	9.3296
2-2	3	9.08552	0.06492	8.9358	9.2352

U std – Na2O reference value 11.795 wt%

Oneway Analysis of Na2O (wt%) By Analytical Blks (LM)



Oneway Anova

Summary of Fit

Rsquare	0.49765
Root Mean Square Error	0.182146
Mean of Response	12.07583
Observations (or Sum Wgts)	12

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	3	0.26293495	0.087645	2.6417	0.1209
Error	8	0.26541832	0.033177		
C. Total	11	0.52835327			

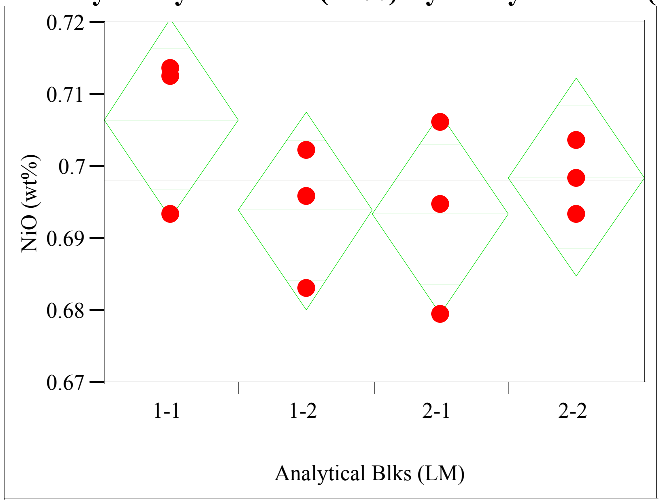
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	12.3162	0.10516	12.074	12.559
1-2	3	12.0421	0.10516	11.800	12.285
2-1	3	12.0331	0.10516	11.791	12.276
2-2	3	11.9118	0.10516	11.669	12.154

Exhibit E.3: SRTC-ML Measurements by Analytical Block for Samples of the Standard Glasses Prepared Using the LM Method *(continued)*

Batch 1 – NiO reference value 0.751 wt%

Oneway Analysis of NiO (wt%) By Analytical Blks (LM)



Oneway Anova

Summary of Fit

Rsquare	0.280686
Root Mean Square Error	0.01037
Mean of Response	0.698178
Observations (or Sum Wgts)	12

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	3	0.00033573	0.000112	1.0406	0.4255
Error	8	0.00086036	0.000108		
C. Total	11	0.00119609			

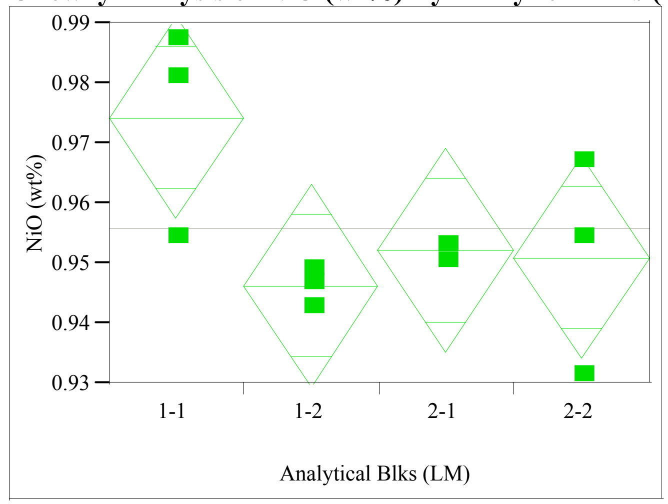
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.706662	0.00599	0.69285	0.72047
1-2	3	0.693937	0.00599	0.68013	0.70774
2-1	3	0.693513	0.00599	0.67971	0.70732
2-2	3	0.698603	0.00599	0.68480	0.71241

Std Error uses a pooled estimate of error variance

U std – NiO reference value 1.12 wt%

Oneway Analysis of NiO (wt%) By Analytical Blks (LM)



Oneway Anova

Summary of Fit

Rsquare	0.52068
Root Mean Square Error	0.012714
Mean of Response	0.955966
Observations (or Sum Wgts)	12

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	3	0.00140484	0.000468	2.8968	0.1018
Error	8	0.00129325	0.000162		
C. Total	11	0.00269809			

Means for Oneway Anova

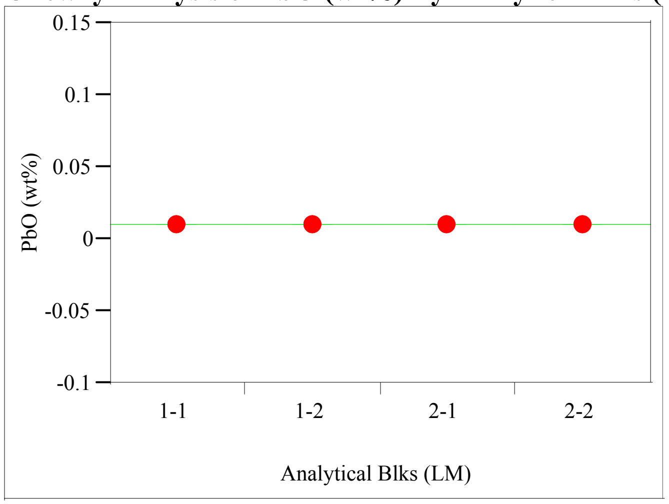
Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.974311	0.00734	0.95738	0.99124
1-2	3	0.946316	0.00734	0.92939	0.96324
2-1	3	0.952254	0.00734	0.93533	0.96918
2-2	3	0.950982	0.00734	0.93405	0.96791

Std Error uses a pooled estimate of error variance

Exhibit E.3: SRTC-ML Measurements by Analytical Block for Samples of the Standard Glasses Prepared Using the LM Method *(continued)*

Batch 1 – PbO reference value ~0 wt%

Oneway Analysis of PbO (wt%) By Analytical Blks (LM)



Oneway Anova

Summary of Fit

Rsquare	0
Root Mean Square Error	2.12e-18
Mean of Response	0.010772
Observations (or Sum Wgts)	12

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	3	0	0	0.0000	1.0000
Error	8	3.6111e-35	4.514e-36		
C. Total	11	3.6111e-35			

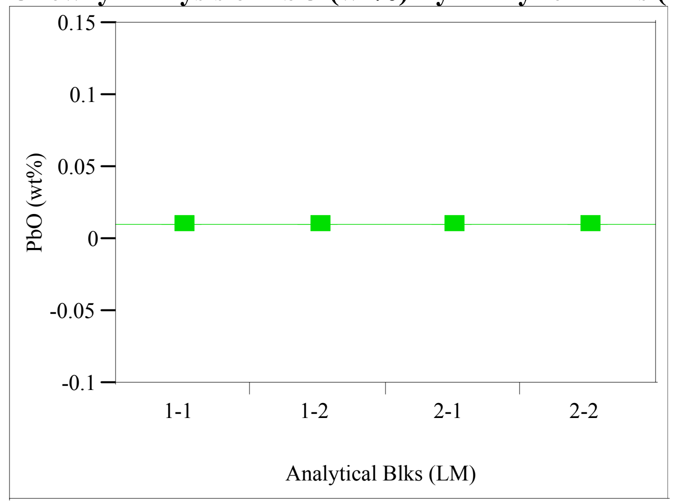
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.010772	1.227e-18	0.01077	0.01077
1-2	3	0.010772	1.227e-18	0.01077	0.01077
2-1	3	0.010772	1.227e-18	0.01077	0.01077
2-2	3	0.010772	1.227e-18	0.01077	0.01077

Std Error uses a pooled estimate of error variance

U std – PbO reference value ~0 wt%

Oneway Analysis of PbO (wt%) By Analytical Blks (LM)



Oneway Anova

Summary of Fit

Rsquare	0
Root Mean Square Error	2.12e-18
Mean of Response	0.010772
Observations (or Sum Wgts)	12

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	3	0	0	0.0000	1.0000
Error	8	3.6111e-35	4.514e-36		
C. Total	11	3.6111e-35			

Means for Oneway Anova

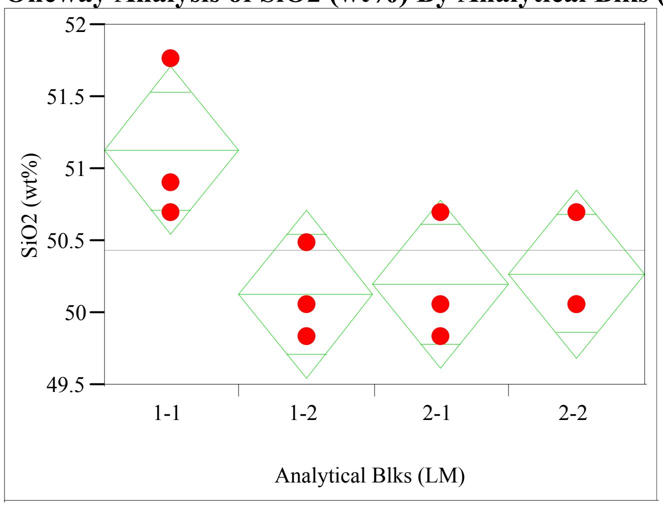
Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.010772	1.227e-18	0.01077	0.01077
1-2	3	0.010772	1.227e-18	0.01077	0.01077
2-1	3	0.010772	1.227e-18	0.01077	0.01077
2-2	3	0.010772	1.227e-18	0.01077	0.01077

Std Error uses a pooled estimate of error variance

Exhibit E.3: SRTC-ML Measurements by Analytical Block for Samples of the Standard Glasses Prepared Using the LM Method *(continued)*

Batch 1 – SiO2 reference value 50.22 wt%

Oneway Analysis of SiO2 (wt%) By Analytical Blks (LM)



Oneway Anova

Summary of Fit

Rsquare	0.562842
Root Mean Square Error	0.436683
Mean of Response	50.434
Observations (or Sum Wgts)	12

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	3	1.9641261	0.654709	3.4333	0.0724
Error	8	1.5255348	0.190692		
C. Total	11	3.4896609			

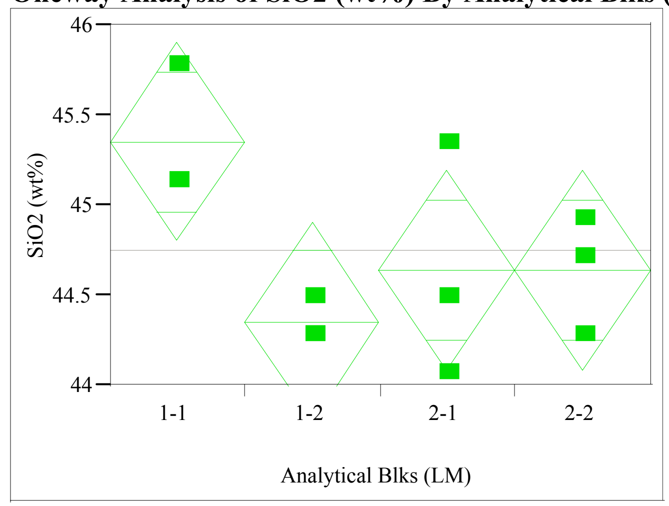
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	51.1293	0.25212	50.548	51.711
1-2	3	50.1309	0.25212	49.550	50.712
2-1	3	50.2022	0.25212	49.621	50.784
2-2	3	50.2736	0.25212	49.692	50.855

Std Error uses a pooled estimate of error variance

U std – SiO2 reference value 45.353 wt%

Oneway Analysis of SiO2 (wt%) By Analytical Blks (LM)



Oneway Anova

Summary of Fit

Rsquare	0.543147
Root Mean Square Error	0.414274
Mean of Response	44.74703
Observations (or Sum Wgts)	12

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	3	1.6323223	0.544107	3.1704	0.0853
Error	8	1.3729813	0.171623		
C. Total	11	3.0053036			

Means for Oneway Anova

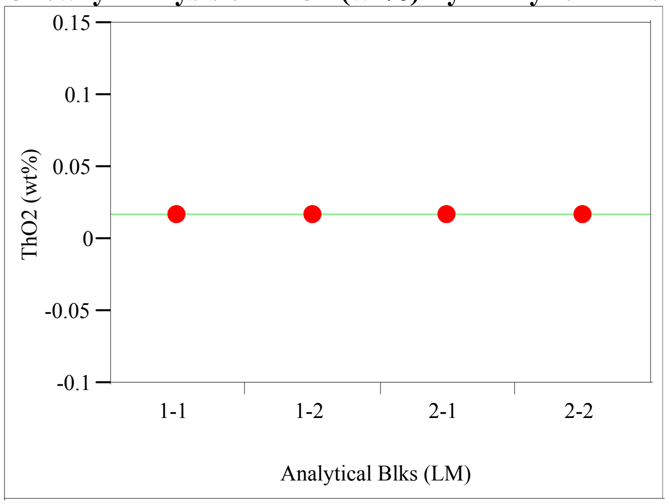
Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	45.3532	0.23918	44.802	45.905
1-2	3	44.3548	0.23918	43.803	44.906
2-1	3	44.6401	0.23918	44.089	45.192
2-2	3	44.6401	0.23918	44.089	45.192

Std Error uses a pooled estimate of error variance

Exhibit E.3: SRTC-ML Measurements by Analytical Block for Samples of the Standard Glasses Prepared Using the LM Method *(continued)*

Batch 1 – ThO2 reference value ~0 wt%

Oneway Analysis of ThO2 (wt%) By Analytical Blks (LM)



Oneway Anova

Summary of Fit

Rsquare	.
Root Mean Square Error	0
Mean of Response	0.017068
Observations (or Sum Wgts)	12

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	3	0	0	.	.
Error	8	0	0		
C. Total	11	0			

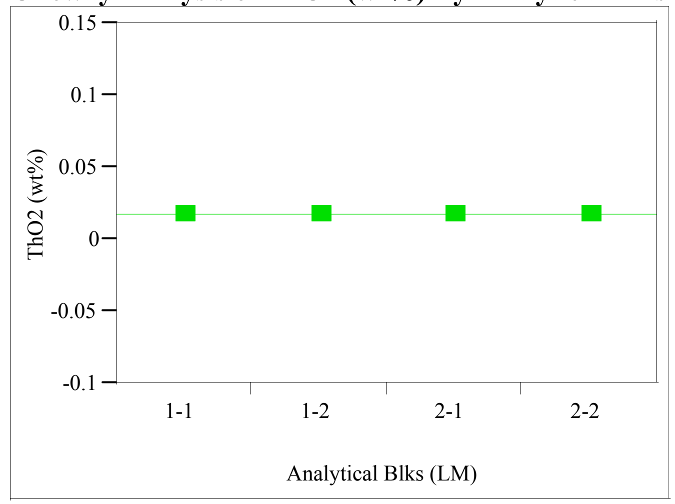
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.017068	0	0.01707	0.01707
1-2	3	0.017068	0	0.01707	0.01707
2-1	3	0.017068	0	0.01707	0.01707
2-2	3	0.017068	0	0.01707	0.01707

Std Error uses a pooled estimate of error variance

U std – ThO2 reference value 0 wt%

Oneway Analysis of ThO2 (wt%) By Analytical Blks (LM)



Oneway Anova

Summary of Fit

Rsquare	.
Root Mean Square Error	0
Mean of Response	0.017068
Observations (or Sum Wgts)	12

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	3	0	0	.	.
Error	8	0	0		
C. Total	11	0			

Means for Oneway Anova

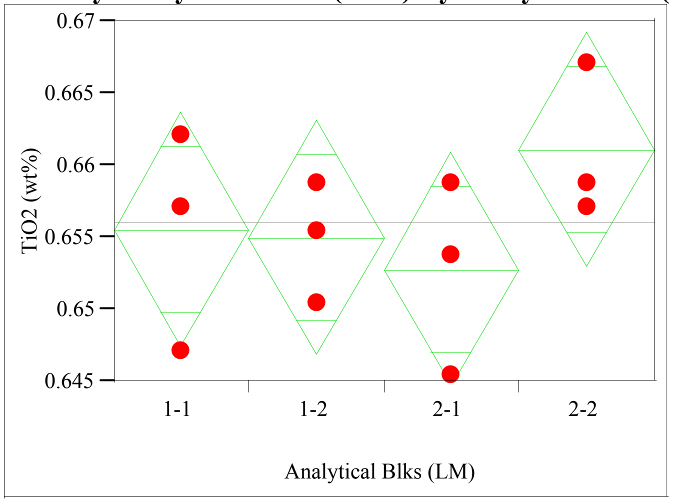
Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.017068	0	0.01707	0.01707
1-2	3	0.017068	0	0.01707	0.01707
2-1	3	0.017068	0	0.01707	0.01707
2-2	3	0.017068	0	0.01707	0.01707

Std Error uses a pooled estimate of error variance

Exhibit E.3: SRTC-ML Measurements by Analytical Block for Samples of the Standard Glasses Prepared Using the LM Method *(continued)*

Batch 1 – TiO2 reference value 0.677 wt%

Oneway Analysis of TiO2 (wt%) By Analytical Blks (LM)



Oneway Anova

Summary of Fit

Rsquare	0.273543
Root Mean Square Error	0.006129
Mean of Response	0.65608
Observations (or Sum Wgts)	12

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	3	0.00011314	0.000038	1.0041	0.4395
Error	8	0.00030048	0.000038		
C. Total	11	0.00041362			

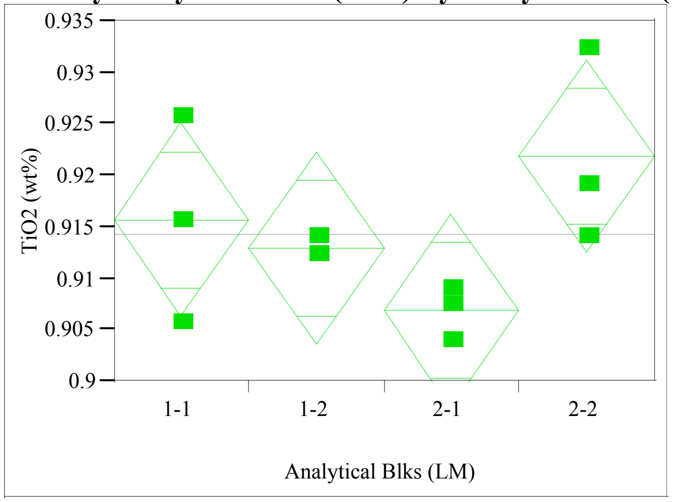
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.655524	0.00354	0.64736	0.66368
1-2	3	0.654968	0.00354	0.64681	0.66313
2-1	3	0.652744	0.00354	0.64458	0.66090
2-2	3	0.661084	0.00354	0.65292	0.66924

Std Error uses a pooled estimate of error variance

U std – TiO2 reference value 1.049 wt%

Oneway Analysis of TiO2 (wt%) By Analytical Blks (LM)



Oneway Anova

Summary of Fit

Rsquare	0.469489
Root Mean Square Error	0.007027
Mean of Response	0.914342
Observations (or Sum Wgts)	12

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	3	0.00034963	0.000117	2.3599	0.1475
Error	8	0.00039508	0.000049		
C. Total	11	0.00074471			

Means for Oneway Anova

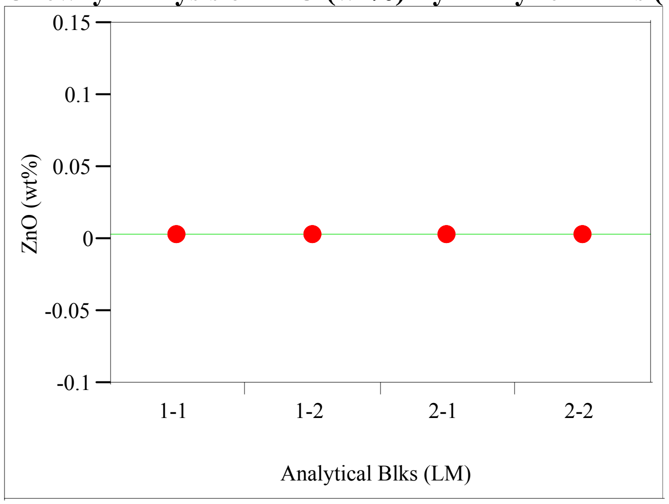
Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.915732	0.00406	0.90638	0.92509
1-2	3	0.912952	0.00406	0.90360	0.92231
2-1	3	0.906836	0.00406	0.89748	0.91619
2-2	3	0.921848	0.00406	0.91249	0.93120

Std Error uses a pooled estimate of error variance

Exhibit E.3: SRTC-ML Measurements by Analytical Block for Samples of the Standard Glasses Prepared Using the LM Method *(continued)*

Batch 1 – ZnO reference value ~0 wt%

Oneway Analysis of ZnO (wt%) By Analytical Blks (LM)



Oneway Anova

Summary of Fit

Rsquare	.
Root Mean Square Error	0
Mean of Response	0.003112
Observations (or Sum Wgts)	12

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	3	0	0	.	.
Error	8	0	0		
C. Total	11	0			

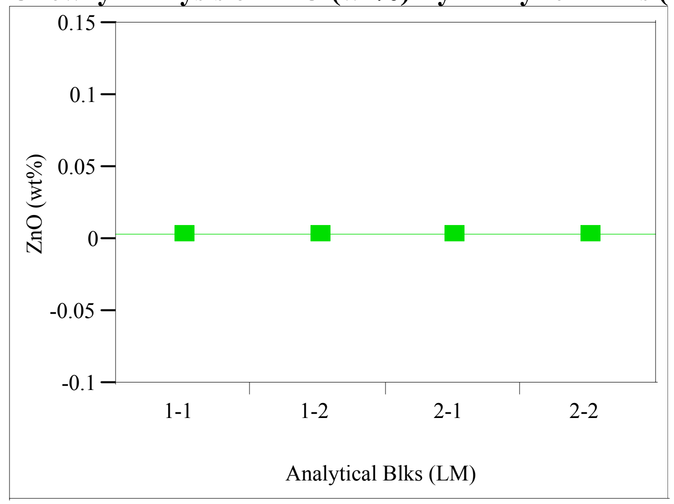
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.003112	0	0.00311	0.00311
1-2	3	0.003112	0	0.00311	0.00311
2-1	3	0.003112	0	0.00311	0.00311
2-2	3	0.003112	0	0.00311	0.00311

Std Error uses a pooled estimate of error variance

U std – ZnO reference value 0 wt%

Oneway Analysis of ZnO (wt%) By Analytical Blks (LM)



Oneway Anova

Summary of Fit

Rsquare	.
Root Mean Square Error	0
Mean of Response	0.003112
Observations (or Sum Wgts)	12

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	3	0	0	.	.
Error	8	0	0		
C. Total	11	0			

Means for Oneway Anova

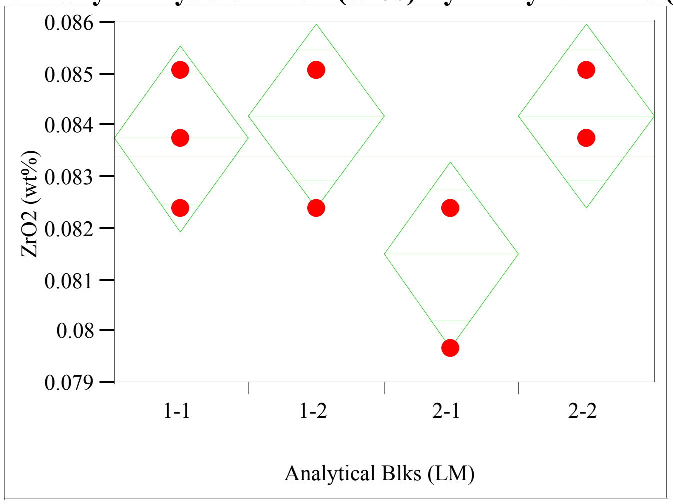
Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.003112	0	0.00311	0.00311
1-2	3	0.003112	0	0.00311	0.00311
2-1	3	0.003112	0	0.00311	0.00311
2-2	3	0.003112	0	0.00311	0.00311

Std Error uses a pooled estimate of error variance

Exhibit E.3: SRTC-ML Measurements by Analytical Block for Samples of the Standard Glasses Prepared Using the LM Method *(continued)*

Batch 1 – ZrO2 reference value 0.098 wt%

Oneway Analysis of ZrO2 (wt%) By Analytical Blks (LM)



Oneway Anova

Summary of Fit

Rsquare	0.507692
Root Mean Square Error	0.001351
Mean of Response	0.083412
Observations (or Sum Wgts)	12

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	3	0.00001505	0.000005	2.7500	0.1123
Error	8	0.00001460	0.0000018		
C. Total	11	0.00002965			

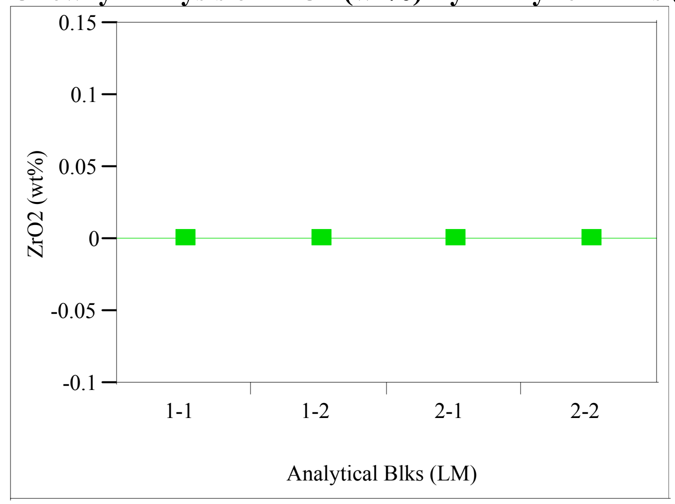
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.083750	0.00078	0.08195	0.08555
1-2	3	0.084200	0.00078	0.08240	0.08600
2-1	3	0.081498	0.00078	0.07970	0.08330
2-2	3	0.084200	0.00078	0.08240	0.08600

Std Error uses a pooled estimate of error variance

U std – ZrO2 reference value 0 wt%

Oneway Analysis of ZrO2 (wt%) By Analytical Blks (LM)



Oneway Anova

Summary of Fit

Rsquare	.
Root Mean Square Error	0
Mean of Response	0.000675
Observations (or Sum Wgts)	12

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	3	0	0	.	.
Error	8	0	0		
C. Total	11	0			

Means for Oneway Anova

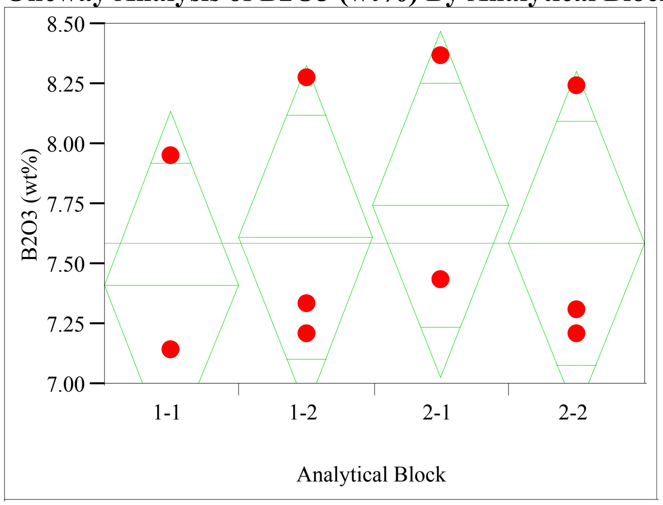
Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.000675	0	0.00068	0.00068
1-2	3	0.000675	0	0.00068	0.00068
2-1	3	0.000675	0	0.00068	0.00068
2-2	3	0.000675	0	0.00068	0.00068

Std Error uses a pooled estimate of error variance

Exhibit E.4: SRTC-ML Measurements by Analytical Block for Samples of the Standard Glasses Prepared Using the PF Method

Batch 1 – B2O3 reference value 7.777wt%

Oneway Analysis of B2O3 (wt%) By Analytical Block



Oneway Anova

Summary of Fit

Rsquare	0.066984
Root Mean Square Error	0.540074
Mean of Response	7.590914
Observations (or Sum Wgts)	12

Analysis of Variance

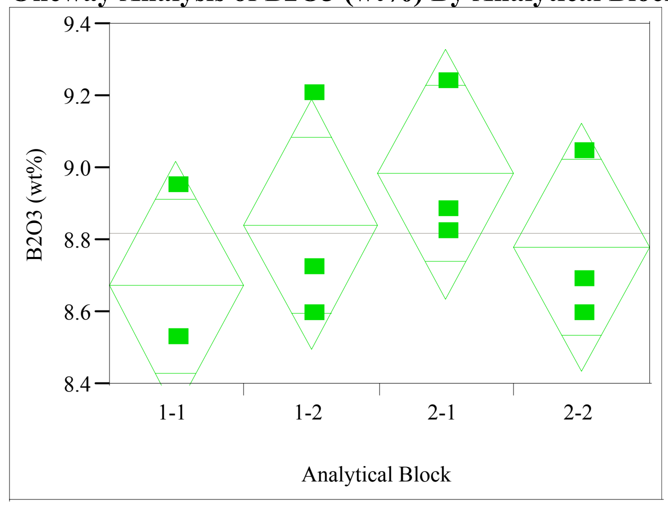
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Block	3	0.1675257	0.055842	0.1914	0.8993
Error	8	2.3334363	0.291680		
C. Total	11	2.5009619			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	7.41650	0.31181	6.6975	8.1355
1-2	3	7.60970	0.31181	6.8907	8.3287
2-1	3	7.74923	0.31181	7.0302	8.4683
2-2	3	7.58823	0.31181	6.8692	8.3073

U std – B2O3 reference value 9.209 wt%

Oneway Analysis of B2O3 (wt%) By Analytical Block



Oneway Anova

Summary of Fit

Rsquare	0.220292
Root Mean Square Error	0.259597
Mean of Response	8.819843
Observations (or Sum Wgts)	12

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Block	3	0.15231962	0.050773	0.7534	0.5506
Error	8	0.53912331	0.067390		
C. Total	11	0.69144293			

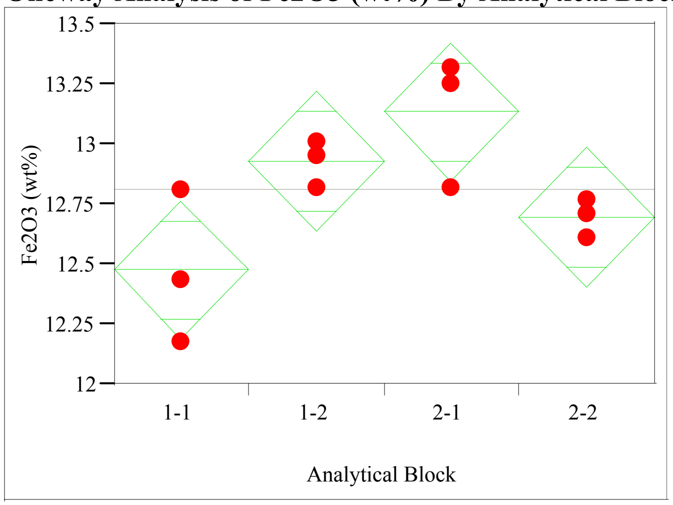
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	8.67226	0.14988	8.3266	9.0179
1-2	3	8.84399	0.14988	8.4984	9.1896
2-1	3	8.98352	0.14988	8.6379	9.3291
2-2	3	8.77959	0.14988	8.4340	9.1252

Exhibit E.4: SRTC-ML Measurements by Analytical Block for Samples of the Standard Glasses Prepared Using the PF Method *(continued)*

Batch 1 – Fe2O3 reference value 12.839 %

Oneway Analysis of Fe2O3 (wt%) By Analytical Block



Oneway Anova

Summary of Fit

Rsquare	0.659467
Root Mean Square Error	0.217178
Mean of Response	12.80892
Observations (or Sum Wgts)	12

Analysis of Variance

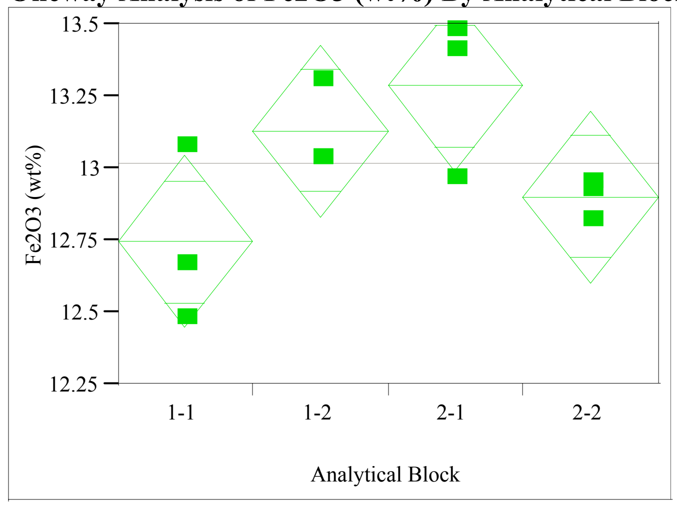
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Block	3	0.7307280	0.243576	5.1642	0.0282
Error	8	0.3773302	0.047166		
C. Total	11	1.1080582			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	12.4765	0.12539	12.187	12.766
1-2	3	12.9293	0.12539	12.640	13.218
2-1	3	13.1342	0.12539	12.845	13.423
2-2	3	12.6957	0.12539	12.407	12.985

U std – Fe2O3 reference value 13.196 wt%

Oneway Analysis of Fe2O3 (wt%) By Analytical Block



Oneway Anova

Summary of Fit

Rsquare	0.564076
Root Mean Square Error	0.224392
Mean of Response	13.01504
Observations (or Sum Wgts)	12

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Block	3	0.52123073	0.173744	3.4506	0.0716
Error	8	0.40281256	0.050352		
C. Total	11	0.92404329			

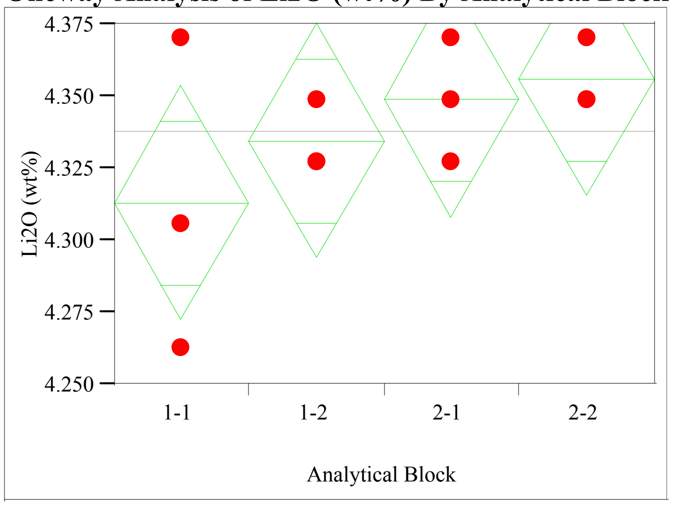
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	12.7434	0.12955	12.445	13.042
1-2	3	13.1294	0.12955	12.831	13.428
2-1	3	13.2867	0.12955	12.988	13.585
2-2	3	12.9007	0.12955	12.602	13.199

Exhibit E.4: SRTC-ML Measurements by Analytical Block for Samples of the Standard Glasses Prepared Using the PF Method *(continued)*

Batch 1 – Li2O reference value 4.429 wt %

Oneway Analysis of Li2O (wt%) By Analytical Block



Oneway Anova

Summary of Fit

Rsquare	0.304348
Root Mean Square Error	0.030447
Mean of Response	4.338093
Observations (or Sum Wgts)	12

Analysis of Variance

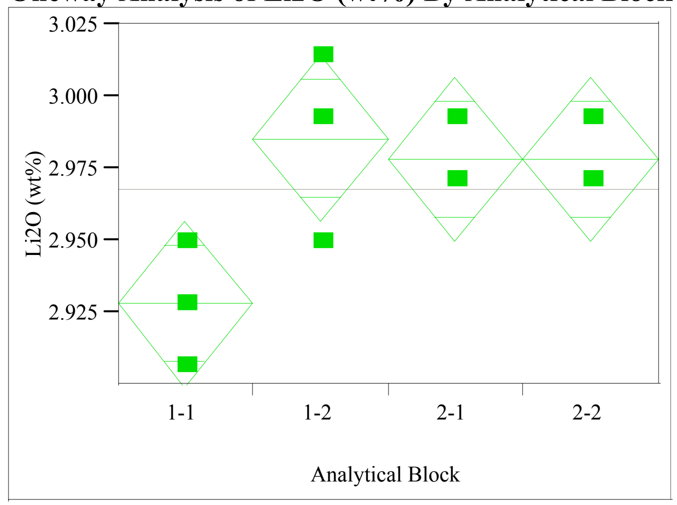
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Block	3	0.00324448	0.001081	1.1667	0.3809
Error	8	0.00741597	0.000927		
C. Total	11	0.01066045			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	4.31298	0.01758	4.2724	4.3535
1-2	3	4.33451	0.01758	4.2940	4.3750
2-1	3	4.34886	0.01758	4.3083	4.3894
2-2	3	4.35603	0.01758	4.3155	4.3966

U std – Li2Oreference value 3.057 wt%

Oneway Analysis of Li2O (wt%) By Analytical Block



Oneway Anova

Summary of Fit

Rsquare	0.630769
Root Mean Square Error	0.021529
Mean of Response	2.967414
Observations (or Sum Wgts)	12

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Block	3	0.00633447	0.002111	4.5556	0.0384
Error	8	0.00370798	0.000463		
C. Total	11	0.01004245			

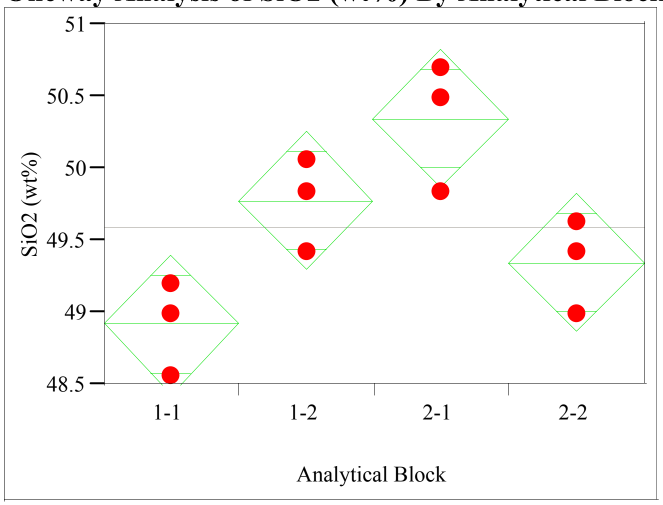
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	2.92794	0.01243	2.8993	2.9566
1-2	3	2.98535	0.01243	2.9567	3.0140
2-1	3	2.97818	0.01243	2.9495	3.0068
2-2	3	2.97818	0.01243	2.9495	3.0068

Exhibit E.4: SRTC-ML Measurements by Analytical Block for Samples of the Standard Glasses Prepared Using the PF Method *(continued)*

Batch 1 – SiO2 reference value 50.22wt%

Oneway Analysis of SiO2 (wt%) By Analytical Block



Oneway Anova

Summary of Fit

Rsquare	0.763066
Root Mean Square Error	0.360098
Mean of Response	49.59611
Observations (or Sum Wgts)	12

Analysis of Variance

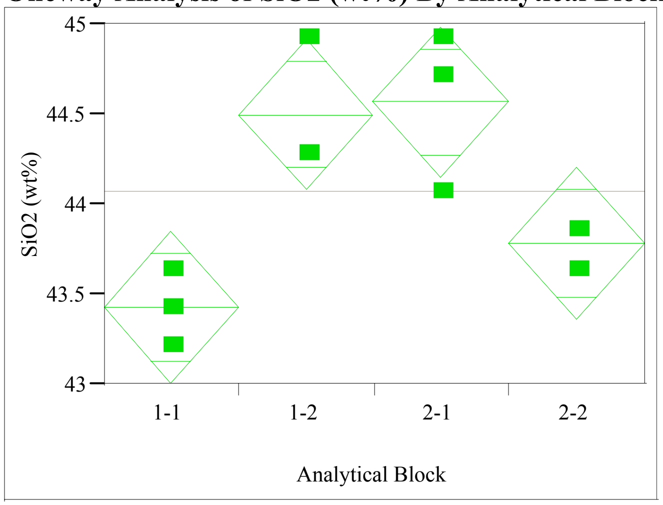
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Block	3	3.3409213	1.11364	8.5882	0.0070
Error	8	1.0373637	0.12967		
C. Total	11	4.3782850			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	48.9187	0.20790	48.439	49.398
1-2	3	49.7744	0.20790	49.295	50.254
2-1	3	50.3449	0.20790	49.865	50.824
2-2	3	49.3465	0.20790	48.867	49.826

U std – SiO2 reference value 45.353 wt%

Oneway Analysis of SiO2 (wt%) By Analytical Block



Oneway Anova

Summary of Fit

Rsquare	0.777778
Root Mean Square Error	0.314896
Mean of Response	44.06958
Observations (or Sum Wgts)	12

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Block	3	2.7764734	0.925491	9.3333	0.0054
Error	8	0.7932781	0.099160		
C. Total	11	3.5697515			

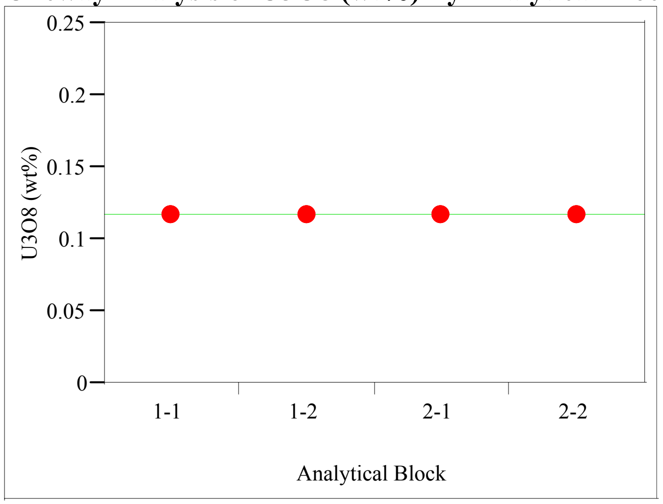
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	43.4278	0.18181	43.009	43.847
1-2	3	44.4974	0.18181	44.078	44.917
2-1	3	44.5687	0.18181	44.150	44.988
2-2	3	43.7843	0.18181	43.365	44.204

Exhibit E.4: SRTC-ML Measurements by Analytical Block for Samples of the Standard Glasses Prepared Using the PF Method *(continued)*

Batch 1 – U3O8 reference value 0 wt%

Oneway Analysis of U3O8 (wt%) By Analytical Block



Oneway Anova

Summary of Fit

Rsquare	.
Root Mean Square Error	0
Mean of Response	0.11792
Observations (or Sum Wgts)	12

Analysis of Variance

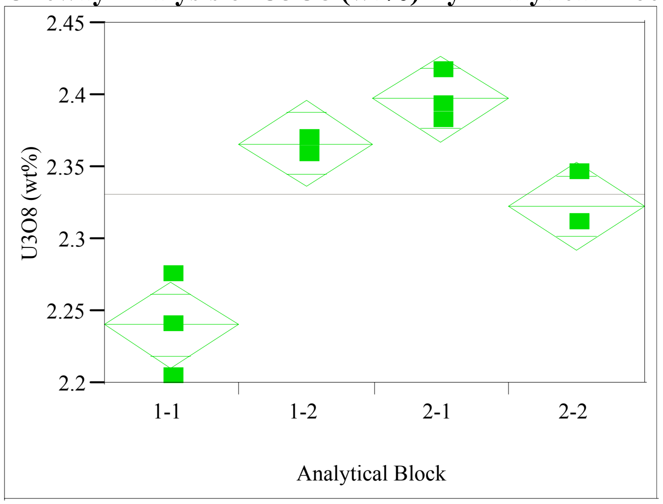
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Block	3	0	0	.	.
Error	8	0	0		
C. Total	11	0			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.117920	0	0.11792	0.11792
1-2	3	0.117920	0	0.11792	0.11792
2-1	3	0.117920	0	0.11792	0.11792
2-2	3	0.117920	0	0.11792	0.11792

U std – U3O8 reference value 2.406 wt%

Oneway Analysis of U3O8 (wt%) By Analytical Block



Oneway Anova

Summary of Fit

Rsquare	0.911178
Root Mean Square Error	0.02258
Mean of Response	2.331868
Observations (or Sum Wgts)	12

Analysis of Variance

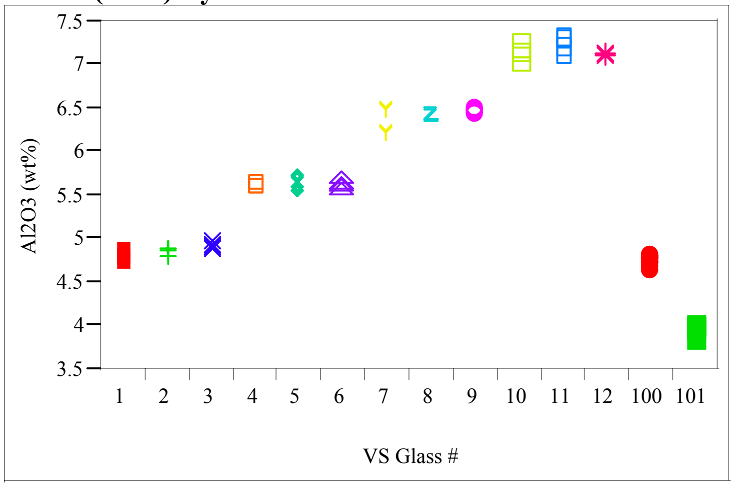
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Block	3	0.04184284	0.013948	27.3561	0.0001
Error	8	0.00407884	0.000510		
C. Total	11	0.04592168			

Means for Oneway Anova

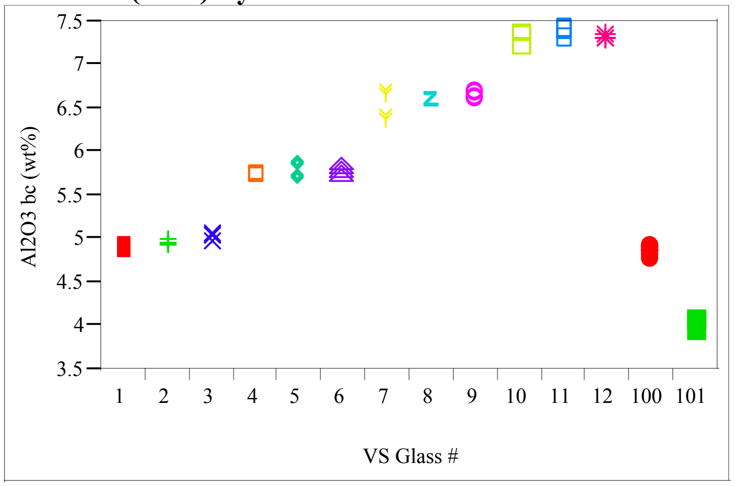
Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	2.24048	0.01304	2.2104	2.2705
1-2	3	2.36626	0.01304	2.3362	2.3963
2-1	3	2.39771	0.01304	2.3676	2.4278
2-2	3	2.32302	0.01304	2.2930	2.3531

Exhibit E.5: SRTC-ML Measurements by Variability Study (VS) Glass Number for Samples Prepared Using the LM Method
(100 – Batch 1; 101 – U std)

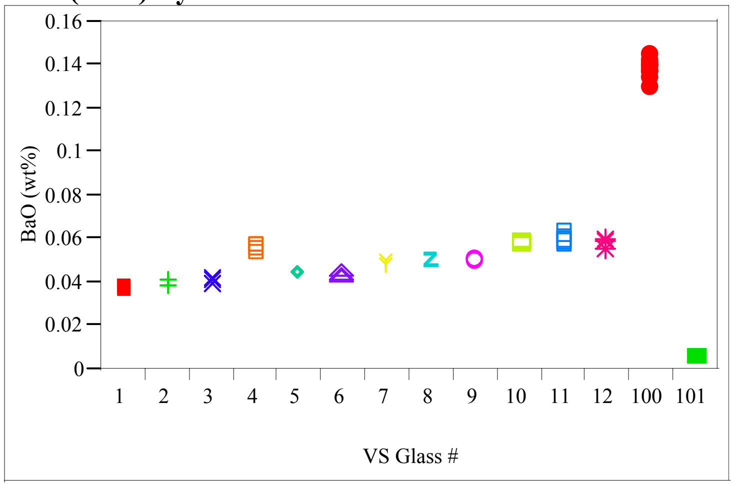
Al2O3 (wt%) By VS Glass #



Al2O3 bc (wt%) By VS Glass #



BaO (wt%) By VS Glass #



BaO bc (wt%) By VS Glass #

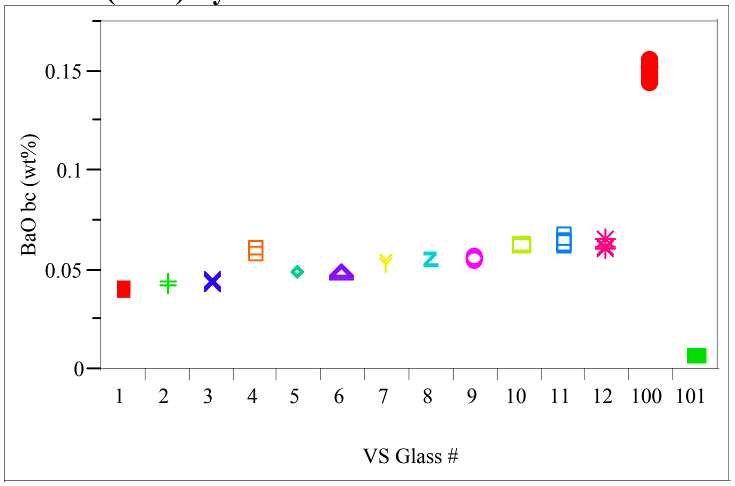
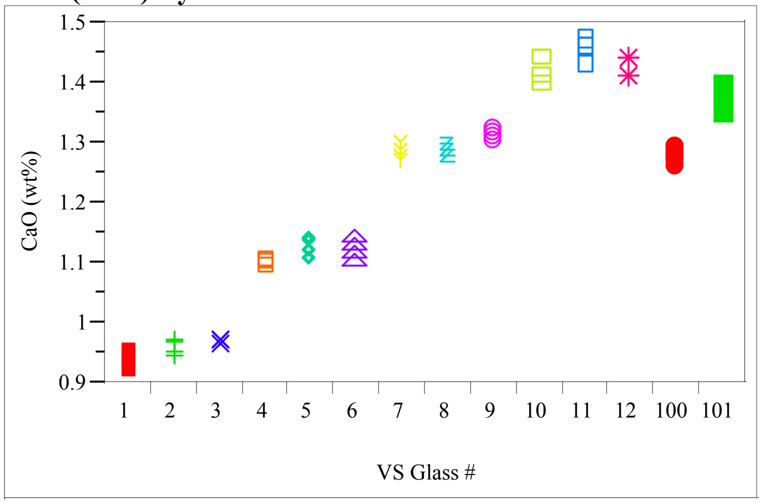
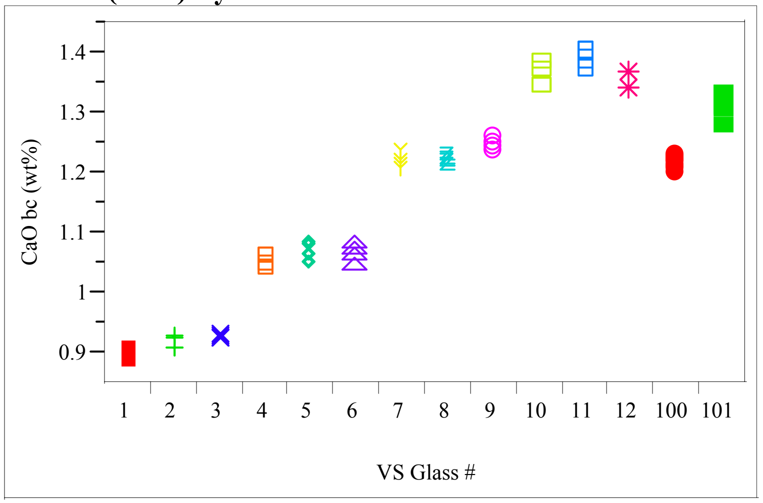


Exhibit E.5: SRTC-ML Measurements by Variability Study (VS) Glass Number for Samples Prepared Using the LM Method (100 – Batch 1; 101 – U std) *(continued)*

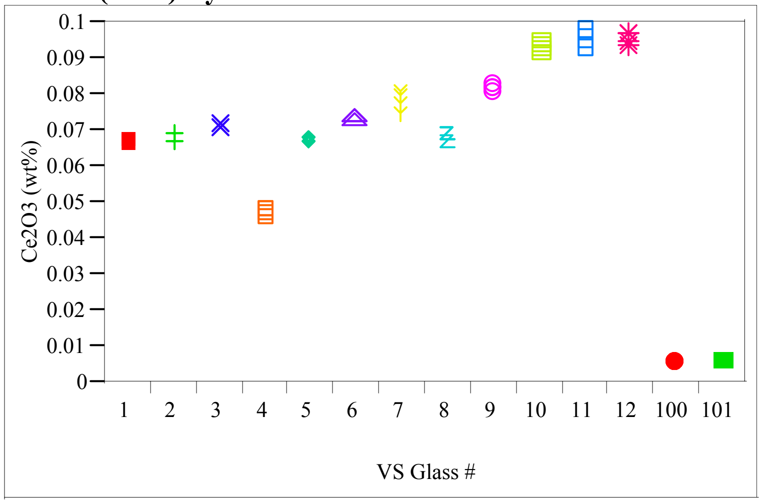
CaO (wt%) By VS Glass #



CaO bc (wt%) By VS Glass #



Ce2O3 (wt%) By VS Glass #



Ce2O3 bc (wt%) By VS Glass #

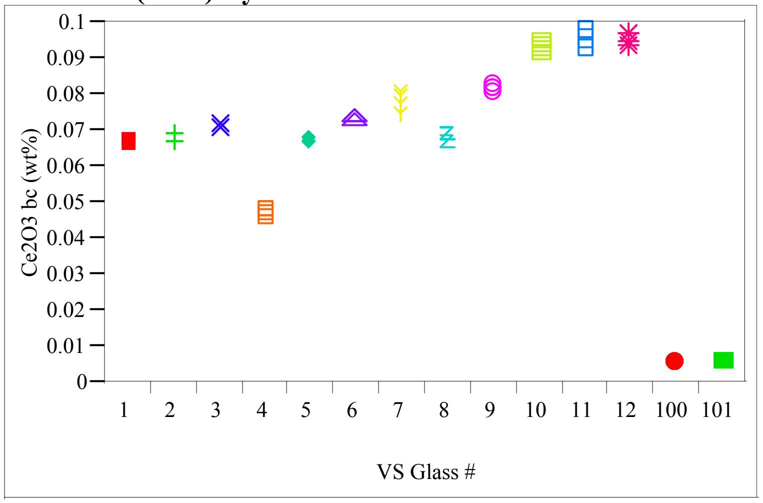
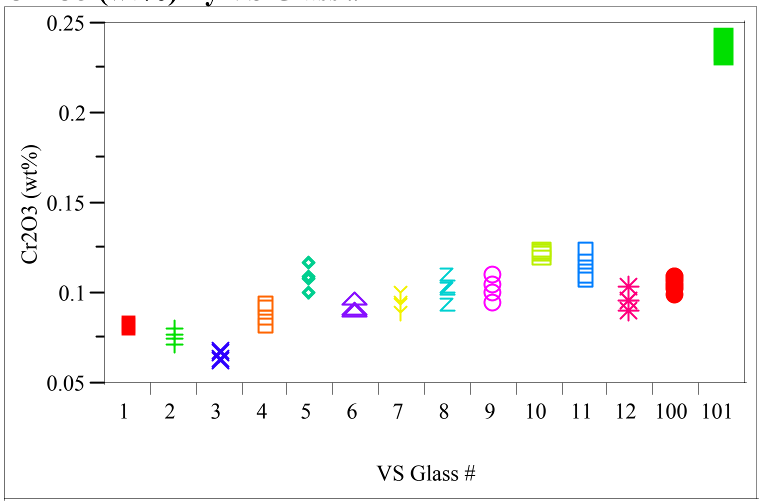
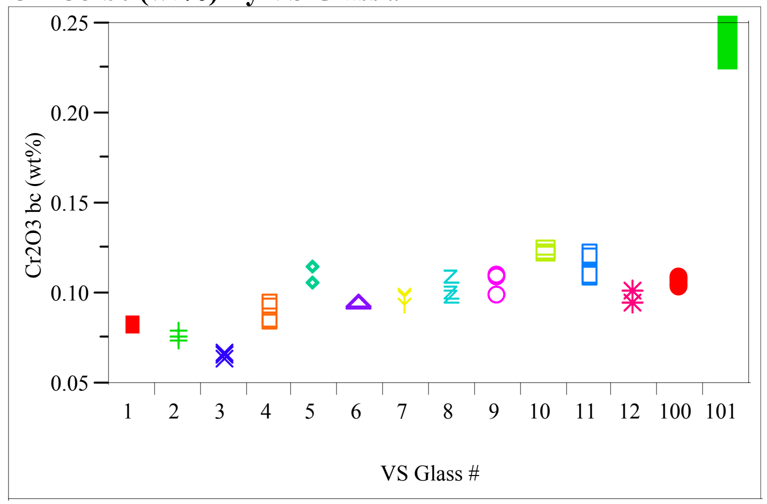


Exhibit E.5: SRTC-ML Measurements by Variability Study (VS) Glass Number for Samples Prepared Using the LM Method (100 – Batch 1; 101 – U std) *(continued)*

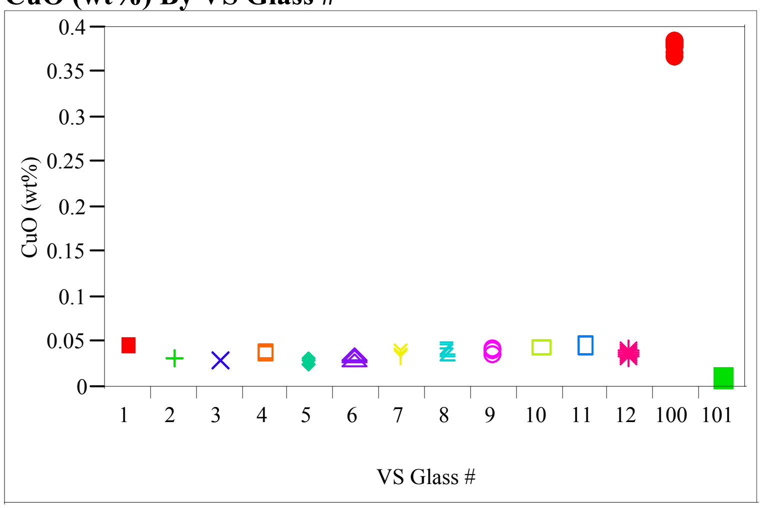
Cr2O3 (wt%) By VS Glass #



Cr2O3 bc (wt%) By VS Glass #



CuO (wt%) By VS Glass #



CuO bc (wt%) By VS Glass #

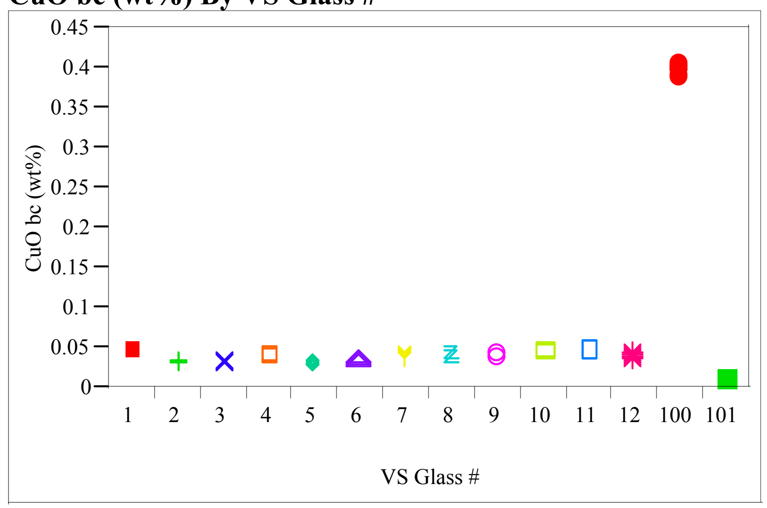
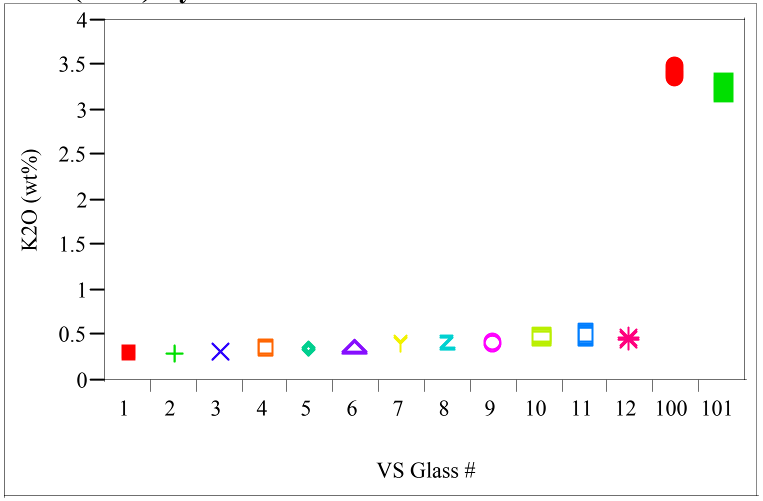
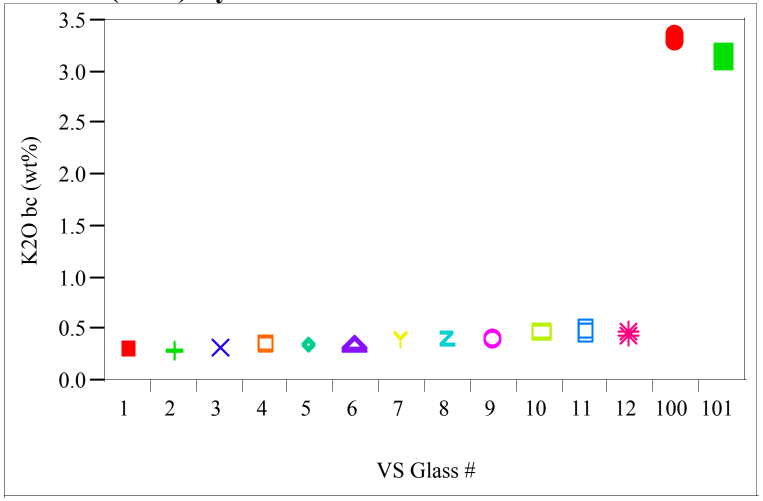


Exhibit E.5: SRTC-ML Measurements by Variability Study (VS) Glass Number for Samples Prepared Using the LM Method (100 – Batch 1; 101 – U std) *(continued)*

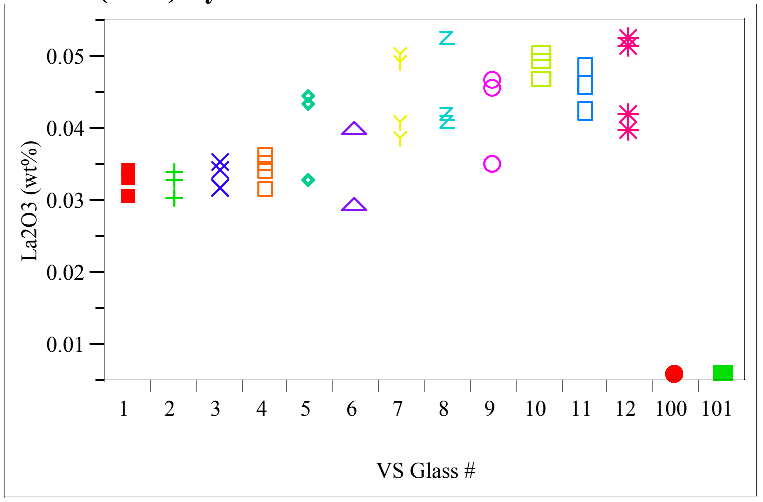
K2O (wt%) By VS Glass #



K2O bc (wt%) By VS Glass #



La2O3 (wt%) By VS Glass #



La2O3 bc (wt%) By VS Glass #

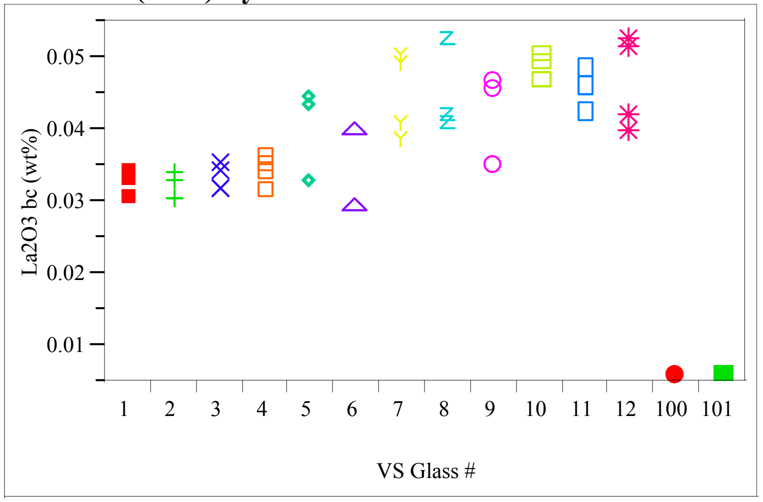
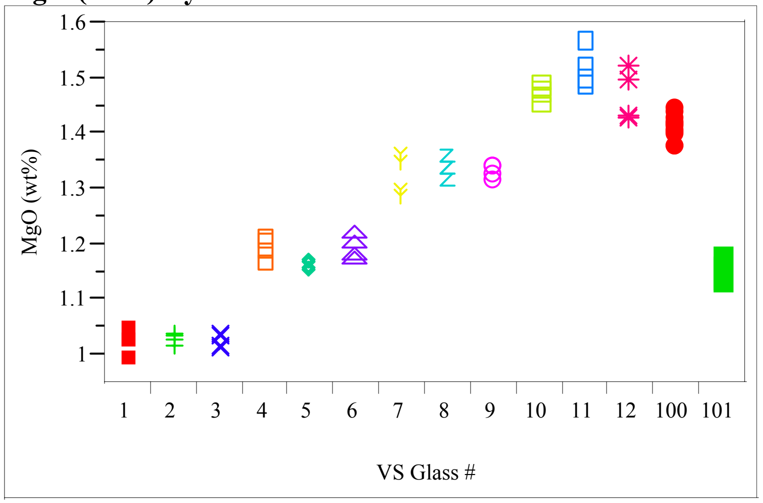
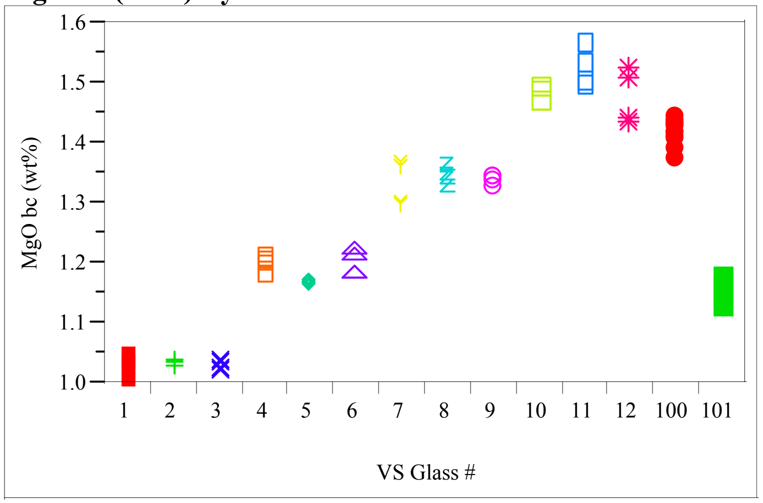


Exhibit E.5: SRTC-ML Measurements by Variability Study (VS) Glass Number for Samples Prepared Using the LM Method (100 – Batch 1; 101 – U std) *(continued)*

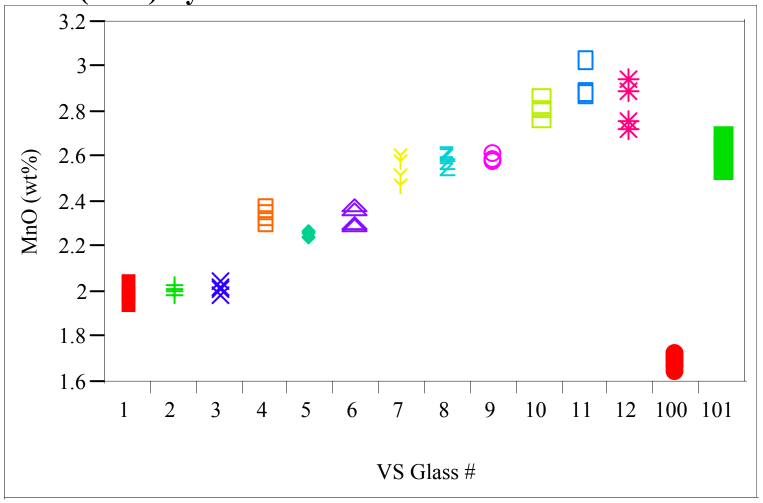
MgO (wt%) By VS Glass #



MgO bc (wt%) By VS Glass #



MnO (wt%) By VS Glass #



MnO bc (wt%) By VS Glass #

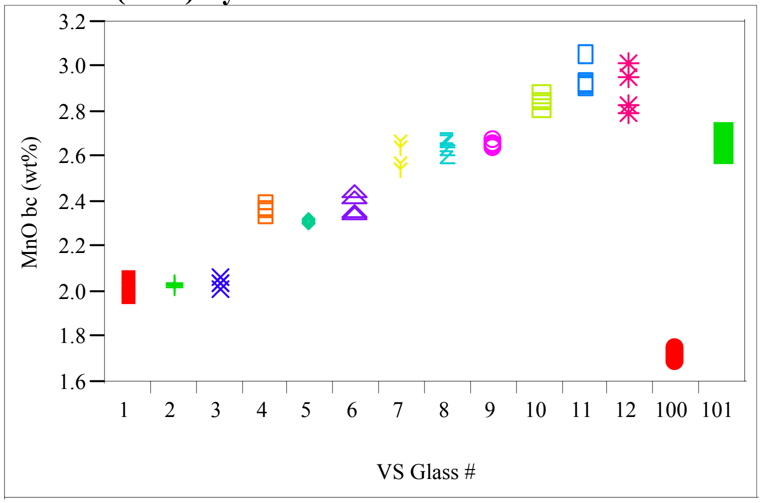
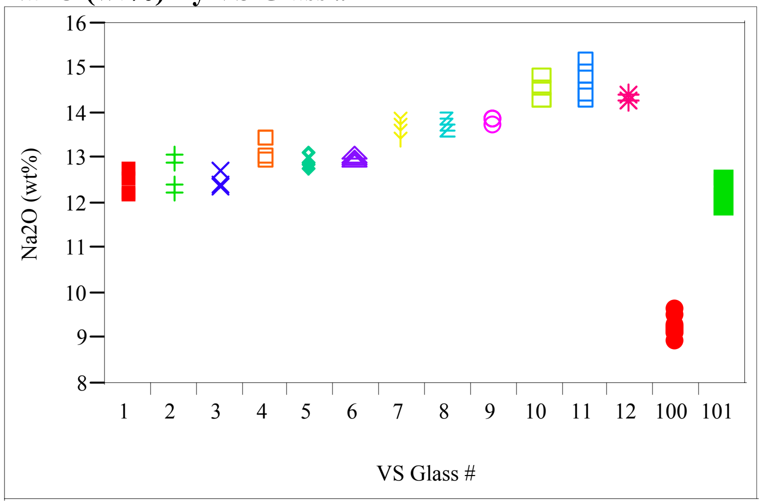
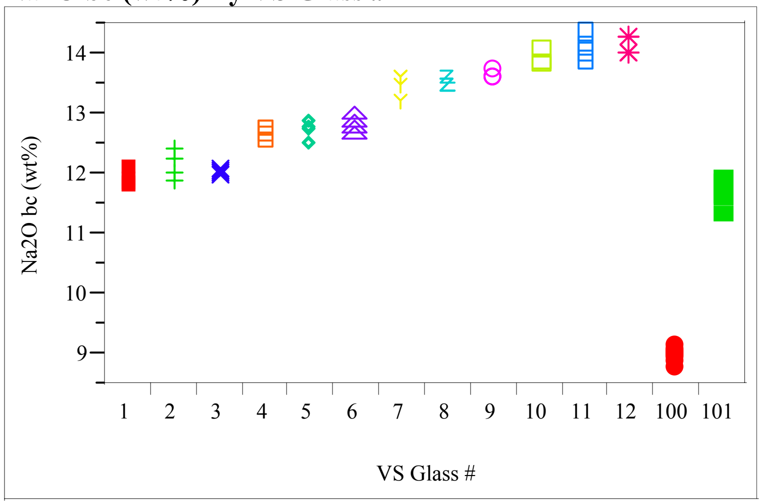


Exhibit E.5: SRTC-ML Measurements by Variability Study (VS) Glass Number for Samples Prepared Using the LM Method (100 – Batch 1; 101 – U std) *(continued)*

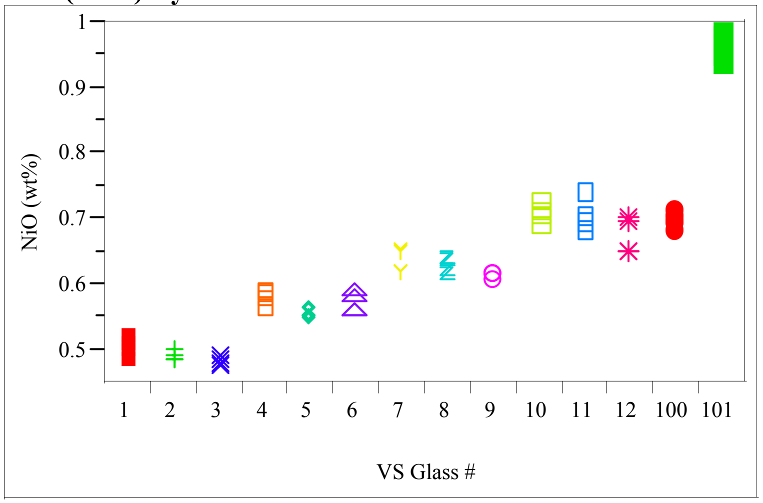
Na2O (wt%) By VS Glass #



Na2O bc (wt%) By VS Glass #



NiO (wt%) By VS Glass #



NiO bc (wt%) By VS Glass #

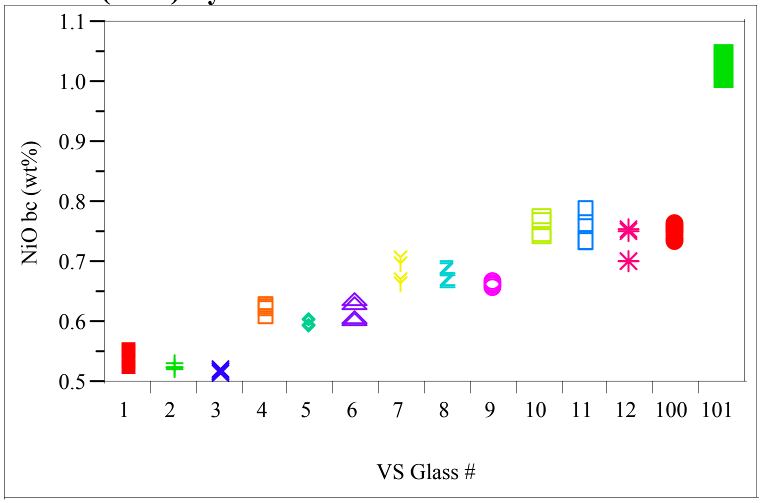
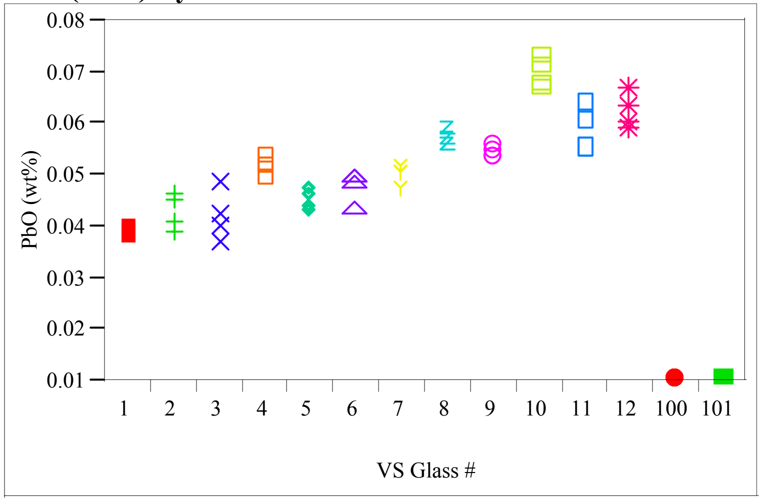
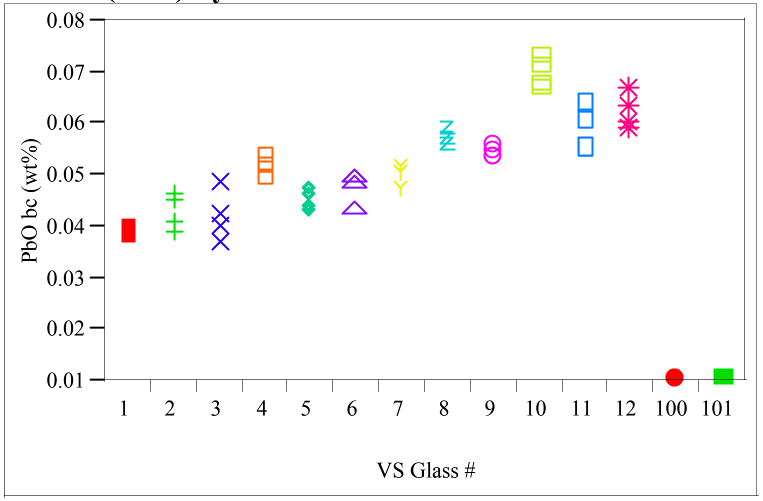


Exhibit E.5: SRTC-ML Measurements by Variability Study (VS) Glass Number for Samples Prepared Using the LM Method (100 – Batch 1; 101 – U std) *(continued)*

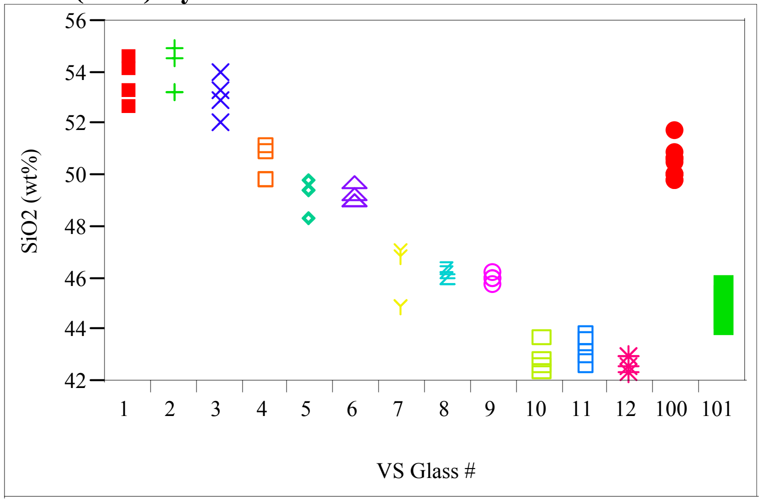
PbO (wt%) By VS Glass #



PbO bc (wt%) By VS Glass #



SiO2 (wt%) By VS Glass #



SiO2 bc (wt%) By VS Glass #

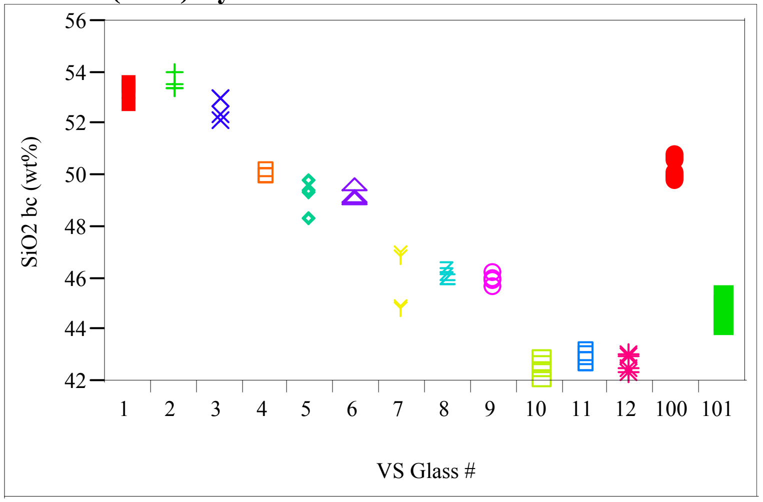
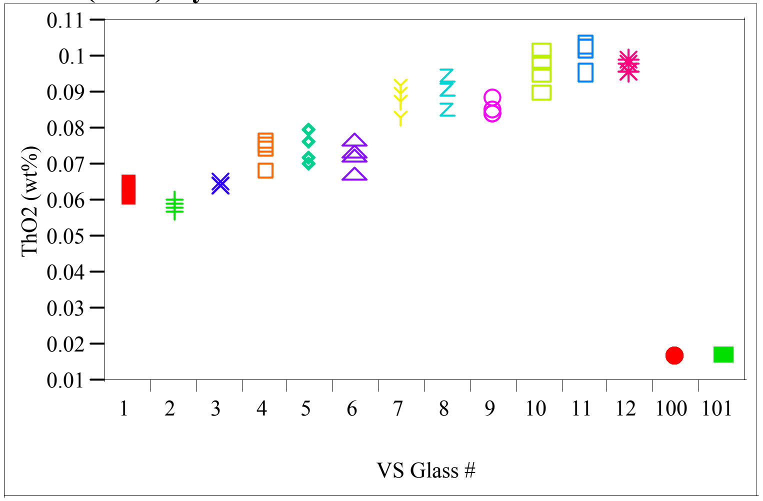
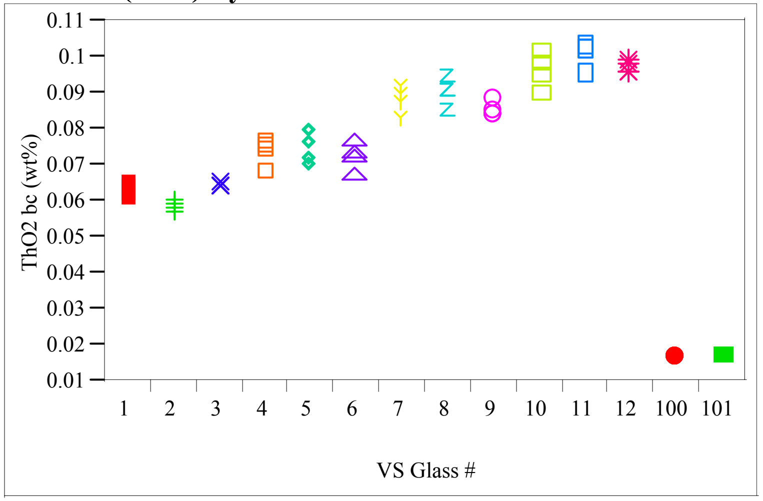


Exhibit E.5: SRTC-ML Measurements by Variability Study (VS) Glass Number for Samples Prepared Using the LM Method (100 – Batch 1; 101 – U std) *(continued)*

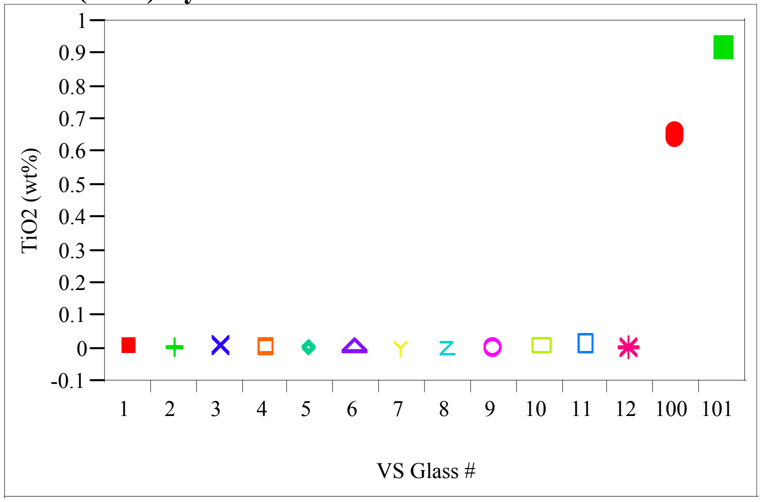
ThO2 (wt%) By VS Glass #



ThO2 bc (wt%) By VS Glass #



TiO2 (wt%) By VS Glass #



TiO2 bc (wt%) By VS Glass #

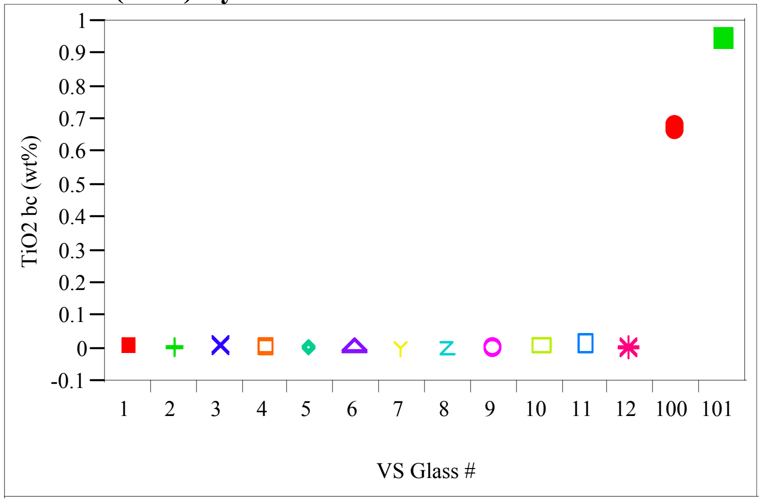
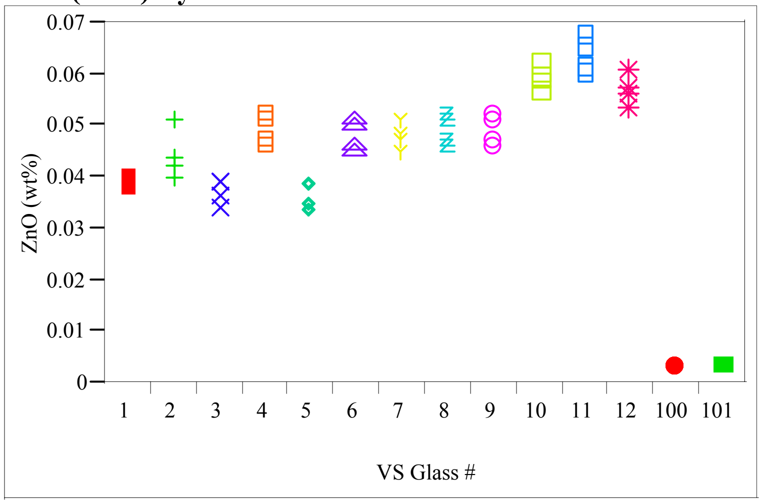
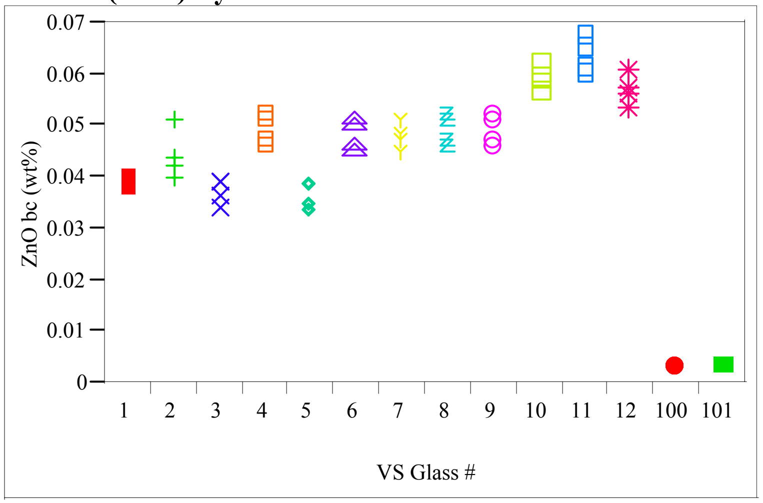


Exhibit E.5: SRTC-ML Measurements by Variability Study (VS) Glass Number for Samples Prepared Using the LM Method (100 – Batch 1; 101 – U std) *(continued)*

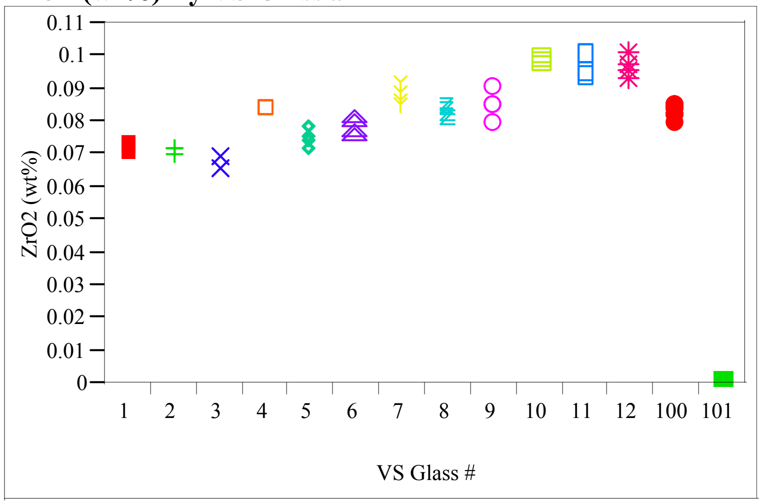
ZnO (wt%) By VS Glass #



ZnO bc (wt%) By VS Glass #



ZrO2 (wt%) By VS Glass #



ZrO2 bc (wt%) By VS Glass #

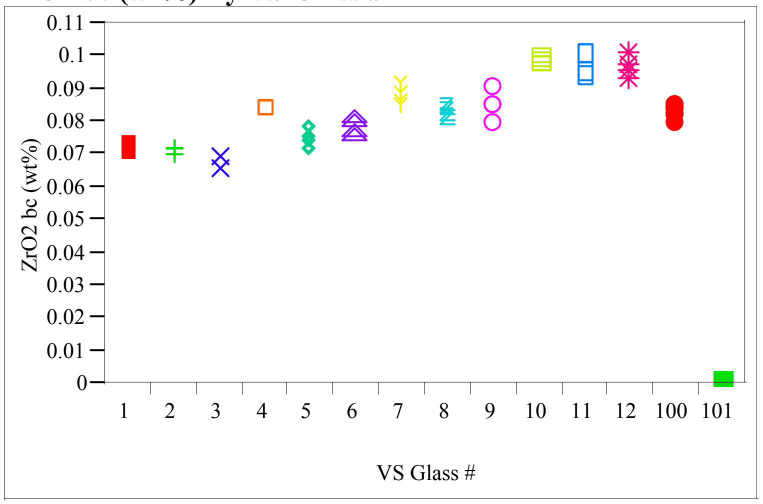
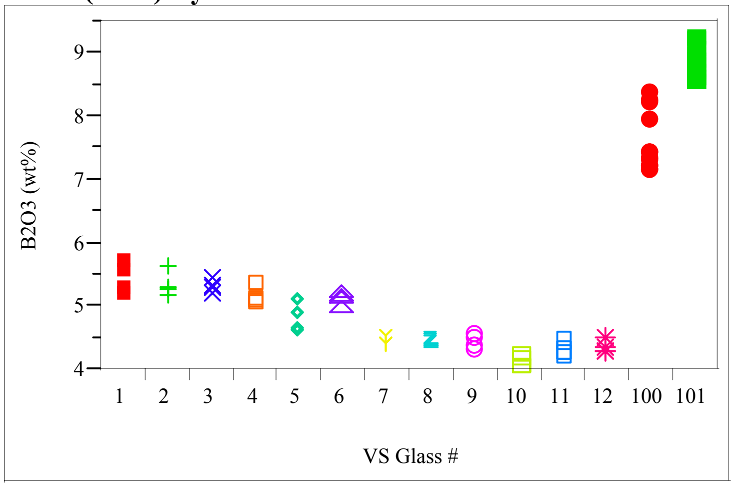
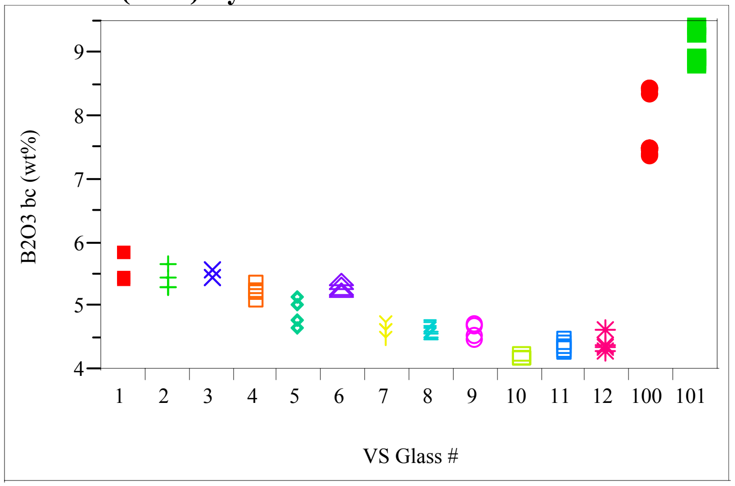


Exhibit E.6: SRTC-ML Measurements by Variability Study (VS) Glass Number for Samples Prepared Using the PF Method
(100 – Batch 1; 101 – U std)

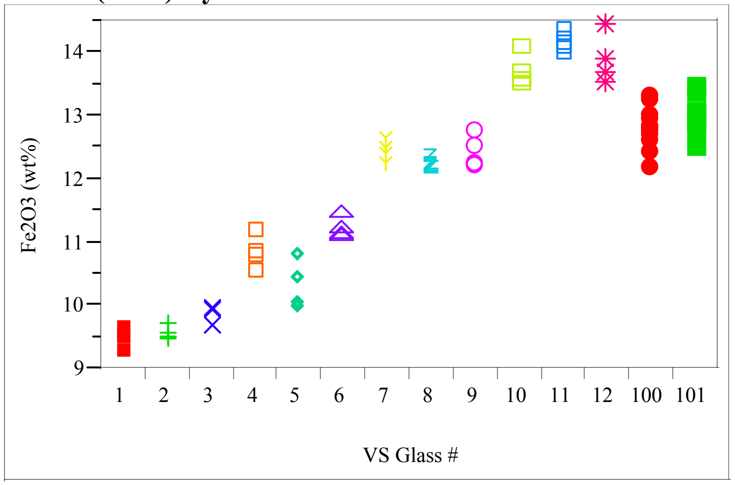
B2O3 (wt%) By VS Glass #



B2O3 bc (wt%) By VS Glass #



Fe2O3 (wt%) By VS Glass #



Fe2O3 bc (wt%) By VS Glass #

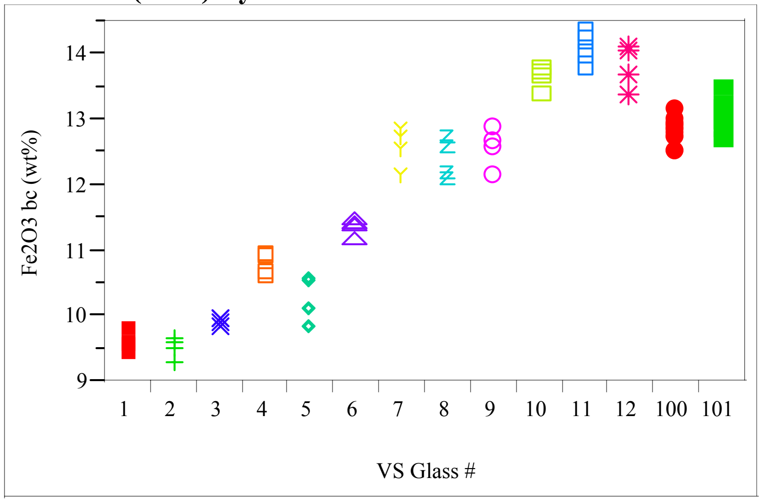
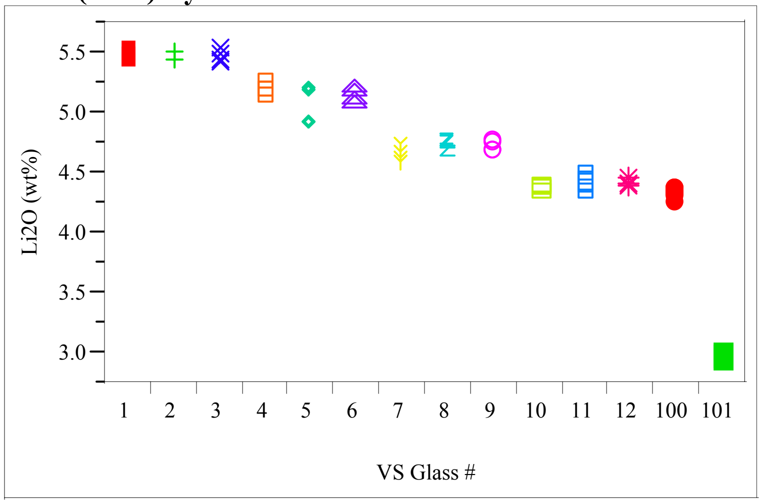
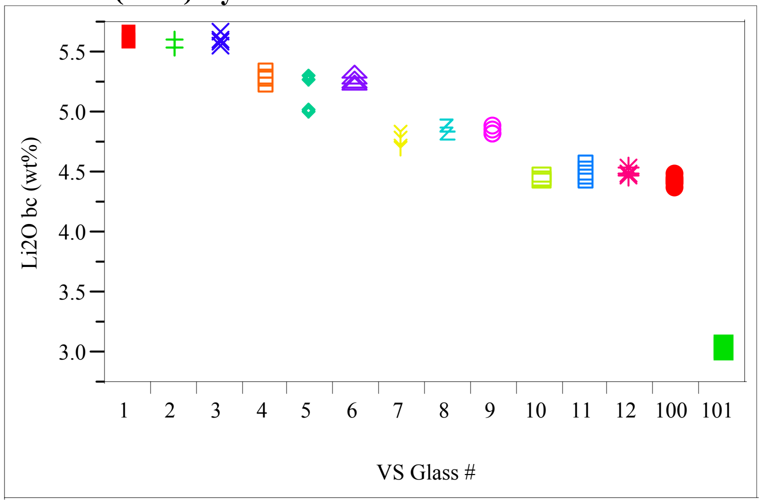


Exhibit E.6: SRTC-ML Measurements by Variability Study (VS) Glass Number for Samples Prepared Using the PF Method
(100 – Batch 1; 101 – U std) ***(continued)***

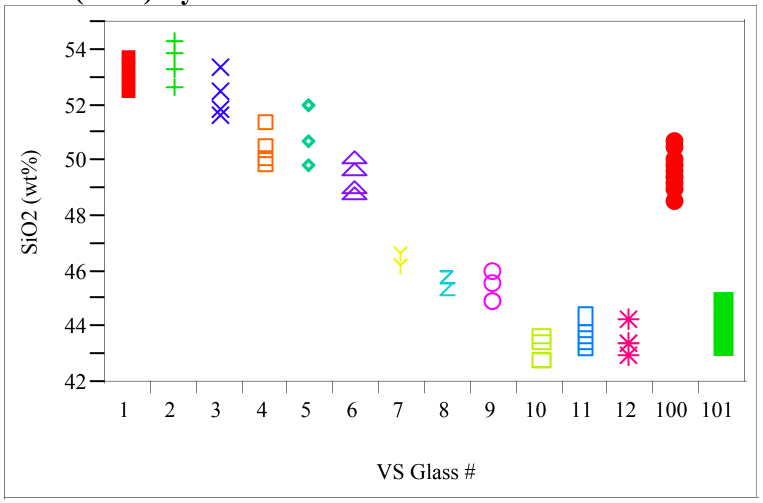
Li2O (wt%) By VS Glass #



Li2O bc (wt%) By VS Glass #



SiO2 (wt%) By VS Glass #



SiO2 bc (wt%) By VS Glass #

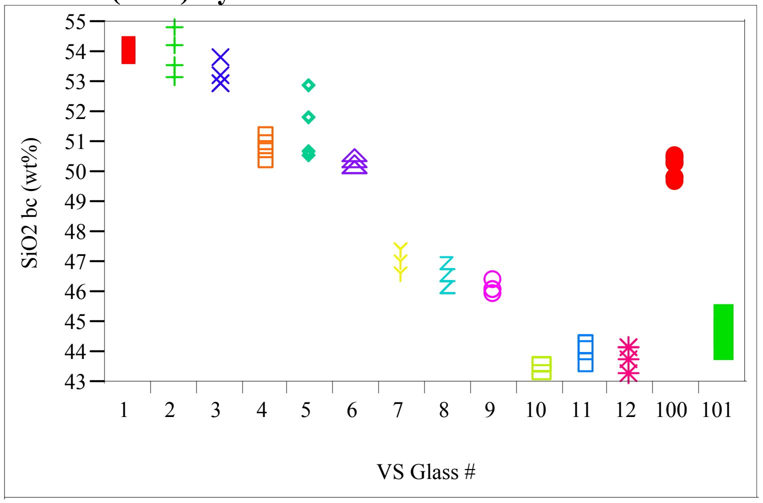
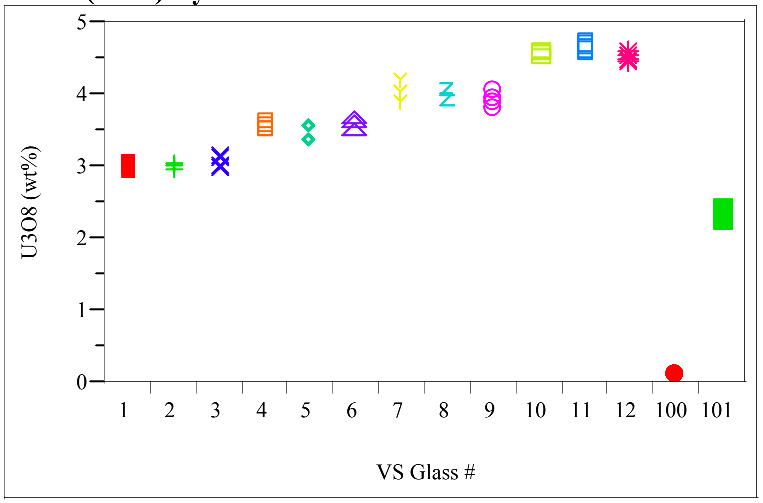


Exhibit E.6: SRTC-ML Measurements by Variability Study (VS) Glass Number for Samples Prepared Using the PF Method
(100 – Batch 1; 101 – U std) ***(continued)***

U3O8 (wt%) By VS Glass #



U3O8 bc (wt%) By VS Glass #

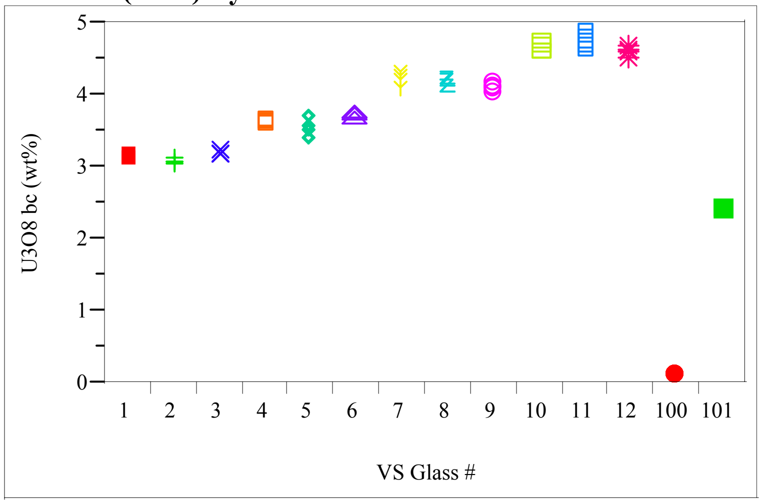
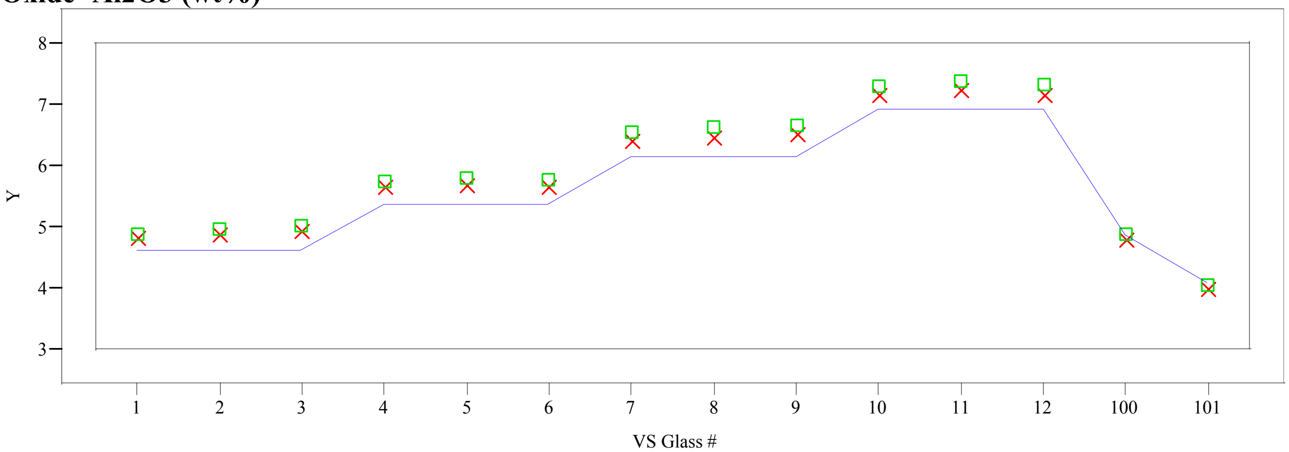


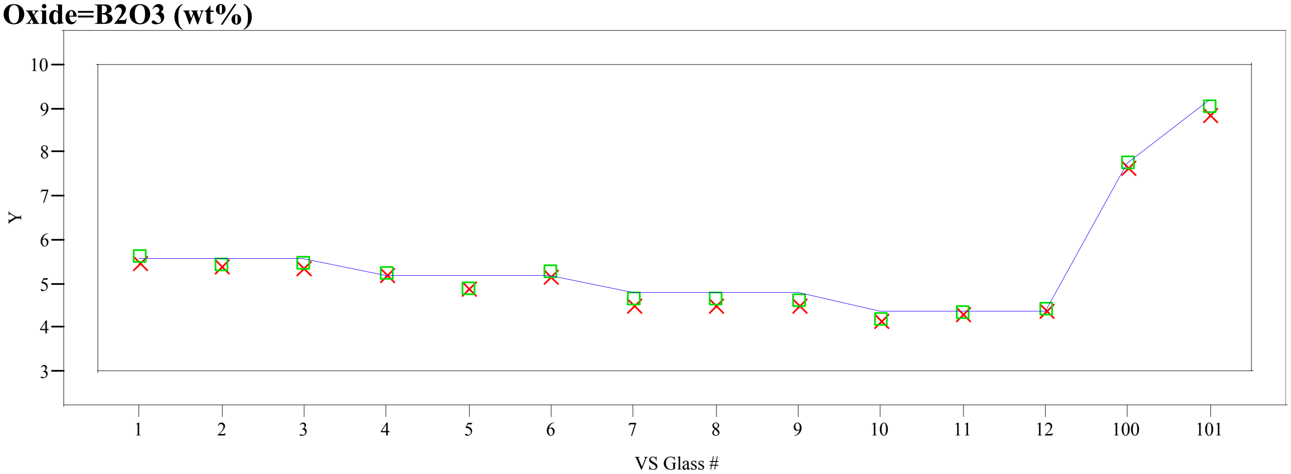
Exhibit E.7: Average Measured and Bias-Corrected (bc) Versus Targeted Compositions by Variability Study (VS) Glass # by Oxide

(100 – Batch 1; and 101 – U std)

Oxide=Al2O3 (wt%)



Oxide=B2O3 (wt%)



Oxide=BaO (wt%)

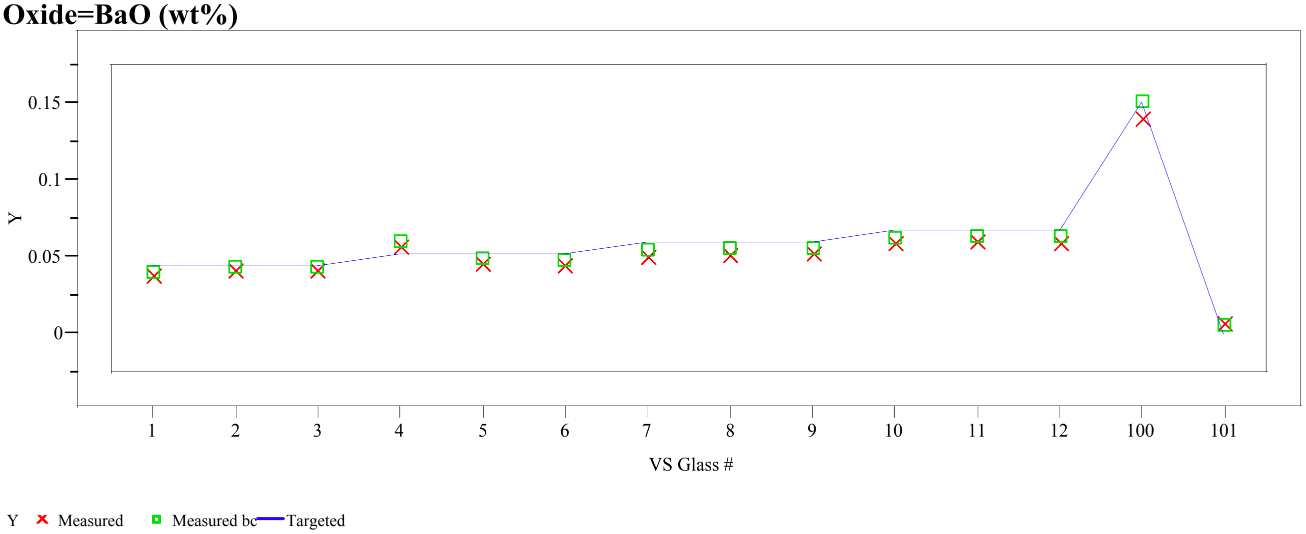
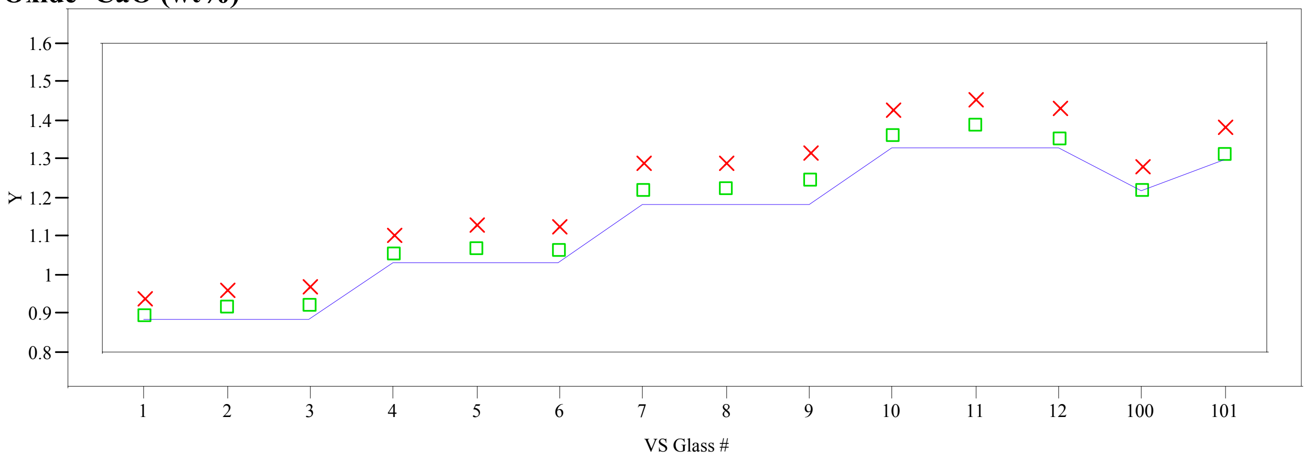


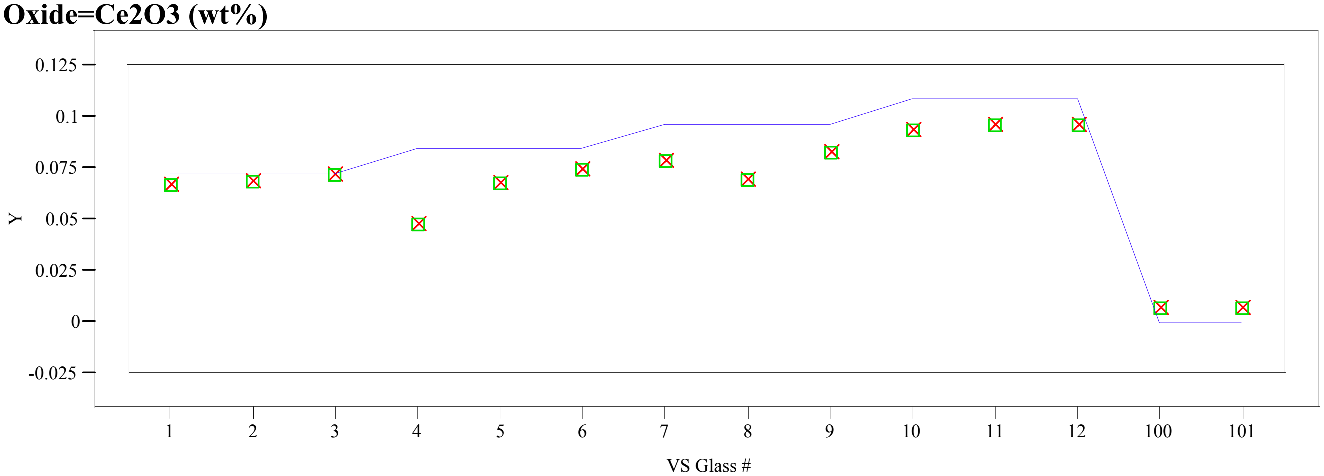
Exhibit E.7: Average Measured and Bias-Corrected (bc) Versus Targeted Compositions by Variability Study (VS) Glass # by Oxide *(continued)*

(100 – Batch 1; and 101 – U std)

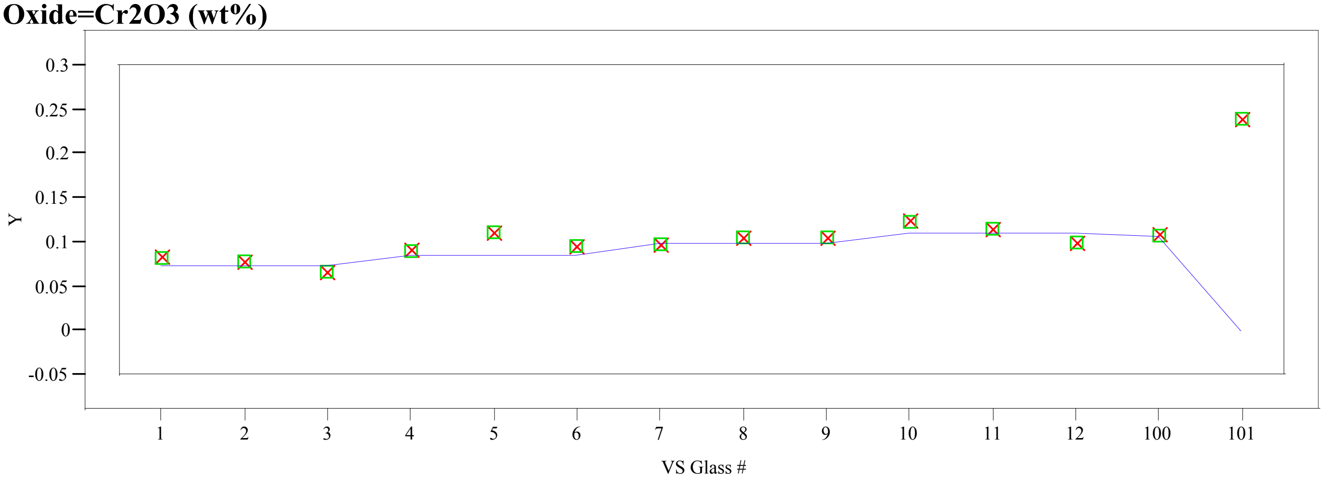
Oxide=CaO (wt%)



Oxide=Ce2O3 (wt%)



Oxide=Cr2O3 (wt%)

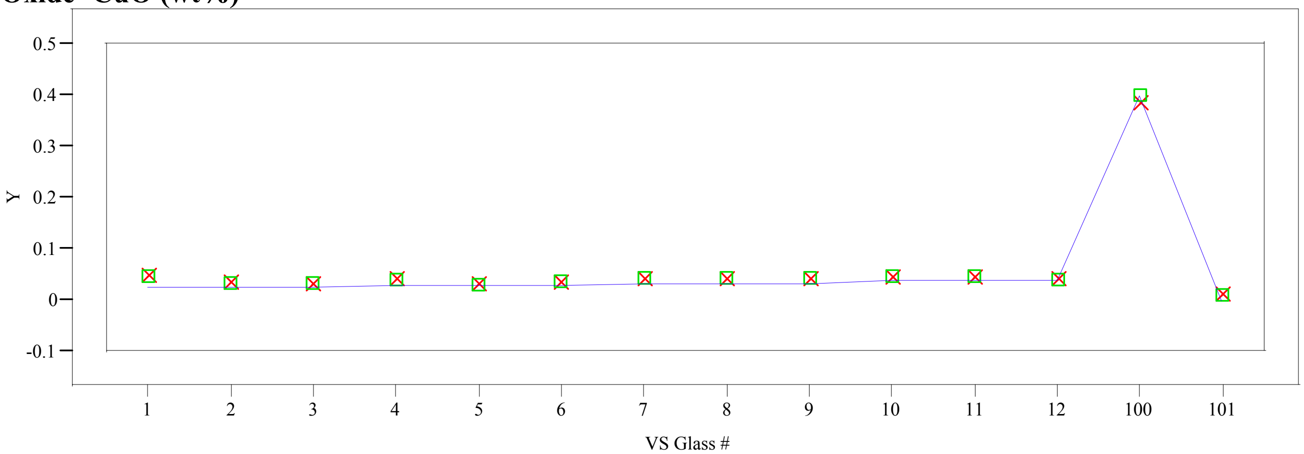


Y × Measured ▫ Measured bc — Targeted

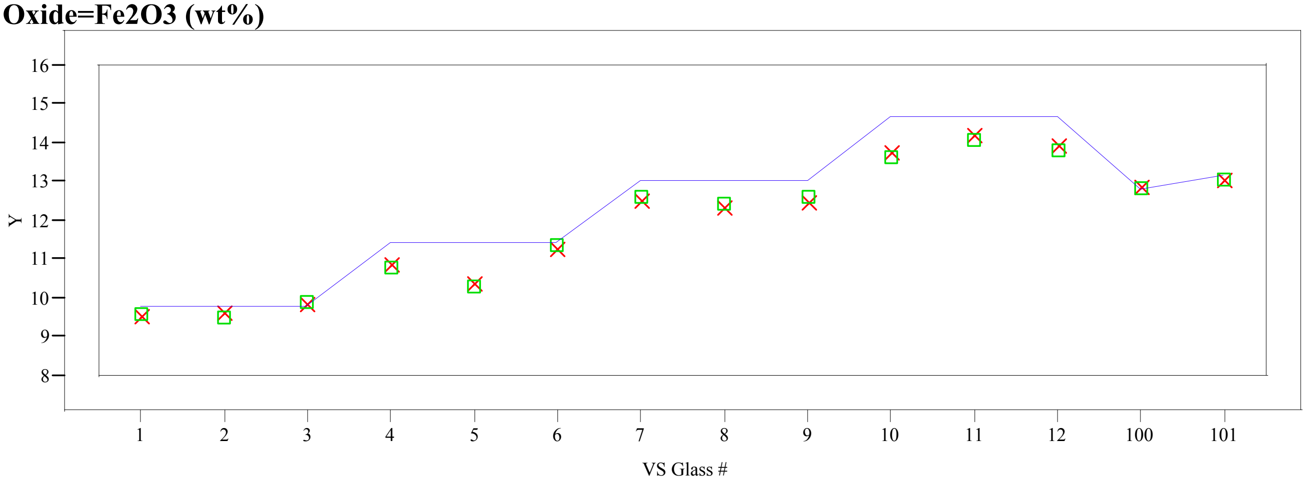
Exhibit E.7: Average Measured and Bias-Corrected (bc) Versus Targeted Compositions by Variability Study (VS) Glass # by Oxide *(continued)*

(100 – Batch 1; and 101 – U std)

Oxide=CuO (wt%)



Oxide=Fe2O3 (wt%)



Oxide=K2O (wt%)

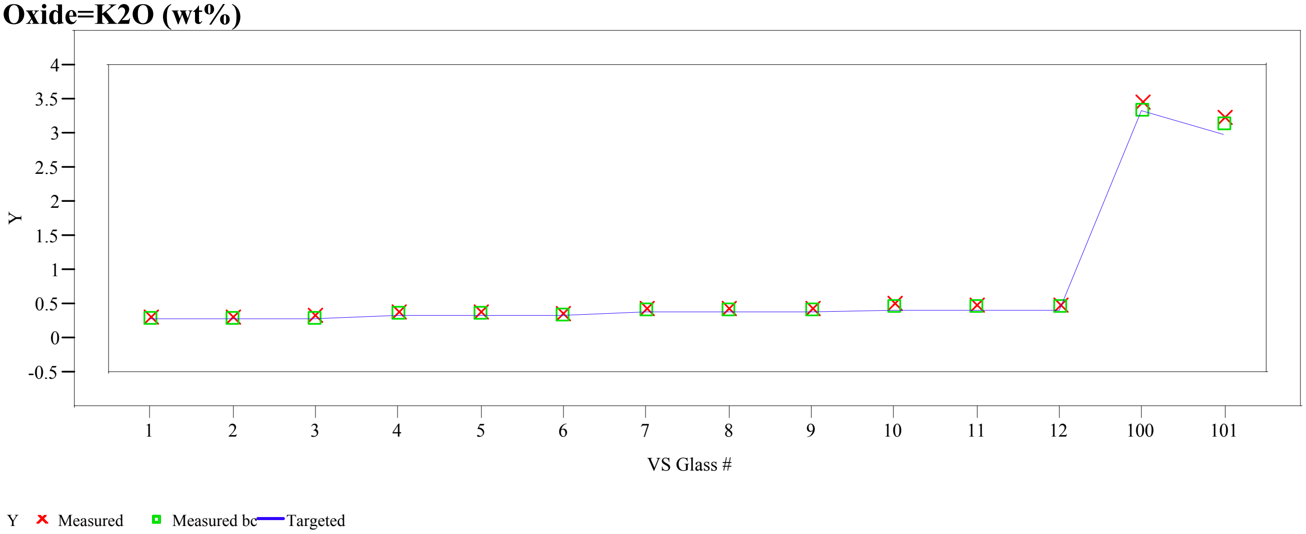
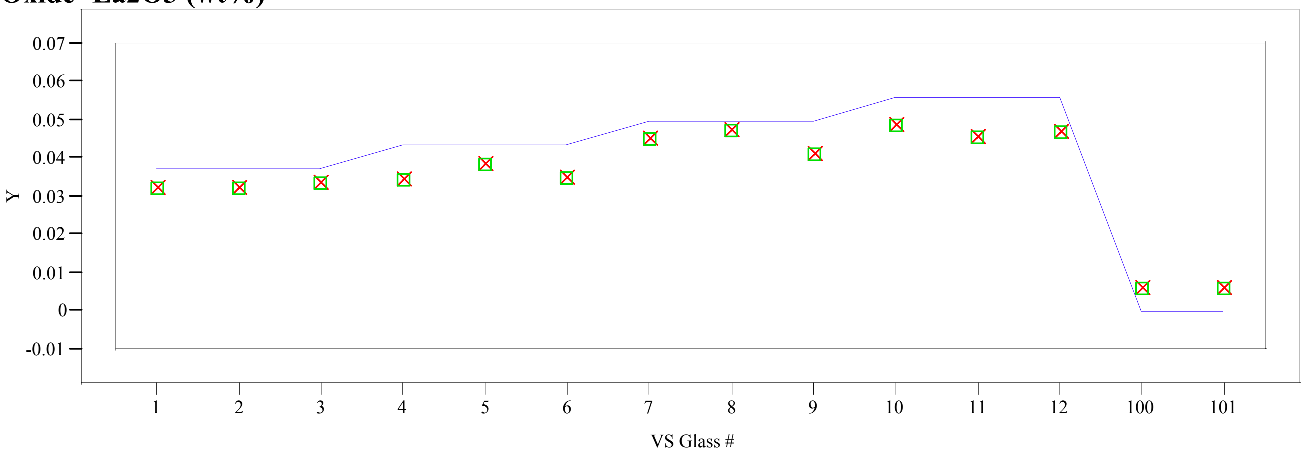


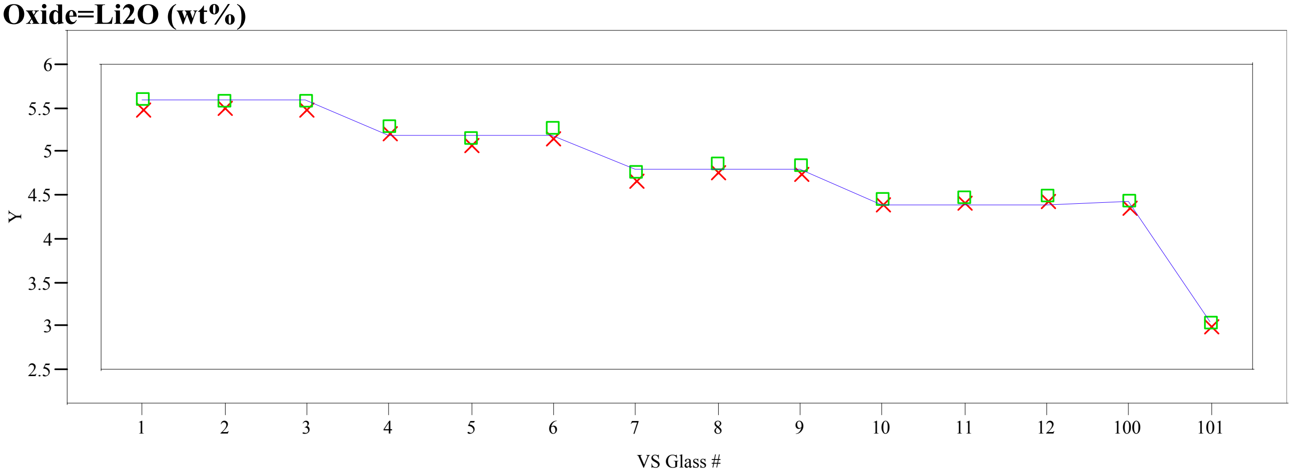
Exhibit E.7: Average Measured and Bias-Corrected (bc) Versus Targeted Compositions by Variability Study (VS) Glass # by Oxide *(continued)*

(100 – Batch 1; and 101 – U std)

Oxide=La2O3 (wt%)



Oxide=Li2O (wt%)



Oxide=MgO (wt%)

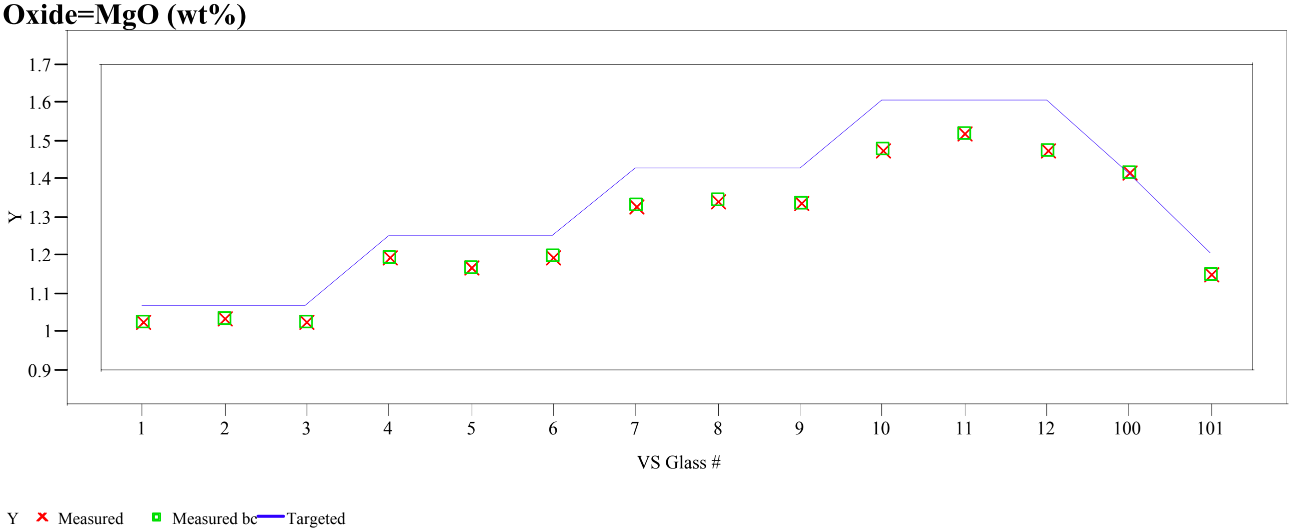
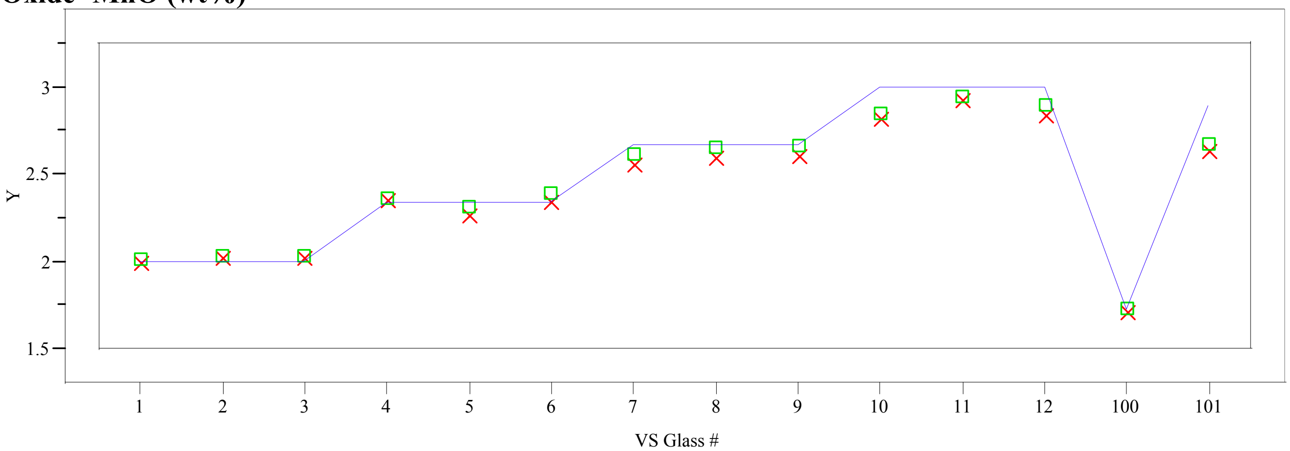


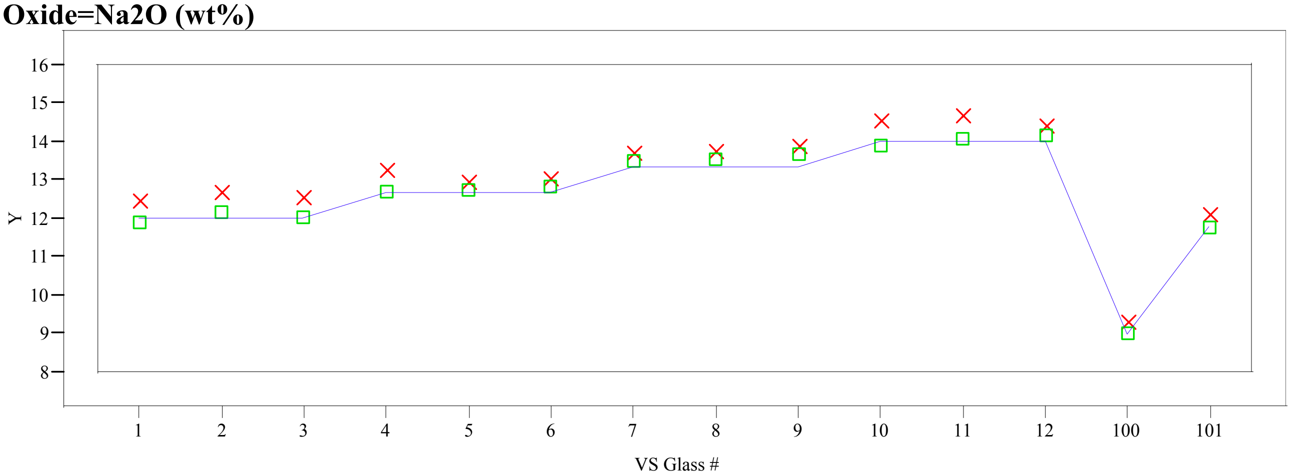
Exhibit E.7: Average Measured and Bias-Corrected (bc) Versus Targeted Compositions by Variability Study (VS) Glass # by Oxide *(continued)*

(100 – Batch 1; and 101 – U std)

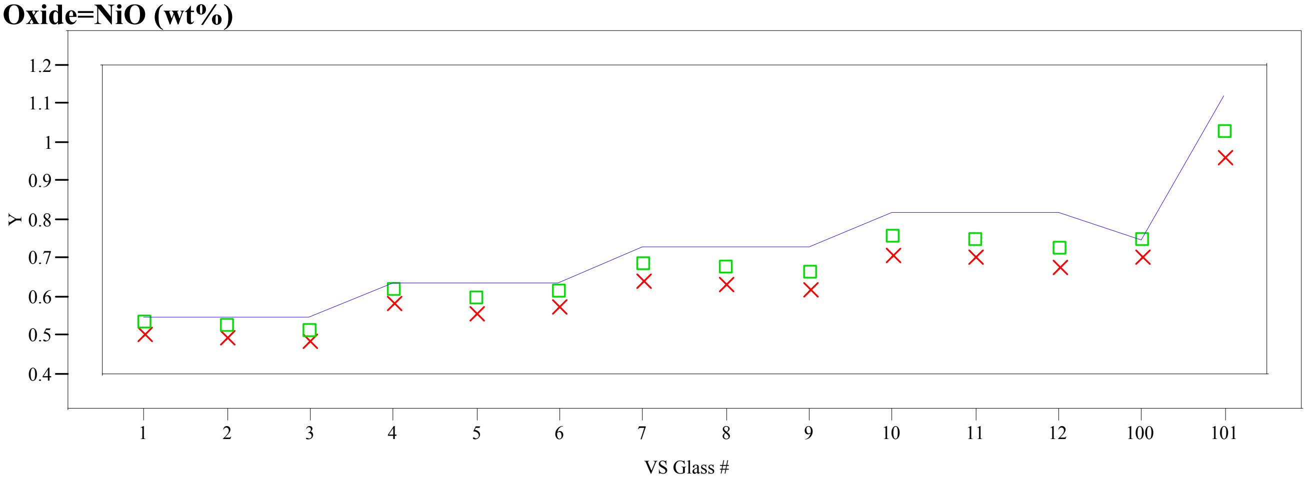
Oxide=MnO (wt%)



Oxide=Na2O (wt%)



Oxide=NiO (wt%)

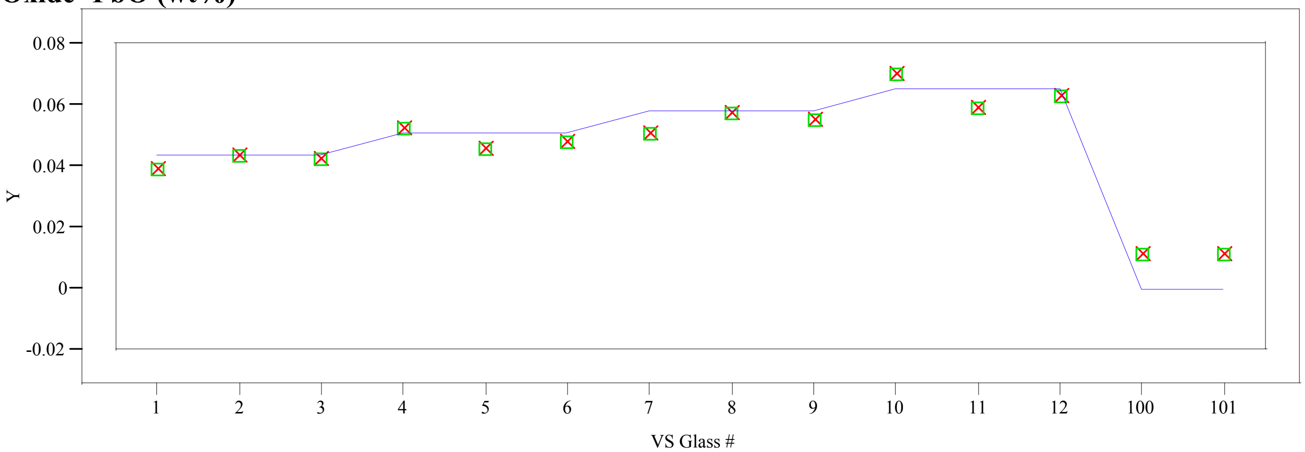


Y × Measured □ Measured bc — Targeted

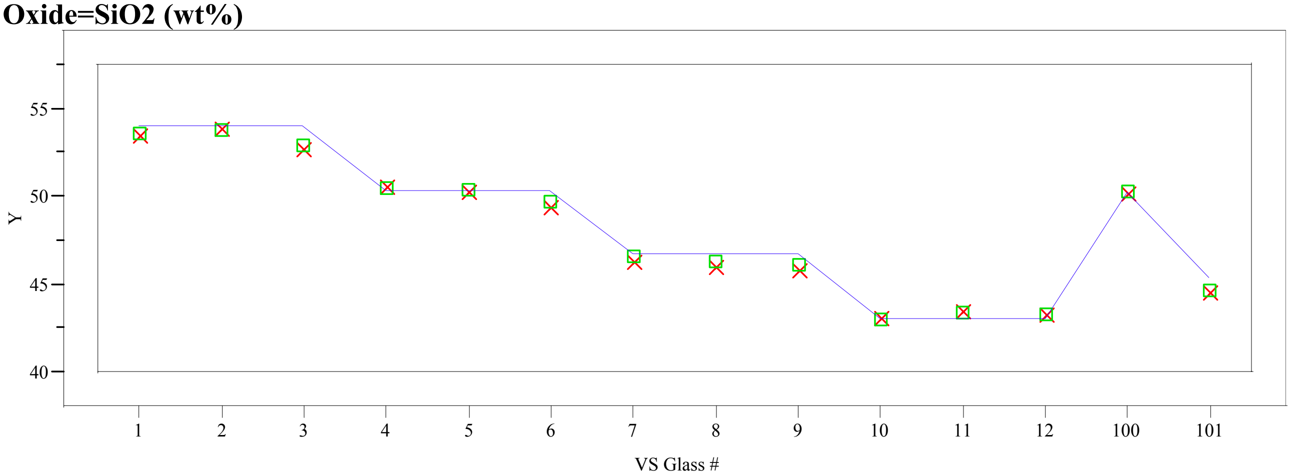
Exhibit E.7: Average Measured and Bias-Corrected (bc) Versus Targeted Compositions by Variability Study (VS) Glass # by Oxide *(continued)*

(100 – Batch 1; and 101 – U std)

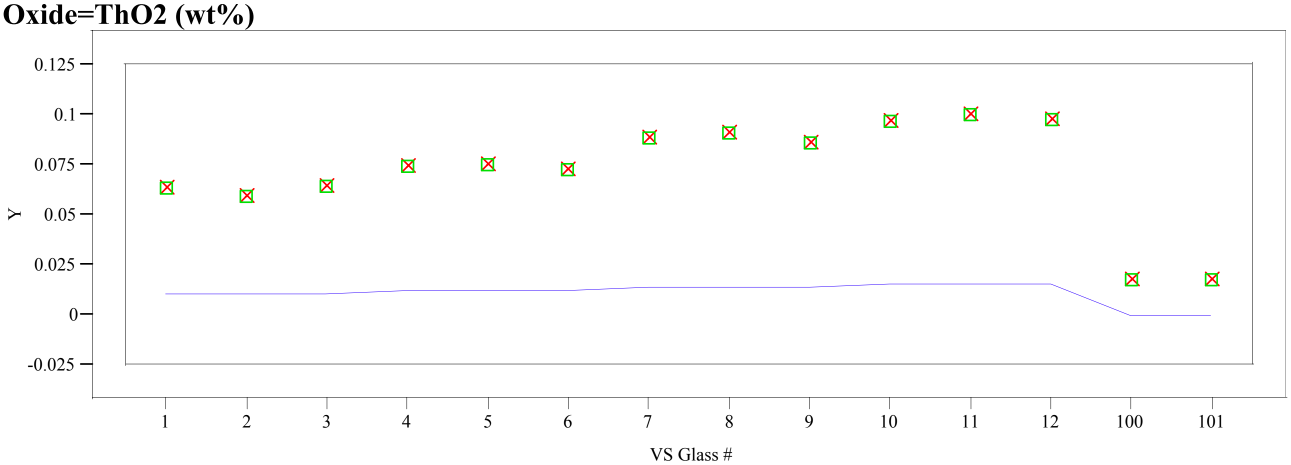
Oxide=PbO (wt%)



Oxide=SiO2 (wt%)



Oxide=ThO2 (wt%)

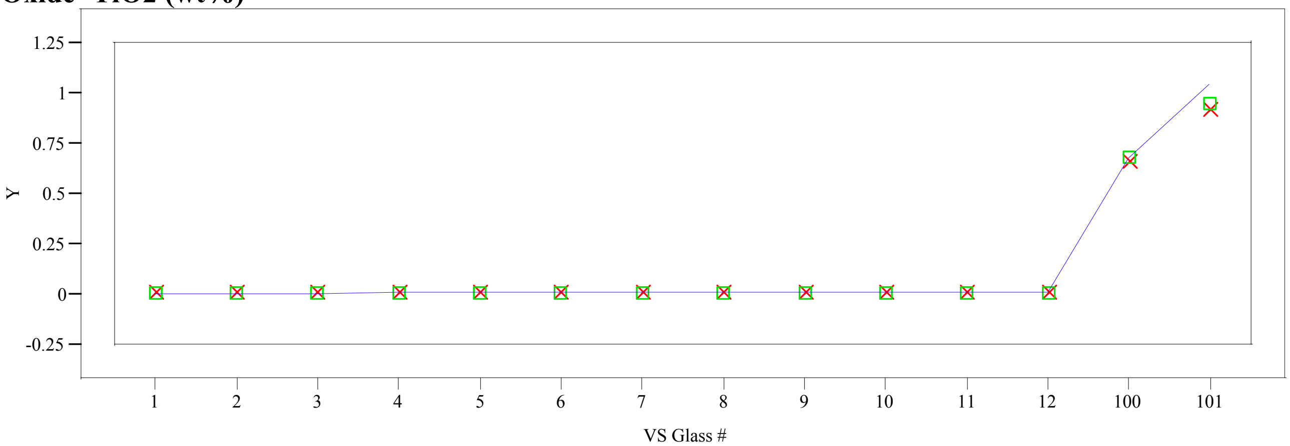


Y × Measured ▫ Measured bc — Targeted

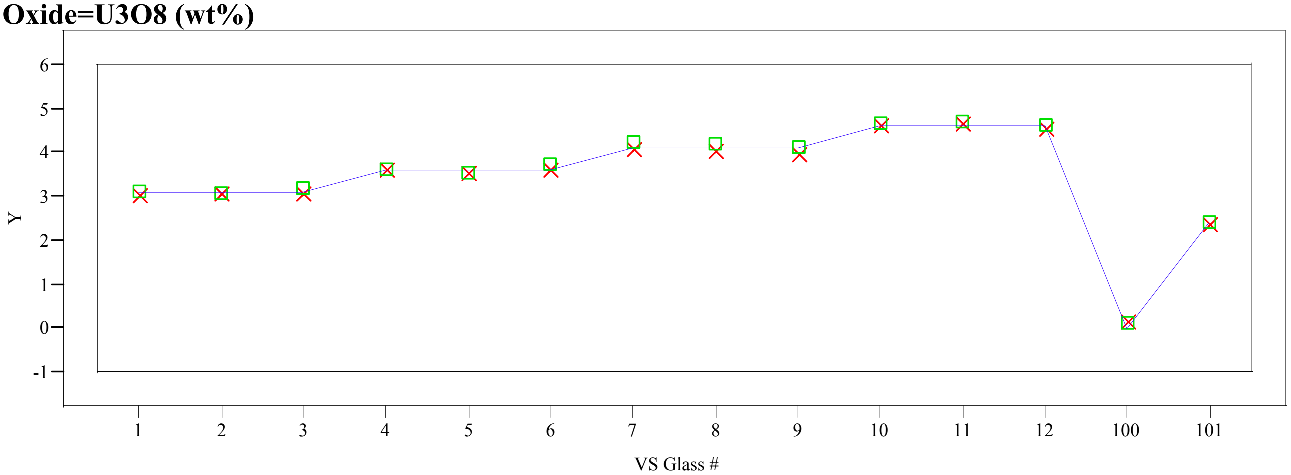
Exhibit E.7: Average Measured and Bias-Corrected (bc) Versus Targeted Compositions by Variability Study (VS) Glass # by Oxide *(continued)*

(100 – Batch 1; and 101 – U std)

Oxide=TiO2 (wt%)



Oxide=U3O8 (wt%)



Oxide=ZnO (wt%)

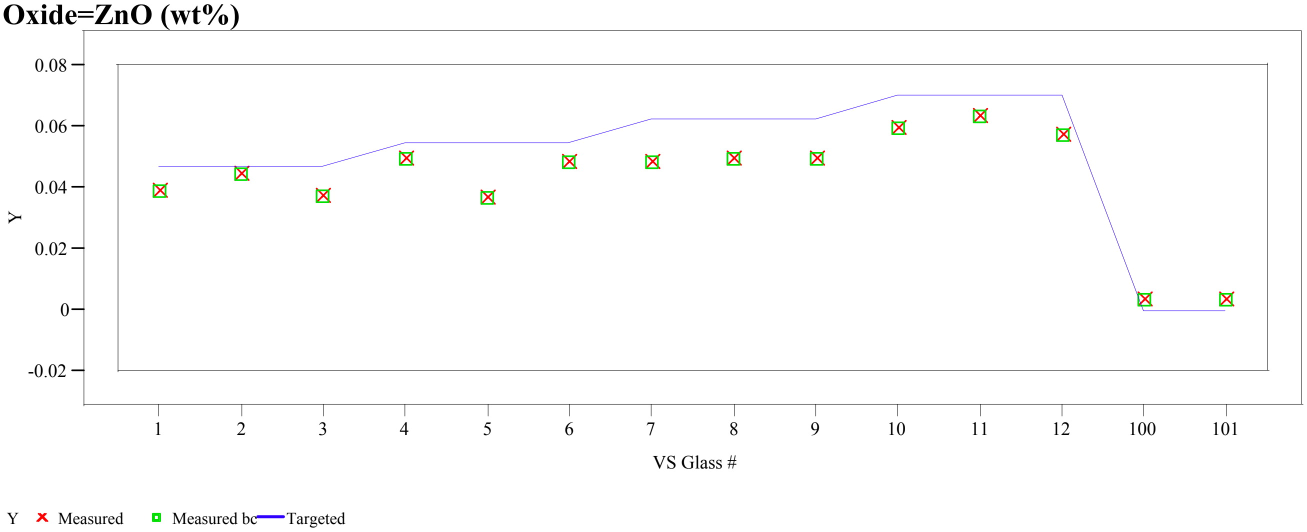
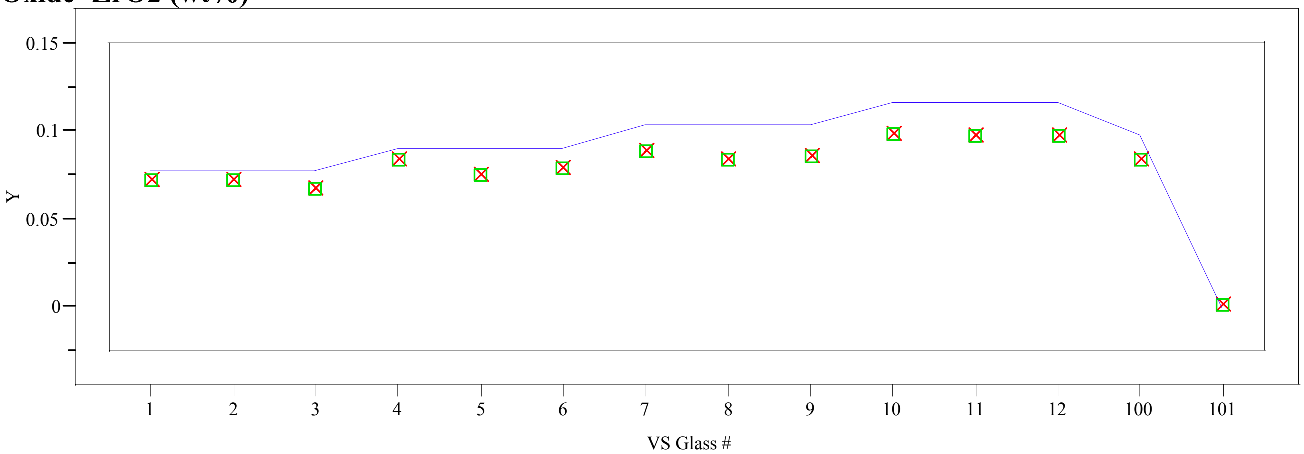


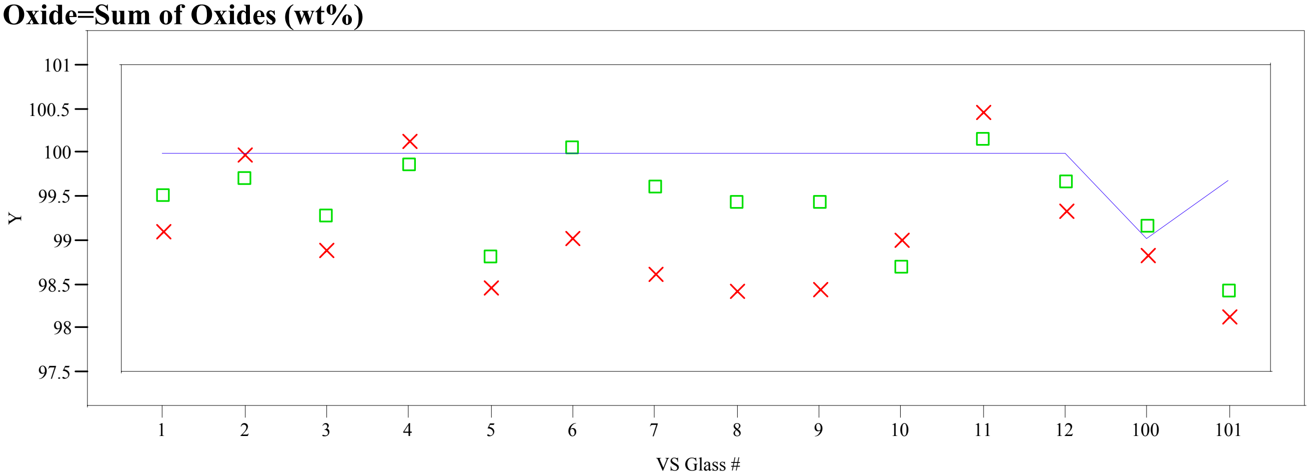
Exhibit E.7: Average Measured and Bias-Corrected (bc) Versus Targeted Compositions by Variability Study (VS) Glass # by Oxide *(continued)*

(100 – Batch 1; and 101 – U std)

Oxide=ZrO2 (wt%)



Oxide=Sum of Oxides (wt%)



Y × Measured □ Measured bc — Targeted

Appendix F

Tables and Exhibits Supporting the Analysis of the PCT Results for the SB2/3 Glasses

Table F.1: SRTC-ML Measurements of the PCT Solutions for the Variability Study (VS) Glasses

Glass	SRTC-ML		Seq	As reported values in parts per million (ppm)						
ID	ID	Block	#	Al	B	Fe	Li	Na	Si	U
ck std	CKSTD	1	1	4.97618	5.09155	4.91791	4.97522	5.18595	4.92369	4.96788
soln std	STD-B1-1	1	2	4.32435	21.0489	4.27127	10.0464	83.1635	47.5287	<0.500
SB2/3-04ccc	P15	1	3	7.80819	10.2204	4.83708	15.7689	60.2749	85.6261	2.12286
SB2/3-01ccc	P23	1	4	6.63729	9.67151	4.95882	16.1252	52.216	88.1613	2.40616
SB2/3-02	P19	1	5	6.48167	10.097	4.53151	15.8926	55.0374	89.2114	2.68473
SB2/3-07	P14	1	6	9.59475	10.3053	5.27087	14.2649	71.1746	80.977	2.1438
SB2/3-11	P48	1	7	12.4575	12.0116	7.6771	15.6971	89.4591	84.3806	2.12993
SB2/3-04	P38	1	8	8.11063	10.2929	5.22512	15.5747	65.589	88.2966	2.17939
ARM	P52	1	9	3.70414	11.1024	0.431865	8.87297	27.9284	36.594	1.56174
EA	P50	1	10	1.0023	38.753	0.347059	12.0438	107.458	53.0644	<0.500
SB2/3-03	P12	1	11	7.52883	10.7057	5.22284	16.6592	57.9093	88.4888	2.37094
soln std	STD-B1-2	1	12	4.3747	19.8032	4.159	10.1997	84.7062	47.7687	<0.500
ck std	CKSTD	1	13	5.14004	4.99696	4.66138	5.1335	5.49818	4.91403	4.97088
SB2/3-06	P09	1	14	8.13054	11.2046	5.73954	16.3252	67.5304	88.9516	2.11469
SB2/3-12	P26	1	15	13.3765	13.0415	10.3923	16.9055	98.6456	87.2422	3.05225
blank	P11	1	16	0.570199	0.813468	0.331429	0.748437	<0.080	0.466287	<0.500
SB2/3-10	P31	1	17	12.1216	11.1216	7.79536	14.314	84.3924	79.4441	2.76126
SB2/3-10ccc	P39	1	18	12.7707	10.7055	9.9524	14.7716	79.0186	78.9709	2.78766
SB2/3-09	P40	1	19	10.4497	11.3801	8.96424	16.1251	79.3572	86.4906	2.74101
SB2/3-01	P41	1	20	6.44445	9.45094	4.31906	15.2327	53.8902	85.3349	2.45428
SB2/3-08	P27	1	21	10.1848	10.8838	7.73133	15.4907	76.3101	83.6284	2.67349
SB2/3-07ccc	P55	1	22	9.2219	10.0057	4.09475	14.319	65.9952	78.1734	2.10553
SB2/3-05	P36	1	23	8.02996	10.6505	5.17223	16.177	66.6142	87.8276	2.00554
soln std	STD-B1-3	1	24	4.44884	20.3871	4.26122	10.3631	85.1258	48.0717	<0.500
ck std	CKSTD	1	25	5.14264	4.97472	4.7712	5.19411	5.40951	4.94986	4.97108
ck std	CKSTD	2	1	4.9996	5.14194	5.07336	4.96076	5.22273	5.03595	5.00286
soln std	STD-B2-1	2	2	3.90716	20.1985	3.87717	9.56315	81.6429	48.8075	<0.500
SB2/3-08	P56	2	3	9.32711	10.5396	7.39036	14.0059	71.3416	82.8893	2.32671
SB2/3-04ccc	P44	2	4	7.29323	9.24732	4.77941	14.4464	56.9914	84.8415	1.98287
SB2/3-05	P42	2	5	7.45581	9.9008	5.07497	14.8564	63.7412	88.306	1.80831
SB2/3-10	P46	2	6	11.1918	10.7947	5.71784	13.7199	83.1618	81.5493	1.99443
SB2/3-10ccc	P03	2	7	12.1833	9.98957	10.1606	13.8404	76.8146	81.1283	2.68503
EA	P54	2	8	0.253543	37.3617	<0.040	10.8222	100.928	51.7911	0.664205
SB2/3-01ccc	P43	2	9	6.02644	9.06919	4.57119	14.9292	49.9402	88.0013	2.39
SB2/3-03	P22	2	10	6.1371	9.31269	5.24877	15.2118	54.3771	88.2761	2.31946
ARM	P37	2	11	3.19168	10.631	<0.040	8.278	26.39	36.7142	1.50184
soln std	STD-B2-2	2	12	3.91962	19.6886	3.77988	9.5611	81.876	48.2714	<0.500
ck std	CKSTD	2	13	4.97827	5.04955	4.97948	4.9329	5.24328	4.99203	4.96258
SB2/3-06	P51	2	14	7.3981	10.4292	5.07998	15.0872	64.6804	88.6591	1.84738
SB2/3-11	P08	2	15	10.9391	11.4088	4.88327	14.2376	85.262	82.0562	1.95992
SB2/3-01	P18	2	16	5.71344	8.6146	3.82559	13.7119	50.1115	83.8772	2.28247

Table F.1: SRTC-ML Measurements of the PCT Solutions for the Variability Study (VS) Glasses

Glass	SRTC-ML		Seq	As reported values in parts per million (ppm)						
ID	ID	Block	#	Al	B	Fe	Li	Na	Si	U
blank	P28	2	17	<0.150	<0.040	<0.040	0.346085	<0.080	<0.200	<0.500
SB2/3-07ccc	P07	2	18	9.09069	9.16714	6.20589	13.2165	63.5617	80.479	2.17348
SB2/3-04	P45	2	19	7.27716	9.31024	4.59755	14.0991	61.1057	84.5951	1.77336
SB2/3-09	P47	2	20	9.63141	10.4404	8.37962	14.779	75.3565	85.7576	2.50782
SB2/3-07	P30	2	21	8.41689	8.98107	3.71958	12.7552	66.0131	77.3253	1.79271
SB2/3-02	P49	2	22	6.07833	9.08014	4.50018	14.769	53.7149	87.5582	2.23576
SB2/3-12	P01	2	23	11.8205	12.1099	5.81862	15.6901	93.2276	86.5978	2.09269
soln std	STD-B2-3	2	24	3.91071	19.9671	3.86631	9.54764	81.4032	48.3903	<0.500
ck std	CKSTD	2	25	4.95597	4.97566	4.97206	4.92093	5.17333	4.9488	4.96056
ck std	CKSTD	3	1	4.97021	5.18295	5.03137	4.94356	5.16146	4.95713	4.97955
soln std	STDB-3-1	3	2	3.97174	20.7059	3.91433	9.60457	80.7723	48.7136	<0.500
SB2/3-11	P35	3	3	11.2995	11.1979	5.96938	14.3466	84.1806	81.4477	2.03559
SB2/3-01	P53	3	4	5.79573	8.50668	3.82806	14.0116	50.9765	84.2296	2.13645
SB2/3-07ccc	P21	3	5	8.88338	8.66693	6.26811	12.7838	61.6809	76.6305	2.47379
SB2/3-04ccc	P16	3	6	7.23975	9.0077	4.6	14.7386	57.1046	85.0905	1.91423
SB2/3-04	P02	3	7	7.37237	8.98499	5.07974	13.9799	59.9598	83.8591	1.94935
SB2/3-06	P04	3	8	7.37715	9.22534	5.89561	13.9228	59.2819	82.8086	2.12847
SB2/3-09	P32	3	9	9.42806	10.1404	7.91779	14.4996	73.6206	82.7794	2.53222
ARM	P17	3	10	3.36892	10.7834	<0.040	8.40615	24.6299	36.2648	<0.500
SB2/3-12	P33	3	11	12.8672	11.4466	8.25869	15.3836	91.4079	85.8809	2.18802
soln std	STD-B3-2	3	12	3.95749	19.9184	3.78385	9.59719	81.2497	48.0648	<0.500
ck std	CKSTD	3	13	4.96868	4.98047	4.97579	4.94323	5.18951	4.92103	4.96692
SB2/3-01ccc	P05	3	14	5.84058	8.6538	3.96738	14.6961	48.3648	85.1115	2.43702
SB2/3-02	P06	3	15	5.8024	8.554	3.84058	14.4358	52.2831	84.296	2.16927
SB2/3-03	P24	3	16	5.89145	8.91758	4.18112	15.0639	53.8089	85.6573	2.35111
SB2/3-07	P29	3	17	8.36662	8.58904	3.50031	12.6206	65.4774	75.3278	1.73115
EA	P25	3	18	0.257806	36.6855	<0.040	10.6489	98.6067	50.5305	<0.500
SB2/3-10	P20	3	19	10.8299	10.5995	4.85587	13.5254	81.7345	79.2054	1.95262
SB2/3-05	P13	3	20	7.36366	9.5229	5.08301	14.6476	62.4282	84.933	1.89086
SB2/3-08	P10	3	21	8.99469	9.37768	6.92961	13.6974	68.8949	80.1066	2.50812
SB2/3-10ccc	P34	3	22	11.8552	9.68227	8.1376	13.9902	76.2891	80.0416	2.01559
soln std	STD-B3-3	3	23	3.91113	19.9587	3.77151	9.52971	80.0804	47.9237	<0.500
ck std	CKSTD	3	24	4.9758	4.99063	5.05047	4.95225	5.17317	4.95274	4.97901

Table F.2: SRTC-ML Measurements of the PCT Solutions for the Variability Study (VS) Glasses After Appropriate Adjustments

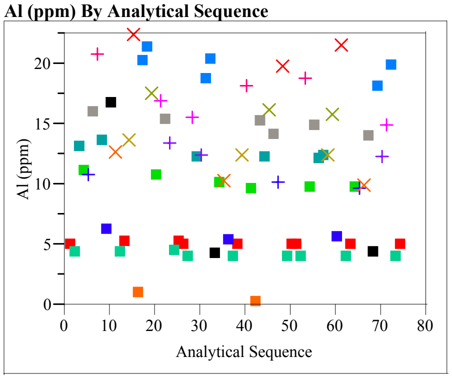
Glass	SRTC-ML		Seq	Values in parts per million (ppm)						
ID	ID	Block	#	Al	B	Fe	Li	Na	Si	U
ck std	CKSTD	1	1	4.976	5.092	4.918	4.975	5.186	4.924	4.968
soln std	STD-B1-1	1	2	4.324	21.049	4.271	10.046	83.164	47.529	0.250
SB2/3-04ccc	P15	1	3	13.014	17.034	8.062	26.282	100.460	142.713	3.538
SB2/3-01ccc	P23	1	4	11.062	16.120	8.265	26.876	87.028	146.938	4.010
SB2/3-02	P19	1	5	10.803	16.829	7.553	26.488	91.731	148.689	4.475
SB2/3-07	P14	1	6	15.992	17.176	8.785	23.775	118.627	134.964	3.573
SB2/3-11	P48	1	7	20.763	20.020	12.795	26.162	149.101	140.637	3.550
SB2/3-04	P38	1	8	13.518	17.155	8.709	25.958	109.317	147.164	3.632
ARM	P52	1	9	6.174	18.504	0.720	14.789	46.548	60.991	2.603
EA	P50	1	10	16.705	645.885	5.784	200.730	1790.970	884.408	4.167
SB2/3-03	P12	1	11	12.548	17.843	8.705	27.766	96.517	147.484	3.952
soln std	STD-B1-2	1	12	4.375	19.803	4.159	10.200	84.706	47.769	0.250
ck std	CKSTD	1	13	5.140	4.997	4.661	5.134	5.498	4.914	4.971
SB2/3-06	P09	1	14	13.551	18.675	9.566	27.209	112.553	148.256	3.525
SB2/3-12	P26	1	15	22.295	21.736	17.321	28.176	164.413	145.407	5.087
blank	P11	1	16	0.950	1.356	0.552	1.247	0.067	0.777	0.417
SB2/3-10	P31	1	17	20.203	18.536	12.993	23.857	140.657	132.409	4.602
SB2/3-10ccc	P39	1	18	21.285	17.843	16.588	24.620	131.700	131.621	4.646
SB2/3-09	P40	1	19	17.417	18.967	14.941	26.876	132.265	144.154	4.568
SB2/3-01	P41	1	20	10.741	15.752	7.199	25.388	89.819	142.228	4.091
SB2/3-08	P27	1	21	16.975	18.140	12.886	25.818	127.186	139.383	4.456
SB2/3-07ccc	P55	1	22	15.370	16.677	6.825	23.865	109.994	130.292	3.509
SB2/3-05	P36	1	23	13.384	17.751	8.621	26.962	111.026	146.382	3.343
soln std	STD-B1-3	1	24	4.449	20.387	4.261	10.363	85.126	48.072	0.250
ck std	CKSTD	1	25	5.143	4.975	4.771	5.194	5.410	4.950	4.971
ck std	CKSTD	2	1	5.000	5.142	5.073	4.961	5.223	5.036	5.003
soln std	STD-B2-1	2	2	3.907	20.199	3.877	9.563	81.643	48.808	0.250
SB2/3-08	P56	2	3	15.545	17.566	12.318	23.344	118.905	138.152	3.878
SB2/3-04ccc	P44	2	4	12.156	15.413	7.966	24.078	94.988	141.405	3.305
SB2/3-05	P42	2	5	12.427	16.502	8.458	24.761	106.237	147.180	3.014
SB2/3-10	P46	2	6	18.653	17.992	9.530	22.867	138.606	135.918	3.324
SB2/3-10ccc	P03	2	7	20.306	16.650	16.935	23.068	128.027	135.217	4.475
EA	P54	2	8	4.226	622.696	0.333	180.370	1682.137	863.187	11.070
SB2/3-01ccc	P43	2	9	10.044	15.116	7.619	24.882	83.235	146.672	3.983
SB2/3-03	P22	2	10	10.229	15.521	8.748	25.354	90.630	147.130	3.866
ARM	P37	2	11	5.320	17.719	0.033	13.797	43.984	61.192	2.503
soln std	STD-B2-2	2	12	3.920	19.689	3.780	9.561	81.876	48.271	0.250
ck std	CKSTD	2	13	4.978	5.050	4.979	4.933	5.243	4.992	4.963
SB2/3-06	P51	2	14	12.330	17.382	8.467	25.146	107.803	147.768	3.079
SB2/3-11	P08	2	15	18.232	19.015	8.139	23.730	142.106	136.763	3.267
SB2/3-01	P18	2	16	9.523	14.358	6.376	22.854	83.521	139.798	3.804
blank	P28	2	17	0.125	0.033	0.033	0.577	0.067	0.167	0.417

Table F.2: SRTC-ML Measurements of the PCT Solutions for the Variability Study (VS) Glasses After Appropriate Adjustments

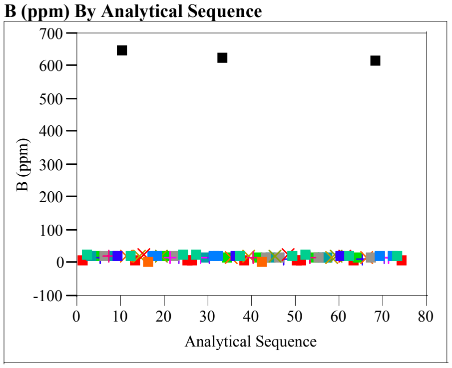
Glass	SRTC-ML		Seq	Values in parts per million (ppm)						
ID	ID	Block	#	Al	B	Fe	Li	Na	Si	U
SB2/3-07ccc	P07	2	18	15.151	15.279	10.343	22.028	105.938	134.134	3.623
SB2/3-04	P45	2	19	12.129	15.517	7.663	23.499	101.845	140.995	2.956
SB2/3-09	P47	2	20	16.053	17.401	13.966	24.632	125.597	142.932	4.180
SB2/3-07	P30	2	21	14.028	14.969	6.199	21.259	110.024	128.878	2.988
SB2/3-02	P49	2	22	10.131	15.134	7.500	24.615	89.527	145.933	3.726
SB2/3-12	P01	2	23	19.701	20.184	9.698	26.151	155.382	144.333	3.488
soln std	STD-B2-3	2	24	3.911	19.967	3.866	9.548	81.403	48.390	0.250
ck std	CKSTD	2	25	4.956	4.976	4.972	4.921	5.173	4.949	4.961
ck std	CKSTD	3	1	4.970	5.183	5.031	4.944	5.161	4.957	4.980
soln std	STDB-3-1	3	2	3.972	20.706	3.914	9.605	80.772	48.714	0.250
SB2/3-11	P35	3	3	18.833	18.664	9.949	23.911	140.304	135.749	3.393
SB2/3-01	P53	3	4	9.660	14.178	6.380	23.353	84.963	140.385	3.561
SB2/3-07ccc	P21	3	5	14.806	14.445	10.447	21.307	102.804	127.720	4.123
SB2/3-04ccc	P16	3	6	12.066	15.013	7.667	24.565	95.176	141.820	3.190
SB2/3-04	P02	3	7	12.288	14.975	8.466	23.300	99.935	139.768	3.249
SB2/3-06	P04	3	8	12.295	15.376	9.826	23.205	98.805	138.017	3.548
SB2/3-09	P32	3	9	15.714	16.901	13.197	24.166	122.703	137.968	4.220
ARM	P17	3	10	5.615	17.973	0.033	14.011	41.051	60.443	0.417
SB2/3-12	P33	3	11	21.446	19.078	13.765	25.640	152.350	143.138	3.647
soln std	STD-B3-2	3	12	3.957	19.918	3.784	9.597	81.250	48.065	0.250
ck std	CKSTD	3	13	4.969	4.980	4.976	4.943	5.190	4.921	4.967
SB2/3-01ccc	P05	3	14	9.734	14.423	6.612	24.494	80.610	141.855	4.062
SB2/3-02	P06	3	15	9.671	14.257	6.401	24.060	87.140	140.496	3.616
SB2/3-03	P24	3	16	9.819	14.863	6.969	25.107	89.683	142.765	3.919
SB2/3-07	P29	3	17	13.945	14.315	5.834	21.035	109.131	125.549	2.885
EA	P25	3	18	4.297	611.426	0.333	177.482	1643.448	842.177	4.167
SB2/3-10	P20	3	19	18.050	17.666	8.093	22.543	136.227	132.012	3.254
SB2/3-05	P13	3	20	12.273	15.872	8.472	24.413	104.049	141.558	3.151
SB2/3-08	P10	3	21	14.991	15.630	11.550	22.829	114.827	133.514	4.180
SB2/3-10ccc	P34	3	22	19.759	16.137	13.563	23.317	127.151	133.405	3.359
soln std	STD-B3-3	3	23	3.911	19.959	3.772	9.530	80.080	47.924	0.250
ck std	CKSTD	3	24	4.976	4.991	5.050	4.952	5.173	4.953	4.979

Exhibit F.1: SRTC-ML PCT Measurements in Analytical Sequence for Study Glasses, EA, ARM, Blanks, and Solution and Check Standards

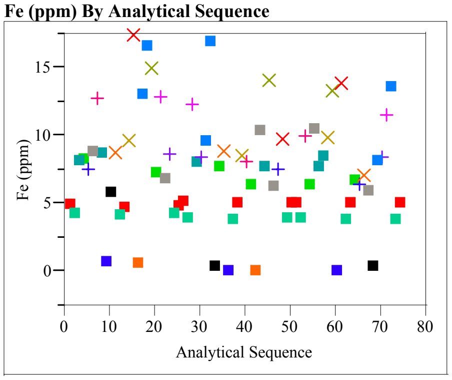
Al (ppm) By Analytical Sequence



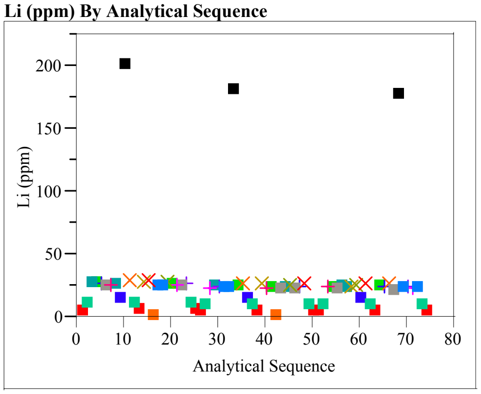
B (ppm) By Analytical Sequence



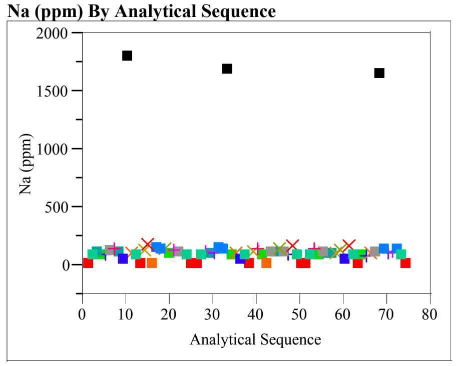
Fe (ppm) By Analytical Sequence



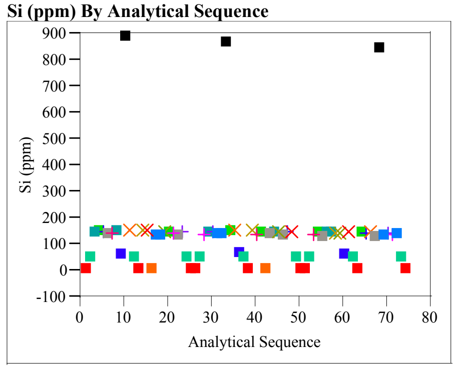
Li (ppm) By Analytical Sequence



Na (ppm) By Analytical Sequence



Si (ppm) By Analytical Sequence



U (ppm) By Analytical Sequence

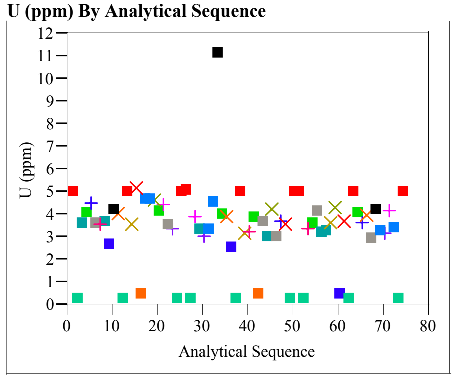
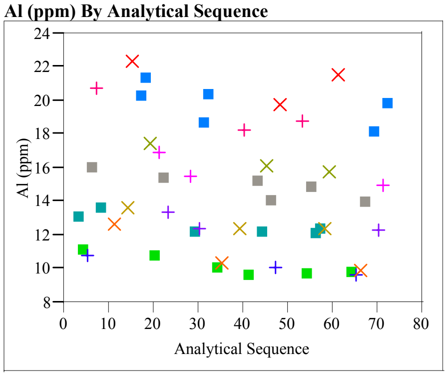
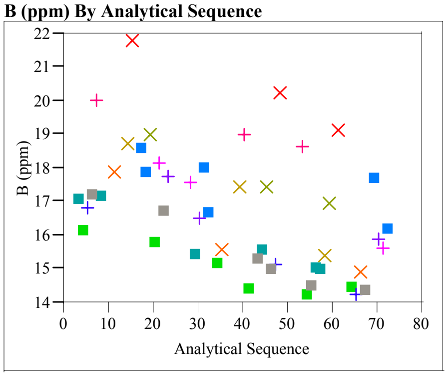


Exhibit F.2: SRTC-ML PCT Measurements in Analytical Sequence for Variability Study (VS) Glasses Only

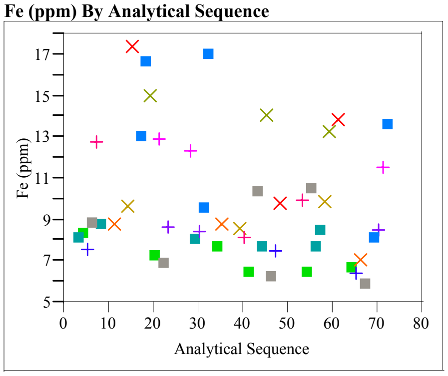
Al (ppm) By Analytical Sequence



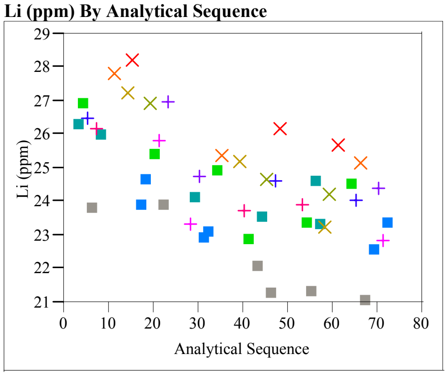
B (ppm) By Analytical Sequence



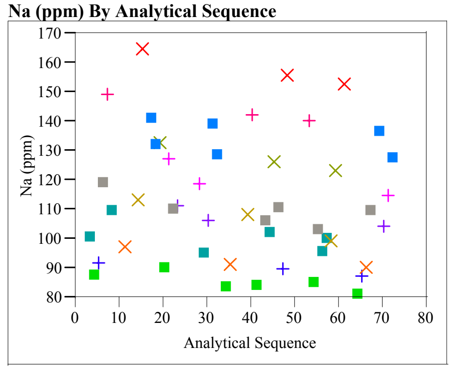
Fe (ppm) By Analytical Sequence



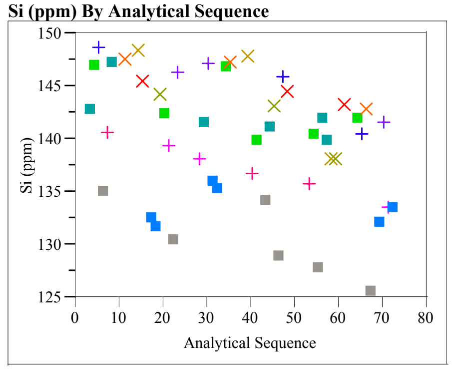
Li (ppm) By Analytical Sequence



Na (ppm) By Analytical Sequence



Si (ppm) By Analytical Sequence



U (ppm) By Analytical Sequence

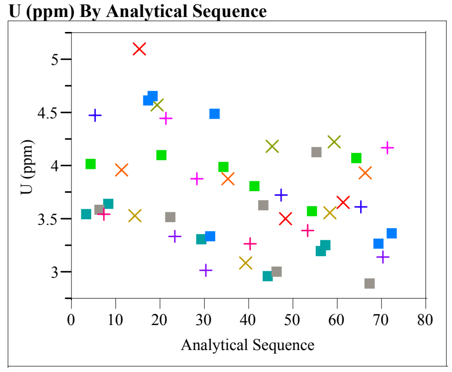
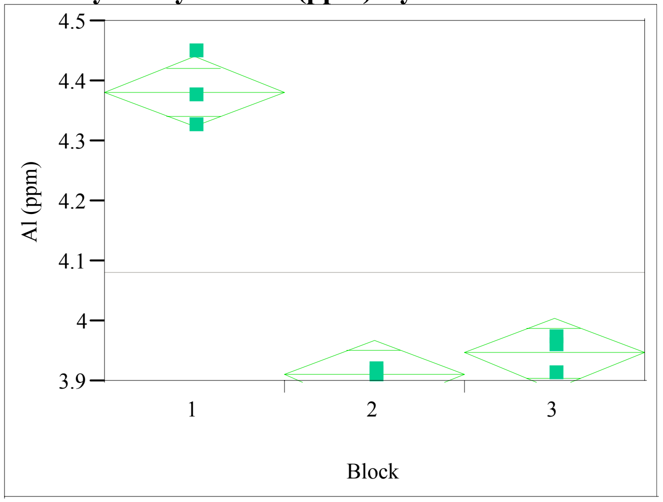


Exhibit F.3: Measurements of the Multi-Element Solution Standard by ICP Block

Oneway Analysis of Al (ppm) By Block



Oneway Anova
Summary of Fit

Rsquare	0.976464
Adj Rsquare	0.968619
Root Mean Square Error	0.04069
Mean of Response	4.080638
Observations (or Sum Wgts)	9

Analysis of Variance

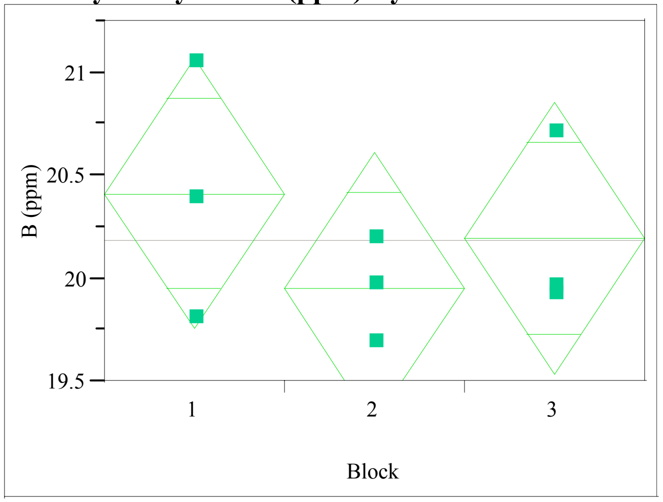
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block	2	0.41216057	0.206080	124.4665	<.0001
Error	6	0.00993425	0.001656		
C. Total	8	0.42209482			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1	3	4.38263	0.02349	4.3251	4.4401
2	3	3.91250	0.02349	3.8550	3.9700
3	3	3.94679	0.02349	3.8893	4.0043

Std Error uses a pooled estimate of error variance

Oneway Analysis of B (ppm) By Block



Oneway Anova
Summary of Fit

Rsquare	0.197453
Adj Rsquare	-0.07006
Root Mean Square Error	0.465587
Mean of Response	20.18627
Observations (or Sum Wgts)	9

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block	2	0.3199970	0.159998	0.7381	0.5169
Error	6	1.3006271	0.216771		
C. Total	8	1.6206241			

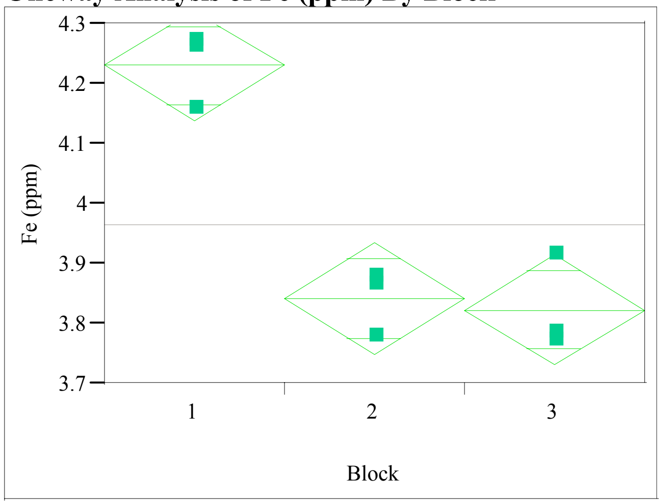
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1	3	20.4131	0.26881	19.755	21.071
2	3	19.9514	0.26881	19.294	20.609
3	3	20.1943	0.26881	19.537	20.852

Std Error uses a pooled estimate of error variance

Exhibit F.3: Measurements of the Multi-Element Solution Standard by ICP Block *(continued)*

Oneway Analysis of Fe (ppm) By Block



Oneway Anova
Summary of Fit

Rsquare	0.924569
Adj Rsquare	0.899426
Root Mean Square Error	0.065736
Mean of Response	3.964949
Observations (or Sum Wgts)	9

Analysis of Variance

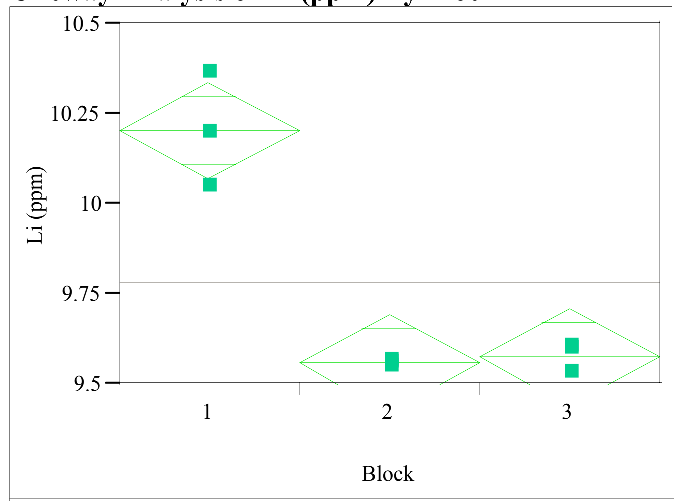
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block	2	0.31780038	0.158900	36.7717	0.0004
Error	6	0.02592759	0.004321		
C. Total	8	0.34372797			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1	3	4.23050	0.03795	4.1376	4.3234
2	3	3.84112	0.03795	3.7483	3.9340
3	3	3.82323	0.03795	3.7304	3.9161

Std Error uses a pooled estimate of error variance

Oneway Analysis of Li (ppm) By Block



Oneway Anova
Summary of Fit

Rsquare	0.937753
Adj Rsquare	0.917004
Root Mean Square Error	0.094615
Mean of Response	9.779173
Observations (or Sum Wgts)	9

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block	2	0.80917664	0.404588	45.1949	0.0002
Error	6	0.05371244	0.008952		
C. Total	8	0.86288908			

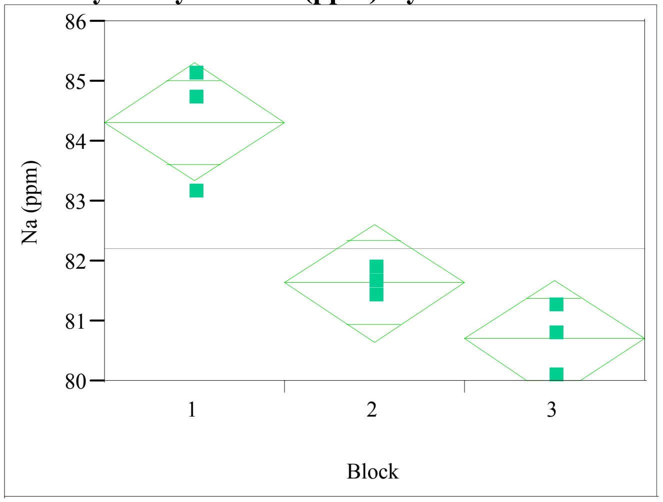
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1	3	10.2031	0.05463	10.069	10.337
2	3	9.5573	0.05463	9.424	9.691
3	3	9.5772	0.05463	9.443	9.711

Std Error uses a pooled estimate of error variance

Exhibit F.3: Measurements of the Multi-Element Solution Standard by ICP Block *(continued)*

Oneway Analysis of Na (ppm) By Block



Oneway Anova
Summary of Fit

Rsquare	0.878813
Adj Rsquare	0.838418
Root Mean Square Error	0.699835
Mean of Response	82.22444
Observations (or Sum Wgts)	9

Analysis of Variance

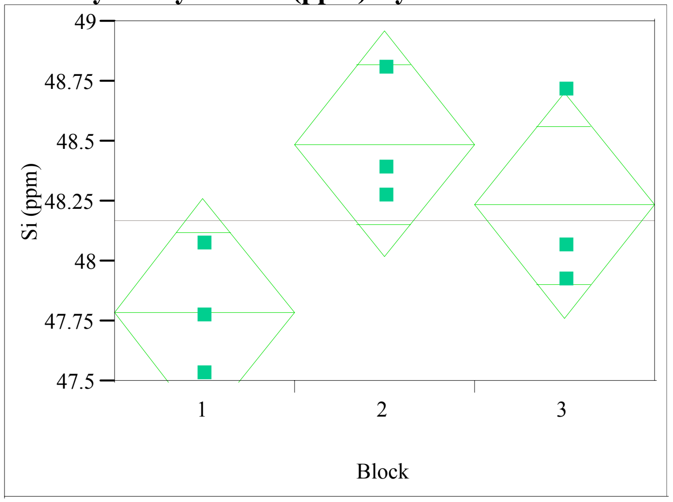
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block	2	21.310014	10.6550	21.7552	0.0018
Error	6	2.938613	0.4898		
C. Total	8	24.248627			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1	3	84.3318	0.40405	83.343	85.321
2	3	81.6407	0.40405	80.652	82.629
3	3	80.7008	0.40405	79.712	81.689

Std Error uses a pooled estimate of error variance

Oneway Analysis of Si (ppm) By Block



Oneway Anova
Summary of Fit

Rsquare	0.532279
Adj Rsquare	0.376372
Root Mean Square Error	0.332051
Mean of Response	48.17116
Observations (or Sum Wgts)	9

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block	2	0.7528613	0.376431	3.4141	0.1023
Error	6	0.6615490	0.110258		
C. Total	8	1.4144102			

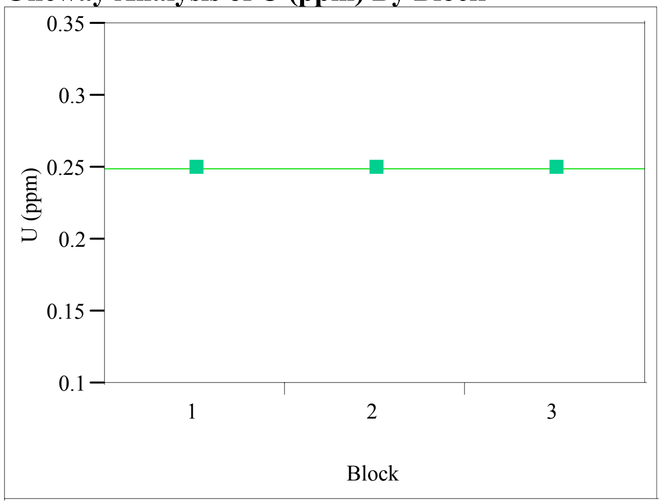
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1	3	47.7897	0.19171	47.321	48.259
2	3	48.4897	0.19171	48.021	48.959
3	3	48.2340	0.19171	47.765	48.703

Std Error uses a pooled estimate of error variance

Exhibit F.3: Measurements of the Multi-Element Solution Standard by ICP Block *(continued)*

Oneway Analysis of U (ppm) By Block



Oneway Anova
Summary of Fit

Rsquare	.
Adj Rsquare	.
Root Mean Square Error	0
Mean of Response	0.25
Observations (or Sum Wgts)	9

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block	2	0	0	.	.
Error	6	0	0		
C. Total	8	0			

Means for Oneway Anova

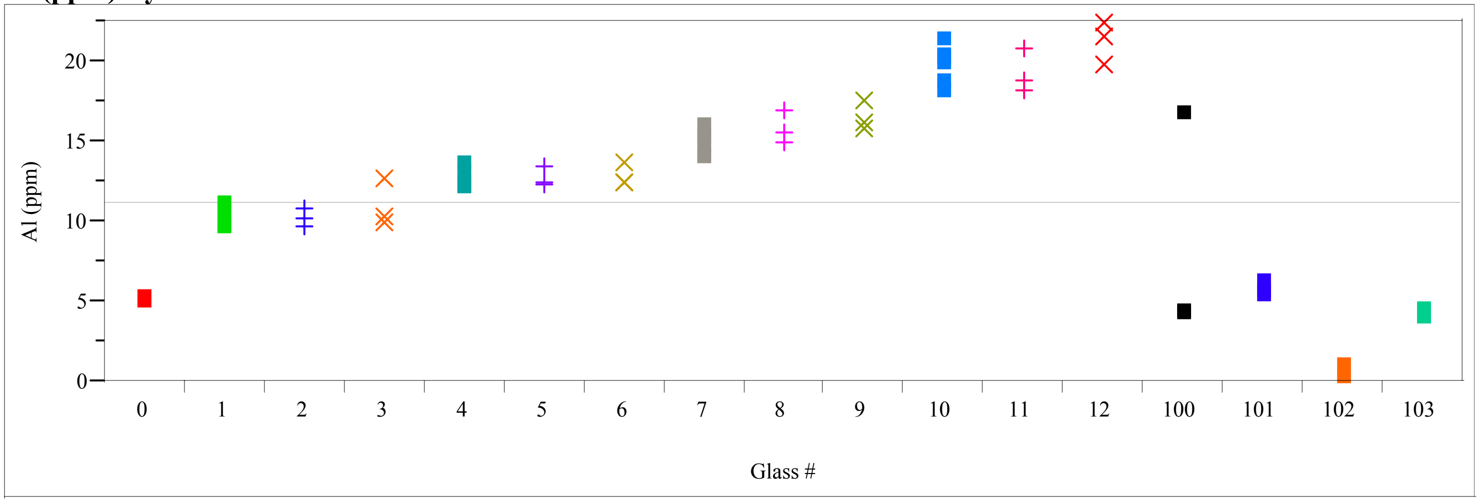
Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1	3	0.250000	0	0.25000	0.25000
2	3	0.250000	0	0.25000	0.25000
3	3	0.250000	0	0.25000	0.25000

Std Error uses a pooled estimate of error variance

Exhibit F.4: SRTC-ML PCT Measurements by Glass Number for Study Glasses and Standards

(0 – Ck Std, 100 – EA, 101 – ARM, 102 – Blank, and 103 – Ck Std)

Al (ppm) By Glass ID



B (ppm) By Glass ID

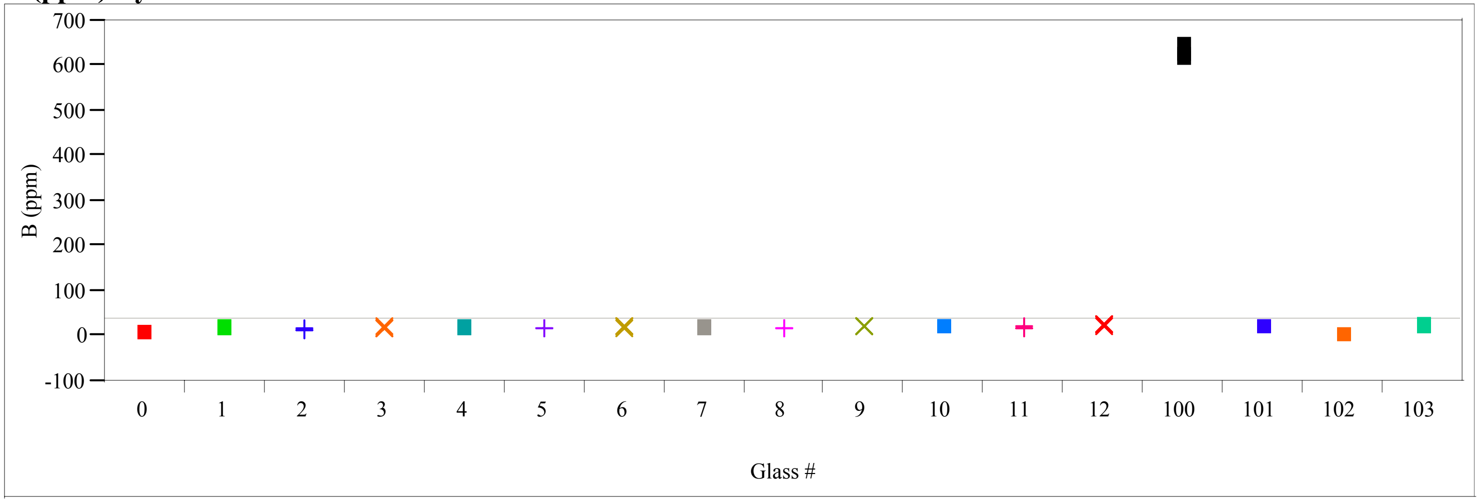
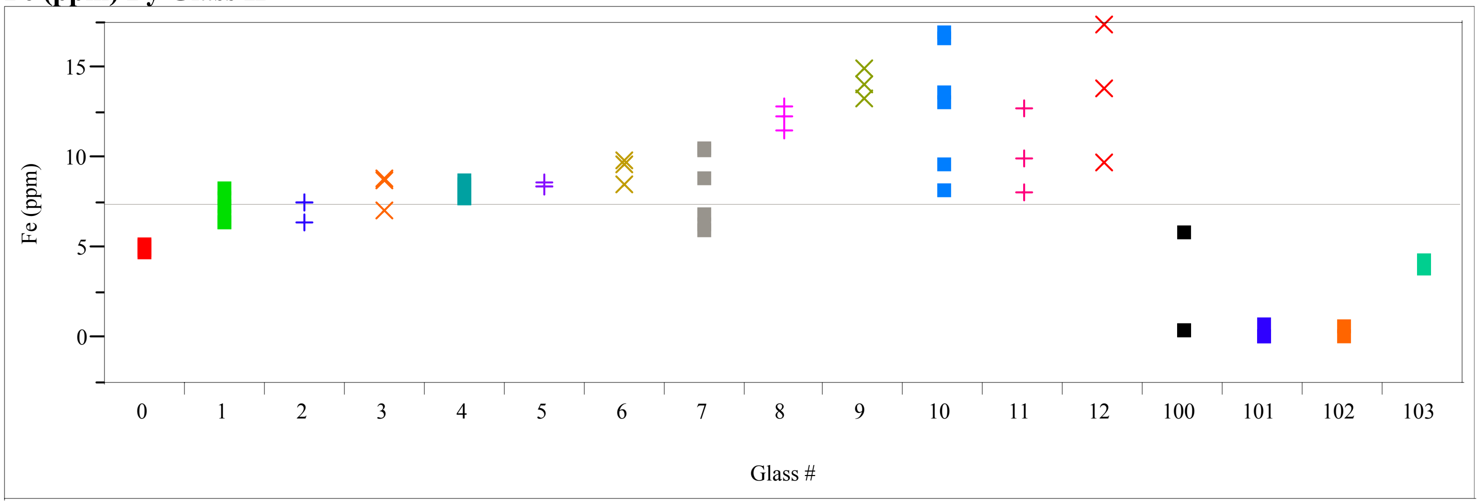


Exhibit F.4: SRTC-ML PCT Measurements by Glass Number for Study Glasses and Standards *(continued)*

(0 – Ck Std, 100 – EA, 101 – ARM, 102 – Blank, and 103 – Ck Std)

Fe (ppm) By Glass ID



Li (ppm) By Glass ID

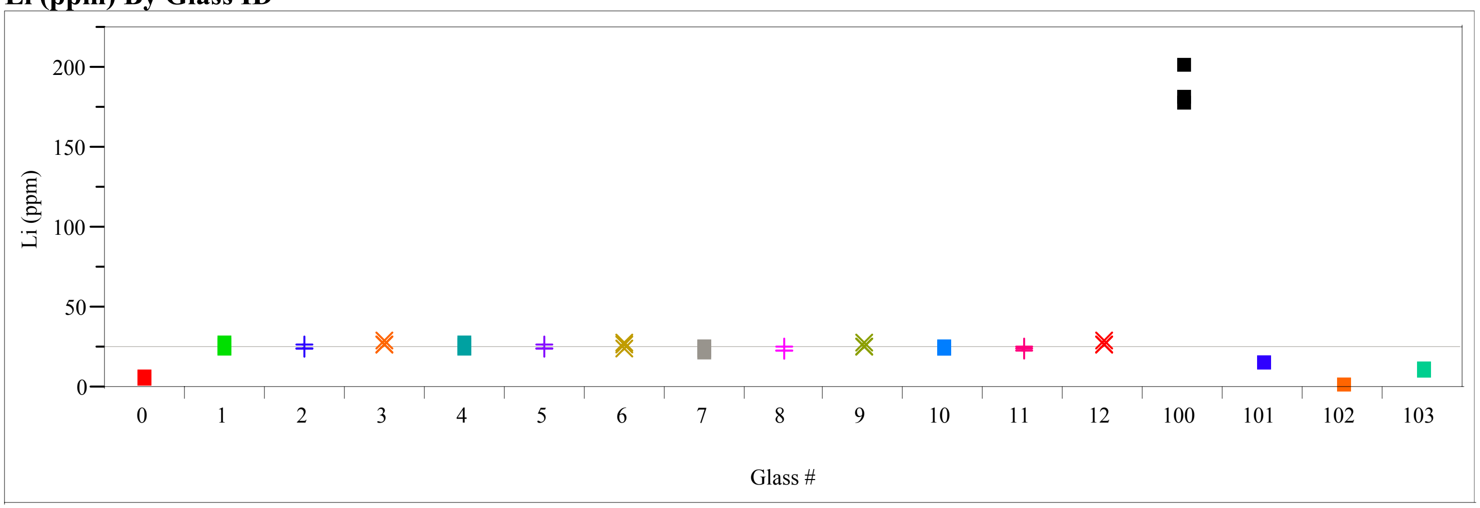
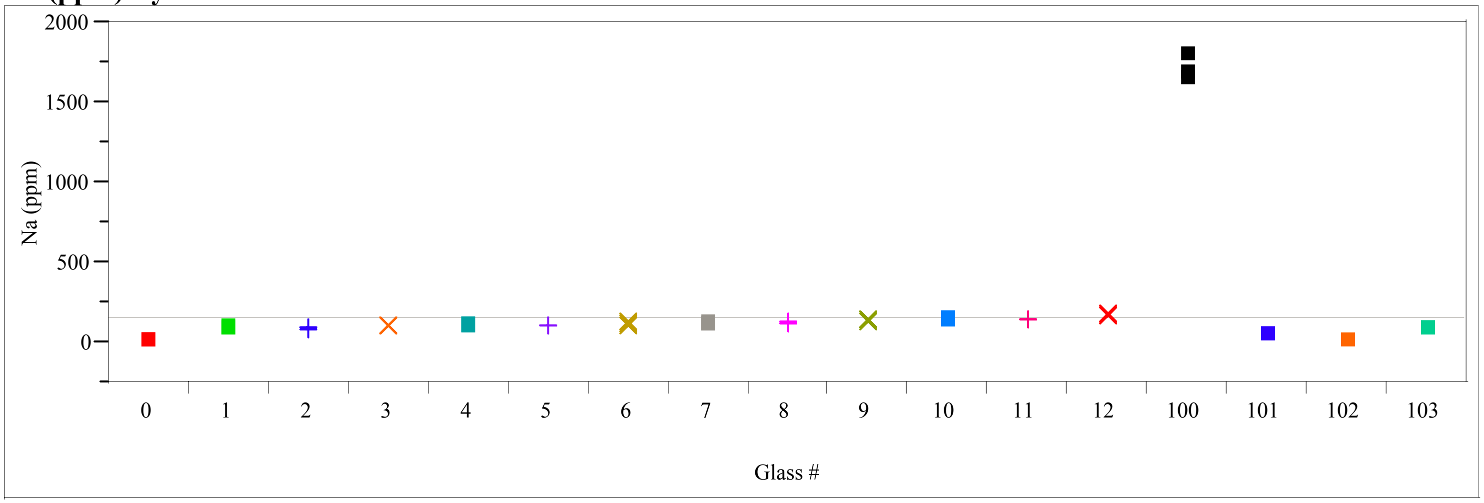


Exhibit F.4: SRTC-ML PCT Measurements by Glass Number for Study Glasses and Standards *(continued)*

(0 – Ck Std, 100 – EA, 101 – ARM, 102 – Blank, and 103 – Ck Std)

Na (ppm) By Glass ID



Si (ppm) By Glass ID

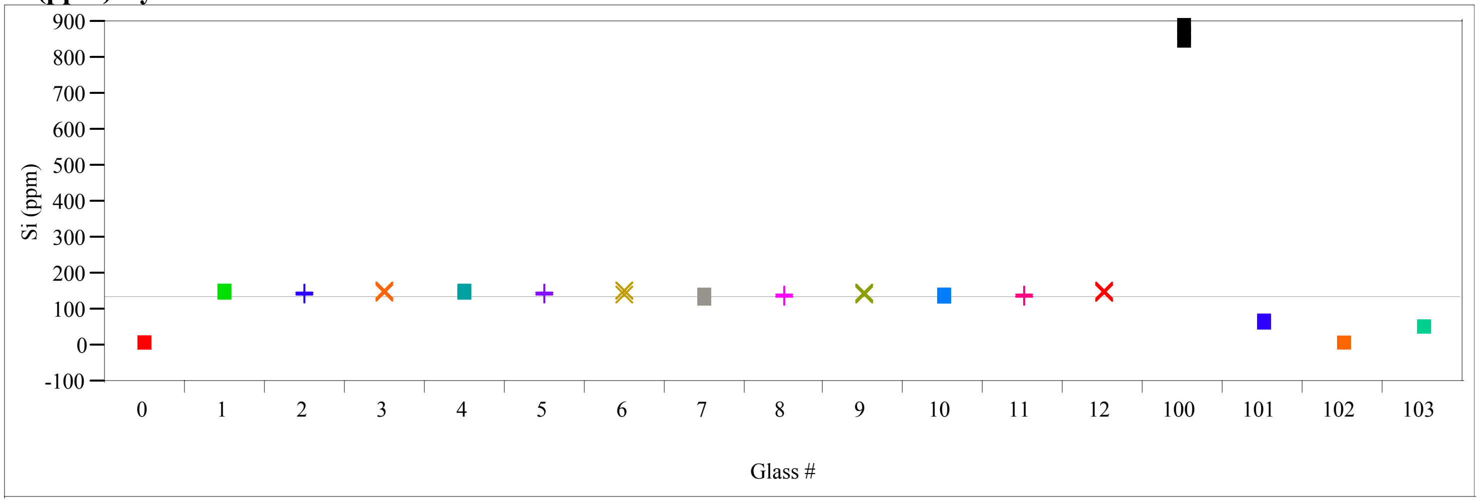


Exhibit F.4: SRTC-ML PCT Measurements by Glass Number for Study Glasses and Standards *(continued)*
(0 – Ck Std, 100 – EA, 101 – ARM, 102 – Blank, and 103 – Ck Std)

U (ppm) By Glass ID

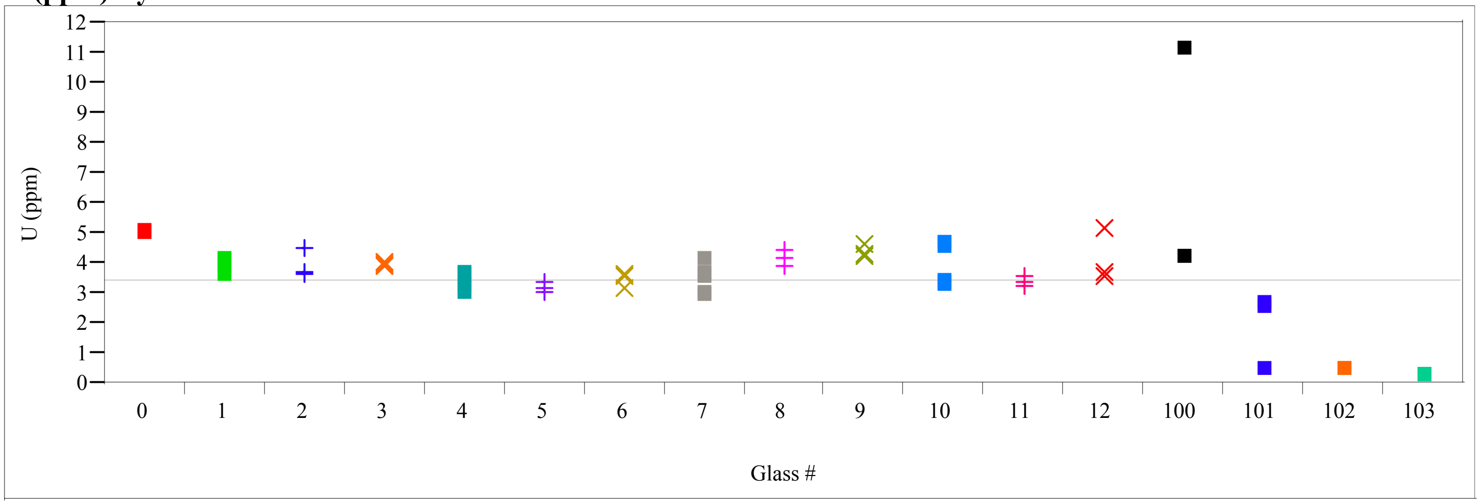
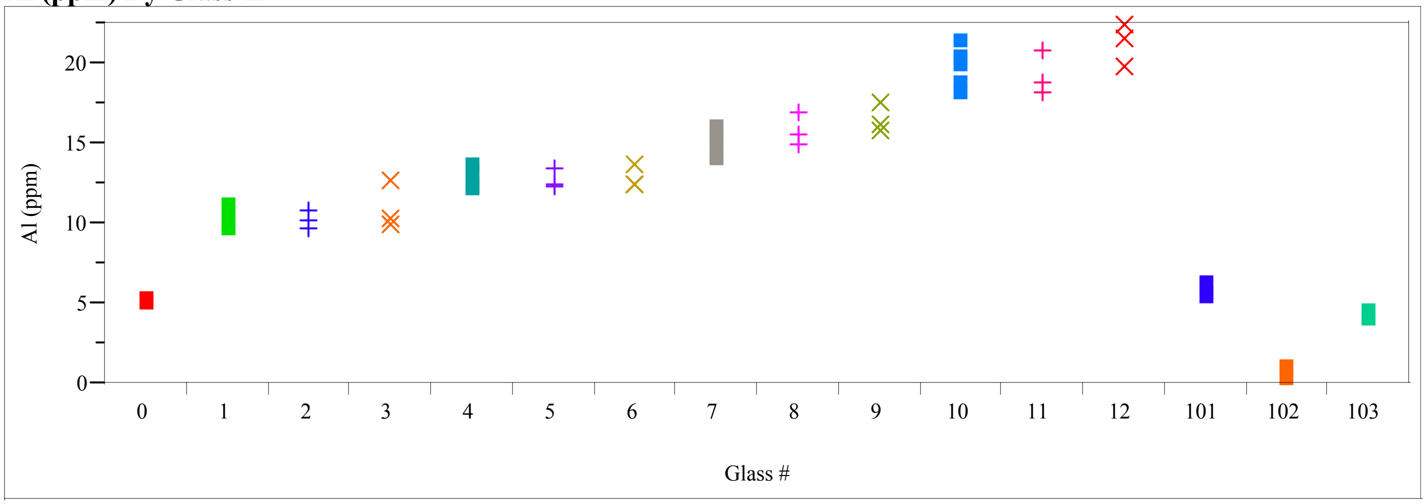


Exhibit F.5: SRTC-ML PCT Measurements by Glass Number for Study Glasses and Standards Except EA

(0 – Ck Std, 101 – ARM, 102 – Blank, and 103 – Soln Std)

Al (ppm) By Glass ID



B (ppm) By Glass ID

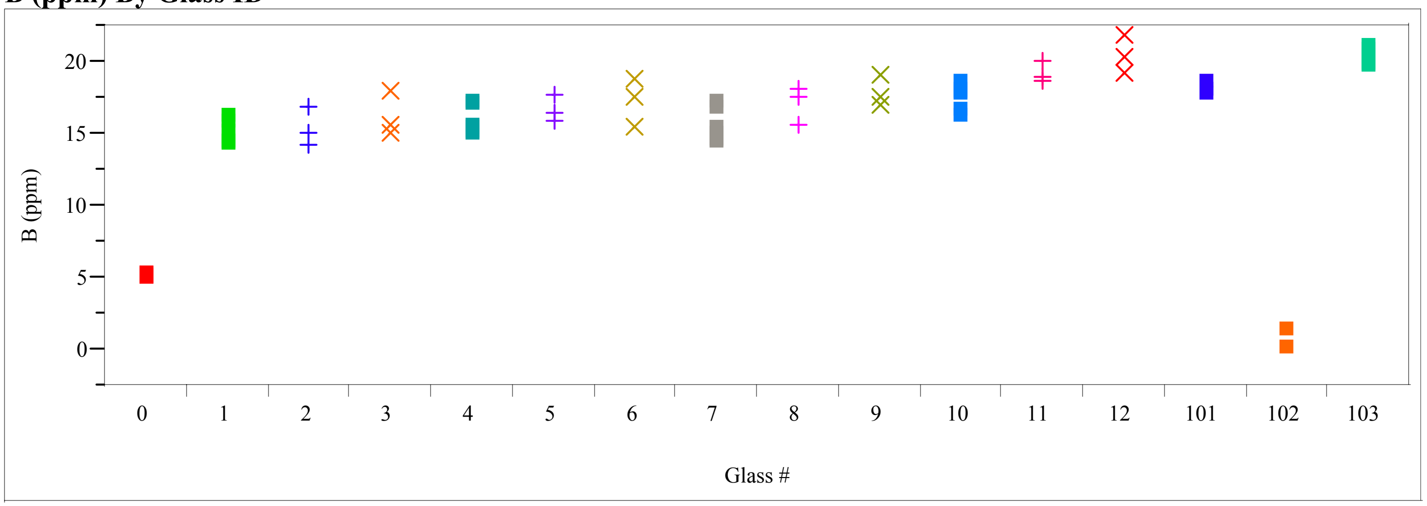
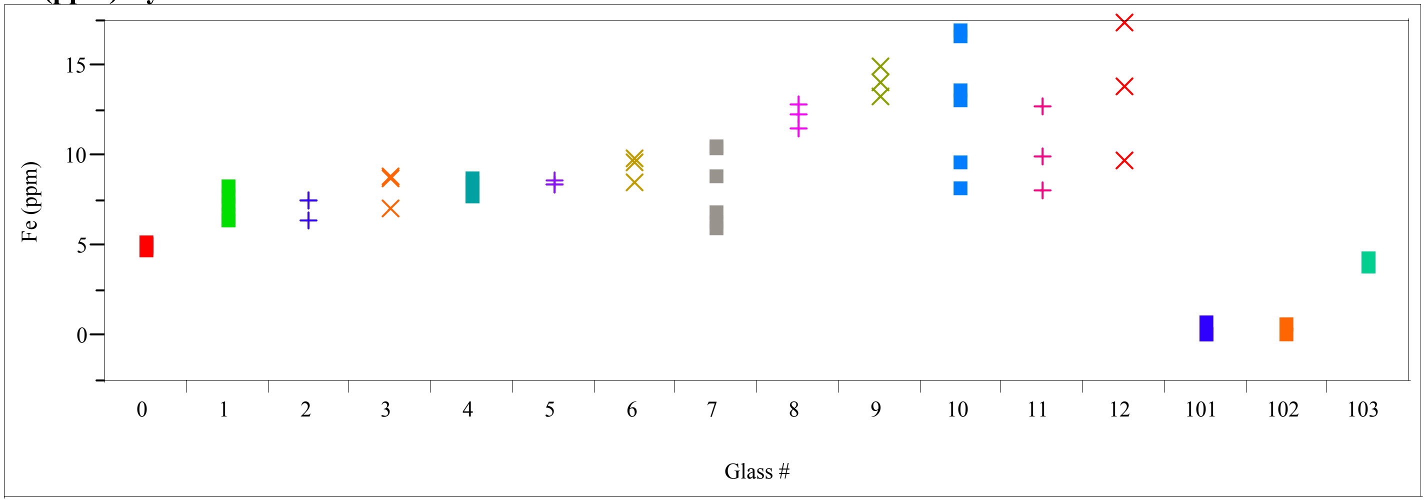


Exhibit F.5: SRTC-ML PCT Measurements by Glass Number for Study Glasses and Standards Except EA *(continued)*

(0 – Blank, 101 – ARM, 102 – Soln Std, and 103 – Ck Std)

Fe (ppm) By Glass ID



Li (ppm) By Glass ID

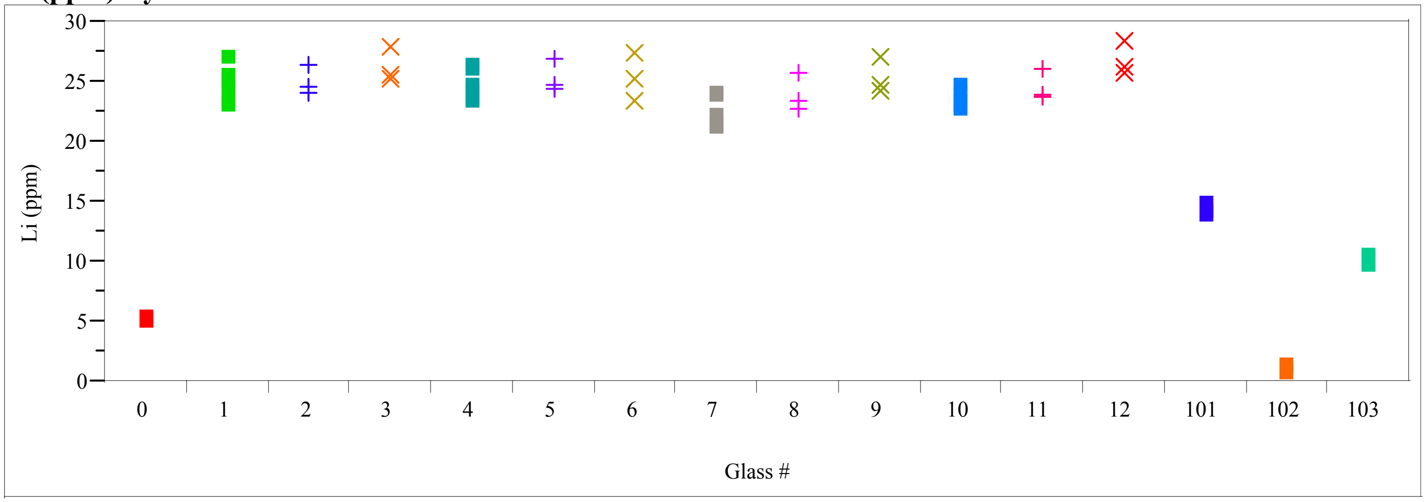
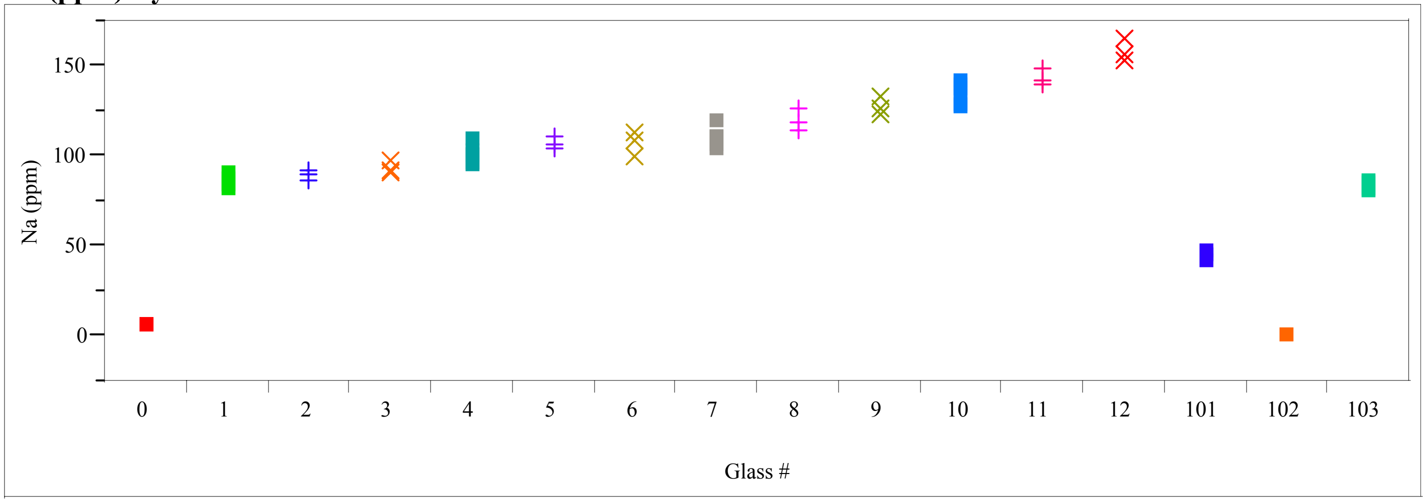


Exhibit F.5: SRTC-ML PCT Measurements by Glass Number for Study Glasses and Standards Except EA *(continued)*

(0 – Ck Std, 101 – ARM, 102 – Blank, and 103 – Soln Std)

Na (ppm) By Glass ID



Si (ppm) By Glass ID

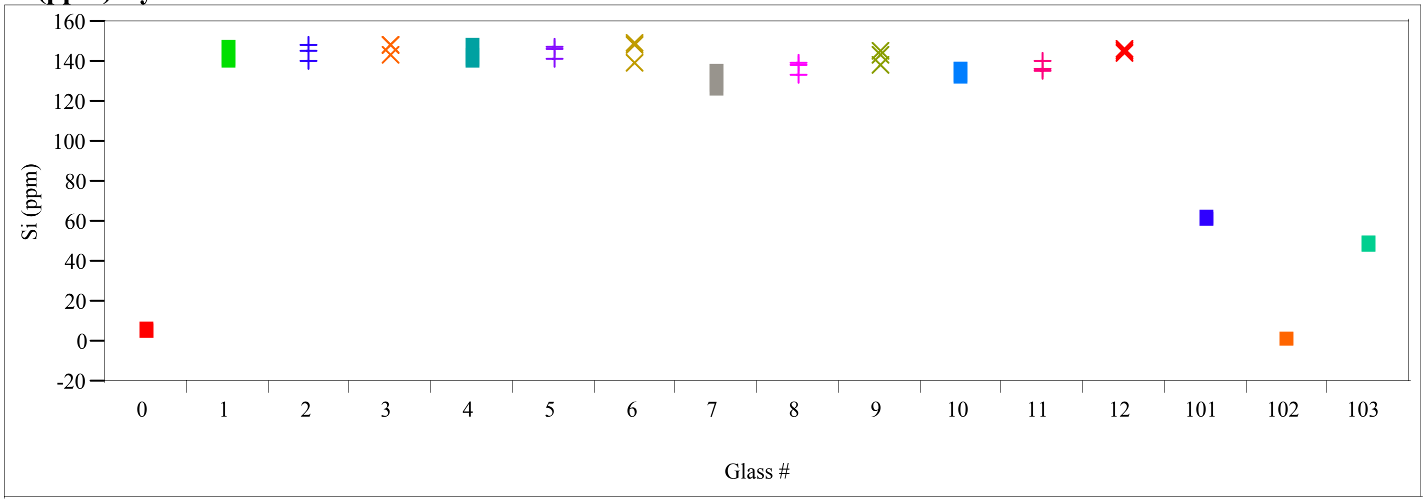


Exhibit F.5: SRTC-ML PCT Measurements by Glass Number for Study Glasses and Standards Except EA *(continued)*

(0 – Ck Std, 101 – ARM, 102 – Blank, and 103 – Soln Std)

U (ppm) By Glass ID

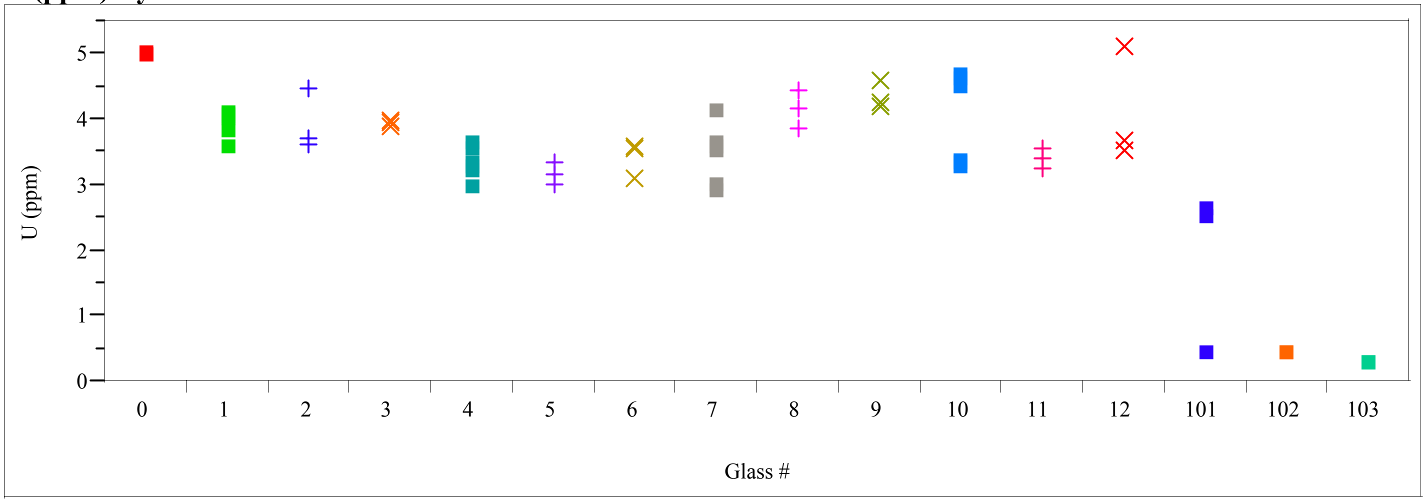
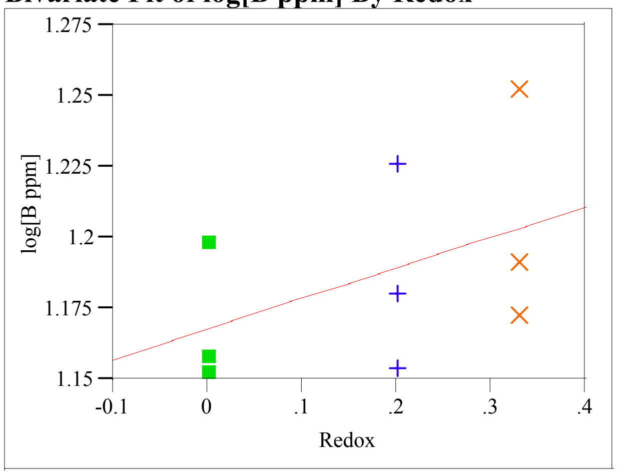


Exhibit F.6: REDOX Effects on PCT Response by REDOX Group *(continued)*

REDOX Group=1 (SB2/3-01, -02, -03)

Bivariate Fit of log[B ppm] By Redox



Linear Fit

log[B ppm] = 1.1676671 + 0.1079085 Redox

Summary of Fit

RSquare	0.207407
RSquare Adj	0.094179
Root Mean Square Error	0.032465
Mean of Response	1.186731
Observations (or Sum Wgts)	9

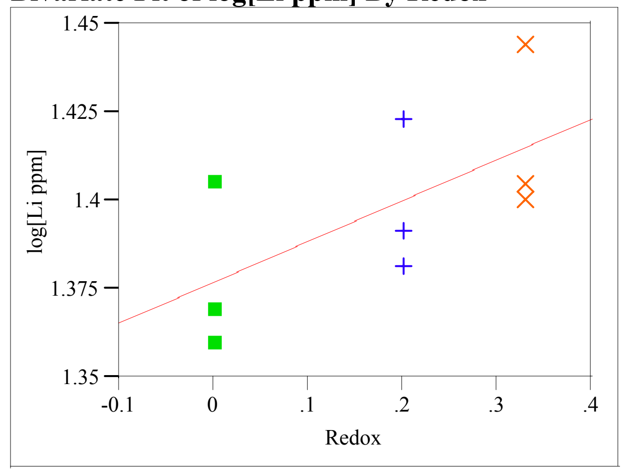
Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.00193062	0.001931	1.8318
Error	7	0.00737774	0.001054	Prob > F
C. Total	8	0.00930836		0.2180

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	1.1676671	0.017763	65.74	<.0001
Redox	0.1079085	0.07973	1.35	0.2180

Bivariate Fit of log[Li ppm] By Redox



Linear Fit

log[Li ppm] = 1.3767664 + 0.1156861 Redox

Summary of Fit

RSquare	0.403012
RSquare Adj	0.317728
Root Mean Square Error	0.021669
Mean of Response	1.397204
Observations (or Sum Wgts)	9

Analysis of Variance

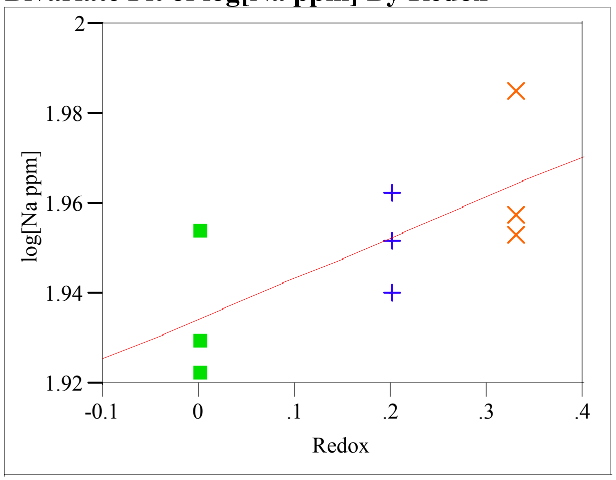
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.00221895	0.002219	4.7255
Error	7	0.00328696	0.000470	Prob > F
C. Total	8	0.00550591		0.0662

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	1.3767664	0.011856	116.12	<.0001
Redox	0.1156861	0.053218	2.17	0.0662

Exhibit F.6: REDOX Effects on PCT Response by REDOX Group *(continued)*

Bivariate Fit of log[Na ppm] By Redox



Linear Fit

log[Na ppm] = 1.9344195 + 0.0904973 Redox

Summary of Fit

RSquare	0.493623
RSquare Adj	0.421284
Root Mean Square Error	0.014106
Mean of Response	1.950407
Observations (or Sum Wgts)	9

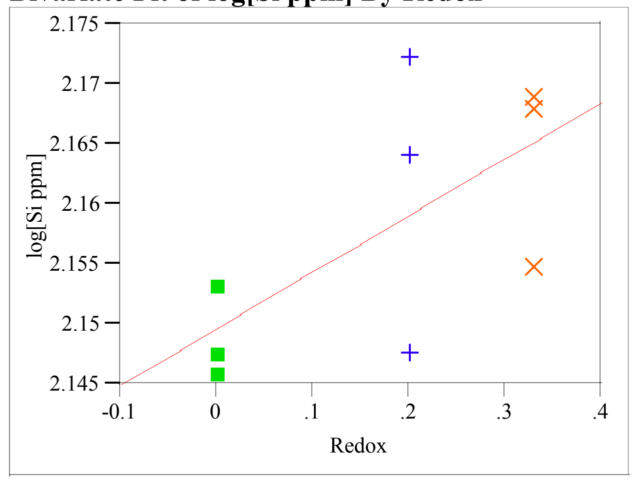
Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.00135786	0.001358	6.8237
Error	7	0.00139294	0.000199	Prob > F
C. Total	8	0.00275081		0.0348

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	1.9344195	0.007718	250.63	<.0001
Redox	0.0904973	0.034644	2.61	0.0348

Bivariate Fit of log[Si ppm] By Redox



Linear Fit

log[Si ppm] = 2.1495391 + 0.0472457 Redox

Summary of Fit

RSquare	0.427945
RSquare Adj	0.346223
Root Mean Square Error	0.008407
Mean of Response	2.157886
Observations (or Sum Wgts)	9

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.00037009	0.000370	5.2366
Error	7	0.00049472	0.000071	Prob > F
C. Total	8	0.00086481		0.0559

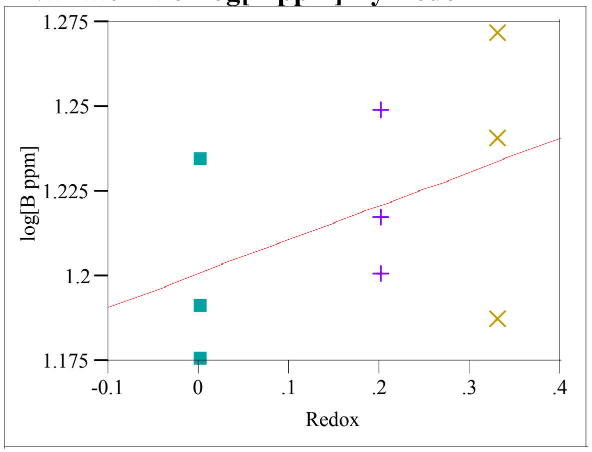
Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	2.1495391	0.0046	467.33	<.0001
Redox	0.0472457	0.020646	2.29	0.0559

Exhibit F.6: REDOX Effects on PCT Response by REDOX Group *(continued)*

Redox Group=2 (SB2/3-04, -05, -06)

Bivariate Fit of log[B ppm] By Redox



Linear Fit

log[B ppm] = 1.2008546 + 0.0996738 Redox

Summary of Fit

RSquare	0.1962
RSquare Adj	0.081371
Root Mean Square Error	0.031049
Mean of Response	1.218464
Observations (or Sum Wgts)	9

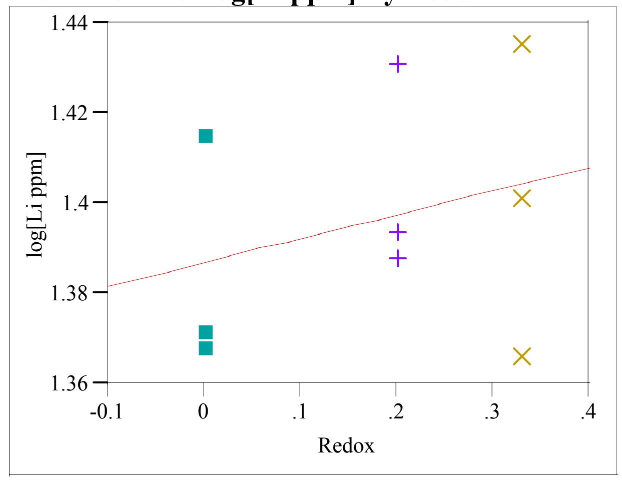
Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.00164720	0.001647	1.7086
Error	7	0.00674831	0.000964	Prob > F
C. Total	8	0.00839551		0.2325

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	1.2008546	0.016988	70.69	<.0001
Redox	0.0996738	0.076253	1.31	0.2325

Bivariate Fit of log[Li ppm] By Redox



Linear Fit

log[Li ppm] = 1.3868446 + 0.0528318 Redox

Summary of Fit

RSquare	0.084088
RSquare Adj	-0.04676
Root Mean Square Error	0.026835
Mean of Response	1.396178
Observations (or Sum Wgts)	9

Analysis of Variance

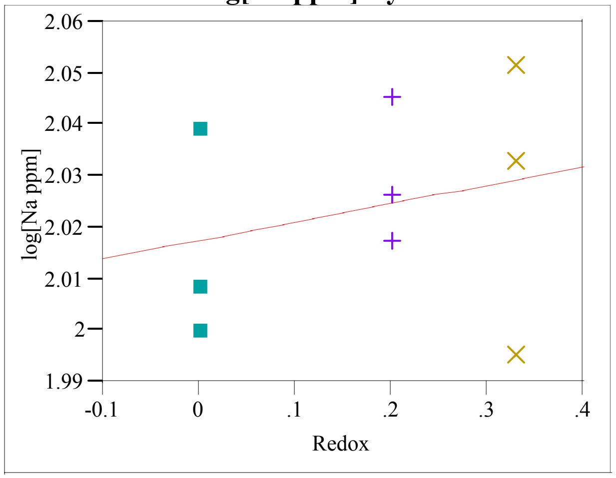
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.00046278	0.000463	0.6427
Error	7	0.00504078	0.000720	Prob > F
C. Total	8	0.00550356		0.4491

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	1.3868446	0.014682	94.46	<.0001
Redox	0.0528318	0.065903	0.80	0.4491

Exhibit F.6: REDOX Effects on PCT Response by REDOX Group *(continued)*

Bivariate Fit of log[Na ppm] By Redox



Linear Fit
log[Na ppm] = 2.0174274 + 0.0359779 Redox

Summary of Fit

RSquare	0.066044
RSquare Adj	-0.06738
Root Mean Square Error	0.020822
Mean of Response	2.023784
Observations (or Sum Wgts)	9

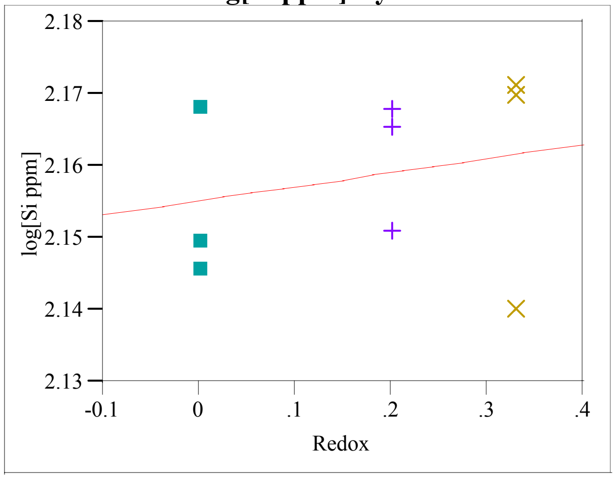
Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.00021461	0.000215	0.4950
Error	7	0.00303491	0.000434	Prob > F
C. Total	8	0.00324953		0.5044

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	2.0174274	0.011392	177.08	<.0001
Redox	0.0359779	0.051137	0.70	0.5044

Bivariate Fit of log[Si ppm] By Redox



Linear Fit
log[Si ppm] = 2.1550757 + 0.0198274 Redox

Summary of Fit

RSquare	0.056101
RSquare Adj	-0.07874
Root Mean Square Error	0.012517
Mean of Response	2.158579
Observations (or Sum Wgts)	9

Analysis of Variance

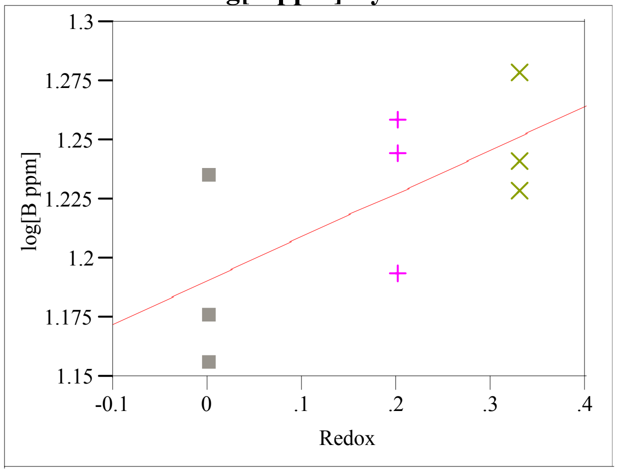
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.00006518	0.000065	0.4161
Error	7	0.00109665	0.000157	Prob > F
C. Total	8	0.00116183		0.5395

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	2.1550757	0.006848	314.69	<.0001
Redox	0.0198274	0.030739	0.65	0.5395

Exhibit F.6: REDOX Effects on PCT Response by REDOX Group *(continued)*

Redox Group=3 (SB2/3-07, -08, -09)
Bivariate Fit of log[B ppm] By Redox



Linear Fit
log[B ppm] = 1.1905259 + 0.1854941 Redox

Summary of Fit

RSquare	0.442741
RSquare Adj	0.363132
Root Mean Square Error	0.032028
Mean of Response	1.223297
Observations (or Sum Wgts)	9

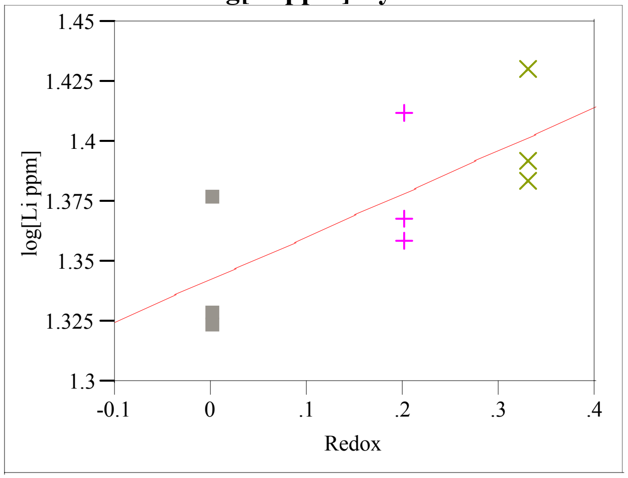
Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.00570485	0.005705	5.5615
Error	7	0.00718046	0.001026	Prob > F
C. Total	8	0.01288532		0.0505

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	1.1905259	0.017524	67.94	<.0001
edox	0.1854941	0.078657	2.36	0.0505

Bivariate Fit of log[Li ppm] By Redox



Linear Fit
log[Li ppm] = 1.3425847 + 0.1798833 Redox

Summary of Fit

RSquare	0.539858
RSquare Adj	0.474124
Root Mean Square Error	0.025559
Mean of Response	1.374364
Observations (or Sum Wgts)	9

Analysis of Variance

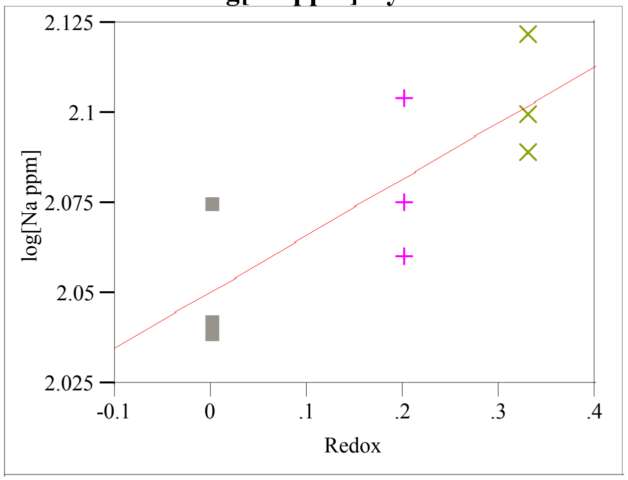
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.00536495	0.005365	8.2127
Error	7	0.00457275	0.000653	Prob > F
C. Total	8	0.00993771		0.0241

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	1.3425847	0.013984	96.01	<.0001
Redox	0.1798833	0.062769	2.87	0.0241

Exhibit F.6: REDOX Effects on PCT Response by REDOX Group *(continued)*

Bivariate Fit of log[Na ppm] By Redox



Linear Fit

log[Na ppm] = 2.0504927 + 0.1560677 Redox

Summary of Fit

RSquare	0.628411
RSquare Adj	0.575327
Root Mean Square Error	0.01847
Mean of Response	2.078065
Observations (or Sum Wgts)	9

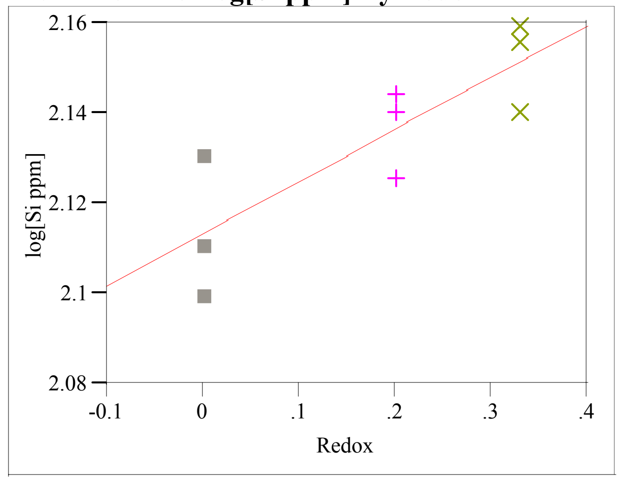
Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.00403841	0.004038	11.8380
Error	7	0.00238797	0.000341	Prob > F
C. Total	8	0.00642638		0.0108

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	2.0504927	0.010106	202.91	<.0001
Redox	0.1560677	0.04536	3.44	0.0108

Bivariate Fit of log[Si ppm] By Redox



Linear Fit

log[Si ppm] = 2.1131973 + 0.1158893 Redox

Summary of Fit

RSquare	0.711054
RSquare Adj	0.669776
Root Mean Square Error	0.01137
Mean of Response	2.133671
Observations (or Sum Wgts)	9

Analysis of Variance

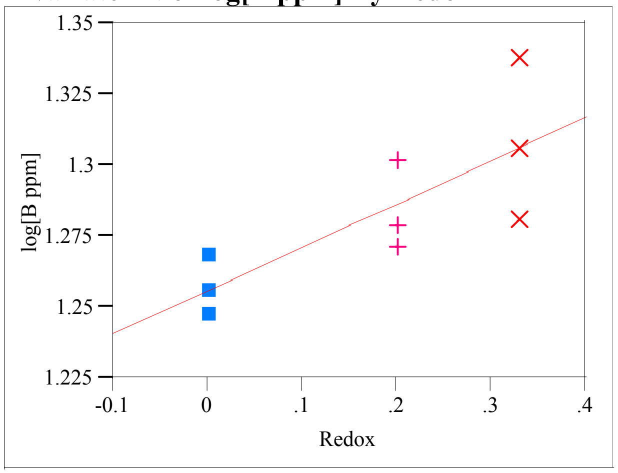
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.00222675	0.002227	17.2260
Error	7	0.00090487	0.000129	Prob > F
C. Total	8	0.00313162		0.0043

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	2.1131973	0.006221	339.71	<.0001
Redox	0.1158893	0.027922	4.15	0.0043

Exhibit F.6: REDOX Effects on PCT Response by REDOX Group *(continued)*

Redox Group=4 (SB2/3-10, -11, -12)
Bivariate Fit of log[B ppm] By Redox



Linear Fit
log[B ppm] = 1.2557879 + 0.1524596 Redox

Summary of Fit

RSquare	0.620029
RSquare Adj	0.565748
Root Mean Square Error	0.018368
Mean of Response	1.282722
Observations (or Sum Wgts)	9

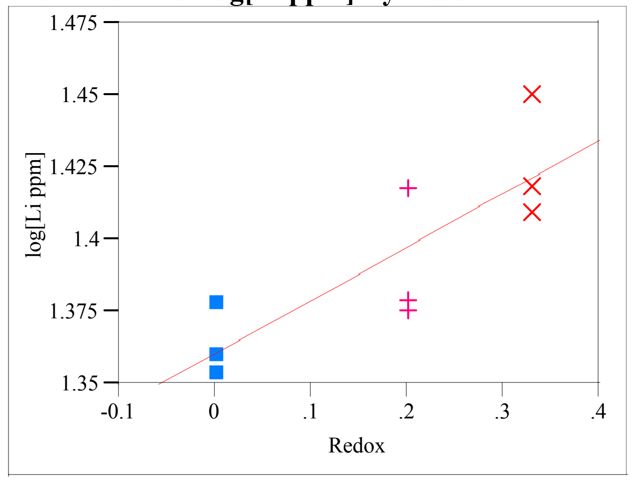
Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.00385385	0.003854	11.4225
Error	7	0.00236174	0.000337	Prob > F
C. Total	8	0.00621559		0.0118

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	1.2557879	0.01005	124.96	<.0001
Redox	0.1524596	0.04511	3.38	0.0118

Bivariate Fit of log[Li ppm] By Redox



Linear Fit
log[Li ppm] = 1.3605823 + 0.1839342 Redox

Summary of Fit

RSquare	0.684387
RSquare Adj	0.6393
Root Mean Square Error	0.019223
Mean of Response	1.393077
Observations (or Sum Wgts)	9

Analysis of Variance

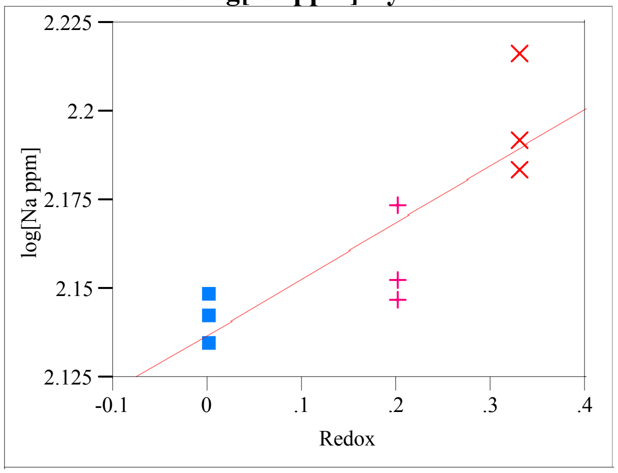
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.00560931	0.005609	15.1791
Error	7	0.00258680	0.000370	Prob > F
C. Total	8	0.00819610		0.0059

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	1.3605823	0.010518	129.36	<.0001
Redox	0.1839342	0.047211	3.90	0.0059

Exhibit F.6: REDOX Effects on PCT Response by REDOX Group *(continued)*

Bivariate Fit of log[Na ppm] By Redox



Linear Fit

log[Na ppm] = 2.1369486 + 0.1603838 Redox

Summary of Fit

RSquare	0.720007
RSquare Adj	0.680008
Root Mean Square Error	0.015392
Mean of Response	2.165283
Observations (or Sum Wgts)	9

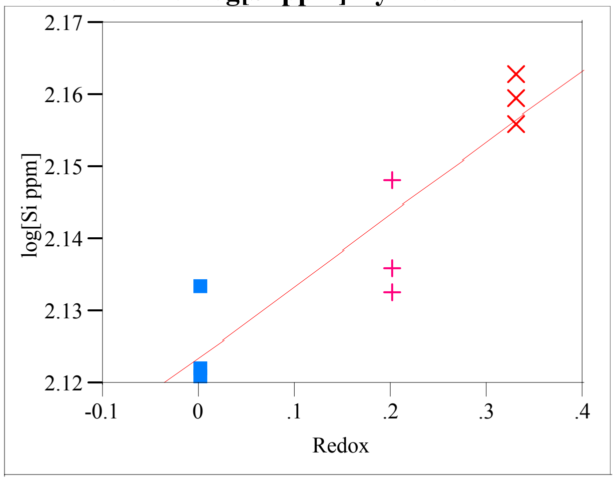
Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.00426487	0.004265	18.0006
Error	7	0.00165850	0.000237	Prob > F
C. Total	8	0.00592337		0.0038

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	2.1369486	0.008422	253.74	<.0001
Redox	0.1603838	0.037802	4.24	0.0038

Bivariate Fit of log[Si ppm] By Redox



Linear Fit

log[Si ppm] = 2.1234794 + 0.1000014 Redox

Summary of Fit

RSquare	0.82737
RSquare Adj	0.802708
Root Mean Square Error	0.00703
Mean of Response	2.141146
Observations (or Sum Wgts)	9

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.00165805	0.001658	33.5490
Error	7	0.00034595	0.000049	Prob > F
C. Total	8	0.00200400		0.0007

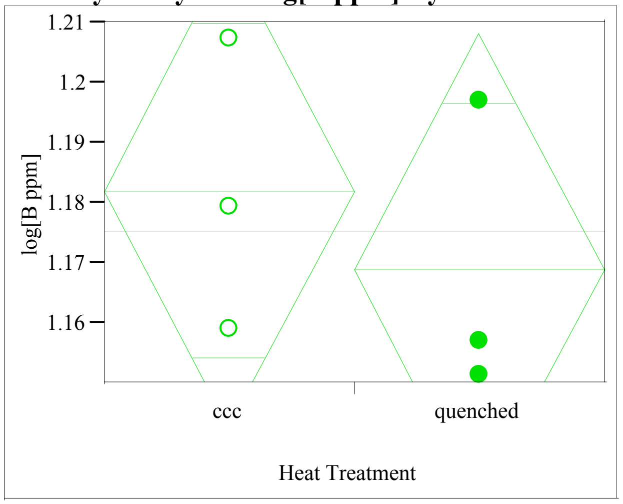
Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	2.1234794	0.003846	552.07	<.0001
Redox	0.1000014	0.017265	5.79	0.0007

Exhibit F.7: Effects of Heat Treatment on PCT Response by Glass Number

Glass #=1 (SB2/3-01 and SB2/3-01ccc)

Oneway Analysis of log[B ppm] By Heat Treatment



Oneway Anova

Summary of Fit

Rsquare	0.098297
Adj Rsquare	-0.12713
Root Mean Square Error	0.024606
Mean of Response	1.175314
Observations (or Sum Wgts)	6

Analysis of Variance

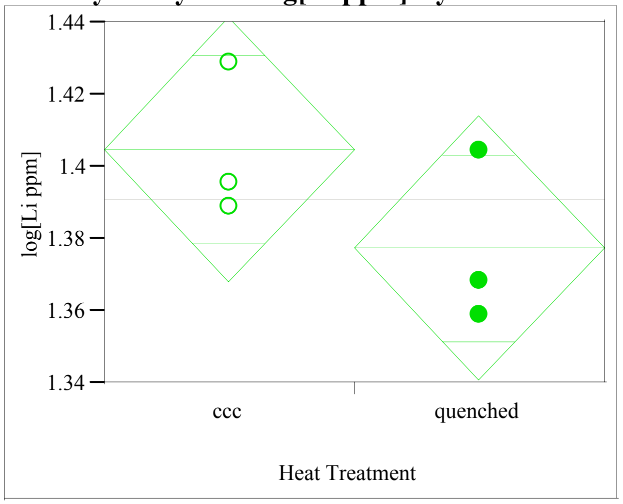
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Heat Treatment	1	0.00026400	0.000264	0.4360	0.5451
Error	4	0.00242173	0.000605		
C. Total	5	0.00268573			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
ccc	3	1.18195	0.01421	1.1425	1.2214
quenched	3	1.16868	0.01421	1.1292	1.2081

Std Error uses a pooled estimate of error variance

Oneway Analysis of log[Li ppm] By Heat Treatment



Oneway Anova

Summary of Fit

Rsquare	0.35069
Adj Rsquare	0.188363
Root Mean Square Error	0.022882
Mean of Response	1.391042
Observations (or Sum Wgts)	6

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Heat Treatment	1	0.00113112	0.001131	2.1604	0.2156
Error	4	0.00209429	0.000524		
C. Total	5	0.00322540			

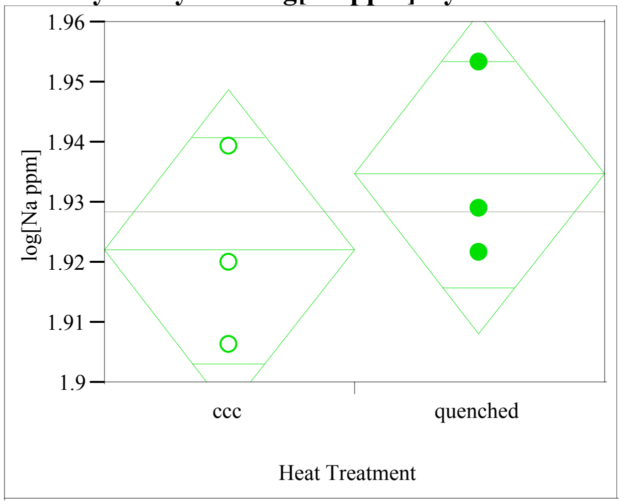
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
ccc	3	1.40477	0.01321	1.3681	1.4415
quenched	3	1.37731	0.01321	1.3406	1.4140

Std Error uses a pooled estimate of error variance

Exhibit F.7: Effects of Heat Treatment on PCT Response by Glass Number *(continued)*

Oneway Analysis of log[Na ppm] By Heat Treatment



Oneway Anova

Summary of Fit

Rsquare	0.179317
Adj Rsquare	-0.02585
Root Mean Square Error	0.016609
Mean of Response	1.928458
Observations (or Sum Wgts)	6

Analysis of Variance

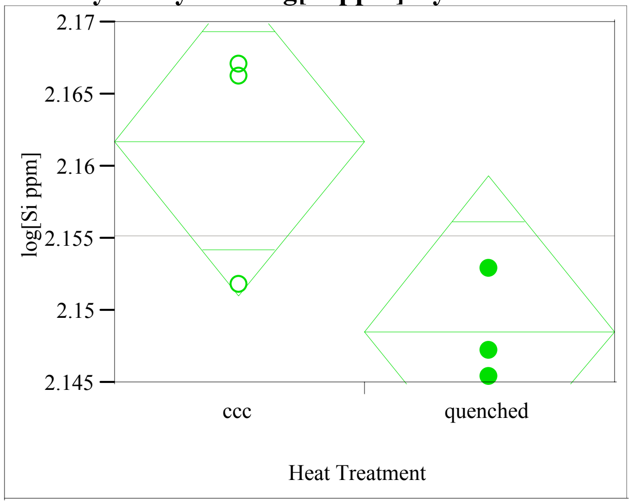
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Heat Treatment	1	0.00024110	0.000241	0.8740	0.4028
Error	4	0.00110343	0.000276		
C. Total	5	0.00134453			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
ccc	3	1.92212	0.00959	1.8955	1.9487
quenched	3	1.93480	0.00959	1.9082	1.9614

Std Error uses a pooled estimate of error variance

Oneway Analysis of log[Si ppm] By Heat Treatment



Oneway Anova

Summary of Fit

Rsquare	0.592971
Adj Rsquare	0.491214
Root Mean Square Error	0.006684
Mean of Response	2.155189
Observations (or Sum Wgts)	6

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Heat Treatment	1	0.00026030	0.000260	5.8273	0.0732
Error	4	0.00017868	0.000045		
C. Total	5	0.00043898			

Means for Oneway Anova

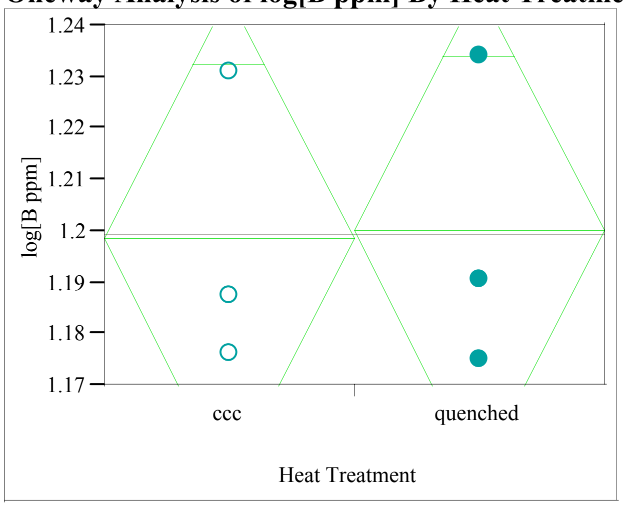
Level	Number	Mean	Std Error	Lower 95%	Upper 95%
ccc	3	2.16178	0.00386	2.1511	2.1725
quenched	3	2.14860	0.00386	2.1379	2.1593

Std Error uses a pooled estimate of error variance

Exhibit F.7: Effects of Heat Treatment on PCT Response by Glass Number *(continued)*

Glass #=4 (SB2/3-04 and SB2/3-04ccc)

Oneway Analysis of log[B ppm] By Heat Treatment



Oneway Anova

Summary of Fit

Rsquare	0.001135
Adj Rsquare	-0.24858
Root Mean Square Error	0.029788
Mean of Response	1.199376
Observations (or Sum Wgts)	6

Analysis of Variance

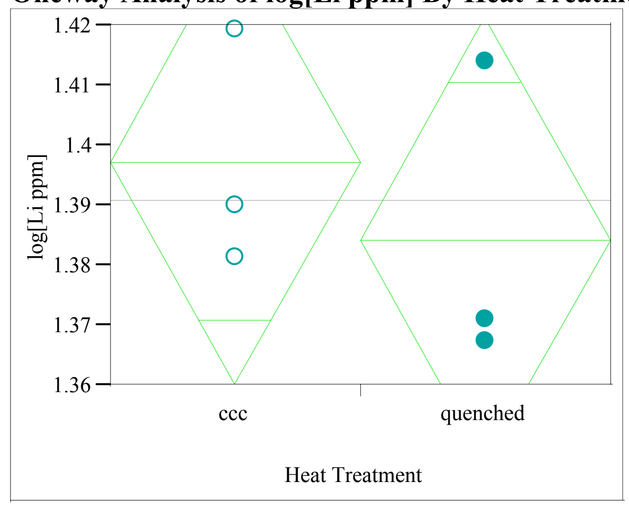
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Heat Treatment	1	0.00000403	0.000004	0.0045	0.9495
Error	4	0.00354929	0.000887		
C. Total	5	0.00355332			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
ccc	3	1.19856	0.01720	1.1508	1.2463
quenched	3	1.20020	0.01720	1.1524	1.2479

Std Error uses a pooled estimate of error variance

Oneway Analysis of log[Li ppm] By Heat Treatment



Oneway Anova

Summary of Fit

Rsquare	0.104746
Adj Rsquare	-0.11907
Root Mean Square Error	0.023215
Mean of Response	1.390713
Observations (or Sum Wgts)	6

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Heat Treatment	1	0.00025223	0.000252	0.4680	0.5315
Error	4	0.00215577	0.000539		
C. Total	5	0.00240800			

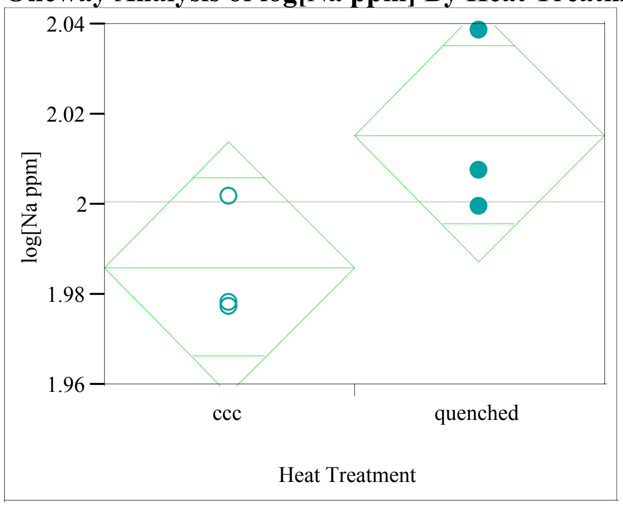
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
ccc	3	1.39720	0.01340	1.3600	1.4344
quenched	3	1.38423	0.01340	1.3470	1.4214

Std Error uses a pooled estimate of error variance

Exhibit F.7: Effects of Heat Treatment on PCT Response by Glass Number *(continued)*

Oneway Analysis of log[Na ppm] By Heat Treatment



Oneway Anova
Summary of Fit

Rsquare	0.513935
Adj Rsquare	0.392419
Root Mean Square Error	0.0175
Mean of Response	2.000756
Observations (or Sum Wgts)	6

Analysis of Variance

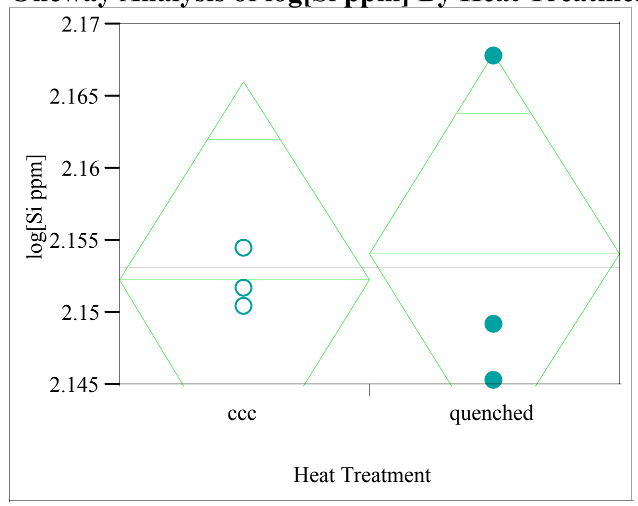
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Heat Treatment	1	0.00129525	0.001295	4.2294	0.1089
Error	4	0.00122501	0.000306		
C. Total	5	0.00252025			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
ccc	3	1.98606	0.01010	1.9580	2.0141
quenched	3	2.01545	0.01010	1.9874	2.0435

Std Error uses a pooled estimate of error variance

Oneway Analysis of log[Si ppm] By Heat Treatment



Oneway Anova
Summary of Fit

Rsquare	0.018261
Adj Rsquare	-0.22717
Root Mean Square Error	0.008597
Mean of Response	2.15318
Observations (or Sum Wgts)	6

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Heat Treatment	1	0.00000550	0.000005	0.0744	0.7985
Error	4	0.00029561	0.000074		
C. Total	5	0.00030111			

Means for Oneway Anova

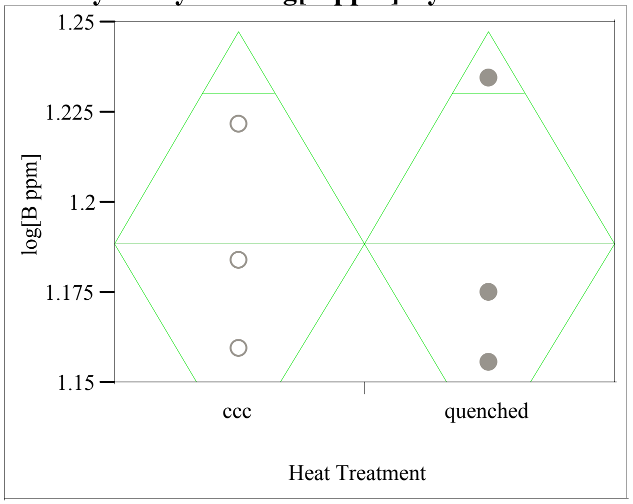
Level	Number	Mean	Std Error	Lower 95%	Upper 95%
ccc	3	2.15222	0.00496	2.1384	2.1660
quenched	3	2.15414	0.00496	2.1404	2.1679

Std Error uses a pooled estimate of error variance

Exhibit F.7: Effects of Heat Treatment on PCT Response by Glass Number *(continued)*

Glass #=7 (SB2/3-07 and SB2/3-07ccc)

Oneway Analysis of log[B ppm] By Heat Treatment



Oneway Anova
Summary of Fit

Rsquare	5.469e-9
Adj Rsquare	-0.25
Root Mean Square Error	0.036667
Mean of Response	1.188637
Observations (or Sum Wgts)	6

Analysis of Variance

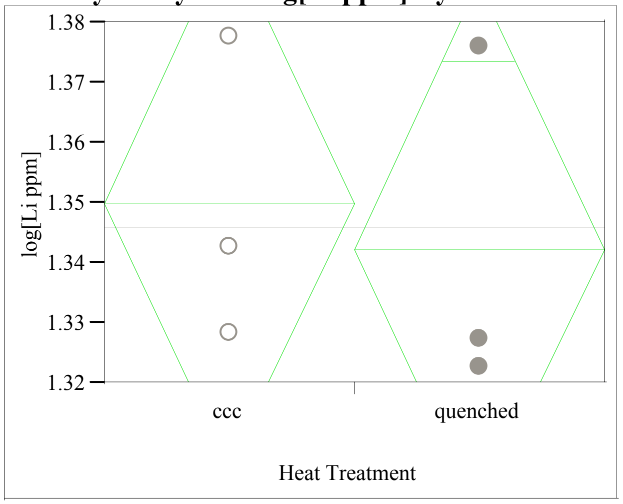
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Heat Treatment	1	0.00000000	0.000000	0.0000	0.9999
Error	4	0.00537781	0.001344		
C. Total	5	0.00537781			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
ccc	3	1.18864	0.02117	1.1299	1.2474
quenched	3	1.18864	0.02117	1.1299	1.2474

Std Error uses a pooled estimate of error variance

Oneway Analysis of log[Li ppm] By Heat Treatment



Oneway Anova
Summary of Fit

Rsquare	0.027552
Adj Rsquare	-0.21556
Root Mean Square Error	0.027471
Mean of Response	1.345978
Observations (or Sum Wgts)	6

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Heat Treatment	1	0.00008553	0.000086	0.1133	0.7533
Error	4	0.00301867	0.000755		
C. Total	5	0.00310420			

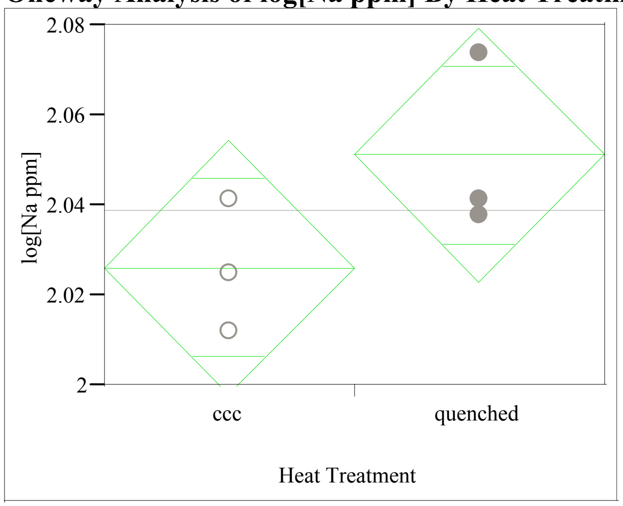
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
ccc	3	1.34975	0.01586	1.3057	1.3938
quenched	3	1.34220	0.01586	1.2982	1.3862

Std Error uses a pooled estimate of error variance

Exhibit F.7: Effects of Heat Treatment on PCT Response by Glass Number *(continued)*

Oneway Analysis of log[Na ppm] By Heat Treatment



Oneway Anova
Summary of Fit

Rsquare	0.433565
Adj Rsquare	0.291956
Root Mean Square Error	0.017542
Mean of Response	2.038675
Observations (or Sum Wgts)	6

Analysis of Variance

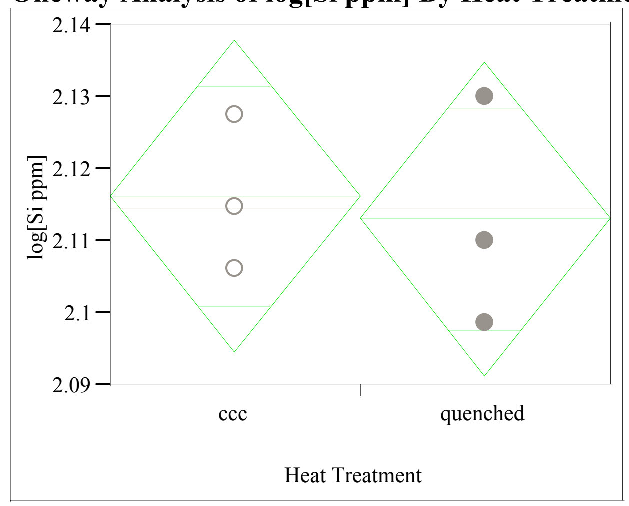
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Heat Treatment	1	0.00094221	0.000942	3.0617	0.1551
Error	4	0.00123096	0.000308		
C. Total	5	0.00217316			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
ccc	3	2.02614	0.01013	1.9980	2.0543
quenched	3	2.05121	0.01013	2.0231	2.0793

Std Error uses a pooled estimate of error variance

Oneway Analysis of log[Si ppm] By Heat Treatment



Oneway Anova
Summary of Fit

Rsquare	0.02008
Adj Rsquare	-0.2249
Root Mean Square Error	0.013553
Mean of Response	2.114654
Observations (or Sum Wgts)	6

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Heat Treatment	1	0.00001506	0.000015	0.0820	0.7889
Error	4	0.00073478	0.000184		
C. Total	5	0.00074984			

Means for Oneway Anova

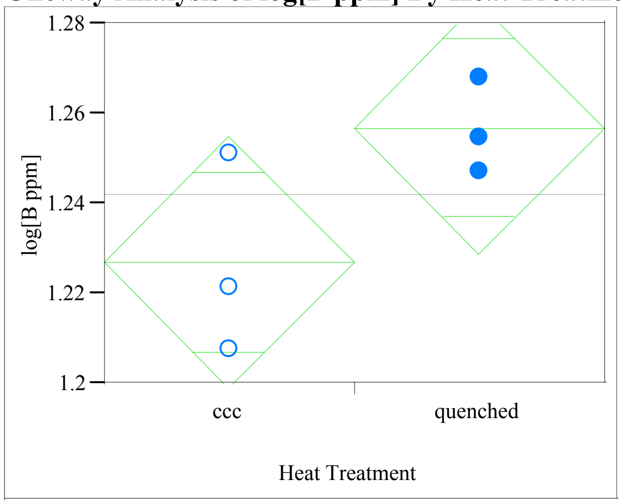
Level	Number	Mean	Std Error	Lower 95%	Upper 95%
ccc	3	2.11624	0.00783	2.0945	2.1380
quenched	3	2.11307	0.00783	2.0913	2.1348

Std Error uses a pooled estimate of error variance

Exhibit F.7: Effects of Heat Treatment on PCT Response by Glass Number *(continued)*

Glass #=10 (SB2/3-10 and SB2/3-10ccc)

Oneway Analysis of log[B ppm] By Heat Treatment



Oneway Anova

Summary of Fit

Rsquare	0.522826
Adj Rsquare	0.403533
Root Mean Square Error	0.01746
Mean of Response	1.241823
Observations (or Sum Wgts)	6

Analysis of Variance

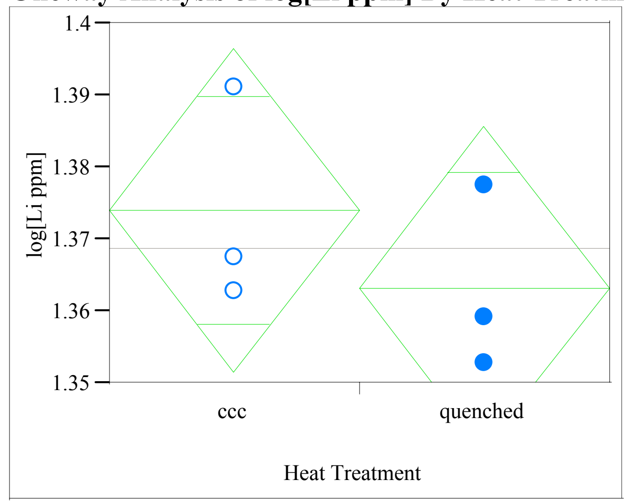
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Heat Treatment	1	0.00133601	0.001336	4.3827	0.1044
Error	4	0.00121935	0.000305		
C. Total	5	0.00255535			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
ccc	3	1.22690	0.01008	1.1989	1.2549
quenched	3	1.25675	0.01008	1.2288	1.2847

Std Error uses a pooled estimate of error variance

Oneway Analysis of log[Li ppm] By Heat Treatment



Oneway Anova

Summary of Fit

Rsquare	0.179428
Adj Rsquare	-0.02572
Root Mean Square Error	0.014029
Mean of Response	1.368634
Observations (or Sum Wgts)	6

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Heat Treatment	1	0.00017214	0.000172	0.8746	0.4026
Error	4	0.00078725	0.000197		
C. Total	5	0.00095940			

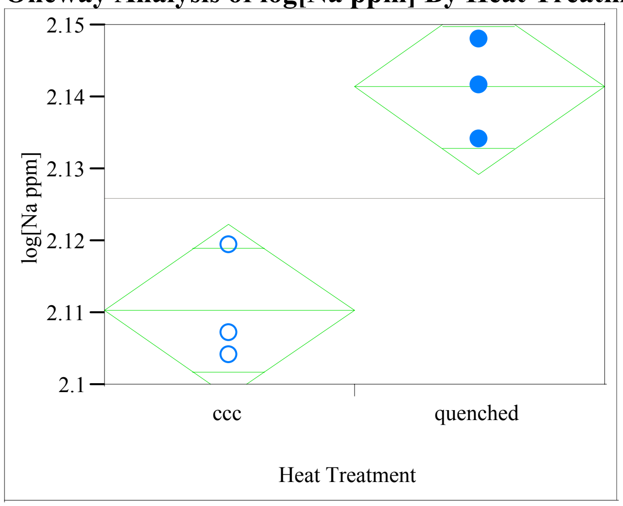
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
ccc	3	1.37399	0.00810	1.3515	1.3965
quenched	3	1.36328	0.00810	1.3408	1.3858

Std Error uses a pooled estimate of error variance

Exhibit F.7: Effects of Heat Treatment on PCT Response by Glass Number *(continued)*

Oneway Analysis of log[Na ppm] By Heat Treatment



Oneway Anova
Summary of Fit

Rsquare	0.863549
Adj Rsquare	0.829437
Root Mean Square Error	0.007546
Mean of Response	2.125902
Observations (or Sum Wgts)	6

Analysis of Variance

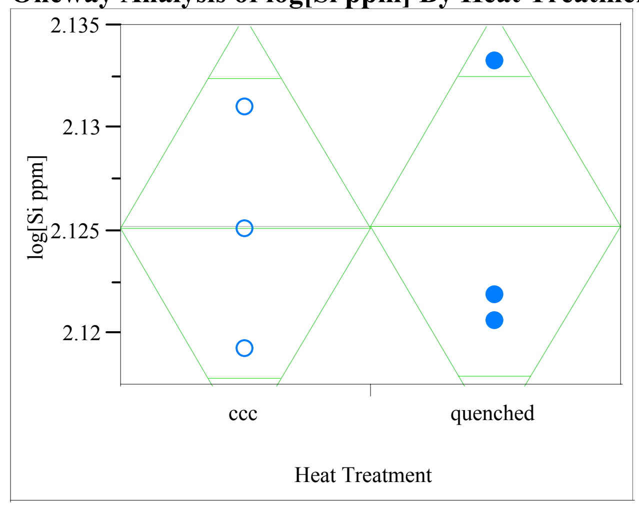
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Heat Treatment	1	0.00144141	0.001441	25.3146	0.0073
Error	4	0.00022776	0.000057		
C. Total	5	0.00166917			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
ccc	3	2.11040	0.00436	2.0983	2.1225
quenched	3	2.14140	0.00436	2.1293	2.1535

Std Error uses a pooled estimate of error variance

Oneway Analysis of log[Si ppm] By Heat Treatment



Oneway Anova
Summary of Fit

Rsquare	0.00008
Adj Rsquare	-0.2499
Root Mean Square Error	0.006433
Mean of Response	2.125223
Observations (or Sum Wgts)	6

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Heat Treatment	1	0.00000001	0.000000	0.0003	0.9866
Error	4	0.00016555	0.000041		
C. Total	5	0.00016557			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
ccc	3	2.12518	0.00371	2.1149	2.1355
quenched	3	2.12527	0.00371	2.1150	2.1356

Std Error uses a pooled estimate of error variance

Exhibit F.8: Correlations and Scatter Plots of Normalized PCTs by Compositional View

Comp View=measured

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	0.9409	0.9738	0.9653
log NL[Li(g/L)]	0.9409	1.0000	0.9377	0.9809
log NL[Na (g/L)]	0.9738	0.9377	1.0000	0.9701
log NL[Si (g/L)]	0.9653	0.9809	0.9701	1.0000

Scatterplot Matrix

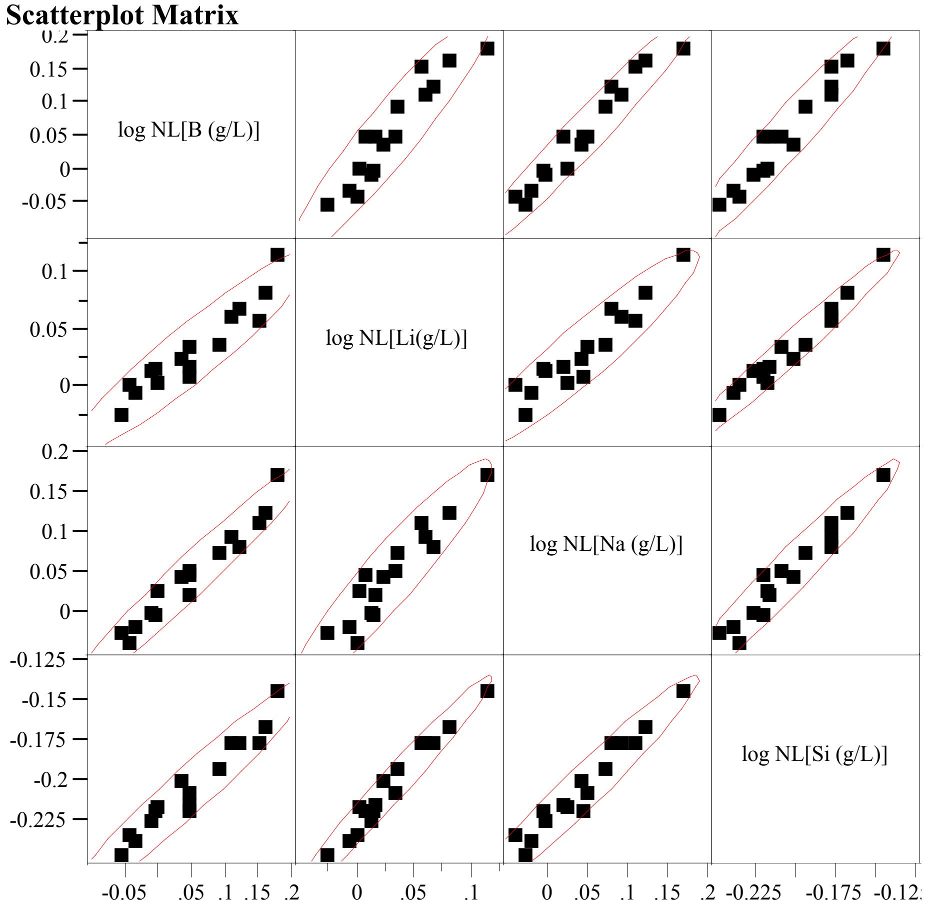


Exhibit F.8: Correlations and Scatter Plots of Normalized PCTs by Compositional View *(continued)*

Comp View=measured bc

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	0.9443	0.9769	0.9660
log NL[Li(g/L)]	0.9443	1.0000	0.9429	0.9821
log NL[Na (g/L)]	0.9769	0.9429	1.0000	0.9724
log NL[Si (g/L)]	0.9660	0.9821	0.9724	1.0000

Scatterplot Matrix

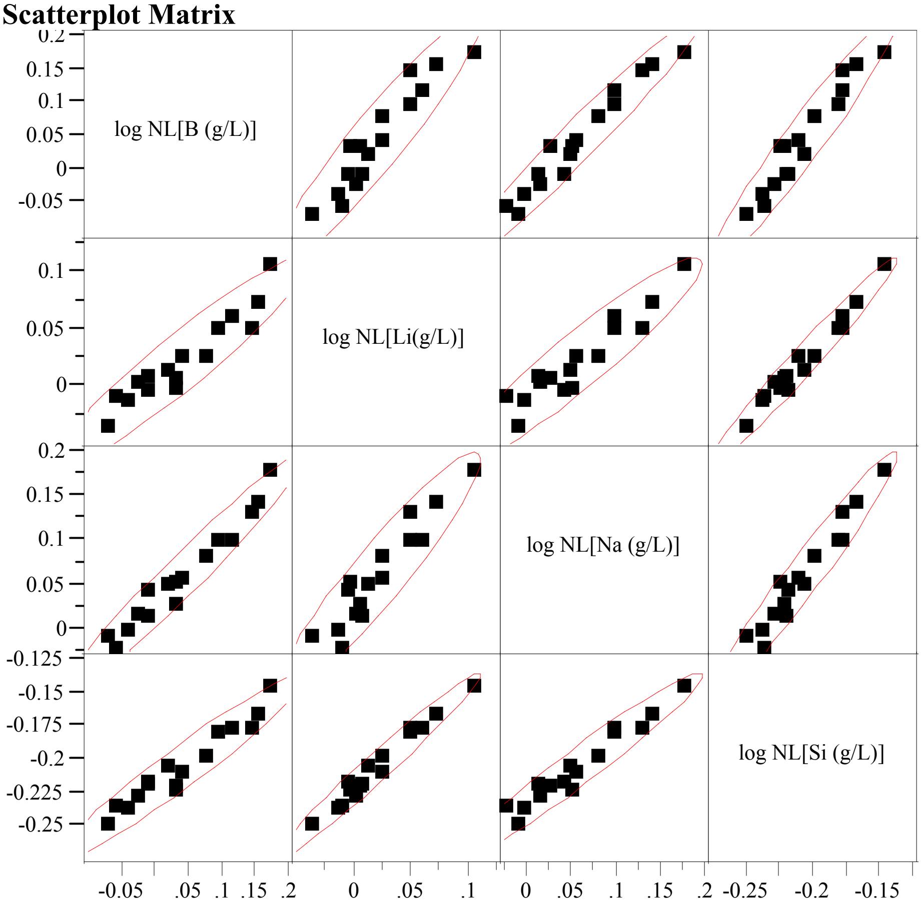


Exhibit F.8: Correlations and Scatter Plots of Normalized PCTs by Compositional View *(continued)*

Comp View=targeted

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	0.9568	0.9813	0.9821
log NL[Li(g/L)]	0.9568	1.0000	0.9403	0.9855
log NL[Na (g/L)]	0.9813	0.9403	1.0000	0.9670
log NL[Si (g/L)]	0.9821	0.9855	0.9670	1.0000

Scatterplot Matrix

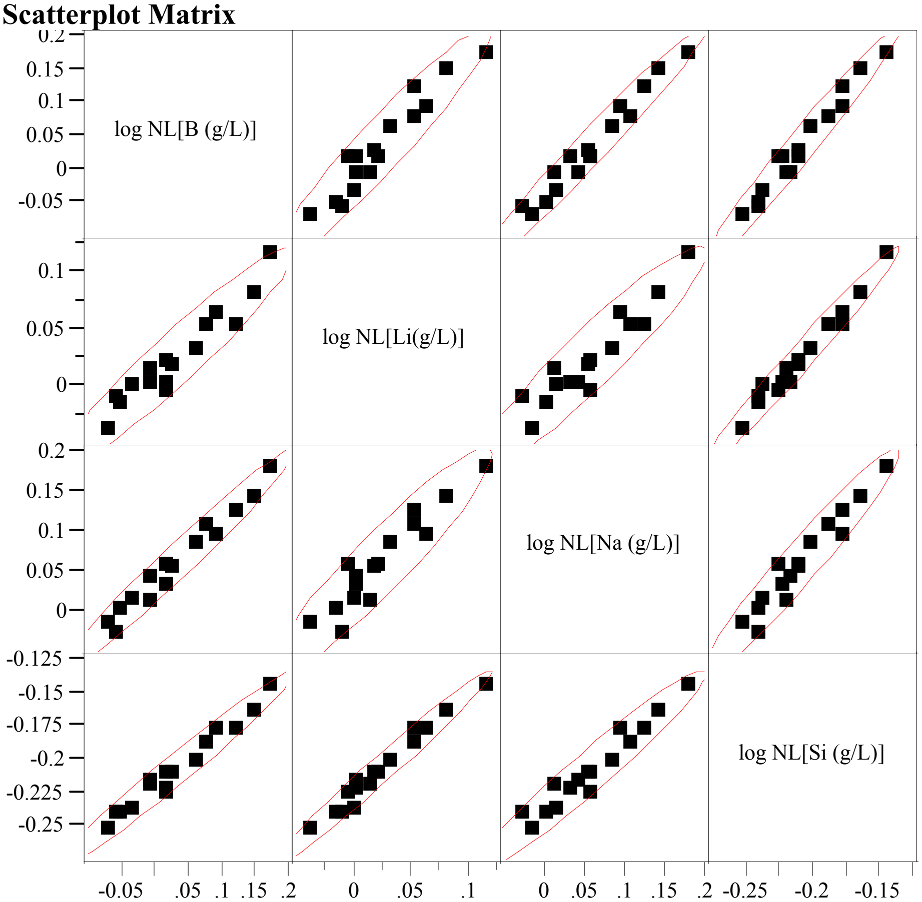


Exhibit F.9: del Gp (ΔG_p) Predictions versus Common Logarithm Normalized Leachate (log NL[.]) for B, Li, Na, and Si by Compositional View

All Data

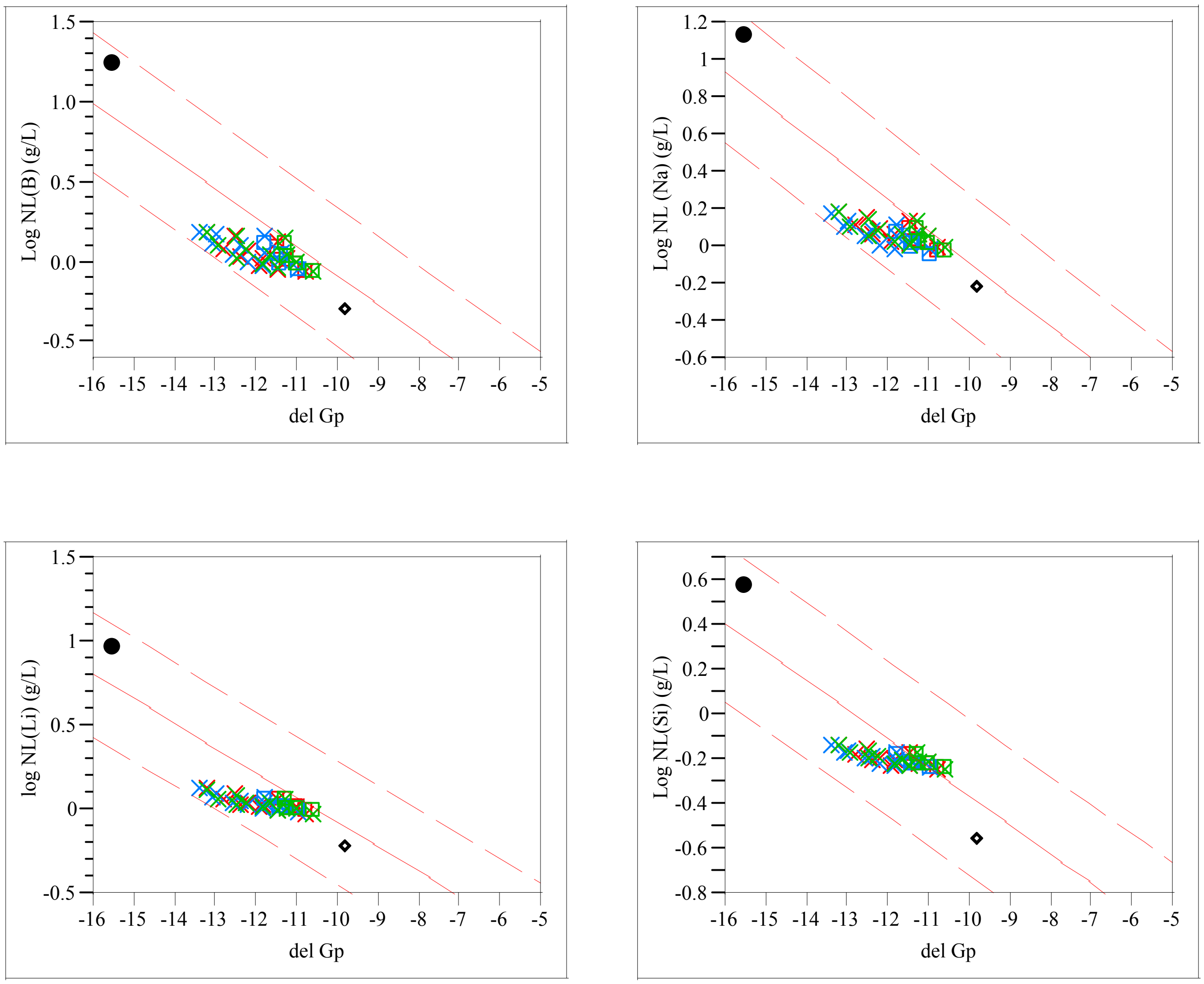


Exhibit F.9: del Gp (ΔG_p) Predictions versus Common Logarithm Normalized Leachate (log NL[.]) for B, Li, Na, and Si by Compositional View (continued)

Targeted Data

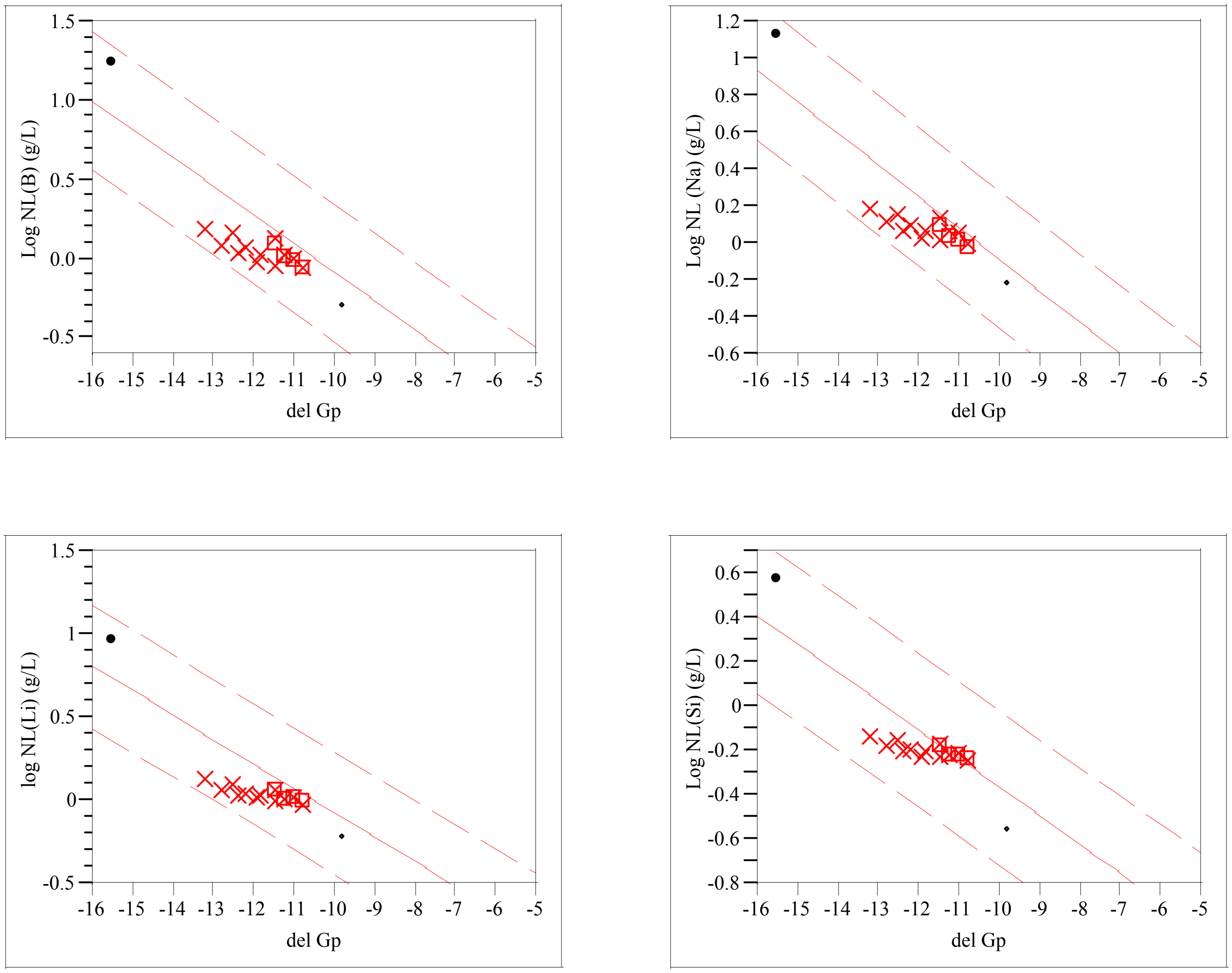


Exhibit F.9: del Gp (ΔG_p) Predictions versus Common Logarithm Normalized Leachate (log NL[.]) for B, Li, Na, and Si by Compositional View (continued)

Measured Data

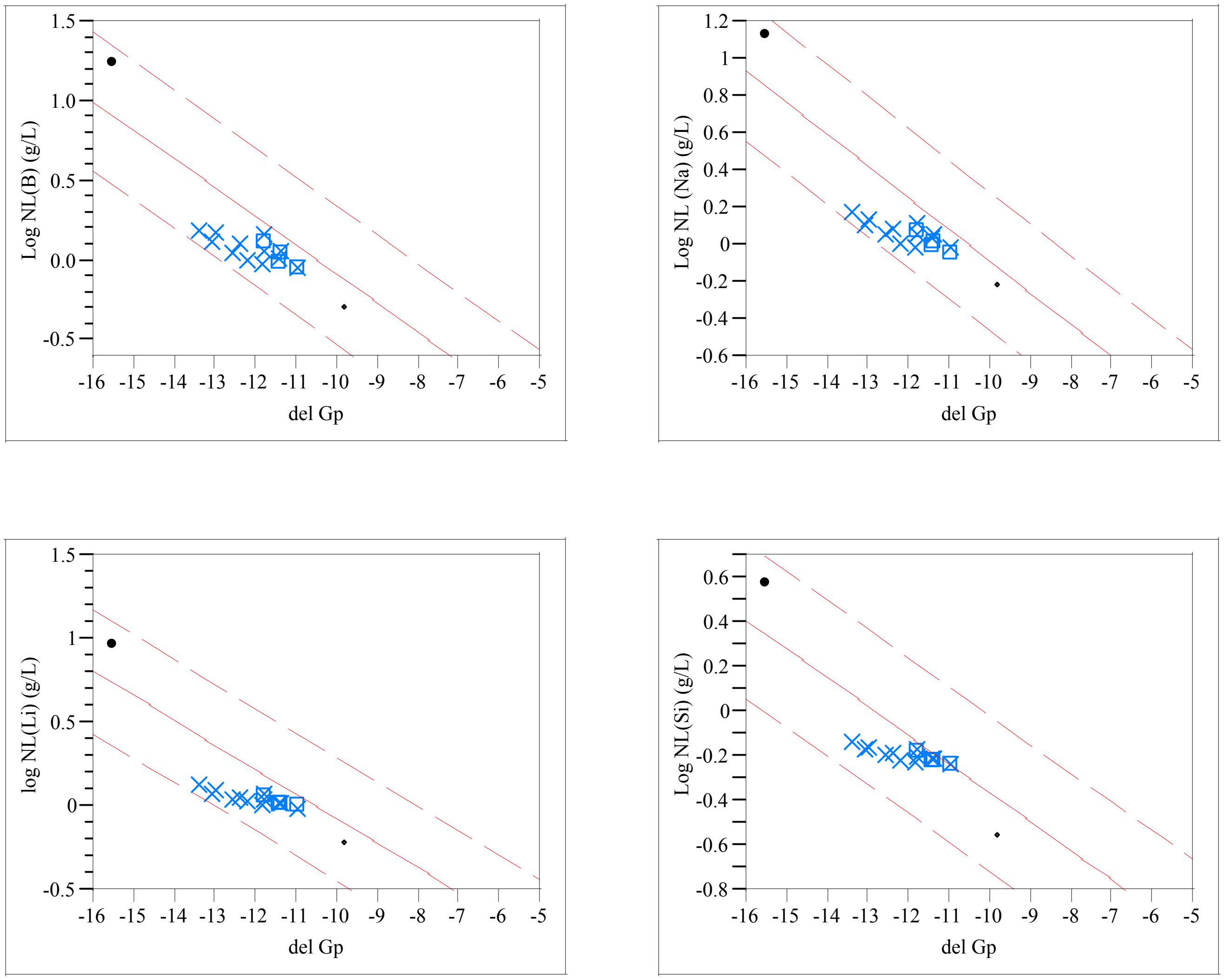


Exhibit F.9: del Gp (ΔG_p) Predictions versus Common Logarithm Normalized Leachate (log NL[.]) for B, Li, Na, and Si by Compositional View (continued)

Measured Bias-Corrected Data

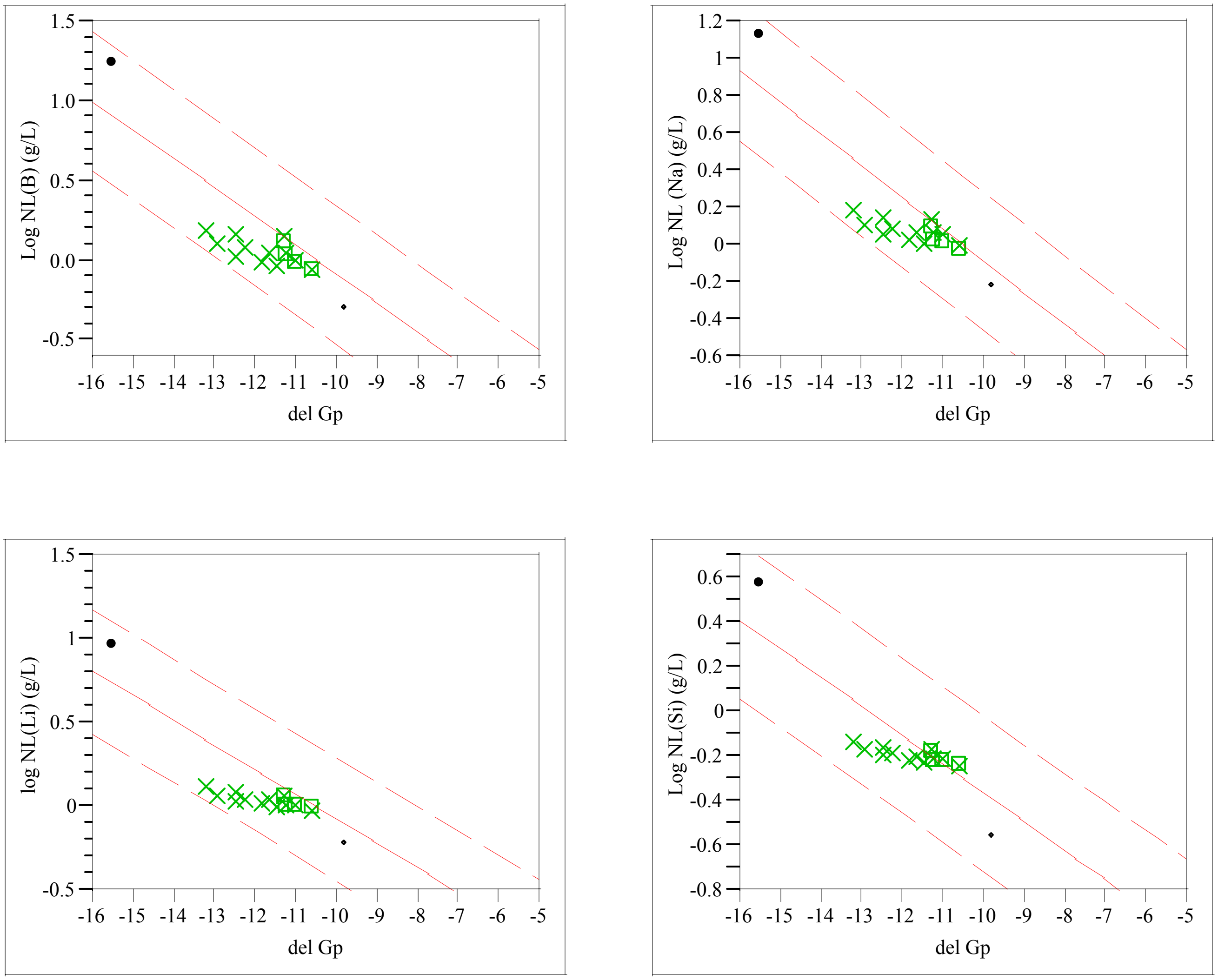
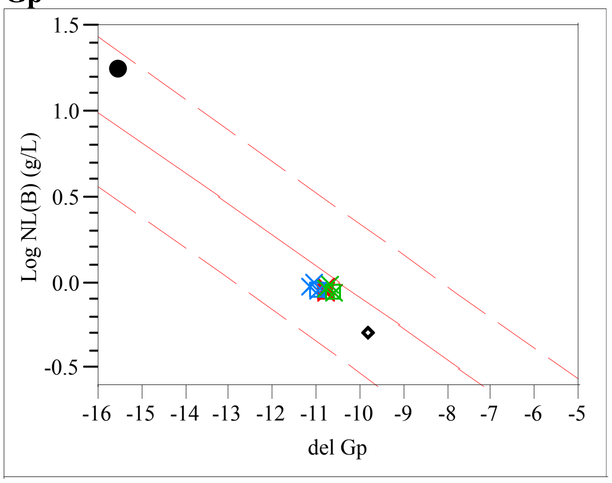


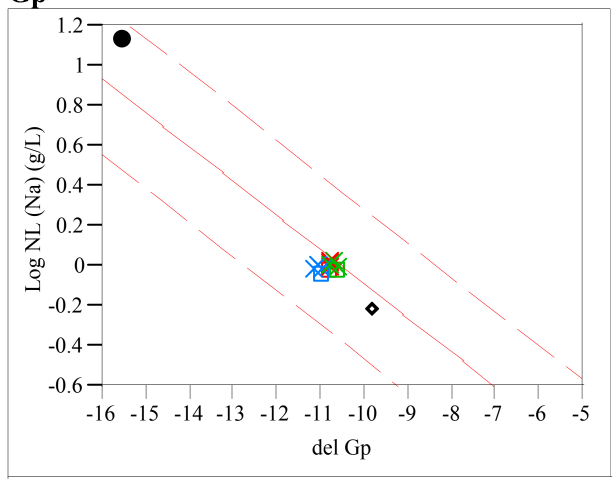
Exhibit F.10: del Gp (ΔG_p) Predictions versus Common Logarithm Normalized Leachate (log NL[.]) for B, Li, Na, and Si by REDOX Group Assuming Fully Oxidized Glasses

REDOX Group 1

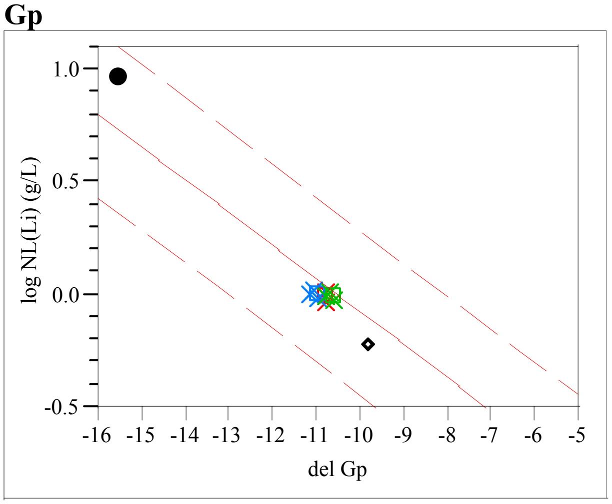
Bivariate Fit of Log NL(B) (g/L) By del Gp



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

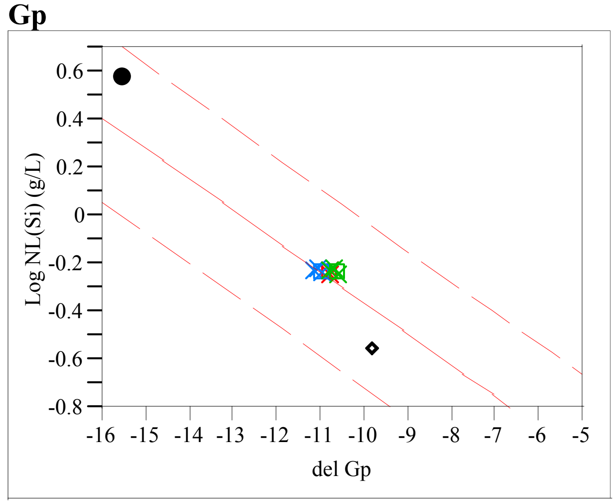
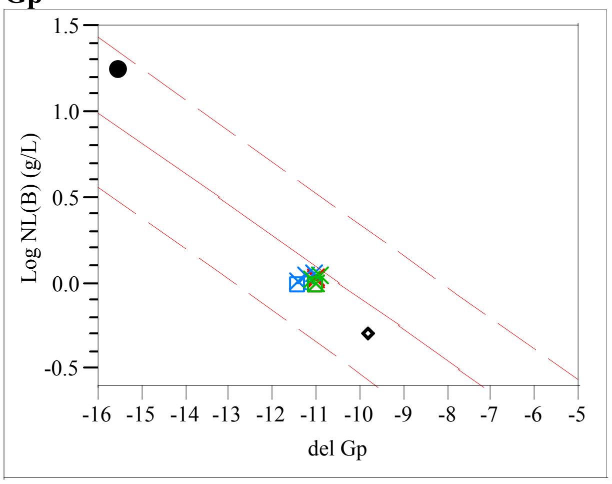


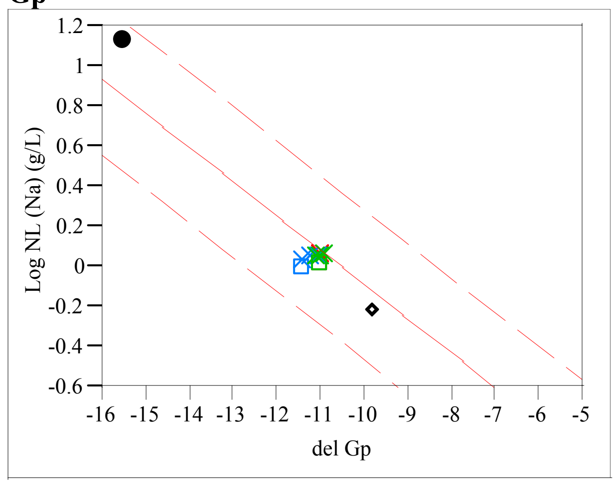
Exhibit F.10: del Gp (ΔG_p) Predictions versus Common Logarithm Normalized Leachate (log NL[.]) for B, Li, Na, and Si by REDOX Group Assuming Fully Oxidized Glasses *(continued)*

REDOX Group 2

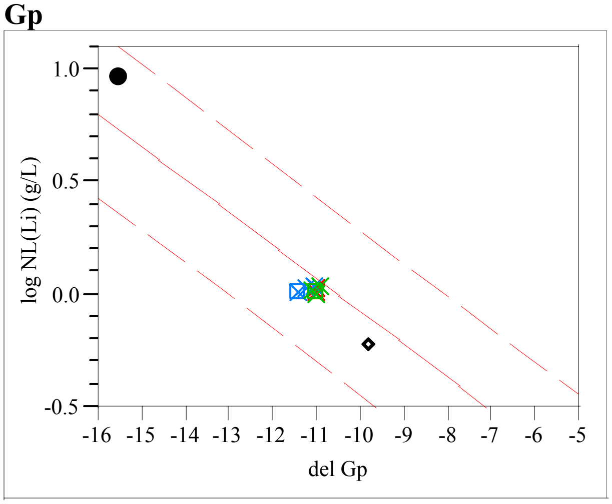
Bivariate Fit of Log NL(B) (g/L) By del Gp



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

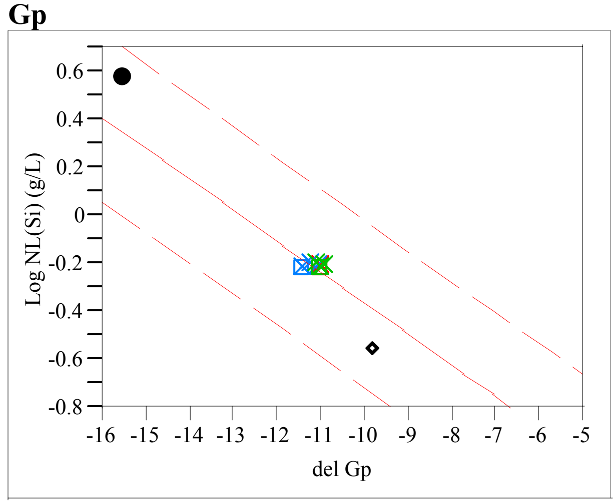
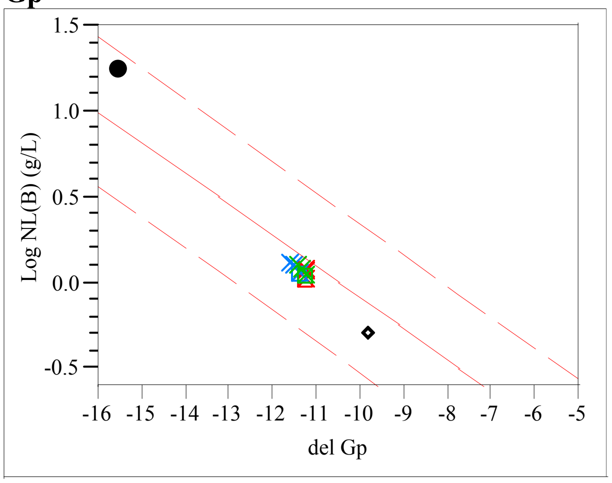


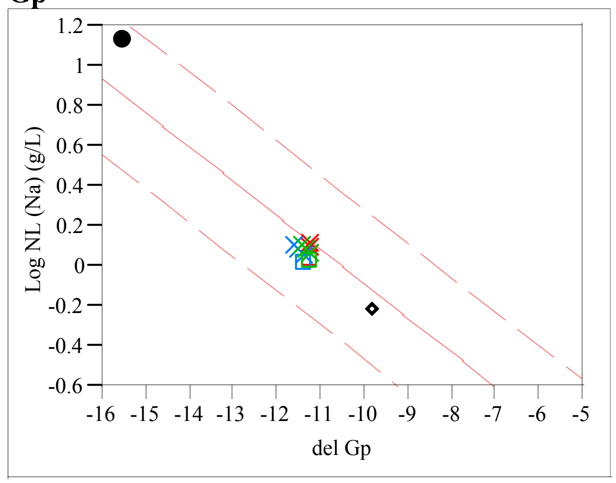
Exhibit F.10: del Gp (ΔG_p) Predictions versus Common Logarithm Normalized Leachate (log NL[.]) for B, Li, Na, and Si by REDOX Group Assuming Fully Oxidized Glasses *(continued)*

REDOX Group 3

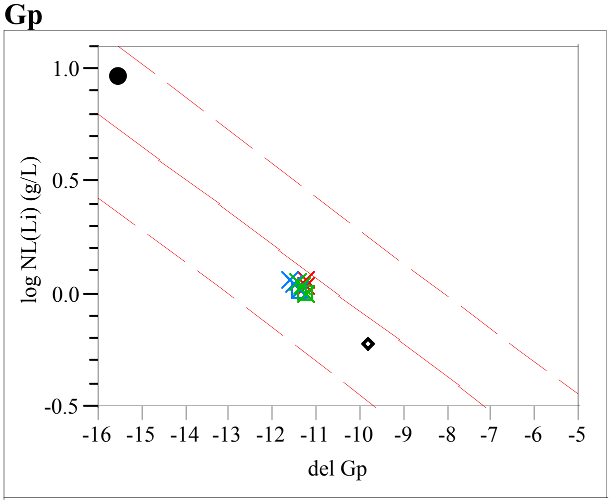
Bivariate Fit of Log NL(B) (g/L) By del Gp



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

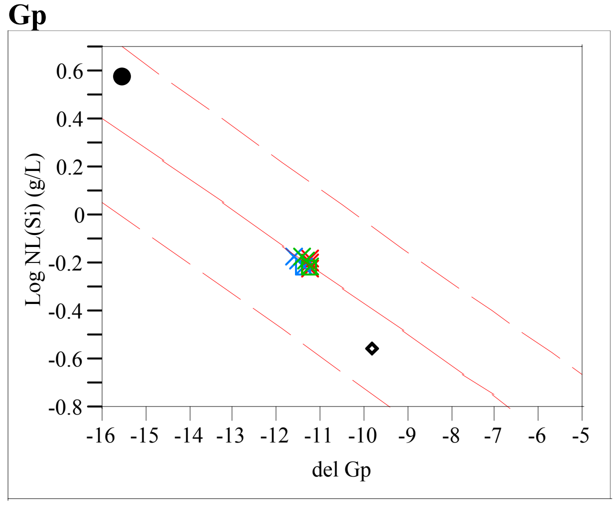
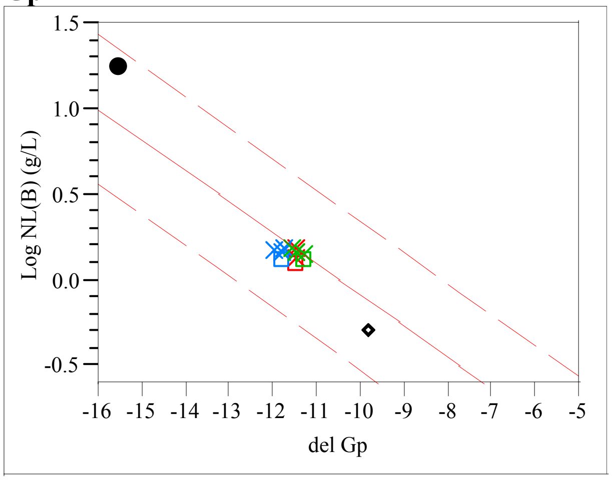


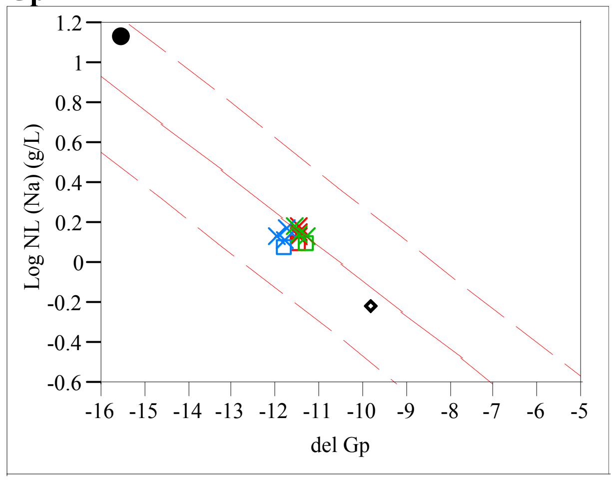
Exhibit F.10: del Gp (ΔG_p) Predictions versus Common Logarithm Normalized Leachate (log NL[.]) for B, Li, Na, and Si by REDOX Group Assuming Fully Oxidized Glasses *(continued)*

REDOX Group 4

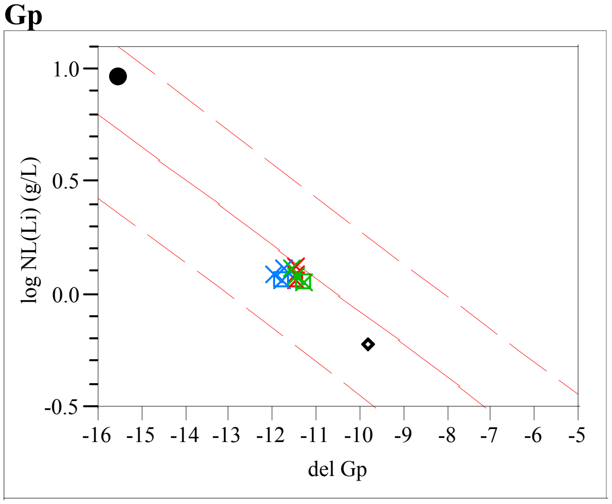
Bivariate Fit of Log NL(B) (g/L) By del Gp



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