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REDUCTION OF CONSTRAINTS:

Phase 1 Experimental Assessment of Centroid-Based Sludge-Only Glasses (U)

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Executive Summary

The Defense Waste Processing Facility (DWPF) uses the homogeneity constraint to discriminate compositions that are likely to result in phase-separated glasses from compositions that are likely to be homogeneous. The technical basis for developing and implementing the phase-separation discriminator into the Product Composition Control System (PCCS) was the fact that the durability of phase-separated glasses can be unpredictable.

The objective of this experimental study was to challenge the homogeneity constraint for sludge-only processing by monitoring the durability responses for both quenched and centerline canister cooled (ccc) glasses within this composition region. If sufficient evidence can establish the fact that although glasses may be unpredictable, they are acceptable based on a predefined acceptance criterion over the composition region of interest, then replacing the homogeneity constraint with the Al_2O_3 and/or sum-of-alkali criterion can be technically defended. More specifically, to replace the homogeneity constraint, glasses within the composition region of interest should be predictable and/or acceptable regardless of the homogeneity classification. In this report, working definitions of predictable and acceptable have been established and utilized.

In this study, all 68 Reduction of Constraints (RC) glasses (when considering both quenched and ccc versions of the 34 target compositions) were predictable and/or acceptable regardless of homogeneity classification. These data support replacing the homogeneity constraint in favor of using the Al_2O_3 and sum-of-alkali constraints to assure that durable products are produced in DWPF. Even though the Phase 1 data support the replacement of the homogeneity constraint, it must be recognized that the 34 target compositions were based on centroid sludge compositions. These data, coupled with similar results from Phase 2, will provide the basis for eliminating the constraint.

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Acronyms

ADS	Analytical Development Section
AES	atomic emission spectroscopy
ANOVA	analysis of variance
ARM	Approved Reference Material
ASTM	American Society for Testing and Materials
ccc	centerline canister cooled
CVS	composition variation study
ΔG_p	preliminary glass dissolution estimator based on free energy of hydration (in kcal/mol)
DWPF	Defense Waste Processing Facility
EA	Environmental Assessment
EDS	energy dispersive spectroscopy
HHF	H modified high-heat feed
HLW	high-level waste
ICP	inductively coupled plasma
IDMS	Integrated DWPF Melter System
LM	lithium-metaborate
MAR	Measurement Acceptability Region
NL	normalized leachate
PAR	Property Acceptability Region
PLF	PUREX low-heat feed
PCCS	Product Composition Control System
PCT	Product Consistency Test
PHF	PUREX high heat feed

PLF	PUREX low heat feed
PMF	PUREX mixed feed
PNNL	Pacific Northwest National Laboratory
PUREX	plutonium uranium extraction
QA	quality assurance
RC	reduction of constraints
R&D	research and development
SB	sludge batch
SEM	scanning electron microscopy
SME	Slurry Mix Evaporator
SP	sodium peroxide
SRS	Savannah River Site
SRTC	Savannah River Technology Center
SRTC-ML	Savannah River Technology Center – Mobile Laboratory
T_L	liquidus temperature
THERMO™	Thermodynamic Hydration Energy Reaction Model
TTR	technical task request
U_{std}	uranium standard
$\eta_{1150°C}$	melt viscosity at 1150°C
WAPS	Waste Acceptance Product Specifications
WL	waste loading
WQR	Waste Qualification Report
WSRC	Westinghouse Savannah River Company
XRD	x-ray diffraction

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1.0 Introduction

Approximately 130-million liters of high-level radioactive waste 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 glass is poured into stainless steel canisters that will eventually be disposed of in a permanent, geological repository.

The Product Composition Control System (PCCS) is used to determine the acceptability of each batch of DWPF melter feed in the Slurry Mix Evaporator (SME). This system imposes several constraints on the composition of the contents of the SME to define acceptability. These constraints relate process or product properties to composition via prediction models. A batch is deemed acceptable if its composition measurements lead to acceptable property predictions after accounting for modeling, analytic, and measurement uncertainties. The baseline document guiding the use of these data and models is "SME Acceptability Determination for DWPF Process Control (U)" by Brown and Postles (1996).

A minimum of three (homogeneity, Al_2O_3, and frit loading) PCCS constraints support the prediction of the glass durability for a given SME batch. The Savannah River Technology Center (SRTC) is reviewing all of the pertinent constraints associated with durability. The purpose of this review is twofold: 1) to revisit these constraints taking into consideration the additional knowledge gained since the beginning of radioactive operations at DWPF and 2) to identify any supplemental studies needed to complement this knowledge so that redundant or overly conservative constraints can be relaxed and/or replaced by more appropriate constraints.

The PCCS homogeneity constraint that is used to discriminate compositions that are likely to result in phase-separated glasses from compositions that are likely to be homogeneous is being evaluated. In this context, phase separation refers to the development of amorphous or glass-in-glass phase separation, not to crystallization. The homogeneity constraint is a linear function of terms representing sludge and frit. This function was obtained from a discriminant analysis of 110 glasses (88 homogeneous and 22 phase-separated) in sludge versus frit-composition space (Brown and Edwards (1995), Jantzen et al. (1995), and Jantzen and Brown (2000)). The technical basis for implementing a phase-separation discriminator into PCCS was the fact that the durability of phase separated glasses can be unpredictable.

Because the decision regarding acceptability is a function of composition and is based on underlying models (e.g., liquidus temperature [T_L], durability, and viscosity) used by PCCS as well as single-component concentration constraints (e.g., Al_2O_3 and Cr_2O_3), waste loadings (WLs) are usually limited by one of the model predictions (taking into account associated uncertainties).[(a)] For example, application of the homogeneity constraint at the Measurement Acceptability Region (MAR) limit for sludge batch 1b (SB1b) eliminated much of the potential composition region from the DWPF window of operability (Edwards and Brown 1998). SRTC identified this issue during a variability study for SB1b. Edwards and Brown (1998) and Edwards (1999) reported the results from that study. The SB1b study, supplemented by an evaluation of an existing property-composition database, led to the formation of two new options for PCCS:

(a) Waste loadings are typically limited by one of the model predictions since their uncertainty (both measured and predicted) will likely be much larger than that of an individual component.

Criterion (1)

- use the alumina constraint as currently implemented in PCCS ($Al_2O_3 \geq 3$ wt%) **and** add a sum-of-alkali[(a)] constraint with an upper limit of 19.3 wt% ($\Sigma M_2O < 19.3$ wt%),

or

Criterion (2)

- adjust the lower limit on the alumina constraint to 4-wt% ($Al_2O_3 \geq 4.0$ wt%).

These options allowed DWPF to relax the homogeneity constraint from a measured acceptance criterion to a property-acceptance criterion for SB1b without changing the existing Al_2O_3 limit.

The Al_2O_3 and sum-of-alkali constraints were based on the fact that Al_2O_3 is known to suppress the formation of amorphous phase separation in borosilicate glasses (Volf 1974; Jantzen et al. 1995; Jantzen and Brown 2000; Hrma et al. 1994) and that sufficient quantities of Al_2O_3 have a positive impact on durability (usually independent of any homogeneity classification). It is also well known that relatively high quantities of alkali metal oxides typically reduce the durability of borosilicate glasses (Volf 1974; Jantzen et al. 1995). It should be noted that durable (as defined by the Product Consistency Test [PCT] [ASTM 1997]) simulated waste glasses have been produced with alkali concentrations exceeding 20 wt% (Kim et al. 1995; Muller et al. 2001; Feng et al. 1996; Vienna et al. 2001; Ebert and Wolf 2000; Hrma et al. 2001). Criterion (1) also constrains the glass composition in a durability region where the strong bases to weak acids are balanced in the leachate (Jantzen et al. 1995). Criterion (2) does not impose an upper alkali constraint, given that Al_2O_3 concentrations are ≥ 4.0 wt%. It is important to note that either criterion should only be applied over the compositional envelopes evaluated, and it may be necessary to impose an upper alkali constraint in certain glass-composition spaces.

Before recommending this potential change to DWPF, Edwards and Brown (1998) evaluated these potential criteria with the existent composition-property database (> 1300 data points)[(b)] to gain a better understanding of the relationship between the alumina and the sum of alkali and the leaching behavior. This evaluation tested the application of one of the two criteria over a larger compositional window and provided some measure of confidence for their application. The database (at that time) consisted of the data used for:

- Thermodynamic Hydration Energy Reaction Model (THERMO™) development and validation (Jantzen et al. 1995)
- the sludge-only processing glasses of the Tank 51 variability study (Peeler 1996a, Peeler 1996b)
- two pour-stream samples from Macrobatch 1 (Edwards 1997)
- the Pacific Northwest National Laboratory (PNNL) Composition Variation Study (CVS) glasses (Hrma et al. 1994)

(a) Alkalis included in this sum are Na_2O, Li_2O, Cs_2O, and K_2O. However, for sludge-only processing, neither Cs_2O nor K_2O is introduced at significant concentrations, so the sum of alkali is based solely on Na_2O and Li_2O.

(b) Over 3900 triplicate analyses (whose logarithms were averaged for each glass sample tested) formed the extensive database.

- the glasses from the Tank 42 variability study (Edwards and Brown 1998; Edwards 1999).

It should be noted that the majority of the property-composition data in the database were based on glasses that had been quenched from the melt temperature, although a significant number of the data were collected from canisters filled from melter runs, such as the Integrated DWPF Melter System (IDMS).

When applying either of the proposed criteria (in conjunction with relaxing the homogeneity constraint to the Property Acceptability Region [PAR]) to those glasses in the extensive database, all but six glasses would be classified as acceptable for processing (basis for acceptability being based on glasses having a conservative log NL [B] < 1.0). As noted by Edwards and Brown (1998), these six glasses were outside the feasible composition range for glasses expected to be produced during the processing of SB1b. More specifically, these glasses contained either low concentrations of Fe_2O_3 (< 2.5 wt%) or high concentrations of B_2O_3 (> 19.6 wt%). Insufficient tetrahedral Fe_2O_3 can lead to the inability to stabilize the glass network against phase separation as discussed by Jantzen and Brown (2000). High B_2O_3 concentrations can promote amorphous phase separation as discussed by Volf (1974), Tovena et al. (1994), and Jantzen et al. (1995). All other glasses that were evaluated by Edwards and Brown (1998) within the composition region of interest with Al_2O_3 exceeding 3 wt% and the ΣM_2O less than 19.3 wt% (Criterion 1) provided PCT results for boron significantly better than those for the Environmental Assessment (EA) standard glass (Jantzen et al. 1993). The data also indicated that if the lower limit for Al_2O_3 were increased to 4.0 wt% (Criterion 2), there was not a need to add an upper sum-of-alkali constraint (over the composition range evaluated) to avoid glasses that may leach comparable to EA.

Based on sludge-compositional information reported by Peeler et al. (2001a), DWPF will not likely process glasses with < 2.5 wt% Fe_2O_3, assuming that blending strategies are effective. With respect to the high B_2O_3 concentrations, the use of existing frits coupled with reasonable waste loadings make the probability of exceeding a B_2O_3 concentration of 19.3 wt% (in glass) almost impossible. However, if the strategy of developing frits for specific sludge- or macro-batches is embraced and implemented for future sludge-only processing (to address throughput or waste loading issues), relatively high B_2O_3 concentrations may be realized (assuming there is technical justification such as improving melt rate). It would then be the responsibility of the development team to understand the potentially negative impacts associated with high B_2O_3 levels and make educated decisions using the systems approach (Jantzen 1986) before making a recommendation.[a]

The technical basis developed by Edwards and Brown (1998) for relaxing the homogeneity constraint to the PAR coupled with implementing one of the proposed equivalent criteria provided compositional flexibility (i.e., it increased the composition operational window) for SB1b operations without compromising product quality. Edwards and Brown (1998) provide a more detailed discussion for the SB1b technical basis. Peeler et al. (2000) successfully used this same strategy for SB2.

The performance of the homogeneity constraint for the compositions tested for both the SB1b and SB2 glasses provided strong evidence that the imposition of the measurement uncertainty for this

(a) It should be noted that the Phase 2 Reduction of Constraints (Herman et al. [2002]) task is using an upper bound for B_2O_3 and lower bound for Fe_2O_3 (in glass) of 12.0 and 5.0 wt%. Therefore, the technical basis for replacing the homogeneity constraint with the Al_2O_3 and sum-of-alkali criterion will be bounded by these two limits unless otherwise justified.

constraint unnecessarily restricts the DWPF operational window. Given the effectiveness of applying the supporting criteria for SB1b and SB2 and the potential limitations of the application of the homogeneity discriminator for projected “sludge-only” glasses, an investigation into the possibility to replace this constraint in favor of the Al_2O_3 and/or sum-of-alkali criteria was initiated in FY2001 (TTR 2001; Peeler et al. 2001b).

Initially, computational outputs were used to assess challenges to homogeneity over composition regions of interest (Peeler et al. 2001a). More specifically, the projected sludge-only composition regions were assessed with respect to predictions of homogeneous versus inhomogeneous glasses (assuming that other processing and product-performance constraints were met). Composition regions assessed were based on combinations of five individual waste types and the projected blends for sludge batch 3 (SB3) and sludge batch 4 (SB4) coupled with three existing DWPF frits (Frit 165, 200, and 320). Glass compositions within this region were assessed (at the PAR) using the current PCCS models, including both the existing and newly developed T_L models. Peeler et al. (2001a) provide a more detailed discussion of the development of the sludge compositional envelopes and the assessment with respect to homogeneity.

In summary, Peeler et al. (2001a) asked “Can the homogeneity constraint be eliminated unconditionally for sludge-only processing?” The short answer provided was “no,” given the state of knowledge at that time. However, based on the assessments provided in that study, there was strong evidence that the homogeneity constraint could be replaced (or the constraint not challenged) if DWPF were to transition to either Frit 165 or Frit 320 and were to implement the new T_L model. Implementing the new T_L model allows for higher WLs to be targeted, which lowers the dependence of the homogeneity constraint (consistent with historical observations). Peeler et al. (2001a) recommended that the assessments be supported with experimental data to confirm these general observations before recommending to DWPF an implementation strategy for replacing the homogeneity constraint. As noted by Peeler et al. (2001a), if it is shown that the homogeneity constraint cannot be unconditionally replaced based on the experimental data, then a path parallel to that developed by Edwards and Brown (1998) and used for SB1b is still a viable option.

One of the primary outcomes from the Phase 1 paper study was a pool of candidate glasses that could be used to support the general observations regarding homogeneity. In fact, upon completion of the Phase 1 assessment, a pool of candidate glasses was available from which glasses could be (and were) selected to experimentally support these assessments. Thirty-three glasses were identified that satisfied the “acceptability criteria” that were established specifically for that study. Although the Phase 1 assessment of these centroid-based glasses rarely challenged homogeneity, six glasses were selected (covering the three frits of interest) that were predicted to be inhomogeneous. The objective of this experimental study is to challenge the homogeneity constraint for sludge-only processing by monitoring the durability responses for both quenched and centerline-canistered cooled (ccc) glasses within this composition region. More specifically, the durability responses will be monitored independent of the homogeneity classification but in terms of predictability and/or acceptability. To replace the homogeneity constraint, one must be able to assure that the application of the Al_2O_3 and/or sum-of-alkali criteria produce glasses that are predictable and/or acceptable irrespective of their homogeneity classification. The results of the 33 Phase 1 centroid-based glasses are the focus of this report.

In this report, experimental data from the 33 Phase 1 centroid-based glasses are presented and discussed. These results will provide an initial evaluation of the dependence of the homogeneity constraint for projected sludge-only processing. However, it is recognized that the 33 glasses are centroid-based and do not account for expected sludge variation during processing. Therefore, a supplemental experimental study (Phase 2 – see Section 8.0 for more detail) is currently underway (Herman et al. 2002) to address this issue.

The "phased" approach being utilized is solely data driven. That is, if it can be shown that glasses (covering the composition region of interest) are either predictable and/or acceptable, then the homogeneity constraint can be replaced with the Al_2O_3 and/or sum-of-alkali criterion. The "phased" approach does not consider a re-evaluation of the homogeneity constraint itself or alternative means of more adequately representing the terms of the constraint – although this may be a technically viable approach.

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2.0 Objective Statement

The overall objective of this task is to develop the fundamental technical data to replace the homogeneity constraint ***for projected sludge-only processing*** as long as the following criteria are satisfied:

Criterion (1)

- use the alumina constraint as currently implemented in PCCS ($Al_2O_3 \geq 3$ wt%) **and** add a sum-of-alkali[(a)] constraint with an upper limit of 19.3 wt% ($\Sigma M_2O < 19.3$ wt%)

or

Criterion (2)

- adjust the lower limit on the alumina constraint to 4-wt% ($Al_2O_3 \geq 4.0$ wt%).

The homogeneity constraint is currently used to discriminate compositions that are likely to result in phase-separated glasses from compositions that are likely to be homogeneous. In this context, phase separation refers to the development of amorphous or glass-in-glass phase separation, not to crystallization. The technical basis for developing and implementing the phase-separation discriminator into PCCS was the fact that the durability of phase-separated glasses can be unpredictable. Although the glasses may be unpredictable, if sufficient evidence (via technical data) can establish the fact that these glasses are acceptable based on predefined acceptance criteria over the composition region of interest, then replacing the homogeneity constraint can be technically defended. More specifically, to replace the homogeneity constraint, glasses within the composition region of interest should be predictable and/or acceptable regardless of the homogeneity classification.

This work has been prepared to address technical issues discussed in Technical Task Request (TTR) HLW/DWPF/TTR-01-0002, Rev. 0 (TTR 2001) and in accordance with the Task Technical and Quality Assurance (QA) Plan (Peeler et al. 2001b).

(a) Alkalis included in this sum are Na_2O, Li_2O, Cs_2O, and K_2O. However, for sludge-only processing, neither Cs_2O nor K_2O are introduced at significant concentrations, so the sum-of-alkali is based solely on Na_2O and Li_2O.

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3.0 Definitions and Assumptions

In this section, a few critical terms are defined, and the technical basis for applying the free energy of hydration (ΔG_p) model to crystallized glasses is discussed. The definitions discussed below should be considered as "working definitions" that apply specifically to this report. They are not intended to be formal definitions.

3.1 Predictability

In this report, predictability is based on the 95% two-sided confidence interval for an individual PCT response as generated by the 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.

3.2 Acceptability

In this report, the term "acceptable" (in reference to a PCT response) is defined as glasses whose 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 MAR to the PAR for Tank 42. This definition is considered to be conservative relative to the EA glass as reported by Jantzen et al. (1993) with uncertainties considered. This limit is also considered conservative with respect to the requirements in the DWPF Waste Acceptance Product Specifications (WAPS 1995), which state: "For acceptance, the mean concentrations of lithium, sodium, and boron in the leachate, after normalizing for the concentrations in the glass, shall each be less than those of the benchmark glass described in the Environmental Assessment for selection of the DWPF waste form. One acceptable method of demonstrating that the acceptance criteria is met, would be to assure that the mean PCT results for each waste type are at least two standard deviations below the mean results of the EA glass." Table 1 shows the normalized releases for boron, lithium, and sodium as reported by Jantzen et al. (1993).

Table 1. Leachate Concentrations of the EA Glass as Reported by Jantzen et al. (1993)

	Leachate Concentrations		
	B (g/L)	**Li (g/L)**	**Na (g/L)**
Mean	16.695	9.565	13.346
Standard Deviation	1.222	0.735	0.902

3.3 Applying ΔG_P to Inhomogeneous Glasses

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. More specifically, as a new phase precipitates in a previously homogeneous glass, it affects the glass matrix, in which it is embedded, both chemically and mechanically. These changes may impact the rate of glass dissolution in water and thus change its chemical durability (Jantzen and Bickford 1985; Cicero et al. 1993; Kim et al. 1995). Jantzen and Bickford (1985) indicated that grain-boundary dissolution was a major contributor to durability (or lack thereof) in crystallized glasses and that grain-boundary dissolution was more of an effect with species that were non-isotropic (such as acmite) than isotropic species (such as spinel) given the isotropic nature of glass or the residual glass matrix. This concept may be more easily visualized by the equation below, where the durability response (as measured by PCT) is a function of the homogeneous glass (or residual glass matrix), the release or dissolution from the crystal(s) formed, the effect of stresses resulting from grain-boundary interfaces with the residual glass matrix, and the effects of amorphous phase separation.

Σ durability response = f(homogeneous) + f(crystal) + f(grain boundary) + f(amorphous phase separation)

Given that the development of crystalline and/or amorphous phase separation does not occur, the durability response is solely a function of the homogeneous glass matrix (for which the ΔG_P model was specifically developed). This latter statement assumes that the application of the homogeneity constraint or the replacement (Al_2O_3 and/or sum-of-alkali) constraints reduces the risk of developing amorphous phase separation; therefore, the potential impacts of that term are negligible. As previously discussed, the formation of spinel (isotropic structure) in a glass matrix typically has minimal impact on the durability response. This suggests that the impacts of components dissolving from the crystals or accelerated dissolution due to grain-boundary stresses are minimal. This being the case (and assuming application of the homogeneity constraint or its replacement criteria), the durability response should approximate that of the homogeneous glass.

This is consistent with the observations by Jantzen and Bickford (1985), Cicero et al. (1993), and the results reported in the WQR (Plodinec et al. 1995) that spinels have little to no impact on the durability response as defined by the PCT. It should be noted that there are some conditions in which this may not hold—even for spinel formation.

In those cases where non-isotropic crystals form in the glass matrix, the terms f(crystal) and f(grain boundary) may not be minimal, and therefore the durability response is a more complex issue. In fact, results presented in the WQR (Plodinec et al. 1995) indicated that glass produced during waste qualification runs (in Canister S00001 from the WP-14 campaign) contained 17-vol% acmite. The PCT results of this material were “almost twice as much as the surrounding bulk glass but still less than $^{1}/_{10}$ the EA glass limit.” In this case, application of the ΔG_P model with respect to predictability may not be justified.

In this report, the ΔG_P model will be applied to both quenched and ccc glasses to test the hypothesis or assumption discussed above. It should be noted that previous studies (Harbour et al. 2000; Herman et al. 2001) have also applied the ΔG_P model to both quenched and ccc glasses.

4.0 Selection of 33 Glass Compositions for Experimental Evaluation

A detailed discussion of the strategy for selecting glass compositions for the Reduction of Constraint (RC) Phase 1 study has been described by Peeler et al. (2001a and 2001b). In general, glass compositions to support the RC task were selected from a pool of 69 candidate centroid-based glasses. The selection process was based solely on established "acceptability" criteria and would support an initial examination of the conservatism in the homogeneity constraint. In addition to homogeneity, assessments (based on predictions) of durability (PCT response), viscosity, T_L (using both the existing and newly developed models), and Al_2O_3 and alkali concentrations were performed.

The properties assessed in this study included durability (PCT) (ASTM 1997) response in terms of ΔG_P, viscosity at 1150°C ($\eta_{1150°C}$), T_L (using both the current and newly developed models), homogeneity, and Al_2O_3 and alkali concentrations. Jantzen et al. (1995) and Brown, et al. (2001a) provide a more detailed discussion on the development of these models. Acceptable predicted properties for this assessment are based on satisfying their respective PAR limit values (see Table 2)—not the more restrictive MAR limits.[(a)] Because the PAR limit for the new T_L model is compositionally dependent (Brown et al. 2001a), the PAR limit was conservatively set at 1010ºC to allow for a quick assessment. In fact, Brown et al. (2001a) have demonstrated that the PAR limits for the new model will not be this restrictive (in terms of limiting the projected compositional operating window) for various glass-forming systems. Therefore, in the assessment discussions that follow, when the new T_L model limits the projected operational window, one must remember the use of this conservatively set PAR limit. More specifically, failing this constraint (as currently defined) does not necessarily mean that it would be an unacceptable glass given the conservative 1010ºC PAR limit.

Table 2. Current PAR Limits for Various Properties

Property	PAR Limit
T_L (existing)	< 1024.95°C
T_L (new)	< 1010°C
Homogeneity	> 210.92
ΔG_P (durability)	> -12.7178
$\eta_{1150°C}$ (melt viscosity)	21.5–105.4 Poise
Al_2O_3	≥ 3.0 wt% (in glass)
Σalkali	< 19.3 wt% (in glass)

Again, the primary objective of this study is to challenge the impact of the homogeneity constraint within a composition region that bounds that expected for sludge-only processing. More specifically, if the PCT responses of glasses within the composition region of interest are predictable and/or acceptable, regardless of the homogeneity classification, then eliminating the homogeneity constraint can be technically defended.

(a) The PAR is the set of compositions that produce acceptable predicted properties. That is, the PAR accounts for only one source of uncertainty—that due to modeling or prediction. The MAR adds measurement error to the PAR.

A glass was classified as "viable" (within the projected operational window and a potential candidate for the Phase 1 experimental portion of the program) if it satisfied all of the constraints listed in Table 2. There were two exceptions to this latter statement:

- To meet programmatic objectives, glasses that met all of the constraints with the exception of homogeneity were considered viable candidates for fabrication and testing (i.e., to assess or challenge the homogeneity constraint).
- Glasses that met one (or both) of the T_L constraints were also considered as potential candidates. For example, a glass that was deemed acceptable by the new model (given the conservative 1010°C PAR limit) but fails the existing model was considered a viable candidate—and vice versa. Only those glasses that failed both T_L models were deemed unacceptable and were excluded from further consideration.

It should be noted that the property criteria used in this study are at the PAR; not the more restrictive MAR limits. These criteria were used to screen the pool of 69 candidate glasses to establish glasses for experimental evaluation. Experimental evaluation of these glasses will provide the initial foundation to determine whether the homogeneity constraint can be replaced (or relaxed) for projected sludge-only processing in favor of the Al_2O_3 and sum-of-alkali criterion. The experimental assessment will parallel those used in previous studies (Edwards and Brown 1998; Peeler et al. 2000) to assess the homogeneity constraint. More specifically, the durability of both quenched and ccc glasses will be evaluated via the PCT.

As a result of the screening process, 33 of the 69 centroid-based glasses met the criteria established to support programmatic objectives. Tables 3 and 4 identify the targeted compositions (major and minor components, respectively) of the 33 RC glasses prepared for this study. The composition of the minor components (referred to as "Others" throughout this report and shown in Table 4) was developed as part of the glass-selection effort for the SB2/Frit 320 variability study (Brown et al. 2001b).

Of the 33 RC glasses, 13 were Frit 165-based glasses (RC-25 – RC-37), 7 were Frit 200-based glasses (RC-38 – RC-44) and 13 were Frit 320-based glasses (RC-45 – RC-57). As previously mentioned, the homogeneity constraint was not overwhelmingly challenged for the individual centroid waste types and sludge batches within the acceptable processing window. In fact, only 6 of the 33 RC glasses were predicted to be inhomogeneous. Four of the 6 were Frit 165-based (RC-27, RC-30, RC-31, and RC-36). The RC-40 (Frit 200-based) and RC-50 (Frit 320-based) glasses were also predicted to be inhomogeneous.

Also shown in Table 3 is a column identified as the "DWPF PAR Operating Window," which represents the comparison of various predicted properties versus the PAR limits as shown in Table 2. For example, the "DWPF PAR Operating Window" nomenclature for RC-25 (a Frit 165, plutonium-uranium extraction (PUREX) low-heat feed (PLF) sludge-based glass at 35.0% waste loading) indicates "Durable; Visc; Not T_L; Homog; New T_L; Al_2O_3; alkali." This nomenclature indicates that this particular glass satisfies the PAR limits (based on predictions using the targeted composition) for durability, viscosity, the new liquidus temperature model (New T_L), homogeneity, the Al_2O_3 lower limit, and the sum of alkali. However, this glass is predicted to fail the old T_L model (as noted by "Not T_L").

Table 3. Target Composition of RC Glasses (major components in mass fraction)

Glass ID	DWPF PAR Operating Window	WL (%)	Sludge[a]	Frit	Al_2O_3	B_2O_3	CaO	Fe_2O_3	Li_2O	MgO	MnO	Na_2O	NiO	SiO_2	U_3O_8	ZrO_2	Others
RC-25	Durable; Visc; ***Not T_L***; Homog; New T_L; Al_2O_3; alkali	35	PLF	165	0.04382	0.06514	0.01571	0.16191	0.04619	0.01042	0.01832	0.12829	0.00659	0.45012	0.03733	0.00695	0.0097
RC-26	Durable; Visc; ***Not T_L***; Homog; New T_L; Al_2O_3; alkali	35	SB3	165	0.04130	0.06514	0.01497	0.15843	0.04620	0.01103	0.02009	0.12918	0.00897	0.44972	0.03867	0.00695	0.0098
RC-27	Durable; Visc; T_L; ***Not Homog***; New T_L; Al_2O_3; alkali	27.5	SB4	165	0.03177	0.07261	0.01114	0.11504	0.05130	0.01225	0.02721	0.12955	0.00561	0.50496	0.02359	0.00761	0.0077
RC-28	Durable; Visc; T_L; Homog; New T_L; Al_2O_3; alkali	30	SB4	165	0.03466	0.07012	0.01216	0.12550	0.04960	0.01246	0.02969	0.12951	0.00612	0.48904	0.02573	0.00739	0.0084
RC-29	Durable; Visc; ***Not T_L***; Homog; New T_L; Al_2O_3; alkali	30	PLF	165	0.03756	0.07012	0.01346	0.13878	0.04959	0.01036	0.01570	0.12853	0.00565	0.48296	0.03199	0.00738	0.0083
RC-30	Durable; Visc; T_L; ***Not Homog***; ***Not New T_L***; Al_2O_3; alkali	35	PHF	165	0.03115	0.06514	0.00613	0.12040	0.04620	0.01663	0.03973	0.12939	0.02938	0.44534	0.05414	0.00696	0.0099
RC-31	Durable; Visc; T_L; ***Not Homog***; New T_L; Al_2O_3; alkali	20	HHF	165	0.08774	0.08008	0.00419	0.02699	0.05640	0.01148	0.01986	0.12949	0.00215	0.56399	0.00409	0.00826	0.0056
RC-32	Durable; Visc; ***Not T_L***; Homog; New T_L; Al_2O_3; alkali	35	SB4	165	0.04044	0.06514	0.01418	0.14642	0.04620	0.01287	0.03463	0.12943	0.00714	0.45722	0.03002	0.00695	0.0098
RC-33	Durable; Visc; ***Not T_L***; Homog; New T_L; Al_2O_3; alkali	37.5	SB4	165	0.04333	0.06265	0.01519	0.15687	0.04450	0.01307	0.03711	0.12939	0.00765	0.44130	0.03217	0.00674	0.0105
RC-34	Durable; Visc; ***Not T_L***; Homog; New T_L; Al_2O_3; alkali	30	SB3	165	0.03540	0.07012	0.01283	0.13579	0.04960	0.01089	0.01722	0.12930	0.00768	0.48262	0.03314	0.00739	0.0084
RC-35	Durable; Visc; T_L; Homog; New T_L; Al_2O_3; alkali	27.5	SB3	165	0.03245	0.07261	0.01176	0.12448	0.05130	0.01081	0.01578	0.12935	0.00704	0.49907	0.03038	0.00761	0.0077
RC-36	Durable; Visc; T_L; ***Not Homog***; New T_L; Al_2O_3; alkali	15	HHF	165	0.06581	0.08506	0.00314	0.02024	0.05980	0.01111	0.01489	0.12961	0.00161	0.59299	0.00307	0.00869	0.0042
RC-37	Durable; Visc; T_L; Homog; New T_L; Al_2O_3; alkali	25	PLF	165	0.03130	0.07510	0.01122	0.11565	0.05299	0.01030	0.01309	0.12878	0.00471	0.51580	0.02666	0.00782	0.0069
RC-38	Durable; Visc; ***Not T_L***; Homog; New T_L; Al_2O_3; alkali	30	SB3	200	0.03540	0.08412	0.01283	0.13579	0.03560	0.01789	0.01722	0.11530	0.00768	0.49662	0.03314	0.00039	0.0084
RC-39	Durable; Visc; T_L; Homog; New T_L; Al_2O_3; alkali	30	SB4	200	0.03466	0.08412	0.01216	0.12550	0.03560	0.01946	0.02969	0.11551	0.00612	0.50304	0.02573	0.00039	0.0084
RC-40	Durable; Visc; T_L; ***Not Homog***; ***Not New T_L***; Al_2O_3; alkali	35	PHF	200	0.03115	0.07814	0.00613	0.12040	0.03320	0.02313	0.03973	0.11639	0.02938	0.45834	0.05414	0.00046	0.0099
RC-41	Durable; Visc; T_L; Homog; New T_L; Al_2O_3; alkali	25	PLF	200	0.03130	0.09010	0.01122	0.11565	0.03799	0.01780	0.01309	0.11378	0.00471	0.53080	0.02666	0.00032	0.0069
RC-42	Durable; Visc; ***Not T_L***; Homog; New T_L; Al_2O_3; alkali	30	PLF	200	0.03756	0.08412	0.01346	0.13878	0.03559	0.01736	0.01570	0.11453	0.00565	0.49696	0.03199	0.00038	0.0083
RC-43	Durable; Visc; ***Not T_L***; Homog; New T_L; Al_2O_3; alkali	32.5	SB4	200	0.03755	0.08113	0.01317	0.13596	0.03440	0.01941	0.03216	0.11597	0.00663	0.48663	0.02788	0.00042	0.0091
RC-44	Durable; Visc; T_L; Homog; New T_L; Al_2O_3; alkali	27.5	SB3	200	0.03245	0.08711	0.01176	0.12448	0.03680	0.01806	0.01578	0.11485	0.00704	0.51357	0.03038	0.00036	0.0077

Glass ID	DWPF PAR Operating Window	WL (%)	Sludge[(a)]	Frit	Al_2O_3	B_2O_3	CaO	Fe_2O_3	Li_2O	MgO	MnO	Na_2O	NiO	SiO_2	U_3O_8	ZrO_2	Others
RC-45	Durable; Visc; ***Not T_L***; Homog; New T_L; Al_2O_3; alkali	35	SB3	320	0.04130	0.05214	0.01497	0.15843	0.05270	0.00453	0.02009	0.12268	0.00897	0.47572	0.03867	0.00045	0.0098
RC-46	Durable; Visc; ***Not T_L***; Homog; New T_L; Al_2O_3; alkali	37.5	PMF	320	0.03060	0.05015	0.01227	0.15478	0.05076	0.00707	0.03993	0.12455	0.01902	0.45633	0.04389	0.00049	0.0106
RC-47	Durable; Visc; ***Not T_L***; Homog; New T_L; Al_2O_3; alkali	35	PLF	320	0.04382	0.05214	0.01571	0.16191	0.05269	0.00392	0.01832	0.12179	0.00659	0.47612	0.03733	0.00045	0.0097
RC-48	Durable; Visc; ***Not T_L***; Homog; New T_L; Al_2O_3; alkali	37.5	SB3	320	0.04425	0.05015	0.01604	0.16974	0.05075	0.00486	0.02152	0.12287	0.00961	0.45827	0.04143	0.00049	0.0105
RC-49	Durable; Visc; T_L; Homog; New T_L; Al_2O_3; alkali	30	SB3	320	0.03466	0.05612	0.01216	0.12550	0.05660	0.00546	0.02969	0.12251	0.00612	0.51704	0.02573	0.00039	0.0084
RC-50	Durable; Visc; T_L; ***Not Homog***; ***Not New T_L***; Al_2O_3; alkali	35	PHF	320	0.03115	0.05214	0.00613	0.12040	0.05270	0.01013	0.03973	0.12289	0.02938	0.47134	0.05414	0.00046	0.0099
RC-51	Durable; Visc; T_L; Homog; New T_L; Al_2O_3; alkali	27.5	SB4	320	0.03177	0.05811	0.01114	0.11504	0.05855	0.00500	0.02721	0.12230	0.00561	0.53396	0.02359	0.00036	0.0077
RC-52	Durable; Visc; T_L; Homog; New T_L; Al_2O_3; alkali	25	PLF	320	0.03130	0.06010	0.01122	0.11565	0.06049	0.00280	0.01309	0.12128	0.00471	0.54580	0.02666	0.00032	0.0069
RC-53	Durable; Visc; ***Not T_L***; Homog; New T_L; Al_2O_3; alkali	40	SB4	320	0.04622	0.04816	0.01621	0.16733	0.04880	0.00728	0.03958	0.12335	0.00817	0.44939	0.03431	0.00052	0.0112
RC-54	Durable; Visc; ***Not T_L***; Homog; New T_L; Al_2O_3; alkali	30	PLF	320	0.03756	0.05612	0.01346	0.13878	0.05659	0.00336	0.01570	0.12153	0.00565	0.51096	0.03199	0.00038	0.0083
RC-55	Durable; Visc; ***Not T_L***; Homog; New T_L; Al_2O_3; alkali	35	SB4	320	0.04044	0.05214	0.01418	0.14642	0.05270	0.00637	0.03463	0.12293	0.00714	0.48322	0.03002	0.00045	0.0098
RC-56	Durable; Visc; T_L; Homog; New T_L; Al_2O_3; alkali	27.5	SB3	320	0.03245	0.05811	0.01176	0.12448	0.05855	0.00356	0.01578	0.12210	0.00704	0.52807	0.03038	0.00036	0.0077
RC-57	Durable; Visc; T_L; Homog; New T_L; Al_2O_3; alkali	30	SB3	320	0.03540	0.05612	0.01283	0.13579	0.05660	0.00389	0.01722	0.12230	0.00768	0.51062	0.03314	0.00039	0.0084

[(a)] Sludge types
PLF: PUREX low heat feed
PHF: PUREX high heat feed
PMF: PUREX mixed feed
HHF: H modified high heat feed
SB3: sludge batch 3
SB4: sludge batch 4

Table 4. Target Composition of RC Glasses "Others" (in mass fraction) [a]

	%Oxide in "Others" Mean
B_2O_3	1.32
BaO	1.74
CdO	6.79
CoO	0.94
Cr_2O_3	11.75
CuO	2.80
La_2O_3	2.03
Li_2O	6.55
ThO_2	1.75
RuO_2	2.88
MoO_3	0.33
P_2O_5	44.60
PbO	4.61
SnO_2	1.00
SrO	1.02
TiO_2	1.33
V_2O_5	1.34
ZnO	2.94
ZrO_2	4.26
SUM	100.00

Consider RC-31 as another example. The "DWPF PAR Operating Window" nomenclature for this Frit 165, H modified high-heat feed (HHF)-based glass at 20-wt% waste loading indicates "Durable; Visc; T_L; Not Homog; New T_L; Al_2O_3; alkali." This nomenclature indicates that this particular glass satisfies the PAR limits (based on predictions using the targeted composition) for durability, viscosity, the old liquidus-temperature model (T_L), the new liquidus-temperature model (New T_L), the Al_2O_3 lower limit, and the sum of alkali. However, this glass is predicted to be inhomogeneous (as noted by "Not Homog"). This glass is a perfect candidate for challenging the homogeneity constraint. That is, this glass would not be processable given the failure to satisfy the homogeneity constraint. However, if it can be demonstrated that the measured PCT release is predictable and/or acceptable, then the argument can be made that it should not be limited from DWPF processing as this glass satisfies the Al_2O_3 and sum-of-alkali criteria. This latter statement is based on the centroid sludge composition and obviously ignores anticipated composition variation.

[a] Concentrations of B_2O_3, Li_2O, and ZrO_2 are shown in Table 4 as "minor" components associated with "Others". These components may also be associated with the frit resulting in "major" components in the glass.

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5.0 Experimental

This section describes the experimental procedures used to fabricate and the analytical techniques used to physically and chemically characterize the RC glasses.

5.1 Glass Fabrication

Tables 3 and 4 identified the targeted compositions (major and minor components, respectively) of the 33 RC glasses prepared for this study. Each batch 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 Batch Preparation Procedure – GTOP-3-003” (SRTC 1994). Batch sheets were filled out as the materials were weighed.[(a)] Once batched, the glasses were melted using a standard procedure. 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, and the temperature was increased at ~8°C/min until the target melt temperature (1150°C) was reached. 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. Observations of the resulting pour patty and residual crucible glass were documented.[(b)]

The pour patty and residual crucible glass were ground, and the crushed glass was subsequently transferred to its original 95% Platinum/5% Gold 250-mL crucible for a second melt at 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. Observations of the resulting pour patty and residual crucible glass were documented.[(c)] Approximately 140 g of glass were 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 heat treatments and property measurements (i.e., chemical composition, crystallinity, and durability). Glasses were stored in marked containers (using the unique RC nomenclature as defined in Table 3).

To bound the effects of thermal history on the product performance, approximately 25 g of each RC glass 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 ccc curve. This terminology will be used in this report to differentiate samples from different cooling regimes (quenched versus ccc). Although recent studies have evaluated the bounding effects of thermal heat treatment of product performance (as defined by the PCT), the development of criterion (1) and criterion (2) for SB1b application (see Section 1.0) was based on primarily quenched glasses.

The analysis of chemical composition results (see Section 6.1 for a more detailed discussion) identified a potential batching and/or measurement error for RC-31. The results indicated that the measured B_2O_3 concentration was well below the targeted value (5.39 wt% measured vs. 8.008 wt% targeted—see Table E.5). This information prompted a review of the batch sheet, which indicated that the quantity of H_3BO_3 (raw material source for B_2O_3) added was indeed in error (14.224 g added while 21.336 g was specified), which would result in a low B_2O_3

(a) Batch sheets can be found in WSRC-NB-2001-00054.
(b) Observations are recorded in WSRC-NB-2001-00054.
(c) Observations of homogeneity were documented in WSRC-NB-2001-00054 for both the pour patty and the residual crucible glass. No visual signs of undissolved solids or compositional inhomogeneities were observed.

concentration with other components being relatively high compared to their initial targets.[(a)] The "as-batched" composition of RC-31 was calculated based on the quantities of raw materials added as indicated on the batch sheet. Table 5 compares the as-batched RC-31 composition (i.e., the misbatched version of RC-31) and the initial targeted composition. Although discussed in detail in Section 6.1, the "as-batched" RC-31 composition and its measured composition agree quite well. It should be noted that based on the "as-batched" composition, RC-31 is predicted to satisfy all property predictions (at the PAR) with the exception of homogeneity—making this glass another candidate glass for challenging homogeneity and supporting programmatic objectives. Although the composition is not a specific frit/sludge combination, its composition is acceptable in terms of the ranges that may be of interest to DWPF. That being said, RC-31 was retained for further property measurements and has been included in the assessment of homogeneity.

Table 5. "As-Batched" Composition of RC-31 (misbatched) Based on Batch Sheet Information Compared to the Initial Targeted Composition (as mass fractions)

	Glass ID			Glass ID	
	RC-31 "As-batched"	**Targeted**		**RC-31 "As-batched"**	**Targeted**
Al_2O_3	0.09030	0.08774	**Na_2O**	0.13200	0.12949
B_2O_3	0.05498	0.08008	**NiO**	0.00220	0.00215
CaO	0.00436	0.00419	**SiO_2**	0.58010	0.56399
Fe_2O_3	0.02780	0.02699	**U_3O_8**	0.00420	0.00409
Li_2O	0.05838	0.05640	**ZrO_2**	0.00844	0.00826
MgO	0.01180	0.01148	**Others**	0.0050	0.0056
MnO	0.02040	0.01986			

As shown in Table 3, the original target of RC-31 was also predicted to be inhomogeneous—a glass based on a 20% WL of HHF coupled with Frit 165. Given that only 6 of the 33 original targeted compositions would challenge the homogeneity constraint, and the fact that schedule and budget permitted, the original RC-31 composition was batched and melted, making a total of 34 RC glasses to be characterized. The rebatched glass (targeting the RC-31 composition shown in Table 3) will be referred to throughout this report as RC-31.5. As discussed in the appropriate sections, subsequent analytical plans were developed and utilized in support of both chemical analysis and PCT assessments for RC-31.5.

5.2 Property Measurements

This section provides a general discussion of the analysis of chemical compositions, crystallization, and the Product Consistency Test.

5.2.1 Chemical Composition Analysis

To confirm that the "as-fabricated" glasses corresponded to the defined target compositions, a representative sample from each RC glass pour patty was submitted to the SRTC Mobile Laboratory (SRTC-ML) for chemical analysis. Edwards (see Appendix A) provided an analytical

(a) To review the "misbatched" RC-31 batch sheet, see WSRC-NB-2001-00054, page 51.

plan that accompanied these samples.[(a)] This plan identified the cations to be analyzed and the dissolution techniques (i.e., sodium peroxide fusion [SP] and lithium-metaborate [LM]) to be used. Each glass was prepared in duplicate for the cation dissolution techniques (SP 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. The results were evaluated to confirm that the targeted glass compositions were adequately met. Glass standards were intermittently run to assess the performance of the ICP over the course of these analyses and for potential bias-correction needs.

5.2.2 Crystallization

Although observations for crystallization were performed and documented,[(b)] representative samples for all "as-fabricated" (or quenched) and ccc RC 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.

Scanning electron microscope (SEM) with energy dispersive spectroscopy (EDS) analysis was also used on select RC glasses to confirm visual and XRD results and to further characterize features or microstructures.

5.2.3 Product Consistency Test

The PCT was performed on each glass to assess chemical durability using technical procedure "Nuclear Waste Glass Product Consistency Test (PCT) Method – GTOP-3-025" (ASTM 1997). The PCT was conducted in triplicate for each RC glass (both quenched and ccc versions). Also included in this experimental test matrix were the EA glass (Jantzen et al. 1993), the Approved Reference Material (ARM-1) glass, and blanks from the sample cleaning batch. Samples were ground, washed, and prepared according to procedure. Fifteen mL of Type I 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 left for 7 days. The resulting solutions (once cooled) were sampled (filtered and acidified), labeled (according to the analytical plan), and analyzed. Edwards provided analytical plans for the SRTC-ML analysis (see Appendices B, C, and D).[(c)] Due to the large number of vessels and limited space in a single PCT oven, three groups of tests were initiated. Groups were based on frit type (e.g., Group #1 – Frit 165-based glasses, Group #2 – Frit 200-based glasses, and Group #3 – Frit 320-based glasses) and each contained the appropriate blanks and glass standards. The overall philosophy of these plans was to provide an opportunity to assess the consistency (repeatability) of the PCT and analytical procedures in the

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(a) Given the batching issues with RC-31, a separate analytical plan was developed for RC-31.5 to support the chemical composition analysis. The analytical plan can be found on page 25 of WSRC-NB-2001-00056.

(b) Observations for the presence or absence of crystallization or undissolved solids are documented in WSRC-NB-2001-00054 and WSRC-NB-2001-00056.

(c) Given the batching issues with RC-31, a separate analytical plan was developed for RC-31.5 to support the analysis of the quenched and CCC PCT solutions. The analytical plan can be found on page 25 of WSRC-NB-2001-00056.

effort to evaluate chemical durability of the RC glasses. Normalized release rates were calculated based on targeted, measured, and bias-corrected compositions using the average of the logs of the leachate concentrations.

6.0 Results and Discussion

This section provides a detailed discussion of the chemical-composition measurements, an assessment of crystallization via XRD and/or SEM/EDS, and analysis of the PCT results.

6.1 A Statistical Review of the Chemical Composition Measurements

In this section, the measured versus targeted compositions of the 34 RC glasses (including RC-31 and RC-31.5) are presented and compared. The targeted compositions for these glasses are provided in Tables 3, 4, and 5. The chemical composition measurements for these glasses were conducted by the SRTC-ML following the analytical plan provided in Appendix A. Two dissolution methods were utilized: samples prepared by lithium metaborate (LM) dissolution were used to measure elemental concentrations of aluminum (Al), calcium (Ca), chromium (Cr), iron (Fe), magnesium (Mg), manganese (Mn), sodium (Na), nickel (Ni), phosphorous (P), titanium (Ti), uranium (U), and zirconium (Zr) while samples prepared by SP dissolution were used to measure elemental concentrations of boron (B), lithium (Li), and silicon (Si). Notice that beyond the minor components of Cr, P, Ti, and Zr, there is an "Others" grouping of additional minor components whose concentrations were not measured. 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).

Appendix E provides numerous tables and exhibits that support the chemical-composition analysis. Table E.1 provides the elemental concentration measurements derived from the samples prepared using LM, and Table E.2 provides the measurements derived from the samples prepared using SP. These two tables also provide measurements for two standards (Batch 1 and a uranium standard, U_{std}, glass) that were included in the analytical plan along with the RC glasses. Tables E.3 and E.4 provide elemental concentration measurements for the re-batched RC-31 glass (referred to as RC-31.5) along with standards. The need for the re-batching was identified as the results from Tables E.1 and E.2 were reviewed (see Section 6.1.4 for more details).

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 composition (measured and bias-corrected) for each glass is determined, and comparisons are made between these measurements and the targeted compositions for these glasses.

6.1.1 Measurements in Analytical Sequence

Exhibit E.1 provides plots of the measurements generated by the SRTC-ML from samples prepared using the LM method. These plots are in analytical sequence with different symbols and colors being used to represent each of the RC and standard glasses. Similar plots for the samples prepared using the SP method are provided in Exhibit E.2. These plots include all of the measurement data from Tables E.1 through E.4.

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.

6.1.2 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 were investigated across the ICP analytical blocks, and the results were used to bias correct the measurements for the RC glasses.

Exhibit E.3 provides statistical analyses of the Batch 1 and U_{std} results generated by the LM prep method by analytical block. The results include an analysis of variance (ANOVA) investigation looking for statistically significant differences among the block means for each of the standards. The results from these statistical tests may be summarized as follows: for the Batch 1 standard, the Al, Ca, Fe, Mg, Mn, Na, Ni, and Ti measurements indicate a significant ICP calibration effect at the 5% significance level, and for the U_{std}, the Al, Ca, Cr, Fe, Mg, Mn, Na, Ni, Ti, and U measurements indicate a significant ICP calibration effect at the 5% significance level. Although statistically significant, the calibration effects do not suggest that the measurements are unacceptable, only that bias correction may be helpful. Also, note that there is similarity between the patterns of behavior for the measurements of the two standards over the analytical blocks for many of the elements. The reference values for the oxide concentrations of the two standards are given in the header for each set of measurements in the exhibit.

Exhibit E.4 provides a similar set of analyses for the B, Li, and Si measurements derived from samples prepared via the SP method. In this exhibit, the Li and Si data for both Batch 1 and the U_{std} show a statistically significant (at the 5% significance level) difference among the ICP analytical/calibration blocks.

Thus, as previously noted, the results suggest that it may be helpful to bias correct the oxide measurements of the RC 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, Ca, Cr, Fe, Mg, Mn, Na, Ni, P, Si, Ti, and Zr and the average measurement for U_{std} for each ICP block for U. Thus, 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, the Batch 1 results were used to bias correct the Al, Ca, Cr, Fe, Mg, Mn, Na, Ni, Si, and Ti measurements. No bias correction was conducted for P or Zr.

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 $\overline{c}_{ijk}$ be the average measurement for the i[th] oxide at analytical block j for the k[th] glass. The bias adjustment was conducted as follows

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

Bias-corrected measurements are indicated by a "bc" suffix, and such adjustments were performed for all of the oxides of this study except P_2O_5 and ZrO_2. Both measured and measured "bc" values are included in the discussion that follows. In these discussions, the bias-corrected values for P_2O_5 and ZrO_2 are the as-measured values (i.e., given that the no bias-correction was performed for these two oxides, which allows a sum of oxides to be computed for the bias-corrected results).

6.1.3 Composition Measurements by Glass Number

Exhibits E.5 and E.6 provide plots of the oxide-concentration measurements by Glass ID (including both the Batch 1, labeled as glass number 0, and U_{std}, labeled as glass number 100, glasses) for the measured and bias-corrected (bc) values for the LM and SP preparation methods, respectively. Different symbols are used to represent the different glasses. In these plots, the re-batched RC-31 (a.k.a., RC-31.5, the initial targeted composition as shown in Table 3) glass measurements are labeled with a "z" to differentiate them from the initially batched (or misbatched) RC-31 measurements, which are labeled with an "x." 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 RC glasses are provided in the sections that follow.

6.1.4 Measured Versus Targeted Compositions

The four measurements for each oxide for each glass (over both dissolution methods) were averaged to determine a representative chemical composition for each glass. These determinations were conducted for the measured and bias-corrected data. A sum of oxides was also computed for each glass, based upon both the measured and bias-corrected values. Table E.5 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 glasses do not sum to 100% due to the "Others" component of the RC glasses and an incomplete coverage of the oxides in the Batch 1 (Glass # 0) and U_{std} (Glass # 100) glasses. In this table, the re-batched RC-31 is labeled as RC-31.5 to distinguish it from the initially batched RC-31. All of the sums of oxides (both measured and bias-corrected) fall within the interval of 95 to 105 wt% except the bias-corrected sum of oxides for RC-45 (94.8%).

Entries in Table E.5 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%. For those oxides whose concentrations are < 0.5 wt% in glass, high relative differences are not uncommon. To help highlight the comparisons among the measured, bias-corrected, and targeted values, Exhibit E.7 provides comparison plots for each glass for each oxide.

Some general observations from Table E.5 and the plots of Exhibit E.7 are offered: The B_2O_3 values for glass number 31 (RC-31) shows that the measured concentration is substantially below the targeted concentration for this glass. The entries for RC-31 in Table E.5 reflect the comparisons between the measured and target concentrations for this glass. This information prompted the closer look at the batch sheet for this glass, which led to the discovery of the batching error discussed in Sections 5.1 and 6.1. A comparison of the targeted "as-batched" and measured compositions of RC-31 is provided in Table E.6.

6.1.5 General Assessment of Targeted Versus Measured Compositions

In general, the CaO measured values are, on average, slightly higher than their targeted values. Bias correction appears to move the measured values closer to their targets. For most of the RC glasses, the measured and bias-corrected Cr_2O_3 values are slightly less than their respective targets. The Fe_2O_3 values miss their respective targets for several of the RC glasses with the misses being mostly below the targeted values; see, for example, glass numbers 45 through 57. The P_2O_5 values appear to fall below targeted values for all of the RC glasses. Finally, the comparisons for the U_3O_8 results show good agreement between the measurements and targeted values.

Overall, these comparisons between the measured and targeted compositions suggest that there were no significant problems in the batching or fabrication of the RC study glasses other than RC-31. However, it appears that there are no issues with RC-31.5 (the rebatched glass).

As previously mentioned, it should be noted that based on the "as-batched" composition, RC-31 is predicted to satisfy all property predictions (at the PAR) with the exception of homogeneity—making this glass another candidate for challenging homogeneity and supporting programmatic objectives. Although the composition is not a specific frit/sludge combination, its composition is acceptable in terms of the ranges that may be of interest to DWPF. That being said, both RC-31.5 and RC-31 were retained for further property measurements and have been included in the assessment of homogeneity—making the total number of glasses equal to 34.

6.2 Crystallization

A representative sample of each as-fabricated (quenched) and thermally heat-treated (ccc) RC glass was submitted for XRD. Note that the use of XRD will not assess the presence of amorphous or glass-in-glass phase separation, which constituted the basis for developing the homogeneity constraint (i.e., glasses exhibiting amorphous phase separation can be unpredictable in terms of their PCT response). The XRD analysis is only intended to analyze for the presence of crystallization at a given detection limit. The development and/or detection of amorphous phase separation was of no concern given the objective and technical approach of this task. Although some XRD patterns are shown in this section, all XRD patterns (both quenched and ccc) can be found in Appendix F.

6.2.1 Quenched

Based on XRD results, all 34 RC glasses (including RC-31 that was misbatched) were amorphous upon fabrication (quenched)—confirming observations. XRD patterns for RC-27Q and RC-36Q (Frit 165-based), RC-40Q and RC-43Q (Frit 200-based), and RC-46Q and RC-50Q (Frit 320-

based) are shown in Figures 1 through 6, respectively. The XRD patterns show the characteristic high background devoid of crystalline spectral lines, indicative of an amorphous (non-crystalline) product. That is, if undissolved solids and/or crystallization were present in the sample in sufficient quantity, well-defined or distinct spectral lines would be observed. The absence of well-defined spectral lines does not provide an indication of chemical homogeneity or the presence/absence of amorphous phase separation, but simply demonstrates the absence of crystalline material. Note that the X-ray diffractometer used in this study has a detection limit of approximately 1.0 vol% in glass based on the run conditions utilized. Undissolved solids and/or crystallization present below this limit would remain undetected by the XRD unit.

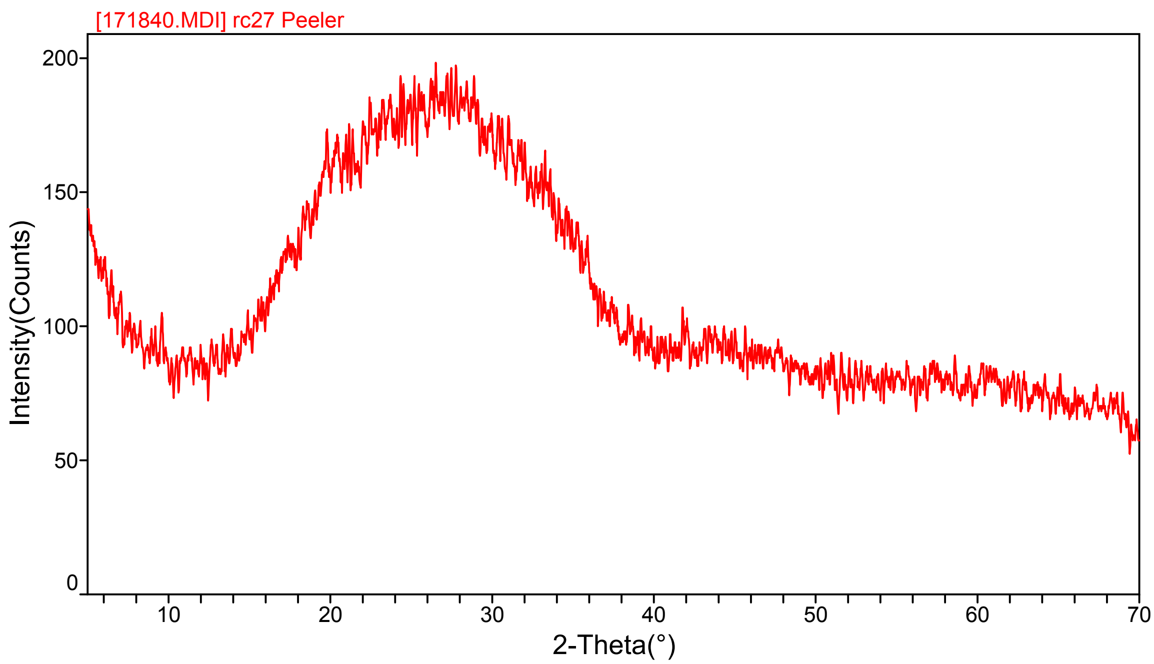

Figure 1. XRD Pattern for RC-27Q

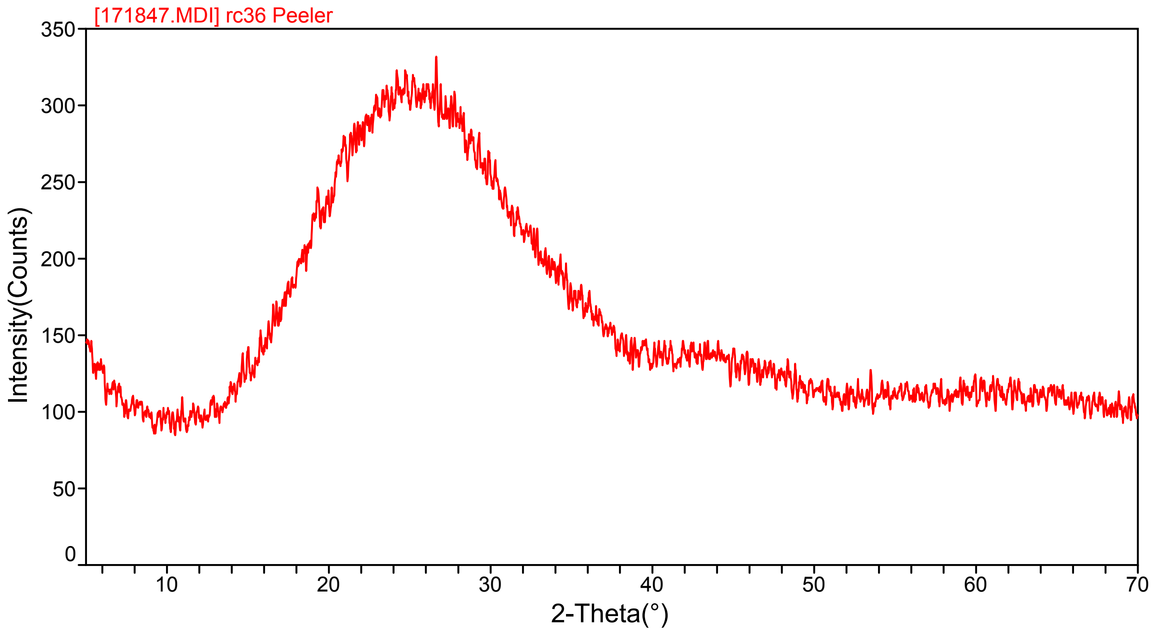

Figure 2. XRD Pattern for RC-36Q

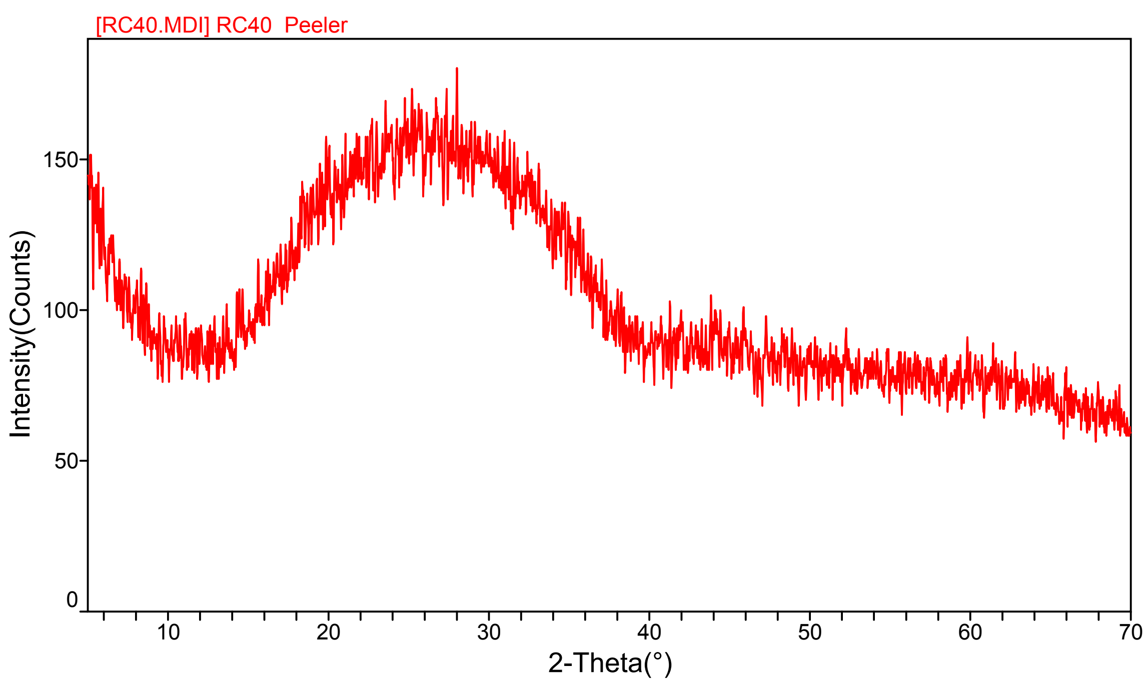

Figure 3. XRD Analysis of RC-40Q

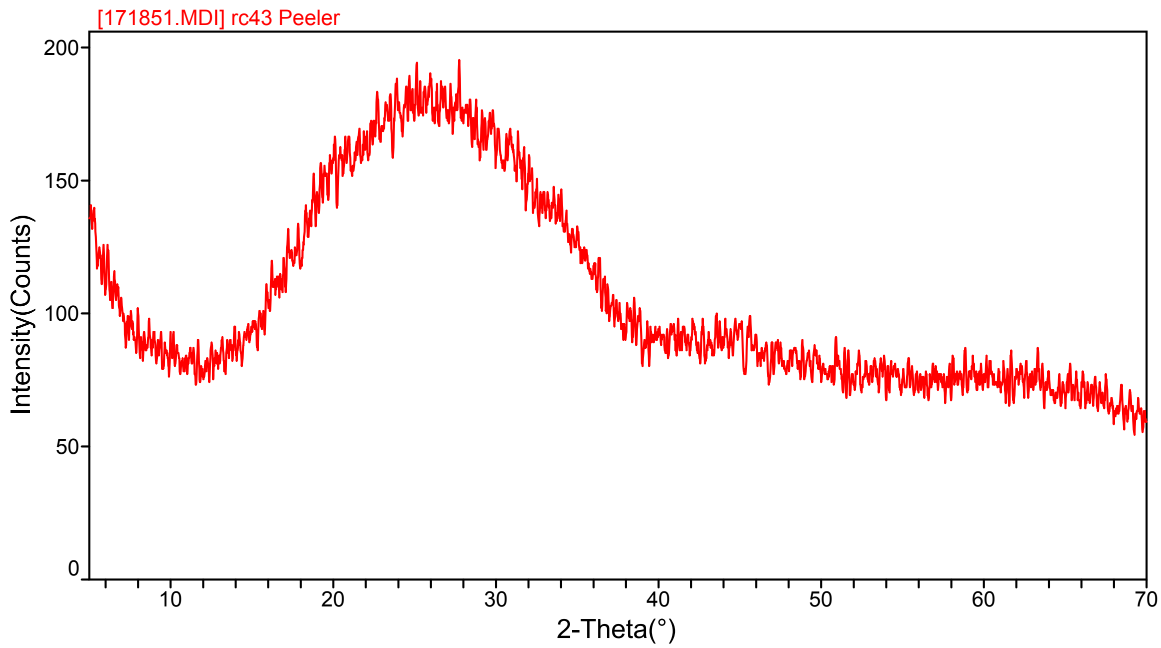

Figure 4. XRD Analysis of RC-43Q

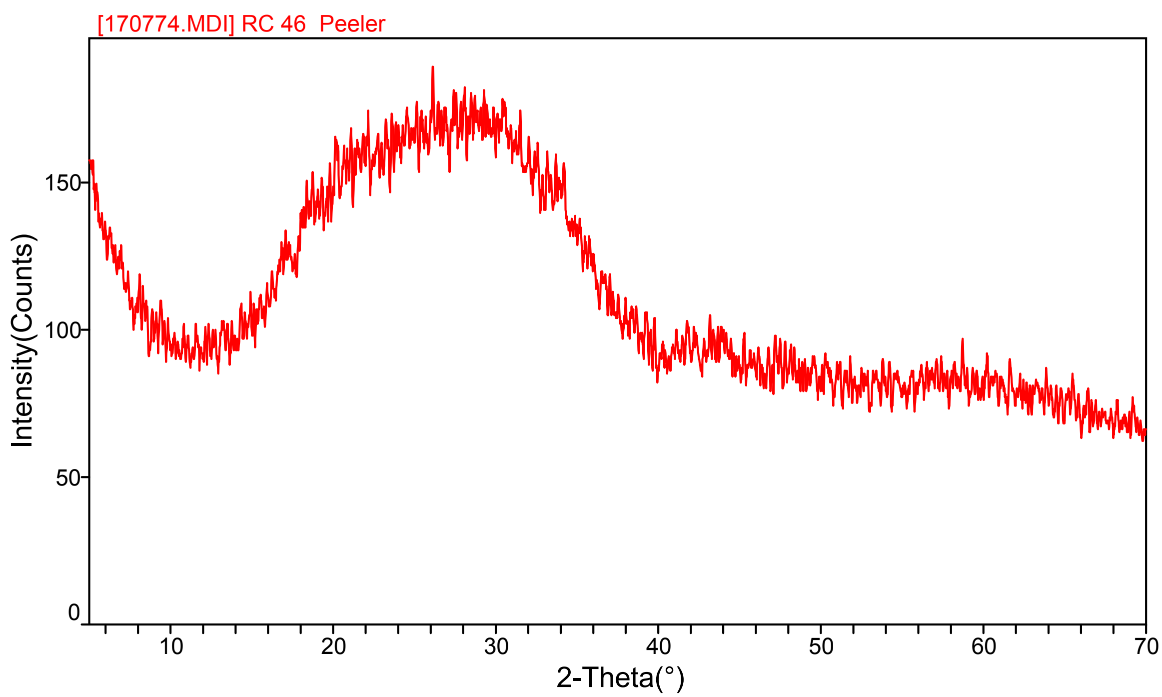

Figure 5. XRD Analysis of RC-46Q

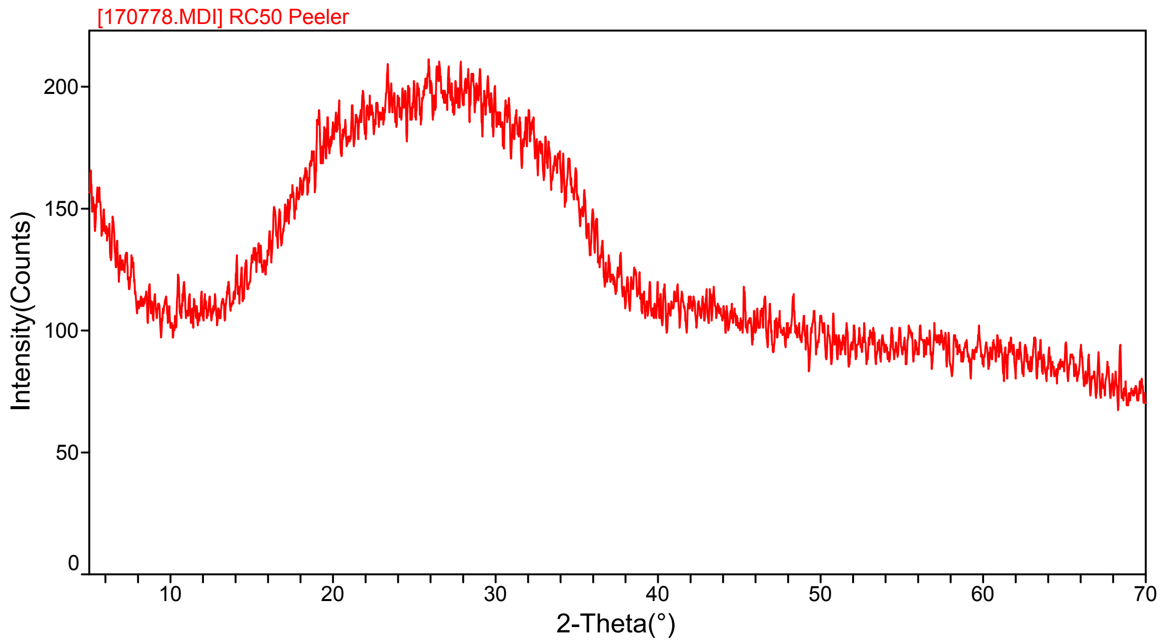

Figure 6. XRD Analysis of RC-50Q

6.2.2 Thermally Heat Treated (ccc)

Of the 13 Frit 165-based ccc glasses, 11 were characterized by XRD as amorphous (i.e., void of crystallization at the detection limit). Spinel (Trevorite – $NiFe_2O_4$) was detected in RC-30ccc and RC-33ccc as shown in Figures 7 and 8, respectively.

SEM/EDS analysis of RC-33ccc is shown in Figures 9 through 12. Figure 9 shows a SEM micrograph (21.5x—relatively low magnification) of a representative RC-33ccc sample. At this relatively low magnification, isolated pockets of crystals are randomly distributed across the surface of the glass. Figure 10 shows a higher magnification micrograph (109x) of the sample in which the morphology of the crystals is more readily apparent. Figure 11 is a higher magnification (1.08kx) micrograph of an isolated crystal within the glassy matrix. EDS analysis (Figure 12) of this crystal indicates high concentrations of iron (Fe), nickel (Ni), and manganese (Mn)—indicative of spinel-type crystals commonly observed in waste glasses and is consistent with the XRD results of Trevorite (see Figure 8). SEM/EDS analysis of RC-30ccc also support XRD results, indicating the presence of spinel-type crystals (e.g., enriched in Fe, Ni, and Mn). It should be noted that dendritic-type crystals appear to be growing from the larger spinel crystal (see Figure 12). Although no EDS analysis was performed in this study on these specific crystals, Bickford and Jantzen (1984) and Jantzen and Bickford (1985) showed similar crystal morphologies and reported these to be acmite ($NaFeSi_2O_6$).

It is of interest that SEM/EDS analyses of RC-25ccc and RC-28ccc indicate the presence of crystals enriched in Fe, Mn, and Ni, although XRD analyses suggest that the ccc versions of these glasses are amorphous. This discrepancy is attributed to the detection limit of the XRD unit of ~ 1 vol%.

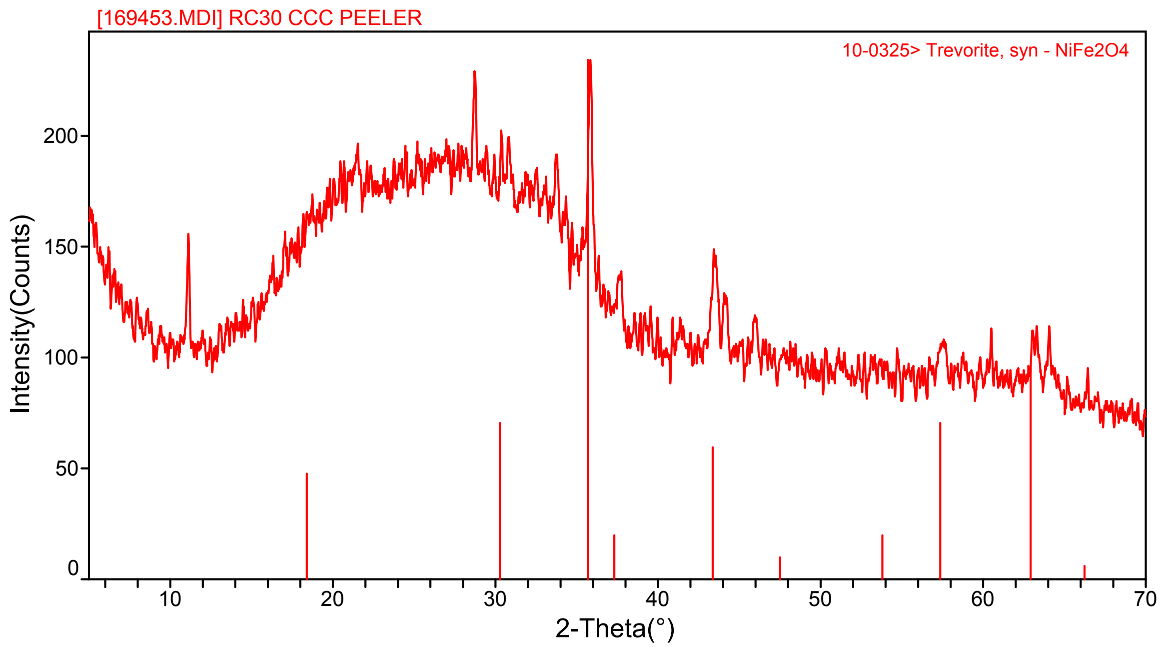

Figure 7. XRD Pattern for RC-30ccc

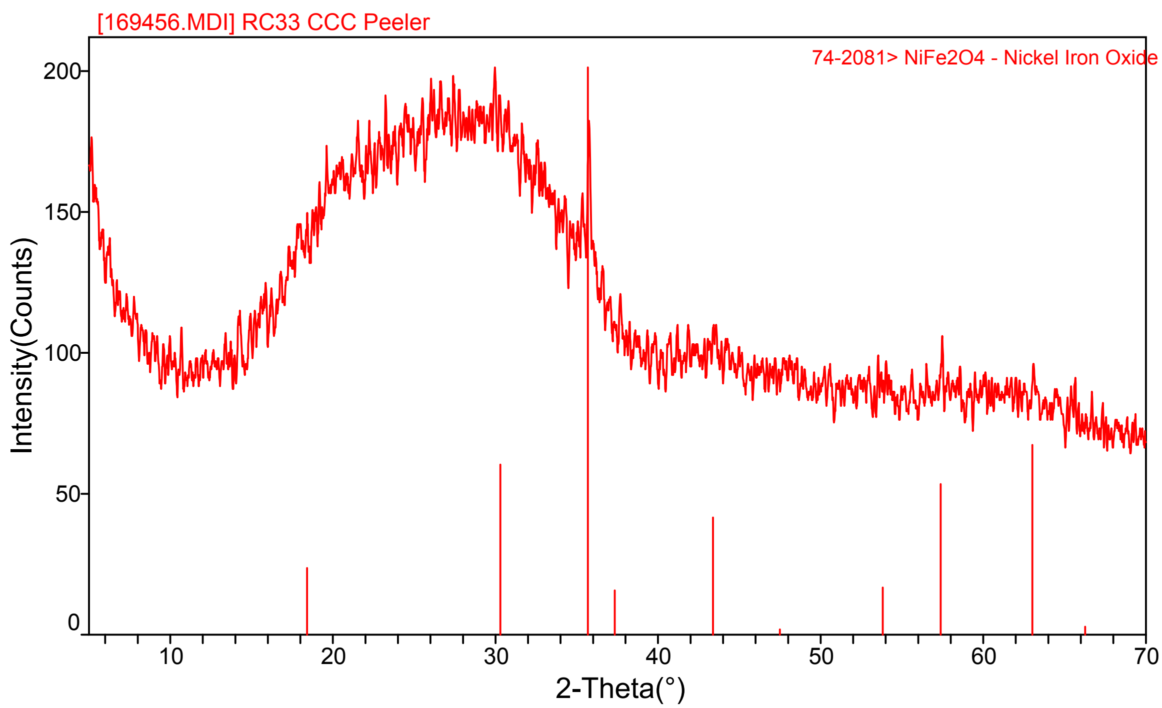

Figure 8. XRD Pattern for RC-33ccc

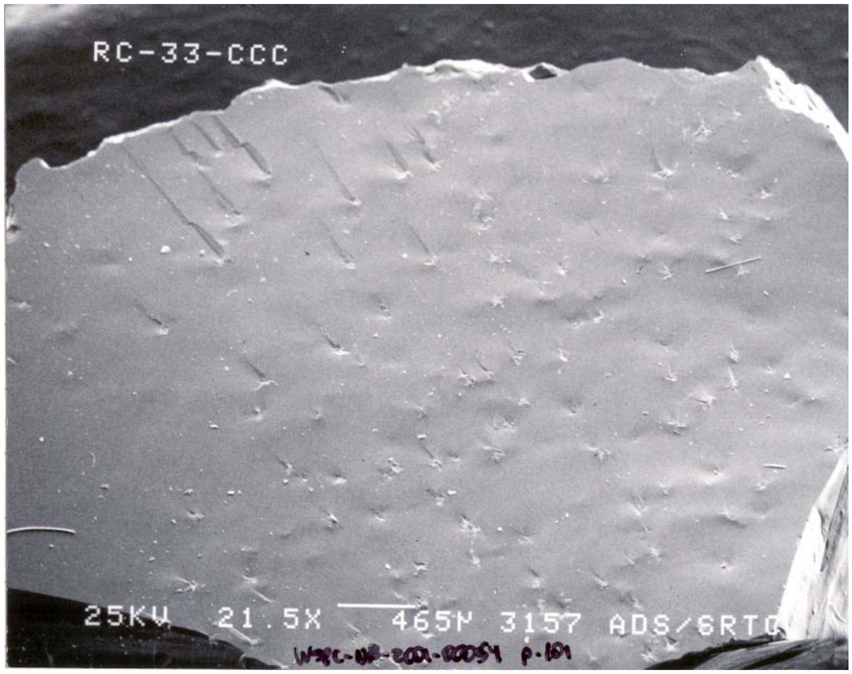

Figure 9. SEM micrograph of RC-33ccc (21.5x)

Figure 10. SEM micrograph of RC-33ccc (109x)

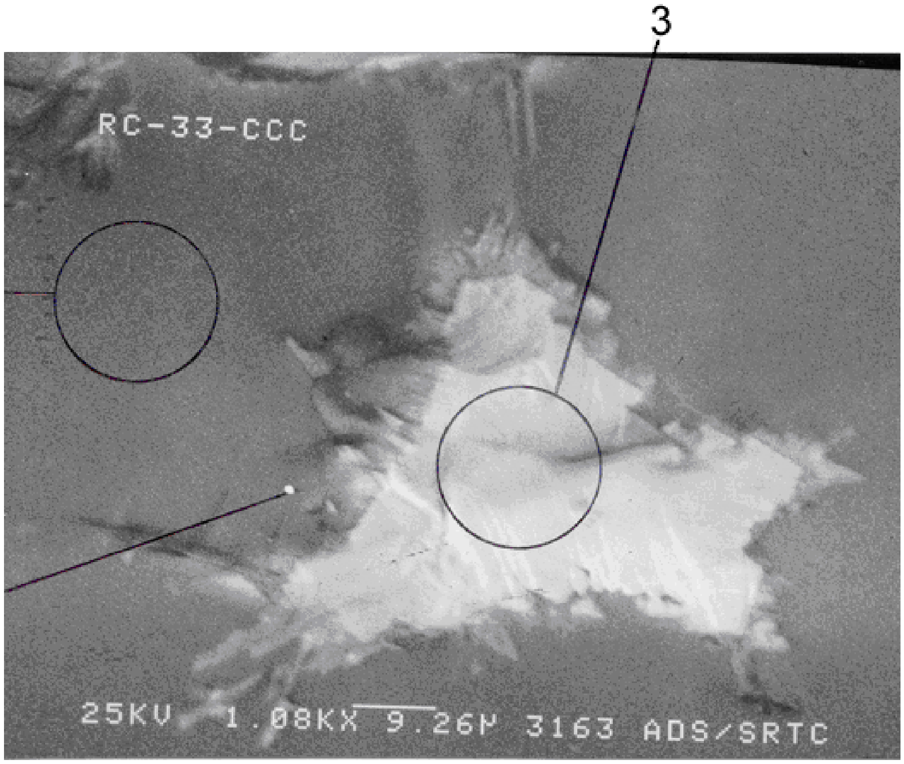

Figure 11. SEM micrograph of RC-33ccc (1.08kx)

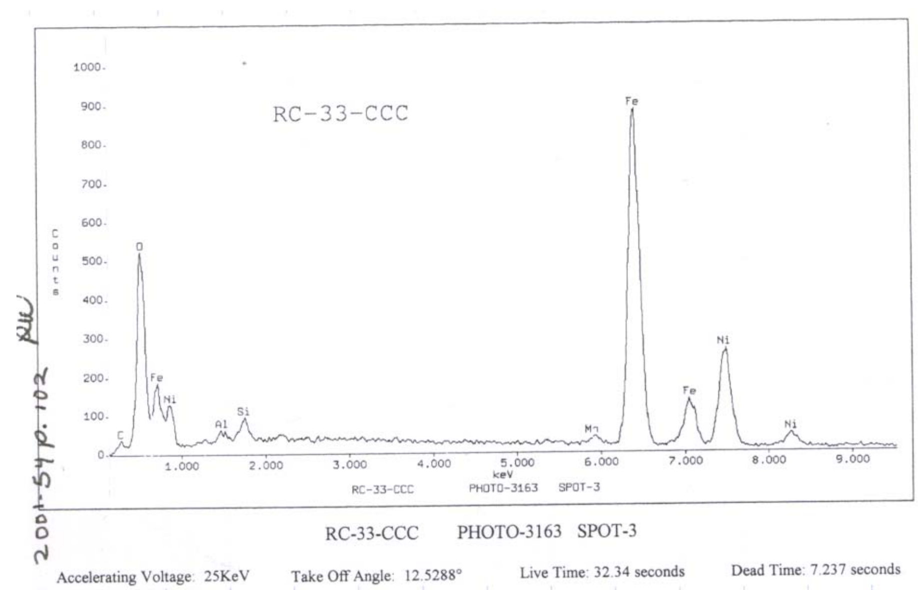

Figure 12. EDS Analysis of RC-33ccc (Spot #3 as shown in Figure 11)

Based on XRD analyses, all of the Frit 200-based glasses contained crystallization after the ccc heat treatment. The SRTC-ADS reported both acmite ($NaFeSi_2O_6$) and spinel (Trevorite – $NiFe_2O_4$) in RC-38ccc, RC-39ccc, RC-40ccc, and RC-44ccc. Acmite was the only phase reported in RC-41ccc, RC-42ccc, and RC-43ccc. Figures 13 and 14 show the XRD patterns of RC-40ccc and RC-43ccc, respectively.

SEM/EDS analysis confirmed the presence of Trevorite in both RC-38ccc and RC-40ccc. Acmite was not reported in the SEM analysis, although XRD identified its presence. Figure 15 is a relatively low magnification (32x) micrograph of RC-40ccc in which extremely small crystals are randomly (but consistently) distributed across the sample surface. Figure 16 shows a 0.53kx micrograph of RC-40ccc where the morphology of the crystals is more readily apparent. Figure 17 shows a 1.61kx micrograph of RC-40ccc, and Figures 18 and 19 show the EDS analyses of Spots 4 and 6, respectively.[a] The EDS analysis indicates that the crystals are enriched in Fe, Mn, and Ni with Cr also being reported in the Spot 6 analysis (Figure 19). These analyses agree well with the RC-40ccc XRD results of Trevorite as shown in Figure 13.

Based on XRD analyses, five of the 13 Frit 320-based glasses contained Trevorite after the ccc heat treatment. These included RC-46ccc, RC-47ccc, RC-48ccc, RC-50ccc, and RC-53ccc. The remaining eight Frit 320-based glasses remained amorphous (i.e., void of crystallization) at the XRD detection limit. Figures 20 and 21 show the XRD patterns of RC-46ccc and RC-50ccc, respectively. SEM/EDS analyses of RC-46ccc, RC-47ccc, RC-50ccc, and RC-53ccc confirmed the presence of Trevorite. As an example, Figure 22 is a relatively low magnification (189x) micrograph of RC-46ccc. Figure 23 is at a slightly higher magnification (375x), which shows three different crystal morphologies: dendritic, "bulk," and "cluster" crystals. The "bulk" (Spot #4) and dendritic (Spot #3) crystals are shown in Figure 24 with their respective EDS analyses shown in Figures 25 and 26. Based on the EDS results, both the bulk and dendritic crystals are enriched in Fe, Mn, and Ni—indicative of spinel or acmite-type structures. Based on relative intensities, the dendritic crystals appear to contain more Mn relative to Fe than in the "bulk" type crystals. It should also be noted that the EDS spectrum for the dendrites (Figure 26) also indicates elevated Ca and Si relative to the bulk crystal (Figure 25). As previously reported, Bickford and Janzten (1984) observed a similar microstructure, which was ultimately identified as acmite. Figure 27 shows a higher magnification micrograph of the crystal "clusters." Based on EDS analysis (Figure 28), these crystals are also enriched in Mn, Fe, and Ni—again supporting the XRD analysis of this sample, which indicated Trevorite.

As with the Frit 165-based glasses, there is a discrepancy between the XRD and SEM/EDS results for one glass—RC-57ccc. While XRD analysis suggested that the glass was amorphous, crystals enriched in Fe, Mn, and Ni were observed via SEM, which indicated the presence of a spinel-type structure in this heat-treated glass. Again, based on these results, it is expected that $< \sim 1$ vol% should be present.

(a) Although not shown, the EDS spectra for Spot 5 is very similar to that of Spot 6 (see Figures 17 and 19).

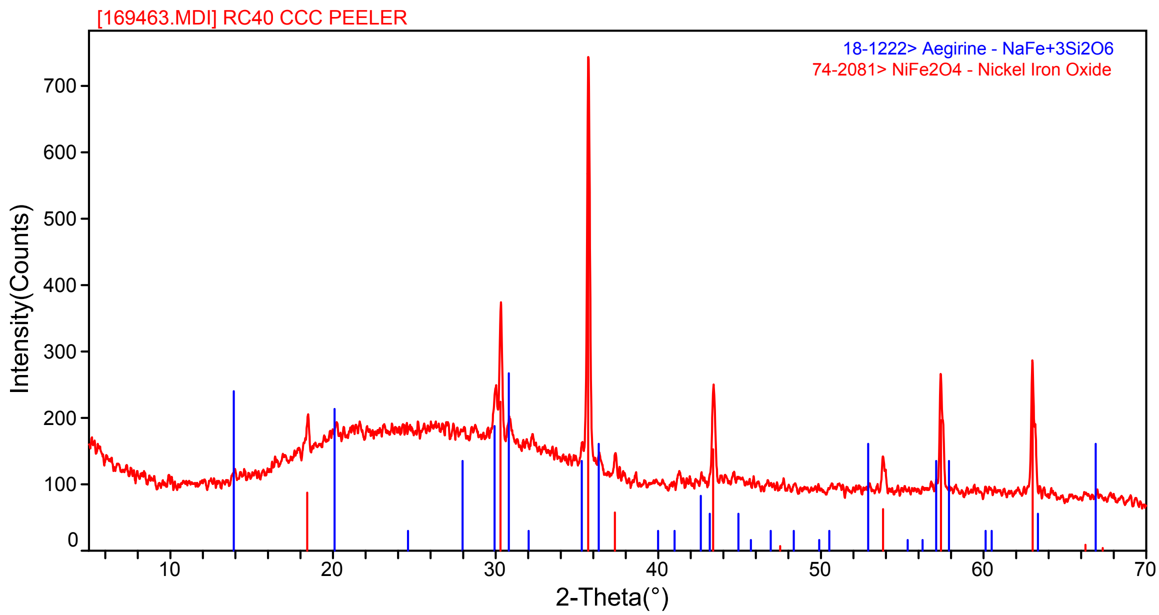

Figure 13. XRD Pattern for RC-40ccc

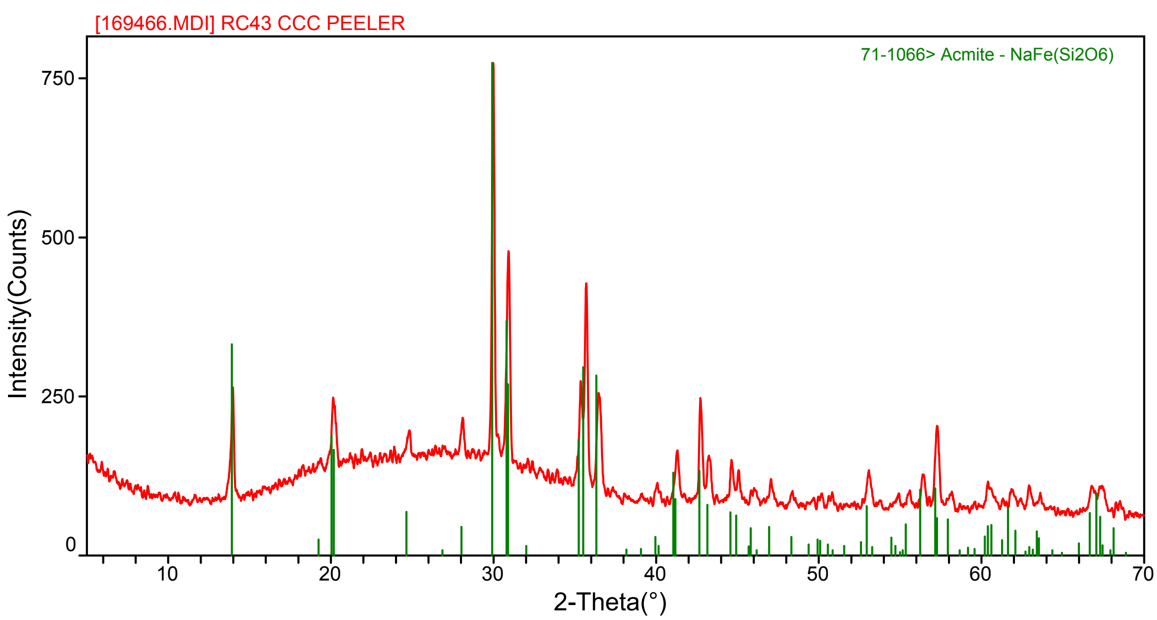

Figure 14. XRD Pattern for RC-43ccc

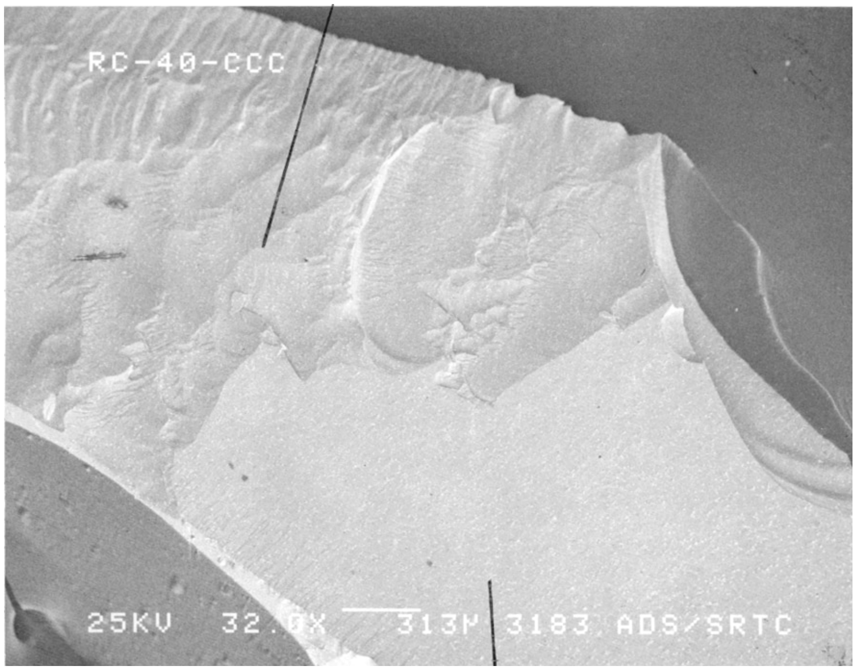

Figure 15. SEM Micrograph of RC-40ccc (32x)

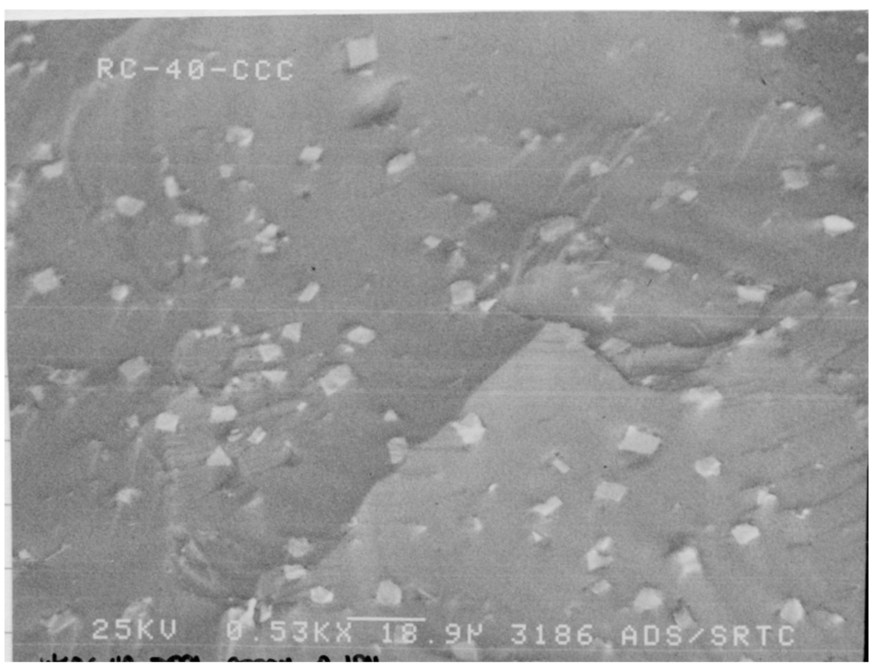

Figure 16. SEM Micrograph of RC-40ccc (530x)

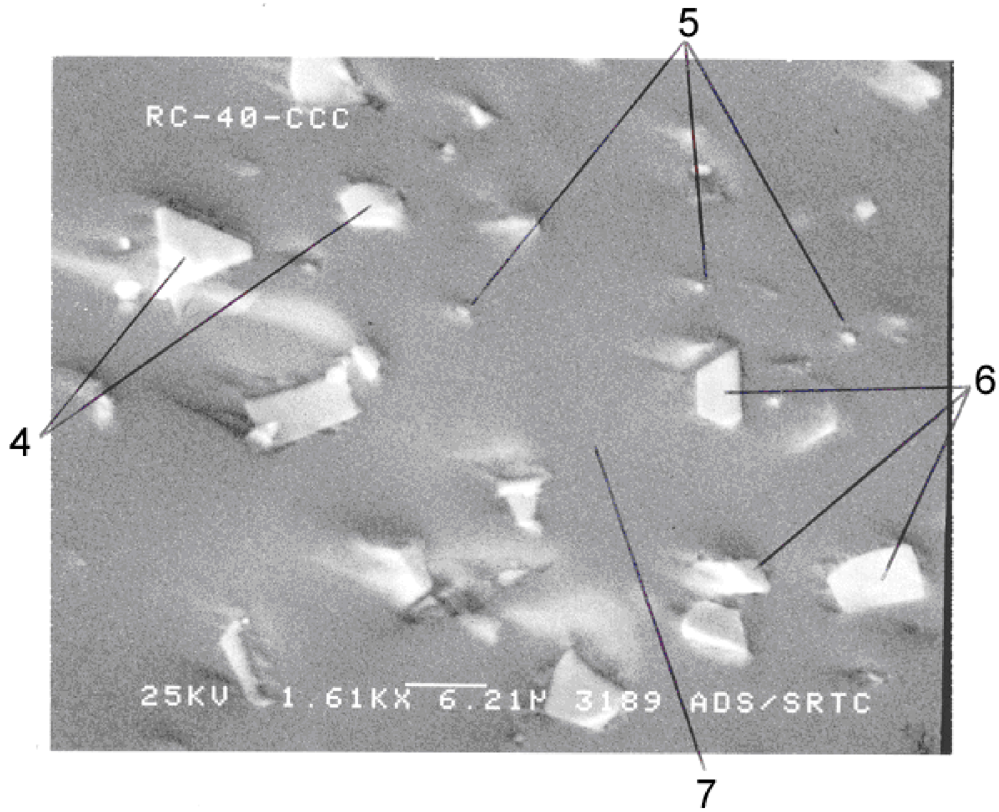

Figure 17. SEM Micrograph of RC-40ccc (1.61kx)

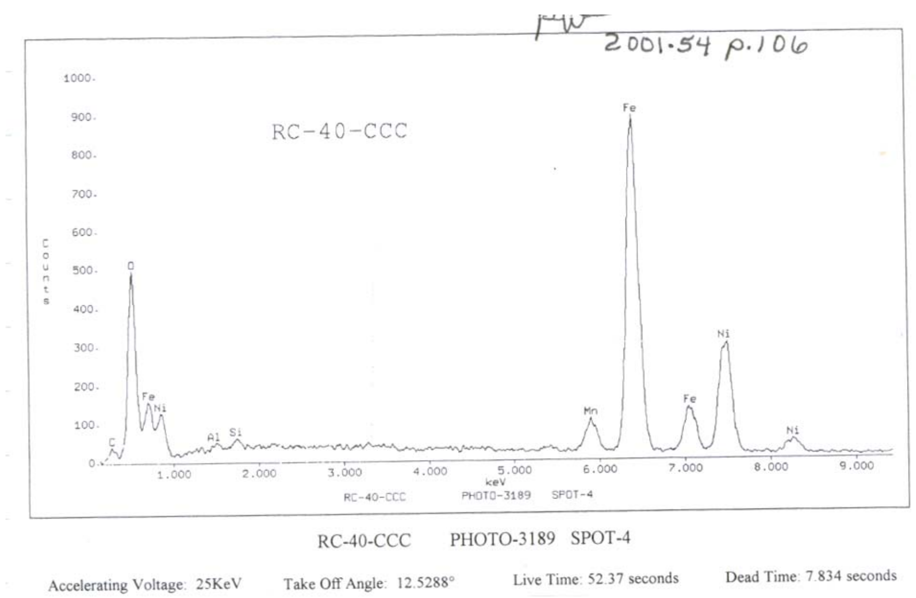

Figure 18. EDS Analysis of RC-40ccc (Spot #4)

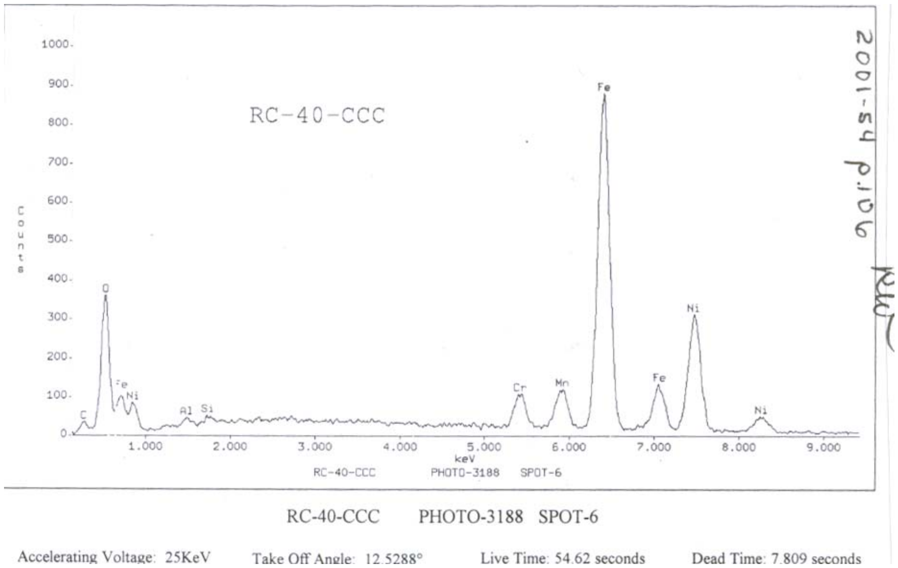

Figure 19. EDS Analysis of RC-40ccc (Spot #6)

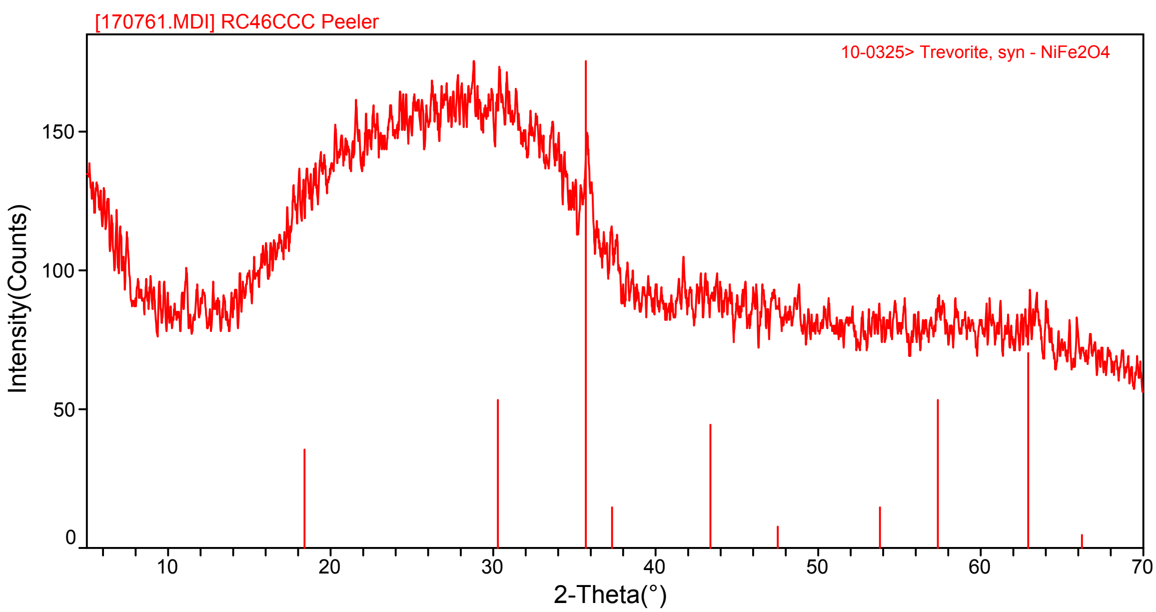

Figure 20. XRD Pattern for RC-46ccc

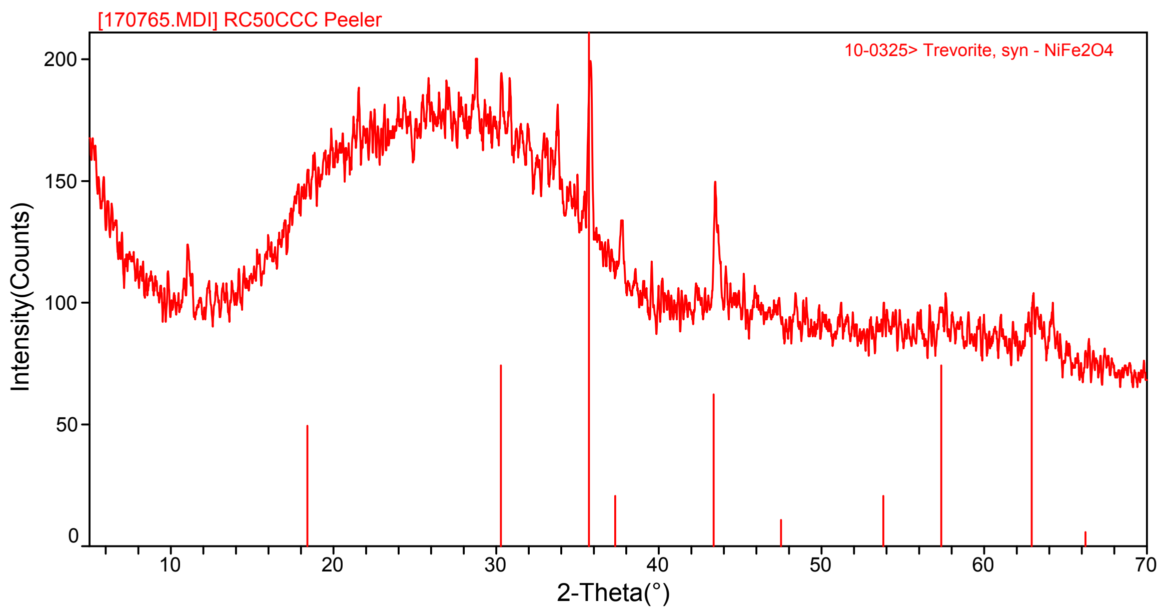

Figure 21. XRD Pattern for RC-50ccc

Figure 22. SEM Micrograph of RC-46ccc (189x)

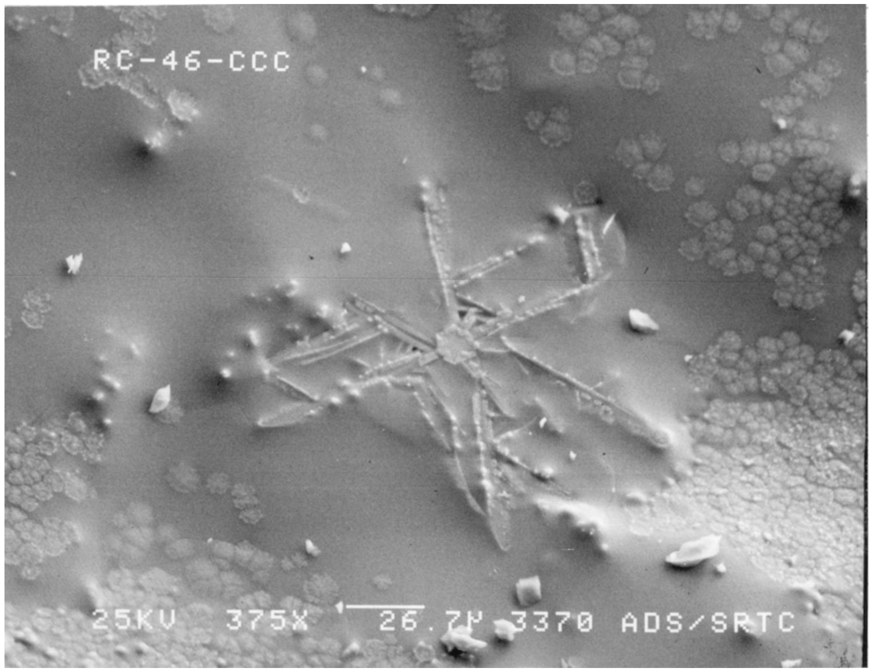

Figure 23. SEM Micrograph of RC-46ccc (375x)

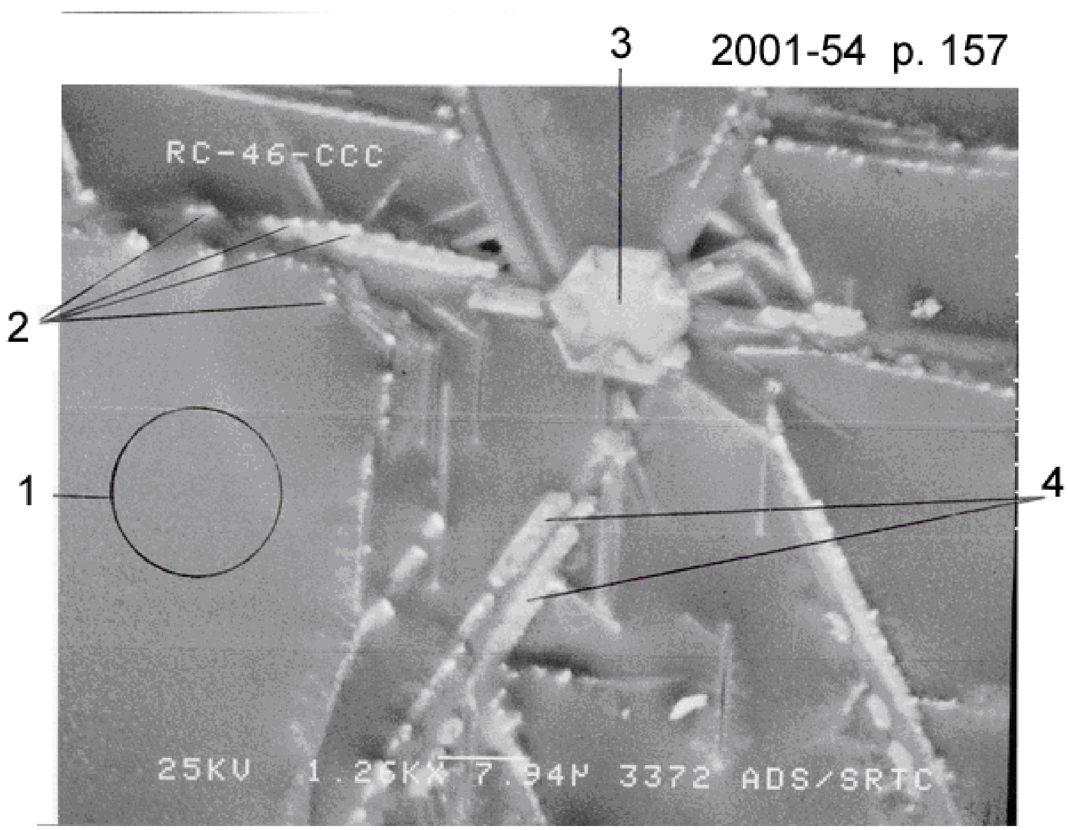

Figure 24. Bulk and Dendritic Crystals Associated with RC-46ccc

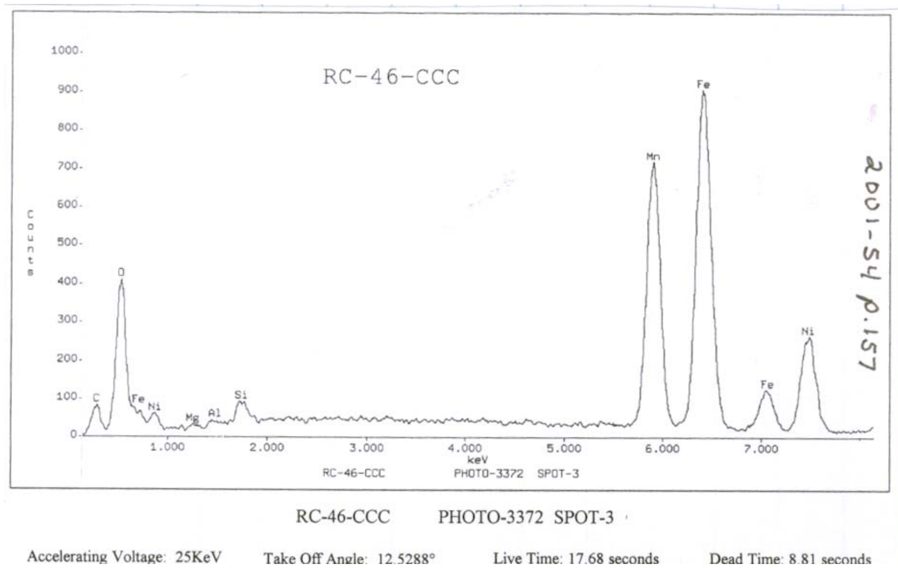

Figure 25. EDS Analysis of Bulk Crystals Associated with RC-46ccc (Spot #3 in Figure 24)

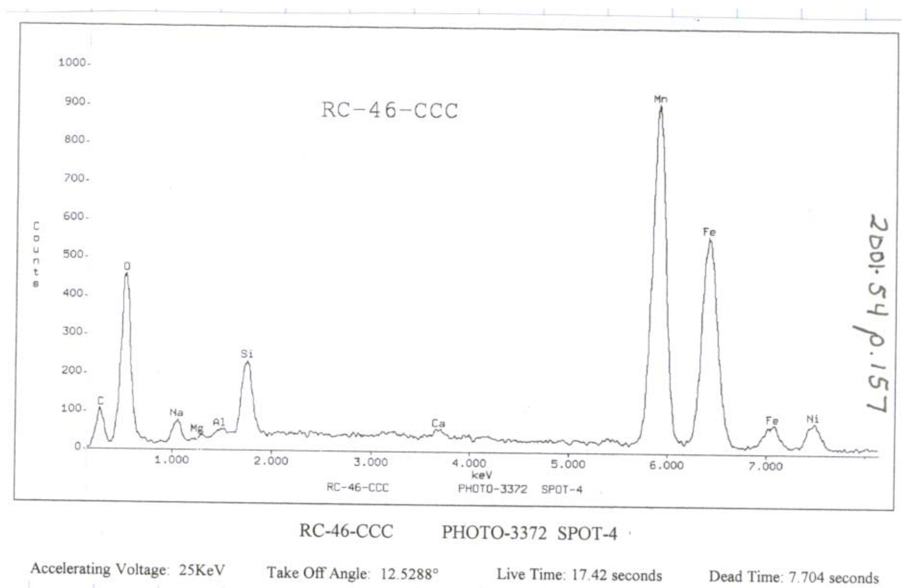

Figure 26. EDS Analysis of Dendritic Crystals Associated with RC-46ccc (Spot #4 in Figure 24)

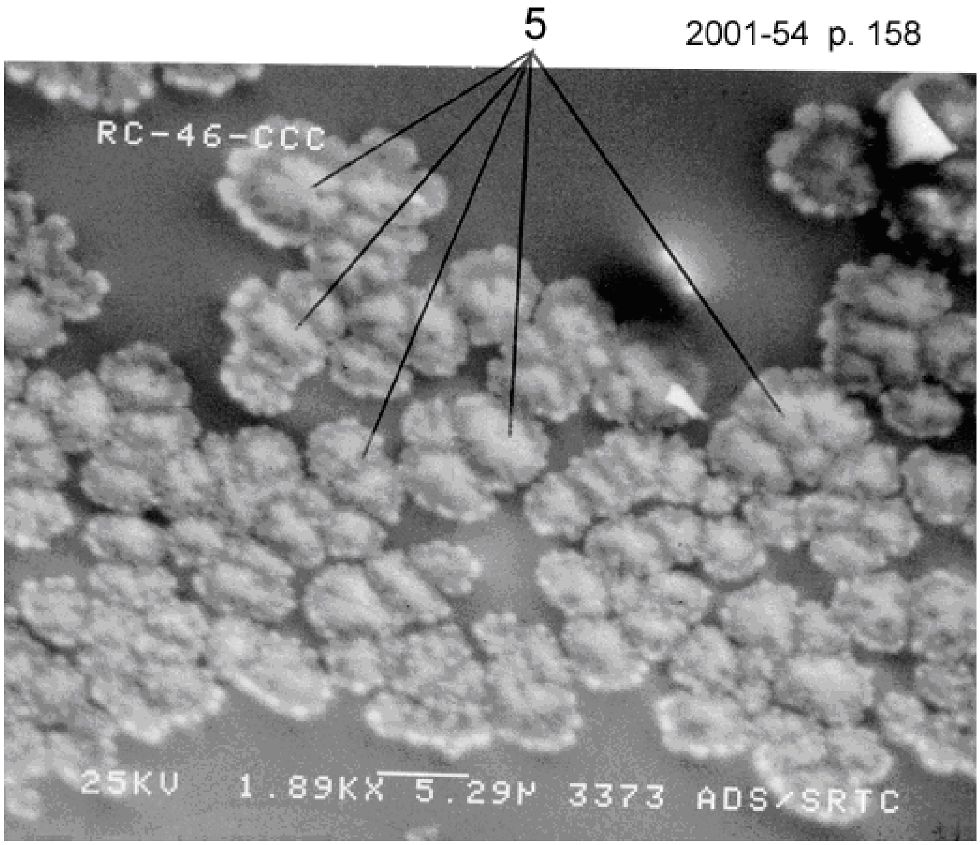

Figure 27. Crystal "Clusters" Associated with RC-46ccc

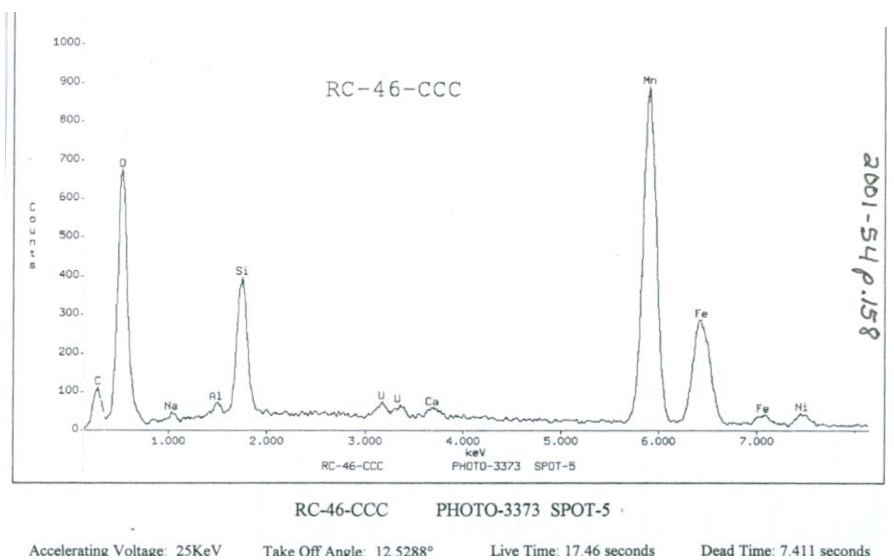

Figure 28. EDS Analysis of RC-46ccc "Clusters" **(Spot #5 in Figure 27)**

As previously mentioned, all of the XRD patterns for both the quenched and ccc versions of each RC glass can be found in Appendix F. Table 6 summarizes the XRD results of the quenched and ccc RC glasses as well as the SEM/EDS analysis.

Table 6. Summary of Quenched and ccc XRD and ccc SEM Analysis of the RC Glasses

Glass	XRD Quenched	XRD ccc	SEM/EDS ccc
RC-25	Amorphous	Amorphous	Fe, Mn, Ni-based crystals and clusters
RC-26	Amorphous	Amorphous	-
RC-27	Amorphous	Amorphous	-
RC-28	Amorphous	Amorphous	Fe, Mn, Ni-based crystals, clusters, and dendrites
RC-29	Amorphous	Amorphous	-
RC-30	Amorphous	Trevorite [(a)]	Fe, Mn, Ni-based crystals
RC-31	Amorphous	Amorphous	-
RC-31.5	Amorphous	Amorphous	-
RC-32	Amorphous	Amorphous	-
RC-33	Amorphous	Trevorite	Fe, Mn, Ni-based crystals
RC-34	Amorphous	Amorphous	-
RC-35	Amorphous	Amorphous	-
RC-36	Amorphous	Amorphous	-
RC-37	Amorphous	Amorphous	-
RC-38	Amorphous	Acmite,[(b)] Trevorite	Fe, Mn, Ni-based crystals
RC-39	Amorphous	Acmite, Trevorite	-
RC-40	Amorphous	Acmite, Trevorite	Fe, Mn, Ni, Cr-based crystals
RC-41	Amorphous	Acmite	-
RC-42	Amorphous	Acmite	-
RC-43	Amorphous	Acmite	-
RC-44	Amorphous	Acmite, Trevorite	-
RC-45	Amorphous	Amorphous	-
RC-46	Amorphous	Trevorite	Fe, Mn, Ni-based crystals, clusters, and dendrites
RC-47	Amorphous	Trevorite	Fe, Mn, Ni-based crystals, clusters, and dendrites
RC-48	Amorphous	Trevorite	-
RC-49	Amorphous	Amorphous	-
RC-50	Amorphous	Trevorite	Fe, Mn, Ni-based crystals
RC-51	Amorphous	Amorphous	-
RC-52	Amorphous	Amorphous	-
RC-53	Amorphous	Trevorite	Fe, Mn, Ni-based crystals
RC-54	Amorphous	Amorphous	-
RC-55	Amorphous	Amorphous	-
RC-56	Amorphous	Amorphous	-
RC-57	Amorphous	Amorphous	Fe, Mn, Ni-based crystals

(a) Trevorite ($NiFe_2O_4$) was reported by XRD analysis.
(b) Acmite (or aegirine) ($NaFeSi_2O_6$) was reported by XRD analysis.

6.3 Durability as Measured by the PCT

This section provides a statistical review of the PCT measurements, the measurements in analytical sequence, the results for the multi-element solution standards, the measurements by glass number, the normalized PCT results, the predicted vs measured PCTs, and the quenched vs ccc results.

6.3.1 A Statistical Review of the PCT Measurements

The PCTs were conducted in groups by frit type (i.e., 165, 200, and 320), and analytical plans (provided in Appendices B, C, and D) were provided to the SRTC-ML to support the measurement of the compositions of the solutions resulting from these PCTs. In addition, leachates for RC-31.5 (the re-batched RC-31 glass), both quenched and ccc, were submitted to the SRTC-ML as part of a supplemental plan that included EA and ARM.[a] Samples of a multi-element, standard solution were also included in all of these analytical plans (as a check on the accuracy of the ICP-AES used for these measurements). The measurements generated by the SRTC-ML for these PCTs are presented and reviewed in this section and Appendix G.

Table G.1 (see Appendix G) provides the elemental leachate concentration measurements determined by the SRTC-ML for the solution samples generated by the PCTs.[b] The PCT results for the ccc glasses are indicated by a "ccc" suffix. One of the quality-control checkpoints for the PCT procedure is solution-weight loss over the course of the 7-day test. A "Yes" in the Table G.1 column with heading "Water-Loss Problem" is used to indicate a solution that fell outside the weight-loss guidelines (weight loss must be less than 5%). Two successful solutions out of the three conducted for a glass are required to generate a representative PCT for that glass (ASTM 1997). This criterion was satisfied for both the quenched and ccc versions of the RC glasses after the PCT results were screened for a water-loss problem. In the discussion that follows, the screened and unscreened (all available) versions of the PCT values are considered in analyses that follow.

Any measurement in the "As-Reported Concentrations" columns of Table G.1 below the detection limit of the analytical procedure (indicated by a "<") was replaced by ½ of the detection limit in the "Concentrations in ppm Adjusted for Dilution Factor" columns. In addition to adjustments for detection limits, these values were adjusted for the dilution factors: the values for the RC and ARM glasses in the as-reported columns were multiplied by 1.6667 to determine the ppm values, and the values for EA were multiplied by 16.6667.

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, the quenched versus ccc results are compared, the PCT values are normalized using the compositions (targeted, measured,

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(a) As previously discussed, given the batching issues with RC-31, a separate analytical plan was developed for RC-31.5 to support the analysis of the quenched and ccc PCT solutions. The analytical plan can be found on page 25 of WSRC-NB-2001-00056.

(b) The symbols used in the Appendix G exhibits are based on the following nomenclature: colored symbols represent the PCT responses (both quenched and ccc) for the various RC glasses and solution standards. The small squares were used for the solution standards and for all individual PCT responses that did not have a water-loss issue. The "x" represents those individual PCT responses in which a water-loss issue (> 5%) was identified.

and bias-corrected) presented in Appendix E, and the normalized PCT values are compared to durability predictions for those compositions generated from the current DWPF model (Brown and Postles 1996).

6.3.2 Measurements in Analytical Sequence

Exhibit G.1 provides plots of the leachate (ppm) concentrations in analytical sequence as generated by the SRTC-ML including all of the standards. The results for one set of PCT values are at much higher concentrations than the others, which distorts the scales of the plots. The higher leachate concentrations correspond to the EA PCT values. Exhibit G.2 provides the same plots with the EA results excluded. No problems are seen in these plots.

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

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

Table 7 summarizes the average measurements and the reference values for the four elements. The results indicate consistent and accurate measurements from the SRTC-ML processes used to conduct these analyses.

Table 7. Results from Samples of the Multi-Element Solution Standard

Analytical Block	Avg (ppm)			
	B	Li	Na	Si
1	21.0	9.9	82.1	52.2
2	20.5	9.6	82.4	50.5
3	20.7	9.7	80.0	50.2
4	20.7	9.6	80.2	50.9
5	20.3	9.7	82.5	50.5
6	20.4	9.7	83.7	50.5
Grand Average	20.6	9.7	81.8	50.8
Reference Value	20	10	81	50
% difference	2.9%	-3.0%	1.0%	1.6%

6.3.4 Measurements by Glass Number

Exhibit G.4 provides plots of the leachate concentrations for each type of submitted sample: the standards (0 – multi-element solution standard, 100 – EA, 101 – ARM, and 102 – blanks), ccc RC glasses, and quenched RC glasses (with the RC glasses being identified by glass number). These plots allow for the assessment of the repeatability of the measurements, which suggests no obvious outliers among these data.

6.3.5 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 PCT values is usually conducted using the measured compositions of the glasses. This is the preferred normalization process. For completeness, the targeted cation and the bias-corrected cation compositions will also be 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 will be 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 G.6 of Appendix G)

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

Normalizing Using Measured Composition (preferred method)

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

Or *Normalizing Using Targeted Composition*

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

Or *Normalizing Using Measured Bias-Corrected Composition*

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

In Step 2, all the PCT values for a glass were used to generate an "unscreened" normalized PCT for that glass, and only those PCT values satisfying the water-loss criterion were used to derive the "screened" normalized PCT for the glass.

Exhibit G.7 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. Both screened and unscreened versions of the PCTs for each glass are considered, both quenched and ccc versions of the glasses are explored, and the normalization of the PCT values using the targeted, measured, and bias-corrected compositional views are represented.

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 pairs of the elements. The smallest correlation (~84%) is between B and Si for the ccc PCT values normalized using the bias-corrected compositions with most of the correlations being above 90%.

Table 8 summarizes the normalized PCT values for the glasses of this study.

Table 8. Both Screened and Not Screened Normalized PCT Values by Glass by Composition View by Heat Treatment

Glass ID	Screened Versus Not Screened	Composition	Results from Quenched Glasses: 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)	Results from ccc Glasses: 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	Not Screened	-	-0.2668	-0.2027	-0.2716	-0.5162	0.541	0.627	0.535	0.305	-	-	-	-	-	-	-	-
ARM	Screened	-	-0.2668	-0.2027	-0.2716	-0.5162	0.541	0.627	0.535	0.305	-	-	-	-	-	-	-	-
ARM	Not Screened	-	-0.2820	-0.2334	-0.3013	-0.5503	0.522	0.584	0.500	0.282	-	-	-	-	-	-	-	-
ARM	Screened	-	-0.2820	-0.2334	-0.3013	-0.5503	0.522	0.584	0.500	0.282	-	-	-	-	-	-	-	-
ARM	Not Screened	-	-0.2479	-0.1977	-0.2448	-0.5155	0.565	0.634	0.569	0.305	-	-	-	-	-	-	-	-
ARM	Screened	-	-0.2479	-0.1977	-0.2448	-0.5155	0.565	0.634	0.569	0.305	-	-	-	-	-	-	-	-
ARM	Not Screened	-	-0.2504	-0.2077	-0.2616	-0.5288	0.562	0.620	0.547	0.296	-	-	-	-	-	-	-	-
ARM	Screened	-	-0.2504	-0.2077	-0.2616	-0.5288	0.562	0.620	0.547	0.296	-	-	-	-	-	-	-	-
	Not Screened	Meas.	0.1475	0.1045	0.0914	-0.1653	1.404	1.272	1.234	0.684	0.1517	0.1417	0.0893	-0.1463	1.418	1.386	1.228	0.714
RC-25		Meas. bc	0.1522	0.1039	0.1110	-0.1594	1.420	1.270	1.291	0.693	0.1564	0.1411	0.1089	-0.1405	1.434	1.384	1.285	0.724
		Target	0.1271	0.0853	0.0928	-0.1615	1.340	1.217	1.238	0.690	0.1313	0.1225	0.0907	-0.1425	1.353	1.326	1.232	0.720
	Screened	Meas.	0.1475	0.1045	0.0914	-0.1653	1.404	1.272	1.234	0.684	0.1517	0.1417	0.0893	-0.1463	1.418	1.386	1.228	0.714
RC-25		Meas. bc	0.1522	0.1039	0.1110	-0.1594	1.420	1.270	1.291	0.693	0.1564	0.1411	0.1089	-0.1405	1.434	1.384	1.285	0.724
		Target	0.1271	0.0853	0.0928	-0.1615	1.340	1.217	1.238	0.690	0.1313	0.1225	0.0907	-0.1425	1.353	1.326	1.232	0.720
	Not Screened	Meas.	0.2152	0.1549	0.1421	-0.1517	1.641	1.429	1.387	0.705	0.1991	0.1745	0.1291	-0.1489	1.582	1.494	1.346	0.710
RC-26		Meas. bc	0.2181	0.1531	0.1629	-0.1467	1.652	1.423	1.455	0.713	0.2020	0.1726	0.1498	-0.1439	1.592	1.488	1.412	0.718
		Target	0.1851	0.1265	0.1317	-0.1354	1.531	1.338	1.354	0.732	0.1690	0.1461	0.1186	-0.1326	1.476	1.400	1.314	0.737
	Screened	Meas.	0.2152	0.1549	0.1421	-0.1517	1.641	1.429	1.387	0.705	0.1991	0.1745	0.1291	-0.1489	1.582	1.494	1.346	0.710
RC-26		Meas. bc	0.2181	0.1531	0.1629	-0.1467	1.652	1.423	1.455	0.713	0.2020	0.1726	0.1498	-0.1439	1.592	1.488	1.412	0.718
		Target	0.1851	0.1265	0.1317	-0.1354	1.531	1.338	1.354	0.732	0.1690	0.1461	0.1186	-0.1326	1.476	1.400	1.314	0.737
	Not Screened	Meas.	0.3537	0.2993	0.2563	0.0161	2.258	1.992	1.804	1.038	0.3031	0.2621	0.2115	-0.0246	2.010	1.829	1.628	0.945
RC-27		Meas. bc	0.3579	0.2985	0.2741	0.0238	2.280	1.988	1.880	1.056	0.3073	0.2613	0.2293	-0.0169	2.029	1.825	1.696	0.962
		Target	0.3170	0.2680	0.2519	0.0034	2.075	1.854	1.786	1.008	0.2665	0.2309	0.2071	-0.0373	1.847	1.702	1.611	0.918
	Screened	Meas.	0.3537	0.2993	0.2563	0.0161	2.258	1.992	1.804	1.038	0.3031	0.2621	0.2115	-0.0246	2.010	1.829	1.628	0.945
RC-27		Meas. bc	0.3579	0.2985	0.2741	0.0238	2.280	1.988	1.880	1.056	0.3073	0.2613	0.2293	-0.0169	2.029	1.825	1.696	0.962
		Target	0.3170	0.2680	0.2519	0.0034	2.075	1.854	1.786	1.008	0.2665	0.2309	0.2071	-0.0373	1.847	1.702	1.611	0.918
	Not Screened	Meas.	0.1890	0.1410	0.1209	-0.1318	1.545	1.383	1.321	0.738	0.1733	0.1435	0.0932	-0.1351	1.490	1.392	1.240	0.733
RC-28		Meas. bc	0.1949	0.1414	0.1407	-0.1234	1.566	1.385	1.383	0.753	0.1792	0.1439	0.1130	-0.1267	1.511	1.393	1.297	0.747
		Target	0.1601	0.1155	0.1220	-0.1344	1.446	1.305	1.324	0.734	0.1444	0.1180	0.0944	-0.1377	1.395	1.312	1.243	0.728
	Screened	Meas.	0.1890	0.1410	0.1209	-0.1318	1.545	1.383	1.321	0.738	0.1733	0.1435	0.0932	-0.1351	1.490	1.392	1.240	0.733
RC-28		Meas. bc	0.1949	0.1414	0.1407	-0.1234	1.566	1.385	1.383	0.753	0.1792	0.1439	0.1130	-0.1267	1.511	1.393	1.297	0.747
		Target	0.1601	0.1155	0.1220	-0.1344	1.446	1.305	1.324	0.734	0.1444	0.1180	0.0944	-0.1377	1.395	1.312	1.243	0.728

Table 8. Both Screened and Not Screened Normalized PCT Values by Glass by Composition View by Heat Treatment *(continued)*

Glass ID	Screened versus Not Screened	Composition	Results from quenched Glasses 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)	Results from ccc Glasses 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)
	Not Screened	Meas.	0.0741	0.0548	0.0342	-0.1911	1.186	1.135	1.082	0.644	0.0942	0.0960	0.0381	-0.1661	1.242	1.247	1.092	0.682
RC-29		Meas. bc	0.0794	0.0551	0.0561	-0.1809	1.201	1.135	1.138	0.659	0.0995	0.0962	0.0599	-0.1559	1.257	1.248	1.148	0.698
		Target	0.0547	0.0393	0.0435	-0.1839	1.134	1.095	1.105	0.655	0.0748	0.0805	0.0473	-0.1590	1.188	1.204	1.115	0.694
	Screened	Meas.	0.0741	0.0548	0.0342	-0.1911	1.186	1.135	1.082	0.644	0.0822	0.0938	0.0415	-0.1731	1.208	1.241	1.100	0.671
RC-29		Meas. bc	0.0794	0.0551	0.0561	-0.1809	1.201	1.135	1.138	0.659	0.0875	0.0940	0.0633	-0.1629	1.223	1.242	1.157	0.687
		Target	0.0547	0.0393	0.0435	-0.1839	1.134	1.095	1.105	0.655	0.0628	0.0783	0.0508	-0.1659	1.156	1.198	1.124	0.682
	Not Screened	Meas.	0.7389	0.6196	0.5863	0.2415	5.482	4.165	3.857	1.744	0.4053	0.3862	0.3139	0.0921	2.543	2.433	2.060	1.236
RC-30		Meas. bc	0.7419	0.6177	0.6070	0.2466	5.519	4.147	4.046	1.764	0.4083	0.3843	0.3346	0.0972	2.560	2.423	2.161	1.251
		Target	0.7268	0.6107	0.5963	0.2540	5.331	4.080	3.947	1.795	0.3932	0.3773	0.3239	0.1046	2.473	2.384	2.108	1.272
	Screened	Meas.	0.7389	0.6196	0.5863	0.2415	5.482	4.165	3.857	1.744	0.4053	0.3862	0.3139	0.0921	2.543	2.433	2.060	1.236
RC-30		Meas. bc	0.7419	0.6177	0.6070	0.2466	5.519	4.147	4.046	1.764	0.4083	0.3843	0.3346	0.0972	2.560	2.423	2.161	1.251
		Target	0.7268	0.6107	0.5963	0.2540	5.331	4.080	3.947	1.795	0.3932	0.3773	0.3239	0.1046	2.473	2.384	2.108	1.272
	Not Screened	Meas.	-0.2336	-0.1101	-0.1239	-0.3391	0.584	0.776	0.752	0.458	-0.2662	-0.1207	-0.1725	-0.3447	0.542	0.757	0.672	0.452
RC-31		Meas. bc	-0.2307	-0.1120	-0.1041	-0.3341	0.588	0.773	0.787	0.463	-0.2633	-0.1226	-0.1526	-0.3397	0.545	0.754	0.704	0.457
		Target	-0.2420	-0.1193	-0.1098	-0.3450	0.573	0.760	0.777	0.452	-0.2746	-0.1299	-0.1584	-0.3506	0.531	0.742	0.694	0.446
	Screened	Meas.	-0.2336	-0.1101	-0.1239	-0.3391	0.584	0.776	0.752	0.458	-0.2662	-0.1207	-0.1725	-0.3447	0.542	0.757	0.672	0.452
RC-31		Meas. bc	-0.2307	-0.1120	-0.1041	-0.3341	0.588	0.773	0.787	0.463	-0.2633	-0.1226	-0.1526	-0.3397	0.545	0.754	0.704	0.457
		Target	-0.2420	-0.1193	-0.1098	-0.3450	0.573	0.760	0.777	0.452	-0.2746	-0.1299	-0.1584	-0.3506	0.531	0.742	0.694	0.446
	Not Screened	Meas.	-0.2238	-0.1525	-0.1812	-0.4062	0.597	0.704	0.659	0.392	-0.2334	-0.1552	-0.1968	-0.3994	0.584	0.699	0.636	0.399
RC-31.5		Meas. bc	-0.2152	-0.1612	-0.1719	-0.4003	0.609	0.690	0.673	0.398	-0.2247	-0.1640	-0.1875	-0.3935	0.596	0.686	0.649	0.404
		Target	-0.2375	-0.1780	-0.1925	-0.4023	0.579	0.664	0.642	0.396	-0.2470	-0.1808	-0.2081	-0.3956	0.566	0.659	0.619	0.402
	Screened	Meas.	-0.2238	-0.1525	-0.1812	-0.4062	0.597	0.704	0.659	0.392	-0.2334	-0.1552	-0.1968	-0.3994	0.584	0.699	0.636	0.399
RC-31.5		Meas. bc	-0.2152	-0.1612	-0.1719	-0.4003	0.609	0.690	0.673	0.398	-0.2247	-0.1640	-0.1875	-0.3935	0.596	0.686	0.649	0.404
		Target	-0.2375	-0.1780	-0.1925	-0.4023	0.579	0.664	0.642	0.396	-0.2470	-0.1808	-0.2081	-0.3956	0.566	0.659	0.619	0.402
	Not Screened	Meas.	0.1476	0.1098	0.1197	-0.1493	1.405	1.288	1.317	0.709	0.1255	0.0919	0.0795	-0.1636	1.335	1.236	1.201	0.686
RC-32		Meas. Bc	0.1535	0.1102	0.1395	-0.1409	1.424	1.289	1.379	0.723	0.1314	0.0923	0.0993	-0.1552	1.353	1.237	1.257	0.699
		Target	0.1426	0.1050	0.1256	-0.1347	1.389	1.274	1.335	0.733	0.1205	0.0871	0.0854	-0.1491	1.320	1.222	1.217	0.709
	Screened	Meas.	0.1370	0.1058	0.1299	-0.1469	1.371	1.276	1.349	0.713	0.1255	0.0919	0.0795	-0.1636	1.335	1.236	1.201	0.686
RC-32		Meas. Bc	0.1429	0.1063	0.1497	-0.1385	1.390	1.277	1.411	0.727	0.1314	0.0923	0.0993	-0.1552	1.353	1.237	1.257	0.699
		Target	0.1320	0.1011	0.1357	-0.1324	1.355	1.262	1.367	0.737	0.1205	0.0871	0.0854	-0.1491	1.320	1.222	1.217	0.709
	Not Screened	Meas.	0.1885	0.1345	0.1527	-0.1386	1.543	1.363	1.421	0.727	0.1632	0.1331	0.1229	-0.1480	1.456	1.358	1.327	0.711
RC-33		Meas. bc	0.1926	0.1337	0.1724	-0.1309	1.558	1.360	1.487	0.740	0.1673	0.1322	0.1426	-0.1404	1.470	1.356	1.389	0.724
		Target	0.1799	0.1272	0.1507	-0.1151	1.513	1.340	1.415	0.767	0.1546	0.1257	0.1209	-0.1245	1.427	1.336	1.321	0.751
	Screened	Meas.	0.1704	0.1233	0.1479	-0.1519	1.481	1.328	1.406	0.705	0.1614	0.1326	0.1189	-0.1484	1.450	1.357	1.315	0.711
RC-33		Meas. bc	0.1745	0.1225	0.1677	-0.1443	1.495	1.326	1.471	0.717	0.1656	0.1318	0.1386	-0.1408	1.464	1.355	1.376	0.723
		Target	0.1618	0.1160	0.1459	-0.1285	1.451	1.306	1.399	0.744	0.1528	0.1253	0.1169	-0.1249	1.422	1.334	1.309	0.750

Table 8. Both Screened and Not Screened Normalized PCT Values by Glass by Composition View by Heat Treatment *(continued)*

Glass ID	Screened versus Not Screened	Composition	Results from Quenched Glasses								Results from ccc Glasses							
			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)	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)
	Not Screened	Meas.	0.1480	0.1117	0.1088	-0.1356	1.406	1.293	1.285	0.732	0.1387	0.1284	0.0869	-0.1413	1.376	1.344	1.222	0.722
RC-34		Meas. bc	0.1533	0.1119	0.1307	-0.1254	1.423	1.294	1.351	0.749	0.1440	0.1287	0.1088	-0.1311	1.393	1.345	1.285	0.739
		Target	0.1260	0.0980	0.1080	-0.1334	1.337	1.253	1.282	0.736	0.1167	0.1148	0.0861	-0.1391	1.308	1.302	1.219	0.726
	Screened	Meas.	0.1480	0.1117	0.1088	-0.1356	1.406	1.293	1.285	0.732	0.1386	0.1214	0.0707	-0.1473	1.376	1.322	1.177	0.712
RC-34		Meas. bc	0.1533	0.1119	0.1307	-0.1254	1.423	1.294	1.351	0.749	0.1439	0.1216	0.0926	-0.1371	1.393	1.323	1.238	0.729
		Target	0.1260	0.0980	0.1080	-0.1334	1.337	1.253	1.282	0.736	0.1166	0.1077	0.0700	-0.1451	1.308	1.281	1.175	0.716
	Not Screened	Meas.	0.1725	0.1372	0.1195	-0.1188	1.488	1.371	1.317	0.761	0.1667	0.1617	0.1078	-0.1067	1.468	1.451	1.282	0.782
RC-35		Meas. bc	0.1772	0.1365	0.1391	-0.1130	1.504	1.369	1.378	0.771	0.1714	0.1611	0.1273	-0.1009	1.484	1.449	1.341	0.793
		Target	0.1548	0.1204	0.1225	-0.1115	1.428	1.319	1.326	0.774	0.1490	0.1450	0.1108	-0.0994	1.409	1.396	1.291	0.795
	Screened	Meas.	0.1725	0.1372	0.1195	-0.1188	1.488	1.371	1.317	0.761	0.1663	0.1560	0.0995	-0.1061	1.466	1.432	1.257	0.783
RC-35		Meas. bc	0.1772	0.1365	0.1391	-0.1130	1.504	1.369	1.378	0.771	0.1710	0.1553	0.1190	-0.1003	1.482	1.430	1.315	0.794
		Target	0.1548	0.1204	0.1225	-0.1115	1.428	1.319	1.326	0.774	0.1486	0.1392	0.1025	-0.0988	1.408	1.378	1.266	0.797
	Not Screened	Meas.	0.7873	0.7416	0.6090	0.3386	6.128	5.516	4.065	2.180	0.6730	0.6338	0.5066	0.2416	4.710	4.304	3.211	1.744
RC-36		Meas. bc	0.7920	0.7409	0.6286	0.3444	6.194	5.507	4.252	2.210	0.6777	0.6332	0.5262	0.2474	4.761	4.297	3.359	1.768
		Target	0.7694	0.7305	0.6108	0.3343	5.880	5.376	4.082	2.159	0.6551	0.6227	0.5084	0.2373	4.519	4.195	3.224	1.727
	Screened	Meas.	0.7873	0.7416	0.6090	0.3386	6.128	5.516	4.065	2.180	0.6730	0.6338	0.5066	0.2416	4.710	4.304	3.211	1.744
RC-36		Meas. bc	0.7920	0.7409	0.6286	0.3444	6.194	5.507	4.252	2.210	0.6777	0.6332	0.5262	0.2474	4.761	4.297	3.359	1.768
		Target	0.7694	0.7305	0.6108	0.3343	5.880	5.376	4.082	2.159	0.6551	0.6227	0.5084	0.2373	4.519	4.195	3.224	1.727
	Not Screened	Meas.	0.2579	0.2148	0.1800	-0.0410	1.811	1.640	1.514	0.910	0.2160	0.1969	0.1425	-0.0676	1.644	1.574	1.388	0.856
RC-37		Meas. bc	0.2638	0.2152	0.1979	-0.0326	1.836	1.641	1.577	0.928	0.2219	0.1973	0.1603	-0.0592	1.667	1.575	1.447	0.873
		Target	0.2350	0.1942	0.1777	-0.0498	1.718	1.564	1.506	0.892	0.1931	0.1763	0.1402	-0.0765	1.560	1.501	1.381	0.839
	Screened	Meas.	0.2579	0.2148	0.1800	-0.0410	1.811	1.640	1.514	0.910	0.2123	0.1927	0.1392	-0.0706	1.630	1.558	1.378	0.850
RC-37		Meas. bc	0.2638	0.2152	0.1979	-0.0326	1.836	1.641	1.577	0.928	0.2182	0.1931	0.1570	-0.0622	1.653	1.560	1.435	0.867
		Target	0.2350	0.1942	0.1777	-0.0498	1.718	1.564	1.506	0.892	0.1894	0.1721	0.1368	-0.0795	1.547	1.486	1.370	0.833
	Not Screened	Meas.	0.0014	0.0035	-0.0515	-0.2639	1.003	1.008	0.888	0.545	0.0379	0.0111	-0.0530	-0.2691	1.091	1.026	0.885	0.538
RC-38		Meas. Bc	0.0061	0.0028	-0.0298	-0.2581	1.014	1.007	0.934	0.552	0.0426	0.0104	-0.0312	-0.2633	1.103	1.024	0.931	0.545
		Target	-0.0230	-0.0253	-0.0590	-0.2572	0.948	0.943	0.873	0.553	0.0136	-0.0177	-0.0605	-0.2624	1.032	0.960	0.870	0.546
	Screened	Meas.	0.0014	0.0035	-0.0515	-0.2639	1.003	1.008	0.888	0.545	0.0323	0.0019	-0.0555	-0.2754	1.077	1.004	0.880	0.530
RC-38		Meas. Bc	0.0061	0.0028	-0.0298	-0.2581	1.014	1.007	0.934	0.552	0.0370	0.0012	-0.0337	-0.2696	1.089	1.003	0.925	0.537
		Target	-0.0230	-0.0253	-0.0590	-0.2572	0.948	0.943	0.873	0.553	0.0079	-0.0269	-0.0630	-0.2688	1.018	0.940	0.865	0.539
	Not Screened	Meas.	0.0154	0.0050	-0.0377	-0.2587	1.036	1.012	0.917	0.551	0.2161	0.1417	0.0512	-0.2239	1.645	1.386	1.125	0.597
RC-39		Meas. bc	0.0201	0.0043	-0.0179	-0.2529	1.047	1.010	0.960	0.559	0.2208	0.1410	0.0710	-0.2181	1.663	1.384	1.178	0.605
		Target	-0.0050	-0.0183	-0.0418	-0.2548	0.989	0.959	0.908	0.556	0.1957	0.1185	0.0471	-0.2201	1.569	1.314	1.114	0.602
	Screened	Meas.	0.0154	0.0050	-0.0377	-0.2587	1.036	1.012	0.917	0.551	0.2161	0.1417	0.0512	-0.2239	1.645	1.386	1.125	0.597
RC-39		Meas. bc	0.0201	0.0043	-0.0179	-0.2529	1.047	1.010	0.960	0.559	0.2208	0.1410	0.0710	-0.2181	1.663	1.384	1.178	0.605
		Target	-0.0050	-0.0183	-0.0418	-0.2548	0.989	0.959	0.908	0.556	0.1957	0.1185	0.0471	-0.2201	1.569	1.314	1.114	0.602

Table 8. Both Screened and Not Screened Normalized PCT Values by Glass by Composition View by Heat Treatment *(continued)*

Glass ID	Screened versus Not Screened	Composition	Results from quenched Glasses 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)	Results from ccc Glasses 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)
	Not Screened	Meas.	0.3079	0.2265	0.1991	-0.1002	2.032	1.685	1.582	0.794	0.5115	0.4523	0.3676	0.0733	3.247	2.833	2.331	1.184
RC-40		Meas. bc	0.3132	0.2268	0.2178	-0.0900	2.057	1.686	1.651	0.813	0.5169	0.4525	0.3863	0.0836	3.287	2.835	2.434	1.212
		Target	0.2893	0.2094	0.2046	-0.0867	1.947	1.620	1.602	0.819	0.4929	0.4351	0.3732	0.0868	3.111	2.724	2.361	1.221
	Screened	Meas.	0.3079	0.2265	0.1991	-0.1002	2.032	1.685	1.582	0.794	0.5115	0.4523	0.3676	0.0733	3.247	2.833	2.331	1.184
RC-40		Meas. bc	0.3132	0.2268	0.2178	-0.0900	2.057	1.686	1.651	0.813	0.5169	0.4525	0.3863	0.0836	3.287	2.835	2.434	1.212
		Target	0.2893	0.2094	0.2046	-0.0867	1.947	1.620	1.602	0.819	0.4929	0.4351	0.3732	0.0868	3.111	2.724	2.361	1.221
	Not Screened	Meas.	0.0166	0.0036	-0.0554	-0.2363	1.039	1.008	0.880	0.580	0.0224	0.0076	-0.0525	-0.2341	1.053	1.018	0.886	0.583
RC-41		Meas. bc	0.0231	0.0042	-0.0367	-0.2297	1.055	1.010	0.919	0.589	0.0289	0.0082	-0.0338	-0.2275	1.069	1.019	0.925	0.592
		Target	0.0003	-0.0050	-0.0517	-0.2444	1.001	0.989	0.888	0.570	0.0061	-0.0010	-0.0488	-0.2423	1.014	0.998	0.894	0.572
	Screened	Meas.	0.0166	0.0029	-0.0560	-0.2355	1.039	1.007	0.879	0.581	0.0153	0.0008	-0.0589	-0.2399	1.036	1.002	0.873	0.576
RC-41		Meas. bc	0.0231	0.0035	-0.0374	-0.2289	1.055	1.008	0.918	0.590	0.0218	0.0014	-0.0402	-0.2333	1.051	1.003	0.912	0.584
		Target	0.0003	-0.0057	-0.0524	-0.2436	1.001	0.987	0.886	0.571	-0.0011	-0.0078	-0.0552	-0.2480	0.998	0.982	0.881	0.565
	Not Screened	Meas.	-0.0172	-0.0158	-0.0803	-0.2692	0.961	0.964	0.831	0.538	0.2792	0.1954	0.0658	-0.2313	1.902	1.568	1.164	0.587
RC-42		Meas. bc	-0.0132	-0.0166	-0.0616	-0.2617	0.970	0.962	0.868	0.547	0.2833	0.1946	0.0845	-0.2238	1.920	1.565	1.215	0.597
		Target	-0.0329	-0.0306	-0.0722	-0.2628	0.927	0.932	0.847	0.546	0.2636	0.1806	0.0738	-0.2249	1.835	1.516	1.185	0.596
	Screened	Meas.	-0.0172	-0.0158	-0.0803	-0.2692	0.961	0.964	0.831	0.538	0.2792	0.1954	0.0658	-0.2313	1.902	1.568	1.164	0.587
RC-42		Meas. bc	-0.0132	-0.0166	-0.0616	-0.2617	0.970	0.962	0.868	0.547	0.2833	0.1946	0.0845	-0.2238	1.920	1.565	1.215	0.597
		Target	-0.0329	-0.0306	-0.0722	-0.2628	0.927	0.932	0.847	0.546	0.2636	0.1806	0.0738	-0.2249	1.835	1.516	1.185	0.596
	Not Screened	Meas.	0.0771	0.0458	0.0069	-0.2337	1.194	1.111	1.016	0.584	0.4113	0.3085	0.1865	-0.1744	2.578	2.035	1.536	0.669
RC-43		Meas. bc	0.0824	0.0460	0.0267	-0.2235	1.209	1.112	1.063	0.598	0.4166	0.3087	0.2064	-0.1642	2.610	2.036	1.608	0.685
		Target	0.0510	0.0212	0.0057	-0.2200	1.125	1.050	1.013	0.603	0.3852	0.2839	0.1853	-0.1607	2.427	1.923	1.532	0.691
	Screened	Meas.	0.0771	0.0458	0.0069	-0.2337	1.194	1.111	1.016	0.584	0.4113	0.3085	0.1865	-0.1744	2.578	2.035	1.536	0.669
RC-43		Meas. bc	0.0824	0.0460	0.0267	-0.2235	1.209	1.112	1.063	0.598	0.4166	0.3087	0.2064	-0.1642	2.610	2.036	1.608	0.685
		Target	0.0510	0.0212	0.0057	-0.2200	1.125	1.050	1.013	0.603	0.3852	0.2839	0.1853	-0.1607	2.427	1.923	1.532	0.691
	Not Screened	Meas.	0.0213	0.0105	-0.0397	-0.2512	1.050	1.025	0.913	0.561	0.0449	0.0193	-0.0559	-0.2617	1.109	1.045	0.879	0.547
RC-44		Meas. bc	0.0260	0.0099	-0.0210	-0.2454	1.062	1.023	0.953	0.568	0.0496	0.0186	-0.0372	-0.2559	1.121	1.044	0.918	0.555
		Target	0.0007	-0.0055	-0.0438	-0.2437	1.002	0.987	0.904	0.571	0.0243	0.0033	-0.0600	-0.2542	1.057	1.008	0.871	0.557
	Screened	Meas.	0.0213	0.0105	-0.0397	-0.2512	1.050	1.025	0.913	0.561	0.0449	0.0193	-0.0559	-0.2617	1.109	1.045	0.879	0.547
RC-44		Meas. bc	0.0260	0.0099	-0.0210	-0.2454	1.062	1.023	0.953	0.568	0.0496	0.0186	-0.0372	-0.2559	1.121	1.044	0.918	0.555
		Target	0.0007	-0.0055	-0.0438	-0.2437	1.002	0.987	0.904	0.571	0.0243	0.0033	-0.0600	-0.2542	1.057	1.008	0.871	0.557
	Not Screened	Meas.	0.1481	0.1295	0.1127	-0.0935	1.406	1.347	1.296	0.806	0.1902	0.1906	0.1264	-0.0578	1.549	1.551	1.338	0.875
RC-45		Meas. bc	0.1528	0.1288	0.1334	-0.0877	1.422	1.345	1.359	0.817	0.1949	0.1899	0.1471	-0.0520	1.566	1.549	1.403	0.887
		Target	0.1242	0.1010	0.1064	-0.1041	1.331	1.262	1.278	0.787	0.1662	0.1621	0.1201	-0.0684	1.466	1.453	1.319	0.854
	Screened	Meas.	0.1481	0.1295	0.1127	-0.0935	1.406	1.347	1.296	0.806	0.1902	0.1906	0.1264	-0.0578	1.549	1.551	1.338	0.875
RC-45		Meas. bc	0.1528	0.1288	0.1334	-0.0877	1.422	1.345	1.359	0.817	0.1949	0.1899	0.1471	-0.0520	1.566	1.549	1.403	0.887
		Target	0.1242	0.1010	0.1064	-0.1041	1.331	1.262	1.278	0.787	0.1662	0.1621	0.1201	-0.0684	1.466	1.453	1.319	0.854

Table 8. Both Screened and Not Screened Normalized PCT Values by Glass by Composition View by Heat Treatment *(continued)*

			Results from quenched Glasses								Results from ccc Glasses							
Glass ID	Screened versus Not Screened	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)	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)
	Not Screened	Meas.	0.5137	0.4276	0.4194	0.1668	3.264	2.676	2.627	1.468	0.3857	0.3548	0.3113	0.0954	2.431	2.264	2.048	1.246
RC-46		Meas. bc	0.5184	0.4269	0.4372	0.1726	3.299	2.672	2.737	1.488	0.3905	0.3542	0.3291	0.1012	2.457	2.260	2.133	1.263
		Target	0.5024	0.4135	0.4237	0.1782	3.180	2.591	2.653	1.507	0.3744	0.3407	0.3156	0.1069	2.368	2.191	2.068	1.279
	Screened	Meas.	0.5137	0.4276	0.4194	0.1668	3.264	2.676	2.627	1.468	0.3857	0.3548	0.3113	0.0954	2.431	2.264	2.048	1.246
RC-46		Meas. bc	0.5184	0.4269	0.4372	0.1726	3.299	2.672	2.737	1.488	0.3905	0.3542	0.3291	0.1012	2.457	2.260	2.133	1.263
		Target	0.5024	0.4135	0.4237	0.1782	3.180	2.591	2.653	1.507	0.3744	0.3407	0.3156	0.1069	2.368	2.191	2.068	1.279
	Not Screened	Meas.	0.1181	0.0998	0.0805	-0.1246	1.312	1.258	1.204	0.751	0.1216	0.1310	0.0722	-0.1092	1.323	1.352	1.181	0.778
RC-47		Meas. bc	0.1240	0.1002	0.1012	-0.1162	1.330	1.260	1.263	0.765	0.1275	0.1314	0.0929	-0.1008	1.341	1.353	1.238	0.793
		Target	0.1046	0.0867	0.0881	-0.1199	1.272	1.221	1.225	0.759	0.1082	0.1180	0.0797	-0.1044	1.283	1.312	1.201	0.786
	Screened	Meas.	0.1181	0.0998	0.0805	-0.1246	1.312	1.258	1.204	0.751	0.1216	0.1310	0.0722	-0.1092	1.323	1.352	1.181	0.778
RC-47		Meas. bc	0.1240	0.1002	0.1012	-0.1162	1.330	1.260	1.263	0.765	0.1275	0.1314	0.0929	-0.1008	1.341	1.353	1.238	0.793
		Target	0.1046	0.0867	0.0881	-0.1199	1.272	1.221	1.225	0.759	0.1082	0.1180	0.0797	-0.1044	1.283	1.312	1.201	0.786
	Not Screened	Meas.	0.2040	0.1568	0.1537	-0.0908	1.600	1.435	1.425	0.811	0.1898	0.1841	0.1407	-0.0815	1.548	1.528	1.383	0.829
RC-48		Meas. bc	0.2081	0.1560	0.1724	-0.0831	1.615	1.432	1.487	0.826	0.1939	0.1832	0.1594	-0.0739	1.563	1.525	1.443	0.844
		Target	0.1877	0.1423	0.1538	-0.0757	1.541	1.388	1.425	0.840	0.1734	0.1696	0.1408	-0.0665	1.491	1.478	1.383	0.858
	Screened	Meas.	0.2040	0.1568	0.1537	-0.0908	1.600	1.435	1.425	0.811	0.1898	0.1841	0.1407	-0.0815	1.548	1.528	1.383	0.829
RC-48		Meas. bc	0.2081	0.1560	0.1724	-0.0831	1.615	1.432	1.487	0.826	0.1939	0.1832	0.1594	-0.0739	1.563	1.525	1.443	0.844
		Target	0.1877	0.1423	0.1538	-0.0757	1.541	1.388	1.425	0.840	0.1734	0.1696	0.1408	-0.0665	1.491	1.478	1.383	0.858
	Not Screened	Meas.	0.1378	0.1256	0.1190	-0.0877	1.373	1.335	1.315	0.817	0.1153	0.1177	0.0875	-0.1001	1.304	1.311	1.223	0.794
RC-49		Meas. bc	0.1437	0.1260	0.1388	-0.0793	1.392	1.337	1.377	0.833	0.1212	0.1181	0.1073	-0.0917	1.322	1.313	1.280	0.810
		Target	0.1225	0.1102	0.1185	-0.0872	1.326	1.289	1.314	0.818	0.1000	0.1023	0.0870	-0.0995	1.259	1.266	1.222	0.795
	Screened	Meas.	0.1378	0.1256	0.1190	-0.0877	1.373	1.335	1.315	0.817	0.1153	0.1177	0.0875	-0.1001	1.304	1.311	1.223	0.794
RC-49		Meas. bc	0.1437	0.1260	0.1388	-0.0793	1.392	1.337	1.377	0.833	0.1212	0.1181	0.1073	-0.0917	1.322	1.313	1.280	0.810
		Target	0.1225	0.1102	0.1185	-0.0872	1.326	1.289	1.314	0.818	0.1000	0.1023	0.0870	-0.0995	1.259	1.266	1.222	0.795
	Not Screened	Meas.	0.4722	0.3755	0.3702	0.1392	2.966	2.374	2.345	1.378	0.3564	0.3540	0.2812	0.1291	2.272	2.260	1.911	1.346
RC-50		Meas. bc	0.4764	0.3747	0.3897	0.1469	2.995	2.370	2.453	1.402	0.3605	0.3532	0.3008	0.1368	2.294	2.255	1.999	1.370
		Target	0.4539	0.3559	0.3785	0.1479	2.844	2.269	2.390	1.406	0.3381	0.3344	0.2895	0.1378	2.178	2.160	1.948	1.373
	Screened	Meas.	0.4722	0.3755	0.3702	0.1392	2.966	2.374	2.345	1.378	0.3564	0.3540	0.2812	0.1291	2.272	2.260	1.911	1.346
RC-50		Meas. bc	0.4764	0.3747	0.3897	0.1469	2.995	2.370	2.453	1.402	0.3605	0.3532	0.3008	0.1368	2.294	2.255	1.999	1.370
		Target	0.4539	0.3559	0.3785	0.1479	2.844	2.269	2.390	1.406	0.3381	0.3344	0.2895	0.1378	2.178	2.160	1.948	1.373
	Not Screened	Meas.	0.1712	0.1513	0.1373	-0.0607	1.483	1.417	1.372	0.870	0.1332	0.1400	0.1072	-0.0789	1.359	1.380	1.280	0.834
RC-51		Meas. bc	0.1760	0.1506	0.1569	-0.0549	1.500	1.415	1.435	0.881	0.1379	0.1393	0.1268	-0.0731	1.374	1.378	1.339	0.845
		Target	0.1547	0.1284	0.1337	-0.0626	1.428	1.344	1.361	0.866	0.1167	0.1171	0.1036	-0.0808	1.308	1.309	1.269	0.830
	Screened	Meas.	0.1712	0.1513	0.1373	-0.0607	1.483	1.417	1.372	0.870	0.1332	0.1400	0.1072	-0.0789	1.359	1.380	1.280	0.834
RC-51		Meas. bc	0.1760	0.1506	0.1569	-0.0549	1.500	1.415	1.435	0.881	0.1379	0.1393	0.1268	-0.0731	1.374	1.378	1.339	0.845
		Target	0.1547	0.1284	0.1337	-0.0626	1.428	1.344	1.361	0.866	0.1167	0.1171	0.1036	-0.0808	1.308	1.309	1.269	0.830

Table 8. Both Screened and Not Screened Normalized PCT Values by Glass by Composition View by Heat Treatment *(continued)*

Glass ID	Screened versus Not Screened	Composition	Results from quenched Glasses								Results from ccc Glasses							
			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)	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)
	Not Screened	Meas.	0.1131	0.1086	0.0938	-0.0985	1.298	1.284	1.241	0.797	0.1016	0.1352	0.0720	-0.0875	1.264	1.365	1.180	0.818
RC-52		Meas. bc	0.1196	0.1092	0.1124	-0.0919	1.317	1.286	1.296	0.809	0.1081	0.1358	0.0907	-0.0809	1.283	1.367	1.232	0.830
		Target	0.0980	0.0961	0.0973	-0.1000	1.253	1.248	1.251	0.794	0.0864	0.1227	0.0755	-0.0890	1.220	1.327	1.190	0.815
	Screened	Meas.	0.1131	0.1086	0.0938	-0.0985	1.298	1.284	1.241	0.797	0.1016	0.1352	0.0720	-0.0875	1.264	1.365	1.180	0.818
RC-52		Meas. bc	0.1196	0.1092	0.1124	-0.0919	1.317	1.286	1.296	0.809	0.1081	0.1358	0.0907	-0.0809	1.283	1.367	1.232	0.830
		Target	0.0980	0.0961	0.0973	-0.1000	1.253	1.248	1.251	0.794	0.0864	0.1227	0.0755	-0.0890	1.220	1.327	1.190	0.815
	Not Screened	Meas.	0.2116	0.1679	0.1612	-0.0882	1.628	1.472	1.449	0.816	0.1419	0.1617	0.1210	-0.0947	1.386	1.451	1.321	0.804
RC-53		Meas. bc	0.2181	0.1685	0.1818	-0.0817	1.652	1.474	1.520	0.829	0.1484	0.1623	0.1417	-0.0881	1.407	1.453	1.386	0.816
		Target	0.1921	0.1444	0.1580	-0.0807	1.556	1.395	1.439	0.830	0.1224	0.1382	0.1179	-0.0872	1.325	1.375	1.312	0.818
	Screened	Meas.	0.2116	0.1679	0.1612	-0.0882	1.628	1.472	1.449	0.816	0.1419	0.1617	0.1210	-0.0947	1.386	1.451	1.321	0.804
RC-53		Meas. bc	0.2181	0.1685	0.1818	-0.0817	1.652	1.474	1.520	0.829	0.1484	0.1623	0.1417	-0.0881	1.407	1.453	1.386	0.816
		Target	0.1921	0.1444	0.1580	-0.0807	1.556	1.395	1.439	0.830	0.1224	0.1382	0.1179	-0.0872	1.325	1.375	1.312	0.818
	Not Screened	Meas.	0.0678	0.0718	0.0595	-0.1407	1.169	1.180	1.147	0.723	0.0929	0.1196	0.0656	-0.1120	1.238	1.317	1.163	0.773
RC-54		Meas. bc	0.0720	0.0709	0.0794	-0.1331	1.180	1.177	1.201	0.736	0.0970	0.1188	0.0854	-0.1044	1.250	1.315	1.217	0.786
		Target	0.0512	0.0582	0.0604	-0.1364	1.125	1.143	1.149	0.731	0.0763	0.1060	0.0664	-0.1076	1.192	1.277	1.165	0.780
	Screened	Meas.	0.0678	0.0718	0.0595	-0.1407	1.169	1.180	1.147	0.723	0.0929	0.1196	0.0656	-0.1120	1.238	1.317	1.163	0.773
RC-54		Meas. bc	0.0720	0.0709	0.0794	-0.1331	1.180	1.177	1.201	0.736	0.0970	0.1188	0.0854	-0.1044	1.250	1.315	1.217	0.786
		Target	0.0512	0.0582	0.0604	-0.1364	1.125	1.143	1.149	0.731	0.0763	0.1060	0.0664	-0.1076	1.192	1.277	1.165	0.780
	Not Screened	Meas.	0.2035	0.1624	0.1539	-0.0635	1.598	1.454	1.425	0.864	0.2084	0.1813	0.1474	-0.0513	1.616	1.518	1.404	0.889
RC-55		Meas. bc	0.2094	0.1628	0.1717	-0.0551	1.619	1.455	1.485	0.881	0.2143	0.1817	0.1652	-0.0429	1.638	1.519	1.463	0.906
		Target	0.1788	0.1405	0.1530	-0.0676	1.509	1.382	1.422	0.856	0.1837	0.1594	0.1464	-0.0554	1.527	1.443	1.401	0.880
	Screened	Meas.	0.2035	0.1624	0.1539	-0.0635	1.598	1.454	1.425	0.864	0.2084	0.1813	0.1474	-0.0513	1.616	1.518	1.404	0.889
RC-55		Meas. bc	0.2094	0.1628	0.1717	-0.0551	1.619	1.455	1.485	0.881	0.2143	0.1817	0.1652	-0.0429	1.638	1.519	1.463	0.906
		Target	0.1788	0.1405	0.1530	-0.0676	1.509	1.382	1.422	0.856	0.1837	0.1594	0.1464	-0.0554	1.527	1.443	1.401	0.880
	Not Screened	Meas.	0.1208	0.1204	0.1138	-0.0920	1.321	1.320	1.299	0.809	0.1330	0.1546	0.1057	-0.0780	1.358	1.428	1.276	0.836
RC-56		Meas. bc	0.1267	0.1208	0.1356	-0.0836	1.339	1.321	1.367	0.825	0.1389	0.1550	0.1276	-0.0696	1.377	1.429	1.341	0.852
		Target	0.1105	0.1137	0.1157	-0.0895	1.290	1.299	1.305	0.814	0.1227	0.1478	0.1076	-0.0755	1.326	1.405	1.281	0.840
	Screened	Meas.	0.1208	0.1204	0.1138	-0.0920	1.321	1.320	1.299	0.809	0.1330	0.1546	0.1057	-0.0780	1.358	1.428	1.276	0.836
RC-56		Meas. bc	0.1267	0.1208	0.1356	-0.0836	1.339	1.321	1.367	0.825	0.1389	0.1550	0.1276	-0.0696	1.377	1.429	1.341	0.852
		Target	0.1105	0.1137	0.1157	-0.0895	1.290	1.299	1.305	0.814	0.1227	0.1478	0.1076	-0.0755	1.326	1.405	1.281	0.840
	Not Screened	Meas.	0.1228	0.1185	0.1156	-0.1013	1.327	1.314	1.305	0.792	0.2594	0.1995	0.1896	-0.0403	1.817	1.583	1.547	0.911
RC-57		Meas. bc	0.1269	0.1177	0.1363	-0.0937	1.339	1.311	1.369	0.806	0.2635	0.1986	0.2103	-0.0326	1.834	1.580	1.623	0.928
		Target	0.1088	0.1031	0.1113	-0.0878	1.285	1.268	1.292	0.817	0.2453	0.1841	0.1853	-0.0267	1.759	1.528	1.532	0.940
	Screened	Meas.	0.1228	0.1185	0.1156	-0.1013	1.327	1.314	1.305	0.792	0.2594	0.1995	0.1896	-0.0403	1.817	1.583	1.547	0.911
RC-57		Meas. bc	0.1269	0.1177	0.1363	-0.0937	1.339	1.311	1.369	0.806	0.2635	0.1986	0.2103	-0.0326	1.834	1.580	1.623	0.928
		Target	0.1088	0.1031	0.1113	-0.0878	1.285	1.268	1.292	0.817	0.2453	0.1841	0.1853	-0.0267	1.759	1.528	1.532	0.940

6.3.6 Predicted versus Measured PCTs

As shown in Table 8, the durabilities for all of the RC glasses are much better than that of EA. (This is indicated for each glass by its normalized leachate being much smaller than that of EA values reported by Jantzen et al. [1993]—see Table 2). Only 8 glasses (out of the 68 when considering both Q and ccc and including RC-31) have NL [B] exceeding 2.5 g/L. These are: RC-30Q, RC-30ccc, RC-36Q, RC-36ccc, RC-40ccc, RC-43ccc, RC-46Q, and RC-50Q. The least durable glass produced was RC-36Q with a NL [B] of 6.194 g/L (based on the measured bias-corrected composition). This glass is acceptable if compared to 16.695 g/L for EA as reported by Jantzen et al. (1993) or using the definition of "acceptability" as defined in this study (log NL [B] < 1.0 g/L or NL [B] < 10 g/L)—see Section 3.0 for more details.

Exhibit G.8 provides a closer look at these results based upon screened or not screened PCTs, the glass chemical compositions (targeted, measured, and bias corrected) and the heat treatment (ccc and quenched). These exhibits provide 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 the measured glass composition (Jantzen et al. 1995). Prediction limits (at a 95% confidence) for an individual PCT result are also plotted along with the linear fit. The EA and ARM results are also indicated on these plots. Exhibit G.9 shows these same results plotted by sludge type while Exhibit G.10 shows them plotted by frit type.

As previously mentioned, all of the RC glasses (both quenched and ccc versions) are acceptable when compared to the EA values as reported by Jantzen et al. (1993) or using the definition of acceptable as defined by this study (log NL [B] < 1.0 g/L). Also, note that the RC glasses are for the most part predictable. Although the ΔG_P model was developed to be applied to a homogeneous glass (Plodinec et al. 1995; 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—see Section 3.3 for more detail. More specifically, as a new phase precipitates in a previously homogeneous glass, it affects the glass matrix, in which it is embedded, both chemically and mechanically. Therefore, the effect of the PCT response depends on the type and extent of crystallization. Those RC glasses with durabilities that fall above the upper confidence limit (i.e., unpredictable) on the ΔG_P plots are listed by leachate element in Tables 9 through 12. Comparing those glasses listed in Table 9 with those glasses that formed either acmite and/or spinel (see Table 6), only RC-36Q, RC-36ccc, and RC-30Q are amorphous (as defined by XRD) and unpredictable. It should be mentioned that the quenched versions of these glasses were also classified as inhomogeneous and may contain some volume fraction of amorphous phase separation. Although unpredictable (and perhaps phase separated), these glasses are acceptable based on the criteria being used in this study. Section 6.4 provides a detailed discussion of those glasses that challenge the homogeneity constraint. As discussed in this section, there were five other RC glasses that were predicted to be inhomogeneous, but based on the measured PCT response and ΔG_P predictions, these glasses were both predictable (reinforcing the minimal impacts on the crystal and grain boundary terms as described in Section 3.3) and acceptable.

Table 9. Glasses with Normalized PCTs for B Above Upper Limit of 95% CI for ΔG_P

Sludge Type	Type Of Frit	Screened or Not Screened PCTs with Compositional View and Heat Treatment	Glass ID With HT	ΔG_P	log NL B (g/L)	Upper Limit of 95% CI	Amount Over Upper Limit
HHF	165	Not Screened/Measured bc/quenched	RC-36	-10.78	0.792	0.344	0.311
HHF	165	Screened/Measured bc/quenched	RC-36	-10.78	0.792	0.344	0.311
SB4	200	Not Screened/Measured bc/ccc	RC-43\ccc	-9.09	0.417	-0.164	0.241
SB4	200	Screened/Measured bc/ccc	RC-43\ccc	-9.09	0.417	-0.164	0.241
HHF	165	Not Screened/Measured/quenched	RC-36	-11.22	0.787	0.339	0.225
HHF	165	Screened/Measured/quenched	RC-36	-11.22	0.787	0.339	0.225
HHF	165	Not Screened/Targeted/quenched	RC-36	-11.26	0.769	0.334	0.200
HHF	165	Screened/Targeted/quenched	RC-36	-11.26	0.769	0.334	0.200
HHF	165	Not Screened/Measured bc/ccc	RC-36\ccc	-10.78	0.678	0.247	0.197
HHF	165	Screened/Measured bc/ccc	RC-36\ccc	-10.78	0.678	0.247	0.197
PHF	200	Not Screened/Measured bc/ccc	RC-40\ccc	-10.00	0.517	0.084	0.177
PHF	200	Screened/Measured bc/ccc	RC-40\ccc	-10.00	0.517	0.084	0.177
SB4	200	Not Screened/Measured/ccc	RC-43\ccc	-9.55	0.411	-0.174	0.153
SB4	200	Screened/Measured/ccc	RC-43\ccc	-9.55	0.411	-0.174	0.153
PLF	200	Not Screened/Measured bc/ccc	RC-42\ccc	-8.85	0.283	-0.224	0.151
PLF	200	Screened/Measured bc/ccc	RC-42\ccc	-8.85	0.283	-0.224	0.151
HHF	165	Not Screened/Measured/ccc	RC-36\ccc	-11.22	0.673	0.242	0.111
HHF	165	Screened/Measured/ccc	RC-36\ccc	-11.22	0.673	0.242	0.111
PHF	200	Not Screened/Measured/ccc	RC-40\ccc	-10.43	0.512	0.073	0.094
PHF	200	Screened/Measured/ccc	RC-40\ccc	-10.43	0.512	0.073	0.094
HHF	165	Not Screened/Targeted/ccc	RC-36\ccc	-11.26	0.655	0.237	0.086
HHF	165	Screened/Targeted/ccc	RC-36\ccc	-11.26	0.655	0.237	0.086
PLF	200	Not Screened/Measured/ccc	RC-42\ccc	-9.26	0.279	-0.231	0.073
PLF	200	Screened/Measured/ccc	RC-42\ccc	-9.26	0.279	-0.231	0.073
SB4	200	Not Screened/Targeted/ccc	RC-43\ccc	-9.90	0.385	-0.161	0.063
SB4	200	Screened/Targeted/ccc	RC-43\ccc	-9.90	0.385	-0.161	0.063
PLF	200	Not Screened/Targeted/ccc	RC-42\ccc	-9.23	0.264	-0.225	0.062
PLF	200	Screened/Targeted/ccc	RC-42\ccc	-9.23	0.264	-0.225	0.062
PHF	200	Not Screened/Targeted/ccc	RC-40\ccc	-10.58	0.493	0.087	0.048
PHF	200	Screened/Targeted/ccc	RC-40\ccc	-10.58	0.493	0.087	0.048
PHF	165	Not Screened/Measured bc/quenched	RC-30	-11.95	0.742	0.247	0.048
PHF	165	Screened/Measured bc/quenched	RC-30	-11.95	0.742	0.247	0.048
SB4	200	Not Screened/Measured bc/ccc	RC-39\ccc	-9.18	0.221	-0.218	0.030
SB4	200	Screened/Measured bc/ccc	RC-39\ccc	-9.18	0.221	-0.218	0.030

Table 10. Glasses with Normalized PCTs for Li Above Upper Limit of 95% CI for ΔG_P

Sludge Type	Type Of Frit	Screened or Not Screened PCTs with Compositional View and Heat Treatment	Glass ID With HT	ΔG_P	log NL Li (g/L)	Upper Limit of 95% CI	Amount Over Upper Limit
HHF	165	Not Screened/Measured bc/quenched	RC-36	-10.78	0.741	0.399	0.342
HHF	165	Screened/Measured bc/quenched	RC-36	-10.78	0.741	0.399	0.342
HHF	165	Not Screened/Measured/quenched	RC-36	-11.22	0.742	0.465	0.277
HHF	165	Screened/Measured/quenched	RC-36	-11.22	0.742	0.465	0.277
HHF	165	Not Screened/Targeted/quenched	RC-36	-11.26	0.730	0.471	0.260
HHF	165	Screened/Targeted/quenched	RC-36	-11.26	0.730	0.471	0.260
HHF	165	Not Screened/Measured bc/ccc	RC-36\ccc	-10.78	0.633	0.399	0.234
HHF	165	Screened/Measured bc/ccc	RC-36\ccc	-10.78	0.633	0.399	0.234
HHF	165	Not Screened/Measured/ccc	RC-36\ccc	-11.22	0.634	0.465	0.169
HHF	165	Screened/Measured/ccc	RC-36\ccc	-11.22	0.634	0.465	0.169
PHF	200	Not Screened/Measured bc/ccc	RC-40\ccc	-10.00	0.453	0.285	0.167
PHF	200	Screened/Measured bc/ccc	RC-40\ccc	-10.00	0.453	0.285	0.167
SB4	200	Not Screened/Measured bc/ccc	RC-43\ccc	-9.09	0.309	0.152	0.157
SB4	200	Screened/Measured bc/ccc	RC-43\ccc	-9.09	0.309	0.152	0.157
HHF	165	Not Screened/Targeted/ccc	RC-36\ccc	-11.26	0.623	0.471	0.152
HHF	165	Screened/Targeted/ccc	RC-36\ccc	-11.26	0.623	0.471	0.152
PHF	200	Not Screened/Measured/ccc	RC-40\ccc	-10.43	0.452	0.347	0.105
PHF	200	Screened/Measured/ccc	RC-40\ccc	-10.43	0.452	0.347	0.105
SB4	200	Not Screened/Measured/ccc	RC-43\ccc	-9.55	0.308	0.219	0.090
SB4	200	Screened/Measured/ccc	RC-43\ccc	-9.55	0.308	0.219	0.090
PLF	200	Not Screened/Measured bc/ccc	RC-42\ccc	-8.85	0.195	0.117	0.078
PLF	200	Screened/Measured bc/ccc	RC-42\ccc	-8.85	0.195	0.117	0.078
PHF	200	Not Screened/Targeted/ccc	RC-40\ccc	-10.58	0.435	0.370	0.065
PHF	200	Screened/Targeted/ccc	RC-40\ccc	-10.58	0.435	0.370	0.065
PHF	165	Not Screened/Measured bc/quenched	RC-30	-11.95	0.618	0.572	0.046
PHF	165	Screened/Measured bc/quenched	RC-30	-11.95	0.618	0.572	0.046
PLF	200	Not Screened/Measured/ccc	RC-42\ccc	-9.26	0.195	0.177	0.019
PLF	200	Screened/Measured/ccc	RC-42\ccc	-9.26	0.195	0.177	0.019
SB4	200	Not Screened/Targeted/ccc	RC-43\ccc	-9.90	0.284	0.270	0.014
SB4	200	Screened/Targeted/ccc	RC-43\ccc	-9.90	0.284	0.270	0.014
PLF	200	Not Screened/Targeted/ccc	RC-42\ccc	-9.23	0.181	0.173	0.008
PLF	200	Screened/Targeted/ccc	RC-42\ccc	-9.23	0.181	0.173	0.008

Table 11. Glasses with Normalized PCTs for Na Above Upper Limit of 95% CI for ΔG_P

Sludge Type	Type Of Frit	Screened or Not Screened PCTs with Compositional View and Heat Treatment	Glass ID With HT	ΔG_P	log NL Na (g/L)	Upper Limit of 95% CI	Amount Over Upper Limit
HHF	165	Not Screened/Measured bc/quenched	RC-36	-10.78	0.629	0.415	0.214
HHF	165	Screened/Measured bc/quenched	RC-36	-10.78	0.629	0.415	0.214
HHF	165	Not Screened/Measured/quenched	RC-36	-11.22	0.609	0.492	0.117
HHF	165	Screened/Measured/quenched	RC-36	-11.22	0.609	0.492	0.117
HHF	165	Not Screened/Targeted/quenched	RC-36	-11.26	0.611	0.498	0.113
HHF	165	Screened/Targeted/quenched	RC-36	-11.26	0.611	0.498	0.113
HHF	165	Not Screened/Measured bc/ccc	RC-36\ccc	-10.78	0.526	0.415	0.111
HHF	165	Screened/Measured bc/ccc	RC-36\ccc	-10.78	0.526	0.415	0.111
PHF	200	Not Screened/Measured bc/ccc	RC-40\ccc	-10.00	0.386	0.282	0.104
PHF	200	Screened/Measured bc/ccc	RC-40\ccc	-10.00	0.386	0.282	0.104
SB4	200	Not Screened/Measured bc/ccc	RC-43\ccc	-9.09	0.206	0.127	0.079
SB4	200	Screened/Measured bc/ccc	RC-43\ccc	-9.09	0.206	0.127	0.079
HHF	165	Not Screened/Measured/ccc	RC-36\ccc	-11.22	0.507	0.492	0.015
HHF	165	Screened/Measured/ccc	RC-36\ccc	-11.22	0.507	0.492	0.015
PHF	200	Not Screened/Measured/ccc	RC-40\ccc	-10.43	0.368	0.355	0.013
PHF	200	Screened/Measured/ccc	RC-40\ccc	-10.43	0.368	0.355	0.013
HHF	165	Not Screened/Targeted/ccc	RC-36\ccc	-11.26	0.508	0.498	0.010
HHF	165	Screened/Targeted/ccc	RC-36\ccc	-11.26	0.508	0.498	0.010

Table 12. Glasses with Normalized PCTs for Si Above Upper Limit of 95% CI for ΔG_P

Sludge Type	Type Of Frit	Screened or Not Screened PCTs with Compositional View and Heat Treatment	Glass ID With HT	ΔG_P	log NL Si (g/L)	Upper Limit Of 95% CI	Amount Over Upper Limit
HHF	165	Not Screened/Measured bc/quenched	RC-36	-10.78	0.344	0.079	0.266
HHF	165	Screened/Measured bc/quenched	RC-36	-10.78	0.344	0.079	0.266
HHF	165	Not Screened/Measured/quenched	RC-36	-11.22	0.339	0.137	0.201
HHF	165	Screened/Measured/quenched	RC-36	-11.22	0.339	0.137	0.201
HHF	165	Not Screened/Targeted/quenched	RC-36	-11.26	0.334	0.142	0.192
HHF	165	Screened/Targeted/quenched	RC-36	-11.26	0.334	0.142	0.192
HHF	165	Not Screened/Measured bc/ccc	RC-36\ccc	-10.78	0.247	0.079	0.169
HHF	165	Screened/Measured bc/ccc	RC-36\ccc	-10.78	0.247	0.079	0.169
PHF	200	Not Screened/Measured bc/ccc	RC-40\ccc	-10.00	0.084	-0.022	0.105
PHF	200	Screened/Measured bc/ccc	RC-40\ccc	-10.00	0.084	-0.022	0.105
HHF	165	Not Screened/Measured/ccc	RC-36\ccc	-11.22	0.242	0.137	0.104
HHF	165	Screened/Measured/ccc	RC-36\ccc	-11.22	0.242	0.137	0.104
HHF	165	Not Screened/Targeted/ccc	RC-36\ccc	-11.26	0.237	0.142	0.095
HHF	165	Screened/Targeted/ccc	RC-36\ccc	-11.26	0.237	0.142	0.095
PHF	200	Not Screened/Measured/ccc	RC-40\ccc	-10.43	0.073	0.033	0.040
PHF	200	Screened/Measured/ccc	RC-40\ccc	-10.43	0.073	0.033	0.040
PHF	200	Not Screened/Targeted/ccc	RC-40\ccc	-10.58	0.087	0.053	0.034
PHF	200	Screened/Targeted/ccc	RC-40\ccc	-10.58	0.087	0.053	0.034
PMF	320	Not Screened/Measured bc/quenched	RC-46	-11.31	0.173	0.148	0.024
PMF	320	Screened/Measured bc/quenched	RC-46	-11.31	0.173	0.148	0.024
PHF	165	Not Screened/Measured bc/quenched	RC-30	-11.95	0.247	0.231	0.015
PHF	165	Screened/Measured bc/quenched	RC-30	-11.95	0.247	0.231	0.015

6.3.7 Quenched Versus Centerline-Cooled Results

As with most high-level waste (HLW) glasses, the RC glasses contain components that tend to precipitate from glass during cooling. As the glass is poured into a canister, crystallization takes place within the temperature interval between the liquidus temperature (T_L) and glass-transition temperature (T_g). A portion of the glass cast into canisters is quenched on the canister walls, and another portion of glass, near the canister centerline, cools more slowly. Thus, the temperature history of the ccc glass is most favorable for crystalline phases to form.

As discussed in Section 3.3, the formation of a new phase affects the glass matrix, in which it is embedded, both chemically and mechanically. These changes may impact the rate of glass dissolution in water and thus change its chemical durability (Jantzen and Bickford 1985; Cicero et al. 1993; Kim et al. 1995). Jantzen and Bickford (1985) indicated that grain-boundary dissolution was a major contributor to durability (or lack thereof) in crystallized glasses and that grain-boundary dissolution was more of an effect with species that were non-isotropic (such as acmite) than isotropic species (such as spinel), given the isotropic nature of glass or the residual glass matrix. The effect of ccc on the PCT of HLW glasses was determined for more than 100 glass compositions (Hrma et al. 1994; Kim et al. 1995). Riley et al. (2001) also indicated that the residual glass composition was the major factor that controlled the PCT response of HLW glasses with durable crystalline phases. Other chemical or mechanical factors, such as concentration gradients and mechanical stresses, played a secondary role.

Exhibits G.5 and G.6 provide a closer look at the quenched versus ccc results for the RC glasses, including a statistical comparison of the average differences due to heat treatment for each element of interest. These paired-t tests indicate no statistically significant (at the 5% level) differences between the PCTs for the two heat treatments for any element of interest (i.e., B, Li, Na, and Si).

An additional look at the log NL (B [g/L]) values for the RC glasses is presented in Figure 29, which provides a plot of the ccc versus quenched results. These results were derived using all of the PCTs (i.e., the unscreened PCTs) with the PCTs normalized (see Section 5.3.1) using the targeted compositions for the RC glasses. Although no statistical difference is seen between the quenched and ccc average log NL (B [g/L]) results for these glasses, nine individual glasses show differences between their quenched and ccc results. These glasses are labeled in Figure 29.

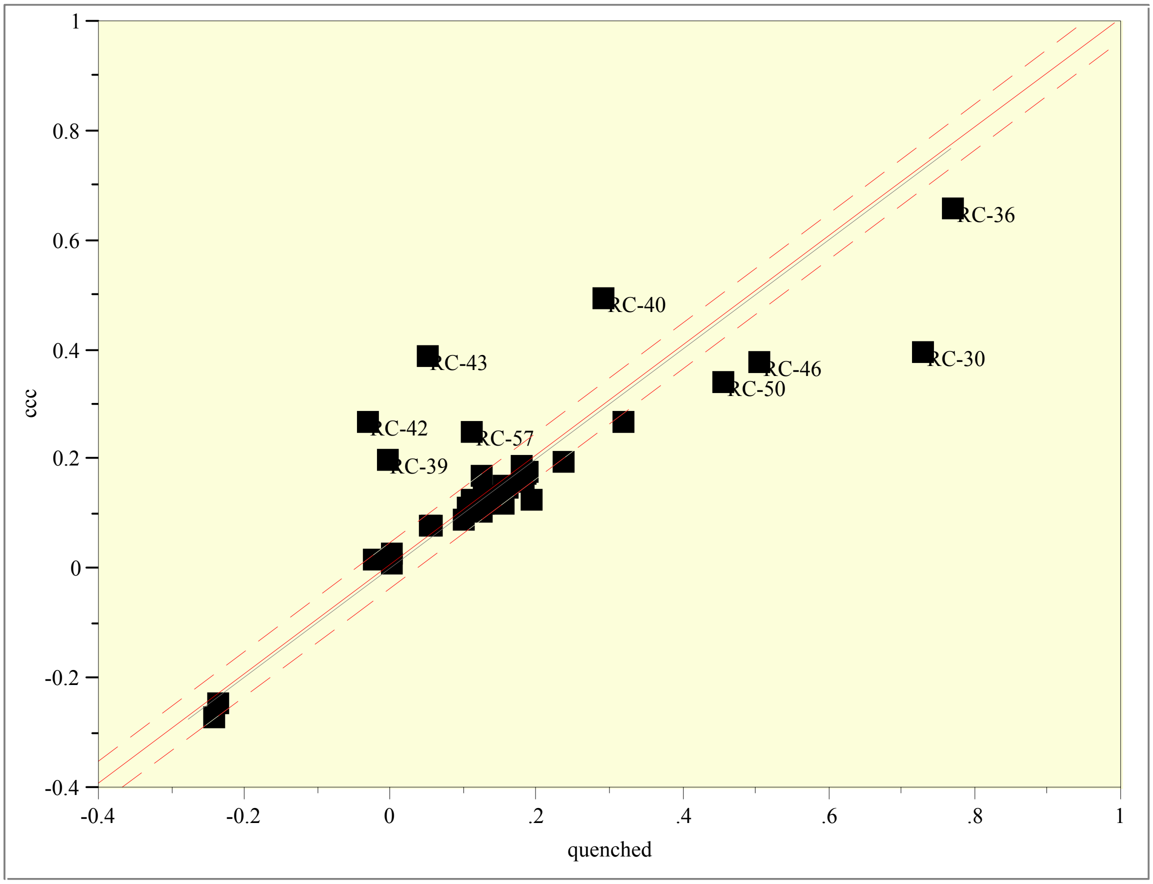

Figure 29. log NL(B [g/L]) for Quenched vs ccc Glasses
(using all PCTs and targeted compositions)

For those glasses shown above the 45° line (RC-39, RC-40, RC-42, RC-43, and RC-57), the quenched version is more durable (lower normalized B release) than its ccc counterpart. For example, the averaged NLs [B] for RC-43Q and RC-43ccc are 1.125 and 2.427 g/L, respectively (based on targeted composition and screened PCT values). For those glasses shown below the 45° line in Figure 29 (RC-30, RC-36, RC-46, and RC-50), the ccc version is more durable (lower normalized B release) than its quenched counterpart. For example, the average NL [B] for RC-30Q and RC-30ccc are 5.331 and 2.473 g/L, respectively (based on targeted composition and screened PCT values). For those glasses lying on (or close to) the 45° line, there is little difference between the NL [B] release of the quenched and ccc versions of that glass.

As described above, insight into the measured PCT difference between the quenched and ccc versions of a specific glass can be gained by the potential effects of crystallization on durability. As previously mentioned, the effects of crystallization on durability (as measured by the PCT response) are highly dependent upon several factors, including the type and extent of crystallization and the resulting residual glass composition.

With respect to the five RC glasses shown above the 45° line in Figure 29, all but one (RC-57) are Frit 200 based glasses and formed acmite or acmite and trevorite (see Table 6) as defined by XRD analysis. It is hypothesized that the significant difference in the PCT response between the quenched and ccc version of these glasses is attributed to an accelerated grain-boundary dissolution (as noted by Jantzen and Bickford [1985]) and/or alteration of the residual glass matrix due to the formation of acmite. That is, the formation of acmite in select ccc samples is expected to have led to the deleterious effect on the PCT response. This latter statement assumes that the formation of spinel has minimal or no impact on durability as described by Jantzen and Bickford (1985) and Cicero et al. (1993).

The XRD analysis of RC-57ccc (see Appendix F or Table 6) suggests that an amorphous product resulted after the ccc heat treatment. However, based on SEM/EDS analysis (see Table 6), crystals were found that were enriched in Fe, Mn, and Ni—indicative of a spinel-type structure. Given the estimated detection limit of the XRD unit of 1 vol% and the conclusions drawn by Jantzen and Bickford (1985) and Cicero et al. (1993), the limited amount of devitrification is not expected to have had the negative impact on durability. The impact of the ccc heat treatment, which resulted in a lower durability product, may be related to other chemical or mechanical factors, such as concentration gradients, accelerated grain boundary dissolution, and/or mechanical stresses, as discussed by Jantzen and Bickford (1985) and Riley et al. (2001).

Note that acmite formed in RC-38ccc, RC-41ccc, and RC-44ccc, but its effect on the PCT response was minimal given that the releases from their quenched counterparts were not statistically significant. The minimal impact on durability in these glasses may be a function of the negligible changes to residual glass matrix composition (e.g., a low volume fraction of acmite or the targeted composition of the glass). This reinforces the fact that the PCT response from a partially crystallized glass is a function of not only the type and extent of crystallization but the impact of devitrification on the resulting residual glass composition (assumed to control the PCT response). Given this, it does not necessarily mean that the formation of acmite will always have a benign impact on durability. In fact, results presented in the WQR (Plodinec et al. 1995) indicated that glass produced during waste qualification runs (in Canister S00001 from the WP-14 campaign) contained 17-vol% acmite. The PCT results of this material were "almost twice as much as the surrounding bulk glass but still less than $^1/_{10}$ the EA glass limit."

The ccc versions of four RC glasses (RC-30, RC-36, RC-46, and RC-50) were more durable than their quenched counterparts (see Figure 29—those below the 45° line). As shown in Table 6, spinel (Trevorite) formed in three of the four. The one exception was RC-36, which remained amorphous after ccc (note that SEM/EDS analysis was not performed). In the case of RC-30, RC-46, and RC-50, it appears that the formation of spinel may actually enhance the durability response potentially as a result of altering the residual glass matrix or causing a secondary effect. It should be mentioned that there are RC glasses (RC-33ccc, RC-47ccc, RC-48ccc, and RC-53ccc) that formed spinel in which their presence or formation had no measurable effect on durability relative to their quenched counterparts. This latter observation is consistent with the results shown by Jantzen and Bickford (1985), Cicero et al. (1993), and in the WQR (Plodinec et al. 1995) where the presence of spinels had little to no effect on the measured PCT response of the glass compared to a non-devitrified counterpart glass.

As previously mentioned, all of the RC glasses (both quenched and ccc) are acceptable based on the working definition being used in this report as well as comparing the normalized releases to those reported for EA (Jantzen et al. 1993). The least durable glass produced was RC-36Q with a NL [B] of 5.880 g/L (or log NL [B] = 0.77 g/L). (Again, acceptable is based on a NL [B] < 10.0 g/L or log NL [B] < 1.0 g/L). Only 8 glasses (out of the 68 when considering both Q and ccc and including RC-31) have an NL [B] exceeding 2.5 g/L—but less than 6.194 g/L, based on RC-36Q (normalized by measured bias-corrected composition).[a] Therefore, regardless of thermal history (or more importantly with respect to the objectives of this task—homogeneity classification) all of the glasses are acceptable in terms of their PCT response relative to EA or based on the definition of acceptability being used in this report.

6.4 Challenges to the Homogeneity Discriminator

The homogeneity constraint is currently used to discriminate compositions that are likely to result in phase-separated glasses from compositions that are likely to be homogeneous. In this context, phase separation refers to the development of amorphous or glass-in-glass phase separation, not to crystallization. The technical basis for developing and implementing the phase-separation discriminator into PCCS was the fact that the durability of phase-separated glasses can be unpredictable. Although the glasses may be unpredictable, if sufficient evidence can establish the fact that although these glasses are acceptable based on a predefined acceptance criterion over the composition region of interest, then replacing the homogeneity constraint with equivalent (yet less restrictive criteria) may be possible. More specifically, to replace the homogeneity constraint, glasses within the composition region of interest should be predictable and/or acceptable regardless of the homogeneity classification.

With respect to the primary task objective, 7 of the 34 (including RC-31, which was misbatched) centroid-based targeted compositions actually challenge the homogeneity constraint. That is, these are glasses predicted to be inhomogeneous based on targeted compositions. It should be mentioned that predictions of homogeneity using both measured and measured bias-corrected values provided similar results for these 7 glasses. However, the following four RC glasses predicted to be homogeneous based on targeted values were predicted to be inhomogeneous based on measured and/or measured bias-corrected: RC-28, RC-37, RC-51 and RC-52. For RC-28 and RC-52, using the measured bias-corrected composition resulted in predictions of inhomogeneity. For RC-37 and RC-53, both measured and measured-bias-corrected resulted in prediction of inhomogeneity. In the discussion that follows, predictions using targeted compositions are primarily used. Predictions using measured and/or measured-bias-corrected compositions are discussed when applicable.

Table 13 summarizes the 13 Frit 165-based RC glasses. The columns in Table 13 indicate the glass ID; homogeneity classification; sludge type; WL; frit; the Al_2O_3, sum-of-alkali, and Fe_2O_3 concentration in glass; the XRD results of both Q and ccc; results of the SEM analysis; and the PCT results for both Q and ccc glasses.

The homogeneity column indicates either a “YES” or “NO,” meaning that the glass is either predicted to be homogeneous or inhomogeneous, respectively, based on the homogeneity discriminator (using the target composition as previously described). The columns showing the XRD results either use an “A” to represent an amorphous glass (again XRD does not indicate the presence or absence of amorphous phase separation, only the presence or absence of crystallization at a given detection limit) or the type of crystal(s) reported by SRTC-ADS. The SEM column is presented either by the elements detected by EDS or by an “NM,” indicating that the glass was not measured.

(a) Normalized boron releases for RC-36Q were 5.880, 6.128, and 6.194 g/L based on target, measured, and measured bias-corrected compositions, respectively.

Table 13. Classification of Frit 165-Based RC Glasses (based on targeted composition) with Related Physical Properties of Interest

ID	Homo	Sludge	WL	Frit	Al_2O_3	$\sum$ alkali	Fe_2O_3	XRD Q	XRD CCC	SEM	PCT Q	PCT CCC
RC-25	YES	PLF	35	165	0.04382	0.17448	0.16191	A	A	Fe, Mn, Ni	-	-
RC-26	YES	SB3	35	165	0.0413	0.17538	0.15843	A	A	NM	-	-
RC-27	NO	SB4	27.5	165	0.03177	0.18085	0.11504	A	A	NM	-	-
RC-28	YES	SB4	30	165	0.03466	0.17911	0.1255	A	A	Fe, Mn, Ni	-	-
RC-29	YES	PLF	30	165	0.03756	0.17812	0.13878	A	A	NM	-	-
RC-30	NO	PHF	35	165	0.03115	0.17559	0.1204	A	Spinel	Fe, Mn, Ni	NP (mbc)	-
RC-31	NO	-	-	-	0.0930	0.1904	0.02780	A	A	NM	-	-
RC-31.5	NO	HHF	20	165	0.08774	0.18589	0.02699	A	A	NM	-	-
RC-32	YES	SB4	35	165	0.04044	0.17563	0.14642	A	A	NM	-	-
RC-33	YES	SB4	37.5	165	0.04333	0.17389	0.15687	A	Spinel	Fe, Mn, Ni	-	-
RC-34	YES	SB3	30	165	0.0354	0.1789	0.13579	A	A	NM	-	-
RC-35	YES	SB3	27.5	165	0.03245	0.18065	0.12448	A	A	NM	-	-
RC-36	NO	HHF	15	165	0.06581	0.18941	0.02024	A	A	NM	NP (all)	NP (all)
RC-37	YES	PLF	25	165	0.0313	0.18177	0.11565	A	A	NM	-	-

As discussed in Section 3.3, although the ΔG_P model was developed to be applied to a homogeneous glass (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. In this report, the ΔG_P model was applied to both quenched and ccc glasses (to assess the predictability)—regardless of the presence or absence of crystallization and/or amorphous phase separation—to test this hypothesis or assumption. It should be noted that previous studies (Harbour et al. 2000; Herman et al. 2001) have also applied the ΔG_P model to both quenched and ccc glasses with success (given the formation of spinels). It should be noted that the formation of non-isotropic crystals (such as acmite) may have a significant impact on the crystallization and grain-boundary terms (see Equation 1) resulting in the classification of "unpredictable."

Therefore, the PCT columns in Table 13 are expressed in terms of predictable ("-") and unpredictable ("NP"), respectively. If "NP" is shown in the last column, the compositional basis for which the PCT is unpredictable is shown in parentheses. For example, "(all)" indicates that the PCT is unpredictable based on all (targeted, measured, and measured-bias corrected) compositional views. The use of "(mbc)," "(m)," and "(t)" represents measured bias-corrected, measured, and targeted compositional views, respectively.

For the Frit 165-based RC glasses, RC-27, RC-30, RC-31, RC-31.5, and RC-36 are predicted to be inhomogeneous based on targeted compositions—glasses of specific interest in this study. Based on the measured PCT response and ΔG_P predictions, with the exception of RC-30 (mbc) and RC-36 (all), all Frit 165-based glasses are predictable regardless of the homogeneity classification. Predictions of homogeneity using measured and/or measured-biased corrected compositions of RC-28 and RC-37 indicate that these glasses may be phase separated as well. However, based on measured PCT response and ΔG_P predictions, these glasses (both quenched and ccc) are predictable regardless of the homogeneity classification. All Frit 165-based glasses are acceptable based on the working definition being used in this report. This provides data (albeit limited and based on centroid glasses) that would support the replacement of the homogeneity constraint based on the current strategy (predictable and/or acceptable). That is, all of the Frit 165-based glasses are either predictable or acceptable.

With respect to the two glasses (RC-30 and RC-36) that are predicted to be inhomogeneous and are not predictable, further discussion is warranted as this was the original intent of the homogeneity discriminator—to exclude glasses predicted to be inhomogeneous given that their PCT response was unpredictable.

RC-30 is unpredictable only when considering the measured-bias corrected version of the quenched glass. All other compositional views of RC-30 (both quenched and ccc) are predictable. It should be noted that the ccc version of this glass is predictable even though spinels are present—again consistent with the observations by Cicero et al. (1993) and the results reported in the WQR (Plodinec et al. 1995) that spinels have little to no impact on the durability response as defined by the PCT. The same can be said of the ccc versions of RC-25, RC-28, and RC-33 (as XRD and/or SEM/EDS analysis indicates the presence of spinel, yet the glasses remain predictable). Some interesting compositional observations with respect to RC-30 are provided below:

- the targeted, measured, and measured-bias corrected Al_2O_3 concentrations are 3.115, 3.259, and 3.246 wt%, respectively, meeting the lower Al_2O_3 concentration criterion proposed by Edwards and Brown (1998)
- the targeted, measured, and measured-bias corrected sum-of-alkali (Li_2O and Na_2O) concentrations are 17.559, 17.767, and 17.264 wt%, respectively, which does not exceed the 19.3 wt% upper limit proposed by Edwards and Brown (1998) when Al_2O_3 concentrations are between 3 and 4 wt%
- the targeted, measured, and measured-bias corrected Fe_2O_3 concentrations are 12.040, 11.334, and 11.332 wt%, respectively, which are well above the 2.5 wt% lower limit that has been shown to produce unpredictable and/or unacceptable glasses (Edwards and Brown 1998).

Because this glass met the compositional constraints (e.g., single-component constraints) and yet remains unpredictable (based on one compositional view of the quenched glass), it could be questioned whether the task should continue (given that these are centroid sludge compositions and this glass meets that criteria for which the discriminator was established). The response is that although the glass is unpredictable, the glass is acceptable in terms of its PCT response regardless of its homogeneity classification. Normalized boron releases are 5.331 g/L (0.727 g/L in log space) and 2.473 g/L (0.393 g/L in log space) for the quenched and ccc versions, respectively. Both the quenched and ccc versions are acceptable based on the working definition and/or relative to EA. Adding to this argument is the fact that only the mbc compositional view of the quenched version is unpredictable regardless of homogeneity classification—all other compositional views are predictable. It is, however, recommended that this glass be included in the Phase 2 assessment to confirm the results presented above.

RC-36 is unpredictable under all compositional views for both quenched and ccc versions. Targeted, measured, and measured bias-corrected Fe_2O_3 concentrations in this glass (see Appendix E) are 2.02, 2.07, and 2.06 wt%, respectively. Based on the analysis by Edwards and Brown (1998), it is not surprising that a glass (such as RC-36) with less than 2.5 wt% Fe_2O_3 is unpredictable. Given that this glass is based on the PHF waste type and blending would be expected, this glass does not dispute the hypothesis or current strategy for this task.

Table 14 summarizes the glass ID; homogeneity classification; sludge type; WL; frit; Al_2O_3, sum-of-alkali and Fe_2O_3 concentrations in glass; the XRD results of both Q and ccc glasses; results of the SEM analysis; and the PCT results for both Q and ccc glasses for the Frit 200-based RC glasses. Based on the measured PCT responses and the ΔG_P predictions, only three of the seven glasses are predictable. It should be noted that only RC-40 was predicted to be inhomogeneous using the targeted composition. Although classified as inhomogeneous, the quenched version of RC-40 is predictable. It should also be noted that even though amorphous phase separation may exist in this glass, it meets the criteria of being either predictable and/or acceptable (in this case both criteria are satisfied). The NL [B] for RC-40Q is 1.947 g/L (based on targeted compositions and screened PCTs).

The four PCT responses, which are not predictable, are associated with RC-39ccc, RC-40ccc, RC-42ccc, and RC-43ccc. Acmite or acmite and spinel are present in each of these ccc'd glasses with NL [B] being 1.569, 3.111, 1.835, and 2.427 g/L, respectively—well below the value reported for the EA glass and the working definition of acceptable being used in this report. Note that RC-38ccc, RC-41ccc, and RC-44ccc also contain acmite or acmite and spinel, but the PCT responses for these glasses are predictable. This indicates that the effect of crystallization on the residual glass matrix may play an important role in defining the overall durability of the system and ultimately its predictability. Again, regardless of homogeneity classification or the issues regarding the potential applicability of the ΔG_P model, all of the Frit 200-based glasses are either predictable and/or acceptable. In fact, results presented in the WQR (Plodinec et al. 1995) indicated that glass produced during waste qualification runs (in Canister S00001 from the WP-14 campaign) contained 17-vol% acmite. The PCT results of this material were "almost twice as much as the surrounding bulk glass but still less than $^1/_{10}$ the EA glass limit." The observations of the four "unpredictable" RC glasses are in line with historical results.

For the Frit 200-based glasses, all of the data (albeit limited and based on centroid compositions) supports the replacement of the homogeneity constraint. More specifically, for the one glass that was predicted to be inhomogeneous, the PCT response was predictable regardless of the potential presence of amorphous phase separation (which was not measured). It should be noted that predictions of homogeneity using both measured and measured bias-corrected compositions agreed with those using targeted compositions.

Table 15 summarizes the homogeneity classification; sludge type; waste loading; frit; Al_2O_3, sum-of-alkali and Fe_2O_3 concentrations in glass; the XRD results of both Q and ccc glasses; and the PCT results for the Frit 320-based RC glasses. Based on the assessment performed by Peeler et al. (2001b), the Frit 320-based systems rarely challenged the homogeneity constraint. Thus, only one of the 13 Frit 320-based glasses (RC-50) is predicted to be inhomogeneous. However, based on the measured PCT response and associated ΔG_P prediction, this glass is both predictable and acceptable—even the ccc version in the presence of spinels. Again, this adds to the growing database that supports the replacement of the homogeneity constraint for sludge-only processing. As previously mentioned, RC-51 and RC-52 are predicted to be inhomogeneous based on measured and/or measured bias-corrected compositional views. Although classified as inhomogeneous from these compositional views, these glasses are both predictable and acceptable. In fact, all of the Frit 320-based RC glasses are predictable and acceptable regardless of homogeneity classification or the presence of crystallization.

Again, it must be recognized that these glasses are based on centroid sludge compositions and do not account for anticipated compositional variation. This is the subject of the Phase 2 experimental study.

Table 14. Classification of Frit 200-based RC Glasses (based on targeted composition) with Related Physical Properties of Interest

ID	Homo	Sludge	WL	Frit	Al_2O_3	alkali	Fe_2O_3	XRD Q	XRD CCC	SEM/EDS	PCT Q	PCT CCC
RC-38	YES	SB3	30	200	0.0354	0.1509	0.13579	A	Acmite/spinel	Fe, Mn, Ni	-	-
RC-39	YES	SB4	30	200	0.03466	0.15111	0.1255	A	Acmite/spinel	NM	-	NP (mbc)
RC-40	NO	PHF	35	200	0.03115	0.14959	0.1204	A	Acmite/spinel	Fe, Mn, Ni	-	NP (all)
RC-41	YES	PLF	25	200	0.0313	0.15177	0.11565	A	Acmite/spinel	NM	-	-
RC-42	YES	PLF	30	200	0.03756	0.15012	0.13878	A	Acmite	NM	-	NP (all)
RC-43	YES	SB4	32.5	200	0.03755	0.15037	0.13596	A	Acmite	NM	-	NP (all)
RC-44	YES	SB3	27.5	200	0.03245	0.15165	0.12448	A	Acmite	NM	-	-

Table 15. Classification of Frit 320-based RC Glasses (based on targeted composition) with Related Physical Properties of Interest

ID	Homo	Sludge	WL	Frit	Al_2O_3	Alkali	Fe_2O_3	XRD Q	XRD CCC	SEM/EDS	PCT Q	PCT CCC
RC-45	YES	SB3	35	320	0.0413	0.17538	0.15843	A	A	NM	-	-
RC-46	YES	PMF	37.5	320	0.0306	0.17531	0.15478	A	Spinel	Fe, Mn, Ni	-	-
RC-47	YES	PLF	35	320	0.04382	0.17448	0.16191	A	Spinel	Fe, Mn, Ni	-	-
RC-48	YES	SB3	37.5	320	0.04425	0.17362	0.16974	A	Spinel	NM	-	-
RC-49	YES	SB4	30	320	0.03466	0.17911	0.1255	A	A	NM	-	-
RC-50	NO	PHF	35	320	0.03115	0.17559	0.1204	A	Spinel	Fe, Mn, Ni	-	-
RC-51	YES	SB4	27.5	320	0.03177	0.18085	0.11504	A	A	NM	-	-
RC-52	YES	PLF	25	320	0.0313	0.18177	0.11565	A	A	NM	-	-
RC-53	YES	SB4	40	320	0.04622	0.17215	0.16733	A	Spinel	Fe, Mn, Ni	-	-
RC-54	YES	PLF	30	320	0.03756	0.17812	0.13878	A	A	NM	-	-
RC-55	YES	SB4	35	320	0.04044	0.17563	0.14642	A	A	NM	-	-
RC-56	YES	SB3	27.5	320	0.03245	0.18065	0.12448	A	A	NM	-	-
RC-57	YES	SB3	30	320	0.0354	0.1789	0.13579	A	A	Fe, Mn, Ni	-	-

7.0 Summary

The homogeneity constraint is currently used to discriminate compositions that are likely to result in phase-separated glasses from compositions that are likely to be homogeneous. The technical basis for developing and implementing the phase-separation discriminator into PCCS was the fact that the durability of phase-separated glasses can be unpredictable. If sufficient evidence can establish the fact that although these glasses may be unpredictable, they are acceptable based on a predefined acceptance criteria over the composition region of interest, then replacing the homogeneity constraint with less restrictive can be technically defended. More specifically, to replace the homogeneity constraint, glasses within the composition region of interest should be predictable and/or acceptable regardless of the homogeneity classification given the application of either the Al_2O_3 and/or sum-of-alkali criteria.

The objective of this experimental study was to challenge the homogeneity constraint for sludge-only processing by monitoring the durability responses for both quenched and ccc glasses within this composition region. More specifically, the durability responses were monitored independent of the homogeneity classification but in terms of predictability and/or acceptability.

In this report, experimental data from the 34 Phase 1 centroid-based glasses were presented and discussed. The 34 RC glasses were selected using predefined criteria and resulted in only 7 glasses predicted to be inhomogeneous (based on targeted compositions). The primary areas of interest included:

(1) assessments to assure that targeted compositions were indeed met,
(2) assessments with respect to crystallization via XRD and/or SEM/EDS analysis (note the development of amorphous phase separation was intentionally not measured), and
(3) assessments of the PCT response as a function of quenched and ccc heat treatments.

These data were then used to draw conclusions regarding the potential limitations of the homogeneity constraint if utilized. The following is a summary of the major conclusions for each of the major areas of interest:

7.1 Compositional Assessment

The chemical composition measurements for the RC glasses were conducted by the SRTC-ML following an analytical plan (see Appendix A). The analytical plan was developed in such a way as to provide the opportunity to evaluate potential sources of error. Based on this assessment, it was concluded that the targeted compositions were indeed met. A batching error did occur for RC-31, which was subsequently rebatched. It should be noted that based on the "as-batched" composition, RC-31 was predicted to satisfy all property predictions (at the PAR) with the exception of homogeneity – making this glass another candidate glass for challenging homogeneity and supporting programmatic objectives.

7.2 Crystallization Assessment

Representative samples of all "as-fabricated" (or quenched) and ccc RC glasses were submitted for XRD and/or SEM/EDS analysis. All of the quenched RC glasses were classified as amorphous based on XRD analysis. Note that no attempt was made to identify the presence of amorphous phase separation. After the RC glasses were thermally heat treated according to the ccc schedule, 17 of the 34 ccc RC glasses did show some degree of crystallization as detected by XRD and/or SEM/EDS analysis. The two crystalline phases detected by XRD and/or SEM/EDS analysis were acmite and trevorite. Trevorite was reported in some glasses based on all three frits, while acmite (alone or with Trevorite) was only reported in the Frit 200-based RC glasses.

7.3 Challenges to the Homogeneity Constraint

With respect to the primary task objective (i.e., challenging the homogeneity constraint), only 7 of the 34 (including RC-31 and RC-31.5) centroid-based targeted compositions actually challenge the homogeneity constraint. The two criteria being used to assess these glasses are predictability and acceptability. As defined in Section 3.0, predictability is based on the 95% two-sided confidence interval for an individual PCT response as generated by the THERMO™ ΔG_p model. 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. Although the ΔG_P model was develop to be applied to a homogeneous glass (WQR [Plodinec et al. 1995] and THERMO™ (Jantzen et al. 1995), application to inhomogeneous glasses does have potential (and technical merit) given the impact of the developing secondary phase(s) is minimal to the overall performance. In this report, the ΔG_P model was applied to both quenched and ccc glasses (to assess the predictability)—regardless of the presence or absence of crystallization and/or amorphous phase separation—to test this hypothesis or assumption. It should be noted that previous studies (Harbour et al. 2000; Herman et al. 2001) have also applied the ΔG_P model to both quenched and ccc glasses with success (given the formation of spinels). It should be noted that the formation of non-isotropic crystals (such as acmite) may have a significant impact on the crystallization and grain boundary terms (see Equation 1) resulting in the classification of "unpredictable."

The term "acceptable" (in reference to a PCT response) is defined as glasses whose log NL [B] is less than 1.0 g/L (or NL [B] < 10 g/L). Both are working definitions defined and used throughout this report and are consistent with previous studies.

When coupling the PCT response with the homogeneity classification (and assuming the ΔG_P model is applicable for all RC glasses), only 7 of the 68 RC glasses (when both heat treatments are considered) were not predictable. Included in this list were the quenched and ccc versions of RC-36, which contained less than 2.5 wt% Fe_2O_3. Based on the analysis by Edwards and Brown (1998), it is not surprising that a glass (such as RC-36) with less than 2.5 wt% Fe_2O_3 is unpredictable. Of the remaining five unpredictable glasses, all contained acmite, spinel, or both. Note that all of the Frit 165 (exception of RC-36 with low Fe_2O_3) and 320-based glasses are predictable regardless of homogeneity classification or the presence of spinels.

In terms of acceptability, all of the RC glasses are well below the predefined limit of log NL [B] < 1.0 g/L (or NL [B] < 10.0 g/L) or the 16.695 g/L for EA as reported by Jantzen et al. (1993). Only 8 glasses (out of the 68 when considering both Q and ccc and including RC-31) have NL [B] exceeding 2.5 g/L. These are: RC-30Q, RC-30ccc, RC-36Q, RC-36ccc, RC-40ccc, RC-43ccc, RC-46Q and RC-50Q. The least durable glass produced was RC-36Q with a NL [B] of 6.194 g/L (based on the measured bias-corrected composition).

These data support the replacement of the homogeneity constraint and the data-driven approach or strategy being developed to utilize the Al_2O_3 and sum-of-alkali constraints to assure that durable products are produced in DWPF. More specifically, the PCT response was predictable and/or acceptable regardless of the homogeneity classification for all 34 RC glasses.

It is recognized that these glasses are based on centroid sludge compositions and do not account for anticipated compositional variation. That is the subject of the Phase 2 experimental study. Given these results and the fact that only centroid-based glasses were evaluated, if one were to ask "Can the homogeneity constraint be replaced unconditionally for sludge-only processing?", then the short answer is "no," given the current state of knowledge. However, based on the assessments provided by Peeler et al. (2001a) and the results presented in this report, there is strong evidence that the homogeneity constraint can be replaced with the less restrictive yet effective Al_2O_3 and/or sum-of-alkali constraints.

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8.0 Path Forward

The Phase 1 glasses were based on centroid sludge compositions and specific frits. Although the Phase 1 data support the elimination of the homogeneity constraint, given the projected sludge-only composition region is not adequately covered, programmatic objectives cannot be realized. More specifically, the data-driven, technical basis for eliminating the homogeneity constraint cannot be fully supported given incomplete compositional coverage. Herman et al. (2002) discuss the Phase 2 strategy to fill in the Phase 1 data gaps in which anticipated sludge variation is accounted for.

The initial rational for Phase 2 was to select glasses primarily from the outer-layer sludge regions and couple these with existing frits. However, based on preliminary Phase 1 data and input from other programs, the focus of the Phase 2 compositional region shifted. The approach taken accounts for potential tank-blending-scheme changes and frit compositional changes that may be made to improve melt rate and/or waste loading. A bounding glass compositional region that takes into account the possible sludge compositional ranges and that would allow for frit optimization will be used instead to select most of the glass compositions for testing. This approach also allows for the homogeneity constraint to be assessed over a broad compositional region that may apply to future DWPF glass compositions resulting from future frit/sludge combinations. In addition, the definition of this compositional region should also provide glass-processing regions of interest for future DWPF research and development (R&D) studies related to increasing the melt rate, throughput, and/or waste loading. If it is shown that the homogeneity constraint cannot be unconditionally replaced based on glasses being predictable and/or acceptable, then a path parallel to that used by Edwards and Brown (1998) for sludge-only processing (e.g., relaxing the homogeneity constraint to the PAR and imposing the Al_2O_3 and/or the sum-of-alkali constraints) is still a viable option.

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Appendix A

AN ANALYTICAL PLAN FOR MEASURING THE CHEMICAL COMPOSITIONS OF GLASSES FOR THE DWPF REDUCTION OF CONSTRAINTS STUDY

SRT-SCS-2001-00036

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SRS savannah river site

WESTINGHOUSE SAVANNAH RIVER COMPANY
INTEROFFICE MEMORANDUM

SRT-SCS-2001-00036

August 22, 2001

To: D. K. Peeler, 773-43A

cc: D. R. Best, 773-41A (wo)
K. G. Brown, 773-42A
E. W. Holtzscheiter, 773-A (es)
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I. A. Reamer, 773-A
E. P. Shine, 773-42A
R. C. Tuckfield, 773-42A
R. J. Workman, 773-A

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

wo – without glass identifiers
es – executive summary only

E. P. Shine, Technical Reviewer — 8/29/01 Date

R. C. Tuckfield, Manager
Statistical Consulting Section — 8/29/01 Date

An Analytical Plan for Measuring the Chemical Compositions of Glasses for the DWPF Reduction of Constraints Study (U)

1.0 EXECUTIVE SUMMARY

A study is being conducted by the Savannah River Technology Center (SRTC) for the Defense Waste Processing Facility (DWPF) that involves investigating the constraints associated with product quality. Thirty-three (33) glass compositions were selected for batching and testing to support this effort.

The chemical compositions of these study glasses 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.

2.0 INTRODUCTION

A study [1] of the constraints associated with product quality (i.e., glass durability) acceptance is being conducted by the Savannah River Technology Center (SRTC) for the Defense Waste Processing Facility (DWPF). Given the effectiveness of applying the new constraints (e.g., Al_2O_3 and alkali constraints) associated with homogeneity for SB1b [2], SB2 [3], and the inherent limitations of the application of the homogeneity discriminator for projected "sludge-only" glasses (i.e., prediction may unnecessarily limit waste loadings), an investigation into the application of these constraints is warranted. Thirty-three (33) glass compositions were selected for batching and testing to support this effort. The sludge-only compositional region was defined based on five independent (and bounding) sludge types and the projected sludge-only processing blending strategies as referenced in the High Level Waste System Plan, Revision 13. Glass compositions within this region are assessed using the current PCCS models (as well as the new T_L model – reference) to support the use of a relaxed homogeneity constraint (to the PAR) coupled with application of one of the equivalent constraints.

The chemical compositions of these 33 study glasses (referred to as "RC" glasses[a]) 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.

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 (SP).

The primary measurements of interest are to be acquired as follows: the samples prepared by lithium metaborate (LM) are to be measured for aluminum (Al), calcium (Ca), chromium (Cr), iron (Fe), magnesium (Mg), manganese (Mn), sodium (Na), nickel (Ni), phosphorous (P), silicon (Si), titanium (Ti), uranium (U), and zirconium (Zr) concentrations. Samples prepared by sodium peroxide (SP) are to be measured for boron (B) and lithium (Li). Samples dissolved by either of these two preparation methods are to be measured using Inductively Coupled Plasma (ICP) – Atomic Emission Spectrometry (AES). It should be noted that there are minor components associated with the RC glasses that will not be measured due to their concentration being below detection limits of the ICP. These minor components include Ba, Cd, Co, Cu, La, Mo, Pb, Ru, Sn, Sr, Th, V, and Zn.

Randomizing the preparation steps and blocking and randomizing the measurements for the ICP 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.

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

[a] This nomenclature was used by Peeler et al. [2] for the MB3 study in which 24 glasses were assessed. In the current study, RC glasses will be labeled RC-25 through RC-57.

potential bias correction. Specifically, several samples of Waste Compliance Plan (WCP) Batch 1 (BCH) [4] and a glass containing uranium (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

Each glass sample submitted to the SRTC-ML will be prepared in duplicate by the LM and SP dissolution methods. Each sample prepared using LM or SP 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, F01 through F33, for the 33 RC glasses batched as part of the reduction of constraints study. The table provides a naming convention that is to be used in analyzing the glasses and reporting the measurements of their compositions.[a]

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

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

Glass ID	Sample ID	Glass ID	Sample ID	Glass ID	Sample ID
RC-25	F04	RC-36	F31	RC-47	F02
RC-26	F09	RC-37	F13	RC-48	F06
RC-27	F28	RC-38	F29	RC-49	F23
RC-28	F16	RC-39	F27	RC-50	F19
RC-29	F15	RC-40	F08	RC-51	F21
RC-30	F01	RC-41	F18	RC-52	F25
RC-31	F30	RC-42	F26	RC-53	F33
RC-32	F11	RC-43	F22	RC-54	F14
RC-33	F24	RC-44	F03	RC-55	F10
RC-34	F12	RC-45	F07	RC-56	F05
RC-35	F17	RC-46	F20	RC-57	F32

3.1 PREPARATION OF THE SAMPLES

Each of the 33 RC glasses included in this analytical plan is to be prepared in duplicate by the LM and SP dissolution method. Thus, the total number of prepared glass samples is determined by $33 \cdot 2 \cdot 2 = 132$, 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. Three blocks of preparation work are provided for each preparation method to facilitate the scheduling of activities by work shift. The identifier for each of the prepared samples indicates the sample identifier (ID), preparation method, and duplicate number.

Table 3a: LM (Lithium Metaborate) Preparation Blocks

1	2	3
F28LM1	F14LM1	F17LM1
F11LM1	F12LM1	F31LM1
F18LM1	F12LM2	F19LM1
F30LM1	F29LM1	F04LM1
F06LM1	F14LM2	F04LM2
F20LM1	F25LM1	F02LM1
F13LM1	F16LM1	F02LM2
F30LM2	F26LM1	F17LM2
F28LM2	F25LM2	F31LM2
F01LM1	F33LM1	F07LM1
F01LM2	F32LM1	F19LM2
F13LM2	F33LM2	F21LM1
F11LM2	F29LM2	F05LM1
F20LM2	F15LM1	F21LM2
F18LM2	F16LM2	F09LM1
F06LM2	F15LM2	F07LM2
F27LM1	F03LM1	F09LM2
F24LM1	F26LM2	F08LM1
F10LM1	F23LM1	F08LM2
F24LM2	F03LM2	F22LM1
F27LM2	F32LM2	F22LM2
F10LM2	F23LM2	F05LM2

Table 3b: SP (Sodium Peroxide) Preparation Blocks

1	2	3
F05SP1	F30SP1	F07SP1
F31SP1	F02SP1	F22SP1
F05SP2	F10SP1	F27SP1
F31SP2	F33SP1	F22SP2
F20SP1	F02SP2	F14SP1
F12SP1	F30SP2	F06SP1
F20SP2	F10SP2	F06SP2
F18SP1	F03SP1	F29SP1
F23SP1	F09SP1	F07SP2
F25SP1	F33SP2	F14SP2
F16SP1	F19SP1	F29SP2
F18SP2	F19SP2	F01SP1
F04SP1	F28SP1	F32SP1
F21SP1	F08SP1	F27SP2
F11SP1	F28SP2	F01SP2
F25SP2	F03SP2	F17SP1
F16SP2	F09SP2	F24SP1
F12SP2	F13SP1	F24SP2
F23SP2	F08SP2	F32SP2
F21SP2	F26SP1	F15SP1
F04SP2	F13SP2	F15SP2
F11SP2	F26SP2	F17SP2

3.2 ICP Calibration Blocks

The glass samples prepared by LM and SP dissolution methods are to be analyzed using ICP instrumentation calibrated for the particular preparation method. After the initial set of cation concentration measurements, the ICP 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 SP-prepared samples are provided in Tables 4 and 5, respectively. The cations to be measured are specified in the header of each of these tables. In these tables, the sample identifiers for the 21 NS 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 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.

Table 4: ICP Blocks and Calibration Groups for Samples Prepared Using LM
(Used to Measure Elemental Al, Ca, Cr, Fe, Mg, Mn, Na, Ni, P, Si, Ti, U, and Zr)

ICP Block 1		ICP Block 2		ICP Block 3	
Calibration 1	**Calibration 2**	**Calibration 1**	**Calibration 2**	**Calibration 1**	**Calibration 2**
BCHLM111	BCHLM121	BCHLM211	BCHLM221	BCHLM311	BCHLM321
USTLM111	USTLM121	USTLM211	USTLM221	USTLM311	USTLM321
F17LM21	F33LM22	F07LM11	F24LM22	F30LM11	F06LM12
F21LM21	F17LM22	F05LM11	F05LM22	F27LM21	F10LM22
F08LM11	F02LM22	F12LM11	F33LM12	F22LM21	F30LM12
F07LM21	F31LM12	F02LM11	F27LM12	F11LM21	F28LM22
F04LM11	F04LM22	F16LM21	F16LM22	F13LM21	F13LM12
F31LM11	F09LM12	F24LM21	F30LM22	F25LM11	F28LM12
F03LM21	F06LM22	F30LM21	F15LM22	F03LM11	F11LM22
F17LM11	F04LM12	F22LM11	F02LM12	F08LM21	F24LM12
F31LM21	F25LM22	F01LM11	F32LM22	F10LM21	F25LM12
F04LM21	F07LM22	F15LM11	F15LM12	F18LM21	F18LM22
F02LM21	F19LM12	F11LM11	F29LM22	F10LM11	F26LM12
BCHLM112	BCHLM122	BCHLM212	BCHLM222	BCHLM312	BCHLM322
USTLM112	USTLM122	USTLM212	USTLM222	USTLM312	USTLM322
F21LM11	F19LM22	F23LM11	F07LM12	F26LM11	F23LM22
F26LM21	F32LM12	F33LM11	F23LM12	F16LM11	F13LM22
F18LM11	F31LM22	F12LM21	F14LM12	F28LM21	F20LM12
F25LM21	F18LM12	F14LM11	F11LM12	F28LM11	F03LM12
F19LM21	F08LM12	F29LM11	F01LM12	F20LM11	F20LM22
F33LM21	F21LM12	F29LM21	F12LM22	F20LM21	F22LM22
F32LM11	F21LM22	F15LM21	F12LM12	F06LM11	F27LM22
F01LM21	F17LM12	F09LM21	F09LM22	F14LM21	F08LM22
F19LM11	F26LM22	F05LM21	F22LM12	F24LM11	F14LM22
F09LM11	F03LM22	F32LM21	F05LM12	F23LM21	F10LM12
F06LM21	F01LM22	F27LM11	F29LM12	F13LM11	F16LM12
BCHLM113	BCHLM123	BCHLM213	BCHLM223	BCHLM313	BCHLM323
USTLM113	USTLM123	USTLM213	USTLM223	USTLM313	USTLM323

Table 5: ICP Blocks and Calibration Groups for Samples Prepared Using SP
(Used to Measure Elemental B and Li)

ICP Block 1		ICP Block 2		ICP Block 3	
Calibration 1	**Calibration 2**	**Calibration 1**	**Calibration 2**	**Calibration 1**	**Calibration 2**
BCHSP111	BCHSP121	BCHSP211	BCHSP221	BCHSP311	BCHSP321
USTSP111	USTSP121	USTSP211	USTSP221	USTSP311	USTSP321
F33SP11	F27SP22	F07SP11	F17SP12	F02SP11	F24SP12
F21SP11	F29SP12	F29SP21	F32SP12	F12SP21	F08SP12
F18SP21	F31SP22	F09SP11	F06SP22	F26SP21	F19SP22
F02SP21	F11SP22	F30SP21	F28SP12	F14SP21	F23SP12
F33SP21	F33SP12	F19SP11	F04SP12	F15SP21	F14SP22
F10SP11	F05SP22	F04SP11	F09SP12	F22SP11	F32SP22
F04SP21	F20SP12	F27SP11	F01SP12	F11SP11	F12SP12
F23SP21	F18SP12	F30SP11	F24SP22	F23SP11	F12SP22
F29SP11	F02SP22	F21SP21	F26SP12	F06SP11	F16SP22
F16SP11	F23SP22	F17SP11	F30SP12	F08SP21	F15SP12
F25SP21	F25SP12	F03SP21	F29SP22	F12SP11	F06SP12
BCHSP112	BCHSP122	BCHSP212	BCHSP222	BCHSP312	BCHSP322
USTSP112	USTSP122	USTSP212	USTSP222	USTSP312	USTSP322
F25SP11	F04SP22	F20SP21	F30SP22	F19SP21	F22SP12
F27SP21	F25SP22	F06SP21	F21SP22	F16SP21	F10SP22
F20SP11	F16SP12	F14SP11	F27SP12	F10SP21	F26SP22
F13SP11	F21SP12	F01SP11	F01SP22	F28SP21	F22SP22
F18SP11	F10SP12	F24SP21	F14SP12	F13SP21	F28SP22
F05SP21	F18SP22	F26SP11	F20SP22	F08SP11	F05SP12
F07SP21	F03SP12	F31SP11	F03SP22	F32SP21	F02SP12
F03SP11	F13SP12	F28SP11	F31SP12	F05SP11	F11SP12
F11SP21	F07SP22	F01SP21	F07SP12	F24SP11	F15SP22
F31SP21	F17SP22	F32SP11	F19SP12	F15SP11	F13SP22
F17SP21	F33SP22	F09SP21	F09SP22	F22SP21	F08SP22
BCHSP113	BCHSP123	BCHSP213	BCHSP223	BCHSP313	BCHSP323
USTSP113	USTSP123	USTSP213	USTSP223	USTSP313	USTSP323

4.0 CONCLUDING COMMENTS

In summary, this analytical plan identifies several ICP calibration blocks in Tables 4 – 5 as well as six preparation blocks in Tables 3a-3b 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 re-measured in its entirety. If for some reason the measurements are not conducted in the sequences presented in this report, a record should be made of the actual order used along with any explanative comments.

The analytical plan indicated in the preceding tables should be modified by the personnel of 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] Peeler, D.K., K.G. Brown, T.B. Edwards, W.E. Daniel, "Reduction of Constraints For DWPF: Task Technical and QA Plan" WSRC-RP-2001-00081, January 2001.

[2] Cicero-Herman, C. A., M. K. Andrews, and T. B. Edwards, "Results of the Tank 42 (Batch 1B) Variability Study, WSRC-TR-98-00180, June 5, 1998.

[3] Peeler, D.K., T.B. Edwards, K.G. Brown, R.J. Workman, and I.A. Reamer, "Reduction of Constraints: Applicability of the Homogeneity Constraint for Macrobatch 3," WSRC-TR-2000-00358, September 2000.

[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^{TM}) (U)," WSRC-TR-93-673, Rev. 1, Volume 2, Table B.1, pp. B.9, 1995.

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Appendix B

AN ANALYTICAL PLAN FOR MEASURING PCT SOLUTIONS FOR THE FRIT 165 GLASSES SUPPORTING THE REDUCTION OF CONSTRAINTS STUDY

SRT-SCS-2001-00047

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WESTINGHOUSE SAVANNAH RIVER COMPANY
INTEROFFICE MEMORANDUM

SRT-SCS-2001-00047

September 27, 2001

To: D. K. Peeler, 773-43A

cc: R. A. Baker, 773-42A
D. R. Best, 773-41A (wo)
K. G. Brown, 773-42A
E. W. Holtzscheiter, 773-A (es)
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I. A. Reamer, 773-A
R. C. Tuckfield, 773-42A
R. J. Workman, 773-A

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

wo – without glass identifiers
es – executive summary only

R. A. Baker, Technical Reviewer — Date: 9/27/2001

R. C. Tuckfield, Manager
Statistical Consulting Section — Date: 9/28/01

An Analytical Plan for Measuring PCT Solutions for the Frit 165 Glasses Supporting the Reduction of Constraints Study (U)

1.0 EXECUTIVE SUMMARY

A study is being conducted by the Savannah River Technology Center (SRTC) for the Defense Waste Processing Facility (DWPF) that involves investigating the constraints associated with product quality. Thirty-three (33) glass compositions were selected for batching and testing to support this effort. These glasses were selected from compositional regions that reflected several frits and basic waste stream types, as well as anticipated sludge batch 3 (SB3) and 4 (SB4) wastes. The frit contribution to the compositions of thirteen of the selected glasses reflected processing using Frit 165.

The thirteen Frit 165 glasses are to be cooled both by quenching and centerline-cooling, and the durabilities of the resulting twenty-six glasses are to be measured in triplicate using the Product Consistency Test, or PCT. Its requirements 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 these 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 study [1] is being conducted by the Savannah River Technology Center (SRTC) for the Defense Waste Processing Facility (DWPF) that involves investigating the constraints associated with product quality. Thirty-three (33) glass compositions were selected for batching and testing to support this effort. These glasses were selected from compositional regions that reflected several frits and basic waste stream types, as well as anticipated sludge batch 3 (SB3) and 4 (SB4) wastes. The frit contribution to the compositions of thirteen of the selected glasses reflected processing using Frit 165. A subsequent (and separate) analytical plan will be prepared in support of those glasses produced using Frit 320; the plan for those glasses produced using Frit 200 has already been issued.

The thirteen Frit 165 glasses are to be cooled both by quenching and centerline-cooling, and the durabilities of the resulting twenty-six glasses are to be measured in triplicate using the Product Consistency Test, or PCT. Its requirements are described in ASTM C1285-97 (Method A) [2].

An "RC" naming scheme was used to identify the glasses selected for study. The identifiers for the Frit 165 glasses are presented in Table 1. The centerline canister-cooled glasses are denoted by a "ccc" suffix.

Table 1: Identifiers for the RC Glasses

Quenched	Centerline Canister Cooled
RC-25	RC-25ccc
RC-26	RC-26ccc
RC-27	RC-27ccc
RC-28	RC-28ccc
RC-29	RC-29ccc
RC-30	RC-30ccc
RC-31	RC-31ccc
RC-32	RC-32ccc
RC-33	RC-33ccc
RC-34	RC-34ccc
RC-35	RC-35ccc
RC-36	RC-36ccc
RC-37	RC-37ccc

This memorandum 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 quenched and centerline-cooled versions of the Frit 165 "RC" glasses are to be subjected to the PCT. The 2 different thermal histories for each of the 13 glasses lead to 26 glasses that are to be measured (in triplicate) using the PCT. In addition to those for the 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 86 sample solutions being required to complete these PCTs.

The leachates from these tests will be diluted by adding 4 mL of 0.4 M HNO_3 to 6 mL of the leachate (a 6:10 volume to volume, v:v, dilution) before being submitted to 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, n01 through n86, for the individual solutions required for the PCTs of these "RC" 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.[a]

Table 2: Solution Identifiers for RC Glasses

Original Sample	Solution Identifier	Original Sample	Solution Identifier	Original Sample	Solution Identifier
RC-25	n37	RC-30	n42	RC-35	n64
RC-25	n11	RC-30	n51	RC-35	n74
RC-25	n46	RC-30	n24	RC-35	n36
RC-25ccc	n16	RC-30ccc	n67	RC-35ccc	n04
RC-25ccc	n60	RC-30ccc	n79	RC-35ccc	n50
RC-25ccc	n76	RC-30ccc	n22	RC-35ccc	n01
RC-26	n10	RC-31	n53	RC-36	n58
RC-26	n47	RC-31	n69	RC-36	n54
RC-26	n35	RC-31	n09	RC-36	n03
RC-26ccc	n06	RC-31ccc	n02	RC-36ccc	n13
RC-26ccc	n05	RC-31ccc	n19	RC-36ccc	n72
RC-26ccc	n57	RC-31ccc	n31	RC-36ccc	n59
RC-27	n14	RC-32	n18	RC-37	n38
RC-27	n32	RC-32	n39	RC-37	n61
RC-27	n40	RC-32	n33	RC-37	n65
RC-27ccc	n15	RC-32ccc	n82	RC-37ccc	n41
RC-27ccc	n63	RC-32ccc	n29	RC-37ccc	n70
RC-27ccc	n43	RC-32ccc	n08	RC-37ccc	n17
RC-28	n20	RC-33	n68	ARM	n23
RC-28	n27	RC-33	n77	ARM	n86
RC-28	n25	RC-33	n07	ARM	n34
RC-28ccc	n52	RC-33ccc	n26	EA	n44
RC-28ccc	n12	RC-33ccc	n75	EA	n30
RC-28ccc	n49	RC-33ccc	n83	EA	n48
RC-29	n85	RC-34	n84	blank	n55
RC-29	n45	RC-34	n78	blank	n80
RC-29	n28	RC-34	n71		
RC-29ccc	n73	RC-34ccc	n21		
RC-29ccc	n81	RC-34ccc	n66		
RC-29ccc	n62	RC-34ccc	n56		

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: boron (B),

[a] 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.

lithium (Li), sodium (Na), and silicon (Si). 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 (ICP) – Atomic Emission Spectrometer (AES). The PCT solutions (as identified in Table 2) are grouped in six ICP blocks for processing by the SRTC-ML in Table 3. Each block requires a different calibration of the ICP.

Table 3: ICP Calibration Blocks for Leachate Measurements

1	2	3	4	5	6
std-b1-1	std-b2-1	std-b3-1	std-b4-1	std-b5-1	std-b6-1
n43	n77	n11	n35	n86	n10
n41	n26	n65	n78	n72	n52
n37	n53	n15	n27	n51	n29
n74	n46	n64	n23	n47	n48
n85	n28	n45	n59	n71	n54
n61	n14	n62	n24	n25	n34
n50	n19	n60	n56	n79	n42
std-b1-2	std-b2-2	std-b3-2	std-b4-2	std-b5-2	std-b6-2
n75	n36	n40	n82	n21	n20
n73	n38	n83	n58	n08	n66
n16	n81	n07	n06	n30	n84
n32	n76	n17	n18	n05	n67
n31	n63	n04	n22	n03	n39
n69	n70	n09	n44	n12	n13
n68	n01	n02	n49	n33	n57
n55	n80	std-b3-3	std-b4-3	std-b5-3	std-b6-3
std-b1-3	std-b2-3				

A multi-element solution standard (denoted by "std-bi-j" where i=1 to 6 represents the block number and j=1, 2, and 3 represents the position in the block) was added at the beginning, middle, and end of each of the 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 six ICP calibration blocks in Table 3 for the SRTC-ML to use in conducting the boron (B), lithium (Li), sodium (Na), and silicon (Si) concentration measurements for the PCT study of the Frit 165 "RC" glasses for the DWPF reduction of constraints 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] Peeler, D.K., K.G. Brown, T.B. Edwards, W.E. Daniel, "Reduction of Constraints for DWPF: Task Technical and QA Plan," WSRC-RP-2001-00081, January 2001.

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

Appendix C

AN ANALYTICAL PLAN FOR MEASURING PCT SOLUTIONS FOR THE FRIT 200 GLASSES SUPPORTING THE REDUCTION OF CONSTRAINTS STUDY

SRT-SCS-2001-00043

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WESTINGHOUSE SAVANNAH RIVER COMPANY
INTEROFFICE MEMORANDUM

SRT-SCS-2001-00043

September 14, 2001

To: D. K. Peeler, 773-43A

cc: R. A. Baker, 773-42A
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R. C. Tuckfield, 773-42A
R. J. Workman, 773-A

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

wo – without glass identifiers
es – executive summary only

R. A. Baker, Technical Reviewer — Date: 9/18/2001

R. C. Tuckfield, Manager
Statistical Consulting Section — Date: 9/18/01

An Analytical Plan for Measuring PCT Solutions for the Frit 200 Glasses Supporting the Reduction of Constraints Study (U)

1.0 EXECUTIVE SUMMARY

A study is being conducted by the Savannah River Technology Center (SRTC) for the Defense Waste Processing Facility (DWPF) that involves investigating the constraints associated with product quality. Thirty-three (33) glass compositions were selected for batching and testing to support this effort. These glasses were selected from compositional regions that reflected several frits and basic waste stream types, as well as anticipated sludge batch 3 (SB3) and 4 (SB4) wastes. The frit contribution to the compositions of seven of the selected glasses reflected processing using Frit 200.

The seven Frit 200 glasses are to be cooled both by quenching and center-line-cooling, and the durabilities of the resulting fourteen glasses are to be measured in triplicate using the Product Consistency Test, or PCT. Its requirements 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 these 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 study [1] is being conducted by the Savannah River Technology Center (SRTC) for the Defense Waste Processing Facility (DWPF) that involves investigating the constraints associated with product quality. Thirty-three (33) glass compositions were selected for batching and testing to support this effort. These glasses were selected from compositional regions that reflected several frits and basic waste stream types, as well as anticipated sludge batch 3 (SB3) and 4 (SB4) wastes. The frit contribution to the compositions of seven of the selected glasses reflected processing using Frit 200. Subsequent (and separate) analytical plans will be prepared in support of those glasses produced using Frit 165 and Frit 320.

The seven Frit 200 glasses are to be cooled both by quenching and center-line-cooling, and the durabilities of the resulting fourteen glasses are to be measured in triplicate using the Product Consistency Test, or PCT. Its requirements are described in ASTM C1285-97 (Method A) [2].

An "RC" naming scheme was used to identify the glasses selected for study. The identifiers for the Frit 200 glasses are presented in Table 1. The centerline canister-cooled glasses are denoted by a "ccc" suffix.

Table 1: Identifiers for the RC Glasses

Quenched	Centerline Canister Cooled
RC-38	RC-38ccc
RC-39	RC-39ccc
RC-40	RC-40ccc
RC-41	RC-41ccc
RC-42	RC-42ccc
RC-43	RC-43ccc
RC-44	RC-44ccc

This memorandum 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 quenched and center-line-cooled versions of the Frit 200 "RC" glasses are to be subjected to the PCT. The 2 different thermal histories for each of the 7 glasses lead to 14 glasses that are to be measured (in triplicate) using the PCT. In addition to those for the study glasses, triplicate PCTs are to be conducted on a sample of ARM glass and a sample of the EA glass. Two reagent blank samples are also to be included in these tests. This results in 50 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, k01 through k50, for the individual solutions required for the PCTs of these "RC" 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.[a]

Table 2: Solution Identifiers for RC Glasses

Original Sample	Solution Identifier	Original Sample	Solution Identifier
RC-38	k50	RC-42ccc	k09
RC-38	k29	RC-42ccc	k16
RC-38	k08	RC-42ccc	k37
RC-38ccc	k32	RC-43	k02
RC-38ccc	k25	RC-43	k44
RC-38ccc	k36	RC-43	k49
RC-39	k30	RC-43ccc	k48
RC-39	k47	RC-43ccc	k27
RC-39	k22	RC-43ccc	k15
RC-39ccc	k41	RC-44	k04
RC-39ccc	k35	RC-44	k39
RC-39ccc	k45	RC-44	k06
RC-40	k12	RC-44ccc	k17
RC-40	k14	RC-44ccc	k43
RC-40	k24	RC-44ccc	k40
RC-40ccc	k11	ARM	k46
RC-40ccc	k20	ARM	k34
RC-40ccc	k38	ARM	k33
RC-41	k23	EA	k18
RC-41	k07	EA	k28
RC-41	k10	EA	k13
RC-41ccc	k21	blank	k26
RC-41ccc	k42	blank	k31
RC-41ccc	k01		
RC-42	k03		
RC-42	k05		
RC-42	k19		

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: boron (B), lithium (Li), sodium (Na), and silicon (Si). 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 (ICP) – Atomic Emission Spectrometer (AES). The PCT solutions (as identified in Table 2) are grouped in three ICP blocks for processing by the SRTC-ML in Table 3. Each block requires a different calibration of the ICP.

[a] 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 Calibration Blocks for Leachate Measurements

1	2	3
std-b1-1	std-b2-1	std-b3-1
k07	k14	k17
k06	k11	k35
k31	k10	k23
k05	k30	k16
k22	k08	k01
k18	k34	k29
k46	k15	k28
k21	k09	k49
std-b1-2	std-b2-2	std-b3-2
k41	k43	k12
k48	k26	k36
k38	k19	k33
k02	k25	k04
k50	k39	k27
k37	k45	k20
k40	k42	k03
k24	k13	k47
k32	k44	std-b3-3
std-b1-3	std-b2-3	

A multi-element solution standard (denoted by "std-bi-j" where i=1, 2, and 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 calibration blocks in Table 3 for the SRTC-ML to use in conducting the boron (B), lithium (Li), sodium (Na), and silicon (Si) concentration measurements for the PCT study of the Frit 200 "RC" glasses for the DWPF reduction of constraints 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] Peeler, D.K., K.G. Brown, T.B. Edwards, W.E. Daniel, "Reduction of Constraints for DWPF: Task Technical and QA Plan" WSRC-RP-2001-00081, January 2001.

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

Appendix D

AN ANALYTICAL PLAN FOR MEASURING PCT SOLUTIONS FOR THE FRIT 320 GLASSES SUPPORTING THE REDUCTION OF CONSTRAINTS STUDY

SRT-SCS-2001-00048

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WESTINGHOUSE SAVANNAH RIVER COMPANY
INTEROFFICE MEMORANDUM

SRT-SCS-2001-00048

October 8, 2001

To: D. K. Peeler, 773-43A

cc: R. A. Baker, 773-42A
D. R. Best, 773-41A (wo)
K. G. Brown, 773-42A
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S. L. Marra, 704-1T
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I. A. Reamer, 773-A
R. C. Tuckfield, 773-42A
R. J. Workman, 773-A

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: 10/15/2001

R. C. Tuckfield, Manager
Statistical Consulting Section — Date: 10/5/01

An Analytical Plan for Measuring PCT Solutions for the Frit 320 Glasses Supporting the Reduction of Constraints Study (U)

1.0 EXECUTIVE SUMMARY

A study is being conducted by the Savannah River Technology Center (SRTC) for the Defense Waste Processing Facility (DWPF) that involves investigating the constraints associated with product quality. Thirty-three (33) glass compositions were selected for batching and testing to support this effort. These glasses were selected from compositional regions that reflected several frits and basic waste stream types, as well as anticipated sludge batch 3 (SB3) and 4 (SB4) wastes. The frit contribution to the compositions of thirteen of the selected glasses reflected processing using Frit 320.

The thirteen Frit 320 glasses are to be cooled both by quenching and centerline-cooling, and the durabilities of the resulting twenty-six glasses are to be measured in triplicate using the Product Consistency Test, or PCT. Its requirements 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 these 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 study [1] is being conducted by the Savannah River Technology Center (SRTC) for the Defense Waste Processing Facility (DWPF) that involves investigating the constraints associated with product quality. Thirty-three (33) glass compositions were selected for batching and testing to support this effort. These glasses were selected from compositional regions that reflected several frits and basic waste stream types, as well as anticipated sludge batch 3 (SB3) and 4 (SB4) wastes. The frit contribution to the compositions of thirteen of the selected glasses reflected processing using Frit 320. Analytical plans for those glasses produced using Frit 200 and Frit 165 have already been issued.

The thirteen Frit 320 glasses are to be cooled both by quenching and centerline-cooling, and the durabilities of the resulting twenty-six glasses are to be measured in triplicate using the Product Consistency Test, or PCT. Its requirements are described in ASTM C1285-97 (Method A) [2].

An "RC" naming scheme was used to identify the glasses selected for study. The identifiers for the Frit 320 glasses are presented in Table 1. The centerline canister-cooled glasses are denoted by a "ccc" suffix. An additional glass, RC-38ccc, also appears in Table 1 even though this glass was prepared to represent a Frit 200 glass. As the earlier PCT results were reviewed, it was discovered that this glass needed to be re-tested.

Table 1: Identifiers for the RC Glasses

Quenched	Centerline Canister Cooled
RC-45	RC-45ccc
RC-46	RC-46ccc
RC-47	RC-47ccc
RC-48	RC-48ccc
RC-49	RC-49ccc
RC-50	RC-50ccc
RC-51	RC-51ccc
RC-52	RC-52ccc
RC-53	RC-53ccc
RC-54	RC-54ccc
RC-55	RC-55ccc
RC-56	RC-56ccc
RC-57	RC-57ccc
	RC-38ccc

This memorandum 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 quenched and centerline-cooled versions of the Frit 320 "RC" glasses are to be subjected to the PCT. The 2 different thermal histories for each of the 13 glasses lead to 26 Frit 320 glasses that are to be measured (in triplicate) using the PCT. In addition to those for the 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. Finally, as indicated in Table 1, a centerline-cooled version of the RC-38 glass (RC-38ccc) is to be included in these tests. The PCT for this glass is to be run in duplicate. Thus, a total of 88 sample solutions are 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, J01 through J88, for the individual solutions required for the PCTs of these "RC" 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.[a]

Table 2: Solution Identifiers for the RC Glasses

Original Sample	Solution Identifier	Original Sample	Solution Identifier	Original Sample	Solution Identifier
RC-45	J65	RC-50	J81	RC-55	J44
RC-45	J18	RC-50	J78	RC-55	J53
RC-45	J20	RC-50	J22	RC-55	J46
RC-45ccc	J04	RC-50ccc	J68	RC-55ccc	J25
RC-45ccc	J58	RC-50ccc	J01	RC-55ccc	J33
RC-45ccc	J41	RC-50ccc	J10	RC-55ccc	J45
RC-46	J66	RC-51	J76	RC-56	J15
RC-46	J70	RC-51	J52	RC-56	J60
RC-46	J07	RC-51	J35	RC-56	J49
RC-46ccc	J21	RC-51ccc	J37	RC-56ccc	J43
RC-46ccc	J48	RC-51ccc	J83	RC-56ccc	J71
RC-46ccc	J69	RC-51ccc	J28	RC-56ccc	J27
RC-47	J67	RC-52	J59	RC-57	J39
RC-47	J32	RC-52	J62	RC-57	J36
RC-47	J19	RC-52	J11	RC-57	J80
RC-47ccc	J86	RC-52ccc	J51	RC-57ccc	J57
RC-47ccc	J74	RC-52ccc	J38	RC-57ccc	J73
RC-47ccc	J08	RC-52ccc	J82	RC-57ccc	J54
RC-48	J79	RC-53	J30	ARM	J55
RC-48	J75	RC-53	J56	ARM	J03
RC-48	J72	RC-53	J02	ARM	J16
RC-48ccc	J61	RC-53ccc	J23	EA	J85
RC-48ccc	J26	RC-53ccc	J42	EA	J06
RC-48ccc	J77	RC-53ccc	J05	EA	J09
RC-49	J24	RC-54	J50	blank	J14
RC-49	J63	RC-54	J34	blank	J88
RC-49	J12	RC-54	J29	RC-38ccc	J13
RC-49ccc	J31	RC-54ccc	J47	RC-38ccc	J87
RC-49ccc	J64	RC-54ccc	J40		
RC-49ccc	J17	RC-54ccc	J84		

[a] 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.

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: boron (B), lithium (Li), sodium (Na), and silicon (Si). 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 (ICP) – Atomic Emission Spectrometer (AES). The PCT solutions (as identified in Table 2) are grouped in six ICP blocks for processing by the SRTC-ML in Table 3. Each block requires a different calibration of the ICP.

Table 3: ICP Calibration Blocks for the Leachate Measurements

1	2	3	4	5	6
std-b1-1	std-b2-1	std-b3-1	std-b4-1	std-b5-1	std-b6-1
J04	J63	J08	J51	J75	J49
J76	J32	J80	J85	J70	J11
J24	J33	J12	J81	J38	J72
J39	J52	J35	J21	J06	J69
J23	J64	J54	J59	J62	J27
J44	J74	J19	J66	J60	J82
J31	J53	J46	J79	J01	J10
std-b1-2	std-b2-2	std-b3-2	std-b4-2	std-b5-2	std-b6-2
J57	J36	J05	J47	J78	J77
J30	J56	J17	J43	J34	J16
J65	J58	J20	J68	J71	J22
J67	J42	J28	J61	J26	J84
J25	J73	J41	J55	J03	J07
J86	J83	J45	J15	J48	J09
J37	J18	J02	J50	J40	J29
J88	J14	J87	J13	std-b5-3	std-b6-3
std-b1-3	std-b2-3	std-b3-3	std-b4-3		

A multi-element solution standard (denoted by "std-bi-j" where i=1 to 6 represents the block number and j=1, 2, and 3 represents the position in the block) was added at the beginning, middle, and end of each of the 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 six ICP calibration blocks in Table 3 for the SRTC-ML to use in conducting the boron (B), lithium (Li), sodium (Na), and silicon (Si) concentration measurements for the PCT study of the Frit 320 "RC" glasses for the DWPF reduction of constraints 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] Peeler, D.K., K.G. Brown, T.B. Edwards, W.E. Daniel, "Reduction of Constraints for DWPF: Task Technical and QA Plan," WSRC-RP-2001-00081, January 2001.

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

Appendix E

TABLES AND EXHIBITS SUPPORTING THE ANALYSIS OF THE CHEMICAL COMPOSITION MEASUREMENTS OF THE RC GLASSES

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Table E.1: Measured Elemental Concentrations (wt%) for the RC Glasses Prepared Using Lithium Metaborate

SRTC-ML ID	Glass ID	Block	Sub-Block	Analytical Sequence	Al	Ca	Cr	Fe	Mg	Mn	Na	Ni	P	Ti	U	Zr
Batch 1	bhllm111	1	1	1	2.63	0.946	0.079	9.00	0.917	1.39	6.97	0.603	<0.017	0.431	<0.100	0.077
U_{std}	uglm111	1	1	2	2.11	0.972	0.171	9.02	0.726	2.08	8.64	0.798	<0.017	0.580	1.97	<0.010
RC-35	f17lm21	1	1	3	1.76	0.938	0.060	8.39	0.638	1.21	9.51	0.515	0.129	0.009	2.59	0.547
RC-51	f21lm21	1	1	4	1.76	0.874	0.060	7.70	0.293	2.03	8.96	0.422	0.129	0.009	1.98	0.027
RC-40	f08lm11	1	1	5	1.72	0.513	0.074	8.13	1.348	3.01	8.62	2.161	0.172	0.014	4.66	0.031
RC-45	f07lm21	1	1	6	2.25	1.19	0.076	10.3	0.266	1.55	9.10	0.674	0.164	0.010	3.26	0.028
RC-25	f04lm11	1	1	7	2.35	1.21	0.075	10.6	0.622	1.41	9.43	0.491	0.161	0.020	3.11	0.497
RC-36	f31lm11	1	1	8	3.47	0.257	0.034	1.45	0.667	1.17	9.68	0.128	0.073	0.007	0.31	0.620
RC-44	f03lm21	1	1	9	1.73	0.903	0.059	8.55	1.10	1.24	8.38	0.535	0.125	0.009	2.57	0.022
RC-35	f17lm11	1	1	10	1.78	0.997	0.066	8.68	0.674	1.22	9.73	0.519	0.127	0.049	2.59	0.590
RC-36	f31lm21	1	1	11	3.46	0.279	0.034	1.46	0.657	1.16	9.53	0.127	0.070	0.007	0.31	0.613
RC-25	f04lm21	1	1	12	2.43	1.24	0.072	10.9	0.632	1.44	9.61	0.550	0.162	0.022	3.19	0.527
RC-47	f02lm21	1	1	13	2.41	1.23	0.076	10.7	0.231	1.43	9.09	0.503	0.161	0.013	3.15	0.027
Batch 1	bchlm112	1	1	14	2.65	0.945	0.080	9.07	0.925	1.40	6.95	0.606	<0.017	0.434	<0.100	0.078
U_{std}	ustdlm112	1	1	15	2.10	0.970	0.173	8.98	0.733	2.10	8.54	0.808	<0.017	0.584	1.98	<0.010
RC-51	f21lm11	1	1	16	1.75	0.883	0.061	7.55	0.302	2.08	8.90	0.444	0.130	0.010	2.04	0.026
RC-42	f26lm21	1	1	17	2.06	1.04	0.063	9.27	1.03	1.25	8.62	0.439	0.139	0.009	2.75	0.024
RC-41	f18lm11	1	1	18	1.72	0.901	0.053	7.94	1.07	1.08	8.48	0.381	0.112	0.045	2.29	0.036
RC-52	f25lm21	1	1	19	1.75	0.885	0.055	7.56	0.168	1.03	9.06	0.359	0.117	0.009	2.27	0.022
RC-50	f19lm21	1	1	20	1.74	0.509	0.080	7.86	0.606	2.99	9.24	2.18	0.166	0.010	4.61	0.029
RC-53	f33lm21	1	1	21	2.47	1.22	0.083	11.0	0.428	2.93	9.08	0.584	0.185	0.011	2.90	0.034
RC-57	f32lm11	1	1	22	1.91	0.978	0.064	8.96	0.226	1.32	8.99	0.587	0.139	0.011	2.85	0.023
RC-30	f01lm21	1	1	23	1.72	0.471	0.074	7.92	0.987	2.99	9.76	2.19	0.168	0.011	4.70	0.507
RC-50	f19lm11	1	1	24	1.73	0.505	0.081	7.93	0.608	3.01	9.40	2.21	0.168	0.011	4.64	0.027
RC-26	f09lm11	1	1	25	2.19	1.11	0.073	10.7	0.655	1.53	9.37	0.658	0.159	0.010	3.22	0.484
RC-48	f06lm21	1	1	26	2.40	1.24	0.081	11.1	0.288	1.65	9.12	0.709	0.179	0.011	3.53	0.038
Batch 1	bhlm113	1	1	27	2.64	0.979	0.080	9.08	0.924	1.40	6.97	0.605	<0.017	0.434	<0.100	0.077
U_{std}	ustlm113	1	1	28	2.10	0.993	0.174	8.94	0.736	2.11	8.56	0.812	<0.017	0.587	1.99	<0.010
Batch 1	bhlm121	1	2	1	2.59	0.943	0.076	9.04	0.907	1.38	7.00	0.596	<0.017	0.423	<0.100	0.073
U_{std}	ustlm121	1	2	2	2.06	0.977	0.168	8.99	0.717	2.07	8.64	0.795	<0.017	0.571	1.92	<0.010

Table E.1: Measured Elemental Concentrations (wt%) for the RC Glasses Prepared Using Lithium Metaborate *(continued)*

SRTC-ML ID	Glass ID	Block	Sub-Block	Analytical Sequence	Al	Ca	Cr	Fe	Mg	Mn	Na	Ni	P	Ti	U	Zr
RC-53	f33lm22	1	2	3	2.38	1.17	0.078	11.0	0.419	2.85	9.08	0.573	0.177	0.004	2.76	0.030
RC-35	f17lm22	1	2	4	1.71	0.905	0.057	8.41	0.626	1.19	9.56	0.505	0.124	0.002	2.48	0.531
RC-47	f02lm22	1	2	5	2.38	1.21	0.071	10.6	0.222	1.39	9.19	0.489	0.157	0.006	3.07	0.023
RC-36	f31lm12	1	2	6	3.39	0.254	0.031	1.44	0.654	1.15	9.71	0.125	0.068	<0.003	0.300	0.605
RC-25	f04lm22	1	2	7	2.38	1.20	0.068	10.6	0.620	1.42	9.64	0.538	0.157	0.015	3.09	0.514
RC-26	f09lm12	1	2	8	2.14	1.08	0.069	10.6	0.645	1.51	9.47	0.651	0.156	0.003	3.11	0.471
RC-48	f06lm22	1	2	9	2.36	1.20	0.077	11.0	0.281	1.62	9.21	0.694	0.172	0.004	3.42	0.042
RC-25	f04lm12	1	2	10	2.30	1.18	0.071	10.7	0.607	1.40	9.51	0.481	0.156	0.013	3.02	0.480
RC-52	f25lm22	1	2	11	1.70	0.853	0.050	7.71	0.161	0.99	8.98	0.349	0.114	<0.003	2.18	0.022
RC-45	f07lm22	1	2	12	2.21	1.15	0.071	10.4	0.255	1.51	9.22	0.649	0.161	0.003	3.17	0.024
RC-50	f19lm12	1	2	13	1.69	0.503	0.076	7.98	0.591	2.95	9.28	2.14	0.162	0.003	4.50	0.024
Batch 1	bchlm122	1	2	14	2.57	0.925	0.075	9.02	0.895	1.36	7.02	0.587	<0.017	0.419	<0.100	0.072
U_{std}	ustlm122	1	2	15	2.05	0.939	0.168	9.02	0.719	2.07	8.70	0.792	<0.017	0.569	1.90	<0.010
RC-50	f19lm22	1	2	16	1.69	0.494	0.076	7.88	0.591	2.93	9.25	2.13	0.164	0.004	4.41	0.026
RC-57	f32lm12	1	2	17	1.85	0.939	0.061	8.94	0.222	1.31	8.99	0.576	0.135	0.004	2.73	0.020
RC-36	f31lm22	1	2	18	3.37	0.275	0.031	1.43	0.648	1.14	9.70	0.124	0.068	<0.003	0.29	0.599
RC-41	f18lm12	1	2	19	1.67	0.870	0.048	7.96	1.04	1.04	8.55	0.367	0.110	0.037	2.20	0.032
RC-40	f08lm12	1	2	20	1.67	0.488	0.069	8.02	1.32	2.94	8.77	2.09	0.164	0.007	4.46	0.027
RC-51	f21lm12	1	2	21	1.69	0.848	0.057	7.57	0.296	2.04	9.01	0.432	0.124	0.003	1.95	0.018
RC-51	f21lm22	1	2	22	1.72	0.852	0.058	7.54	0.293	2.03	9.12	0.421	0.127	<0.003	1.92	0.019
RC-35	f17lm12	1	2	23	1.74	0.971	0.062	8.55	0.664	1.20	9.85	0.509	0.125	0.042	2.50	0.571
RC-42	f26lm22	1	2	24	2.02	1.01	0.059	9.27	1.01	1.22	8.68	0.430	0.137	<0.003	2.67	0.020
RC-44	f03lm22	1	2	25	1.69	0.884	0.055	8.60	1.07	1.21	8.48	0.521	0.123	<0.003	2.50	0.018
RC-30	f01lm22	1	2	26	1.69	0.464	0.070	7.90	0.956	2.93	9.70	2.12	0.161	0.004	4.52	0.487
Batch 1	bchlm123	1	2	27	2.59	0.958	0.075	8.95	0.891	1.35	7.01	0.584	<0.017	0.419	<0.100	0.072
U_{std}	ustlm123	1	2	28	2.06	0.948	0.167	8.96	0.713	2.07	8.67	0.790	<0.017	0.571	1.93	<0.010
Batch 1	bchlm211	2	1	1	2.56	0.946	0.072	8.93	0.896	1.36	7.03	0.589	<0.017	0.419	<0.100	0.072
U_{std}	ustlm211	2	1	2	2.04	0.941	0.164	8.93	0.719	2.07	8.73	0.790	<0.017	0.569	1.92	<0.010
RC-45	f07lm11	2	1	3	2.14	1.09	0.065	9.82	0.249	1.48	8.88	0.641	0.155	0.005	3.06	0.023
RC-56	f05lm11	2	1	4	1.69	0.857	0.050	8.30	0.201	1.22	9.03	0.528	0.119	0.006	2.40	0.014
RC-34	f12lm11	2	1	5	1.88	0.971	0.058	8.99	0.643	1.32	9.75	0.578	0.139	0.006	2.70	0.513

Table E.1: Measured Elemental Concentrations (wt%) for the RC Glasses Prepared Using Lithium Metaborate *(continued)*

SRTC-ML ID	Glass ID	Block	Sub-Block	Analytical Sequence	Al	Ca	Cr	Fe	Mg	Mn	Na	Ni	P	Ti	U	Zr
RC-47	f02lm11	2	1	6	2.37	1.22	0.068	10.5	0.219	1.38	9.28	0.484	0.157	0.008	3.04	0.023
RC-28	f16lm21	2	1	7	1.83	0.922	0.059	8.58	0.727	2.22	9.63	0.460	0.136	0.004	2.14	0.504
RC-33	f24lm21	2	1	8	2.15	1.08	0.065	9.98	0.730	0.562	9.22	0.520	0.160	0.006	2.51	0.423
RC-31	f30lm21	2	1	9	4.67	0.385	0.038	1.95	0.707	1.59	10.3	0.170	0.092	0.003	0.362	0.603
RC-43	f22lm11	2	1	10	1.98	0.986	0.061	9.01	1.10	2.40	8.73	0.493	0.142	0.004	2.29	0.021
RC-30	f01lm11	2	1	11	1.75	0.496	0.071	8.06	1.02	3.08	10.1	2.24	0.173	0.007	4.66	0.522
RC-29	f15lm11	2	1	12	1.99	1.01	0.057	9.44	0.621	1.22	9.80	0.426	0.135	0.005	2.66	0.511
RC-32	f11lm11	2	1	13	2.16	1.11	0.066	9.87	0.707	0.536	9.78	0.516	0.157	0.053	2.40	0.472
Batch 1	bchlm212	2	1	14	2.57	0.937	0.071	9.10	0.898	1.35	6.99	0.588	<0.017	0.421	<0.100	0.072
U_{std}	ustlm212	2	1	15	2.04	0.962	0.164	9.15	0.718	2.05	8.73	0.791	<0.017	0.569	1.91	<0.010
RC-49	f23lm11	2	1	16	1.85	0.914	0.058	8.57	0.322	2.23	9.17	0.454	0.134	0.004	2.10	0.016
RC-53	f33lm11	2	1	17	2.36	1.16	0.077	11.1	0.422	2.86	9.07	0.569	0.180	0.006	2.73	0.029
RC-34	f12lm21	2	1	18	1.87	0.963	0.058	9.25	0.650	1.32	9.85	0.583	0.139	0.006	2.71	0.514
RC-54	f14lm11	2	1	19	2.00	0.989	0.058	9.32	0.189	1.22	9.15	0.430	0.138	0.007	2.64	0.017
RC-38	f29lm11	2	1	20	1.90	0.949	0.064	9.01	1.06	1.340	8.51	0.582	0.138	0.005	2.73	0.020
RC-38	f29lm21	2	1	21	1.86	0.933	0.069	8.75	1.03	1.29	8.31	0.560	0.136	0.005	2.60	0.018
RC-29	f15lm21	2	1	22	1.97	0.992	0.056	9.76	0.605	1.20	9.78	0.416	0.134	0.004	2.64	0.503
RC-26	f09lm21	2	1	23	2.10	1.07	0.064	10.9	0.629	1.46	9.54	0.631	0.151	0.004	3.02	0.455
RC-56	f05lm21	2	1	24	1.73	0.881	0.051	8.62	0.204	1.23	9.40	0.532	0.124	0.006	2.44	0.015
RC-57	f32lm21	2	1	25	1.83	0.930	0.057	9.08	0.218	1.30	9.11	0.568	0.133	0.006	2.71	0.019
RC-39	f27lm11	2	1	26	1.84	0.893	0.067	8.74	1.18	2.34	8.44	0.472	0.140	0.004	2.12	0.000
Batch 1	bchlm213	2	1	27	2.56	1.03	0.072	9.38	0.909	1.38	7.29	0.595	<0.017	0.421	<0.100	0.018
U_{std}	ustlm213	2	1	28	2.04	0.959	0.164	9.42	0.720	2.07	9.04	0.797	<0.017	0.567	1.90	<0.010
Batch 1	bchlm221	2	2	1	2.57	1.04	0.076	8.97	0.904	1.36	7.06	0.592	<0.017	0.423	<0.100	0.077
U_{std}	ustlm221	2	2	2	2.06	0.997	0.167	8.92	0.717	2.06	8.71	0.797	<0.017	0.573	1.93	<0.010
RC-33	f24lm22	2	2	3	2.15	1.08	0.069	9.99	0.732	0.567	9.17	0.525	0.160	0.006	2.51	0.428
RC-56	f05lm22	2	2	4	1.74	0.892	0.054	8.27	0.204	1.23	9.28	0.529	0.125	0.006	2.48	0.018
RC-53	f33lm12	2	2	5	2.36	1.17	0.080	10.7	0.420	2.85	9.11	0.565	0.180	0.006	2.76	0.031
RC-39	f27lm12	2	2	6	1.84	0.898	0.067	8.84	1.18	2.34	8.44	0.471	0.137	0.004	2.12	0.017
RC-28	f16lm22	2	2	7	1.83	0.928	0.063	8.47	0.736	2.25	9.67	0.466	0.140	0.004	2.12	0.508
RC-31	f30lm22	2	2	8	4.69	0.470	0.042	1.95	0.714	1.61	10.2	0.175	0.096	0.004	0.36	0.609

Table E.1: Measured Elemental Concentrations (wt%) for the RC Glasses Prepared Using Lithium Metaborate *(continued)*

SRTC-ML ID	Glass ID	Block	Sub-Block	Analytical Sequence	Al	Ca	Cr	Fe	Mg	Mn	Na	Ni	P	Ti	U	Zr
RC-29	f15lm22	2	2	9	1.99	1.02	0.061	9.24	0.621	1.22	9.67	0.425	0.139	0.005	2.65	0.516
RC-47	f02lm12	2	2	10	2.39	1.24	0.072	10.4	0.225	1.39	9.21	0.487	0.163	0.009	3.07	0.033
RC-57	f32lm22	2	2	11	1.86	0.963	0.060	8.57	0.217	1.28	8.84	0.562	0.134	0.006	2.80	0.023
RC-29	f15lm12	2	2	12	2.01	1.02	0.060	9.14	0.617	1.21	9.71	0.426	0.136	0.005	2.72	0.517
RC-38	f29lm22	2	2	13	1.85	0.927	0.069	8.84	1.04	1.30	8.30	0.559	0.136	0.009	2.60	0.022
Batch 1	bchlm222	2	2	14	2.60	0.988	0.075	8.64	0.909	1.37	6.95	0.593	<0.017	0.430	<0.100	0.076
U_{std}	ustlm222	2	2	15	2.09	1.01	0.166	8.63	0.707	2.04	8.53	0.785	<0.017	0.577	1.97	<0.010
RC-45	f07lm12	2	2	16	2.17	1.12	0.067	9.51	0.244	1.45	8.68	0.624	0.156	0.005	3.12	0.027
RC-49	f23lm12	2	2	17	1.87	0.947	0.060	8.14	0.318	2.19	8.88	0.448	0.137	0.004	2.14	0.019
RC-54	f14lm12	2	2	18	2.02	1.02	0.060	8.78	0.188	1.20	8.81	0.426	0.139	0.008	2.71	0.021
RC-32	f11lm12	2	2	19	2.17	1.12	0.070	9.47	0.712	0.542	9.41	0.523	0.165	0.054	2.43	0.477
RC-30	f01lm12	2	2	20	1.74	0.491	0.075	7.83	1.01	3.06	9.73	2.246	0.169	0.006	4.66	0.509
RC-34	f12lm22	2	2	21	1.88	0.989	0.060	8.70	0.632	1.30	9.41	0.572	0.139	0.006	2.74	0.516
RC-34	f12lm12	2	2	22	1.90	0.987	0.060	8.65	0.625	1.28	9.29	0.563	0.137	0.006	2.73	0.514
RC-26	f09lm22	2	2	23	2.13	1.10	0.066	10.0	0.610	1.43	9.04	0.618	0.152	0.005	3.05	0.458
RC-43	f22lm12	2	2	24	1.98	1.01	0.063	8.80	1.07	2.33	8.31	0.483	0.144	0.004	2.30	0.023
RC-56	f05lm12	2	2	25	1.70	0.892	0.051	7.98	0.196	1.18	8.68	0.510	0.123	0.006	2.44	0.017
RC-38	f29lm12	2	2	26	1.89	0.949	0.064	9.02	1.07	1.34	8.51	0.584	0.140	0.005	2.73	0.020
Batch 1	bchlm223	2	2	27	2.58	0.953	0.075	8.61	0.905	1.37	6.82	0.592	<0.017	0.428	<0.100	0.076
U_{std}	ustlm223	2	2	28	2.05	0.958	0.167	8.59	0.720	2.05	8.45	0.796	<0.017	0.578	1.93	<0.010
Batch 1	bchlm311	3	1	1	2.58	0.939	0.072	8.86	0.919	1.38	6.96	0.596	<0.017	0.422	<0.100	0.071
U_{std}	ustlm311	3	1	2	2.06	0.980	0.167	8.86	0.735	2.10	8.64	0.808	<0.017	0.575	1.92	<0.010
RC-31	f30lm11	3	1	3	4.69	0.339	0.035	1.90	0.717	1.60	9.97	0.171	0.092	0.002	0.36	0.611
RC-39	f27lm21	3	1	4	1.84	0.893	0.067	8.77	1.18	2.33	8.46	0.471	0.139	0.003	2.11	0.017
RC-43	f22lm21	3	1	5	2.00	0.973	0.061	9.04	1.13	2.43	8.49	0.499	0.147	0.004	2.29	0.021
RC-32	f11lm21	3	1	6	2.20	1.10	0.067	9.97	0.743	0.562	9.84	0.546	0.164	0.049	2.50	0.497
RC-37	f13lm21	3	1	7	1.71	1.00	0.052	8.13	0.623	1.02	9.64	0.367	0.116	0.003	2.25	0.557
RC-52	f25lm11	3	1	8	1.70	0.840	0.047	7.50	0.162	1.03	9.04	0.368	0.115	0.003	2.24	0.016
RC-44	f03lm11	3	1	9	1.68	0.863	0.053	8.40	1.11	1.24	8.33	0.532	0.126	0.003	2.48	0.015
RC-40	f08lm21	3	1	10	1.68	0.521	0.065	8.06	1.37	3.01	8.72	2.15	0.169	0.012	4.52	0.024
RC-55	f10lm21	3	1	11	2.13	1.02	0.070	9.67	0.381	2.66	8.90	0.543	0.163	0.004	2.42	0.024

Table E.1: Measured Elemental Concentrations (wt%) for the RC Glasses Prepared Using Lithium Metaborate *(continued)*

SRTC-ML ID	Glass ID	Block	Sub-Block	Analytical Sequence	Al	Ca	Cr	Fe	Mg	Mn	Na	Ni	P	Ti	U	Zr
RC-41	f18lm21	3	1	12	1.70	0.885	0.045	7.92	1.07	1.07	8.43	0.374	0.109	0.039	2.21	0.029
RC-55	f10lm11	3	1	13	2.17	1.06	0.072	9.81	0.380	2.64	9.04	0.540	0.161	0.005	2.48	0.019
Batch 1	bchlm312	3	1	14	2.60	0.945	0.071	8.94	0.914	1.37	6.95	0.594	<0.017	0.424	<0.100	0.071
U_{std}	ustlm312	3	1	15	2.07	0.948	0.168	8.97	0.741	2.10	8.60	0.815	<0.017	0.582	1.93	<0.010
RC-42	f26lm11	3	1	16	2.03	1.01	0.058	9.28	1.04	1.25	8.55	0.444	0.140	0.004	2.68	0.018
RC-28	f16lm11	3	1	17	1.85	0.913	0.060	8.56	0.755	2.29	9.54	0.472	0.140	0.003	2.11	0.515
RC-27	f28lm21	3	1	18	1.66	0.907	0.052	8.12	0.754	2.07	9.39	0.422	0.123	0.003	1.92	0.516
RC-27	f28lm11	3	1	19	1.69	0.927	0.052	8.13	0.753	2.07	9.58	0.422	0.133	0.003	1.95	0.523
RC-46	f20lm11	3	1	20	1.65	0.934	0.073	10.0	0.414	2.93	9.23	1.35	0.175	0.005	3.65	0.022
RC-46	f20lm21	3	1	21	1.68	0.916	0.074	9.76	0.425	2.96	9.23	1.38	0.177	0.005	3.67	0.023
RC-48	f06lm11	3	1	22	2.35	1.19	0.072	10.8	0.283	1.64	9.01	0.705	0.173	0.005	3.44	0.021
RC-54	f14lm21	3	1	23	2.03	1.03	0.058	8.97	0.191	1.23	8.94	0.437	0.141	0.005	2.66	0.015
RC-33	f24lm11	3	1	24	2.34	1.15	0.071	10.8	0.845	0.634	9.83	0.591	0.177	0.014	2.70	0.486
RC-49	f23lm21	3	1	25	1.88	0.919	0.059	8.39	0.336	2.31	9.04	0.480	0.140	0.004	2.16	0.016
RC-37	f13lm11	3	1	26	1.65	0.827	0.047	7.79	0.608	1.00	9.15	0.356	0.112	0.002	2.17	0.542
Batch 1	bchlm313	3	1	27	2.59	0.931	0.072	8.98	0.931	1.39	6.83	0.603	<0.017	0.428	<0.100	0.070
U_{std}	ustlm313	3	1	28	2.06	0.940	0.168	8.98	0.744	2.11	8.53	0.816	<0.017	0.581	1.91	<0.010
Batch 1	bchlm321	3	2	1	2.61	0.960	0.073	9.04	0.915	1.39	6.98	0.594	<0.017	0.428	<0.100	0.074
U_{std}	ustlm321	3	2	2	2.07	0.953	0.165	9.02	0.725	2.08	8.63	0.799	<0.017	0.578	1.95	<0.010
RC-48	f06lm12	3	2	3	2.35	1.19	0.073	10.8	0.282	1.64	9.13	0.699	0.172	0.004	3.48	0.038
RC-55	f10lm22	3	2	4	2.13	1.04	0.071	9.87	0.376	2.64	9.16	0.536	0.160	0.003	2.46	0.021
RC-31	f30lm12	3	2	5	4.66	0.391	0.037	1.98	0.712	1.60	9.99	0.168	0.094	<0.003	0.36	0.605
RC-27	f28lm22	3	2	6	1.65	1.09	0.053	8.11	0.749	2.06	9.43	0.418	0.125	<0.003	1.92	0.516
RC-37	f13lm12	3	2	7	1.63	0.843	0.048	7.82	0.598	0.99	9.30	0.350	0.112	<0.003	2.18	0.535
RC-27	f28lm12	3	2	8	1.67	0.921	0.052	8.23	0.748	2.07	9.65	0.417	0.132	<0.003	1.95	0.519
RC-32	f11lm22	3	2	9	2.21	1.14	0.069	10.1	0.741	0.565	9.90	0.544	0.165	0.048	2.53	0.498
RC-33	f24lm12	3	2	10	2.33	1.17	0.070	10.9	0.825	0.623	10.0	0.574	0.177	0.012	2.75	0.482
RC-52	f25lm12	3	2	11	1.72	0.861	0.049	7.60	0.162	1.03	9.20	0.363	0.116	0.002	2.28	0.019
RC-41	f18lm22	3	2	12	1.70	0.917	0.047	8.01	1.05	1.06	8.59	0.371	0.112	0.038	2.24	0.032
RC-42	f26lm12	3	2	13	2.03	1.03	0.059	9.35	1.03	1.25	8.77	0.441	0.138	0.004	2.70	0.022
Batch 1	bchlm322	3	2	14	2.59	0.940	0.073	9.03	0.917	1.38	6.99	0.595	<0.017	0.427	<0.100	0.073

Table E.1: Measured Elemental Concentrations (wt%) for the RC Glasses Prepared Using Lithium Metaborate *(continued)*

SRTC-ML ID	Glass ID	Block	Sub-Block	Analytical Sequence	Al	Ca	Cr	Fe	Mg	Mn	Na	Ni	P	Ti	U	Zr
U_{std}	ustlm322	3	2	15	2.06	0.965	0.166	9.05	0.727	2.08	8.79	0.798	<0.017	0.577	1.93	<0.010
RC-49	f23lm22	3	2	16	1.87	0.930	0.061	8.44	0.335	2.30	9.22	0.478	0.143	<0.003	2.20	0.017
RC-37	f13lm22	3	2	17	1.71	1.02	0.054	8.21	0.624	1.02	9.92	0.366	0.118	<0.003	2.27	0.557
RC-46	f20lm12	3	2	18	1.64	0.925	0.075	10.1	0.418	2.96	9.43	1.35	0.176	0.004	3.65	0.025
RC-44	f03lm12	3	2	19	1.67	0.869	0.055	8.58	1.09	1.23	8.57	0.529	0.124	<0.003	2.48	0.016
RC-46	f20lm22	3	2	20	1.68	0.929	0.075	9.99	0.425	2.98	9.44	1.37	0.175	0.004	3.68	0.029
RC-43	f22lm22	3	2	21	2.01	0.992	0.063	9.22	1.13	2.44	8.79	0.497	0.150	0.004	2.34	0.024
RC-39	f27lm22	3	2	22	1.84	0.902	0.067	8.73	1.17	2.32	8.61	0.468	0.141	0.003	2.11	0.018
RC-40	f08lm22	3	2	23	1.69	0.520	0.066	8.26	1.35	3.00	8.87	2.13	0.166	0.011	4.58	0.026
RC-54	f14lm22	3	2	24	2.03	1.05	0.059	9.15	0.192	1.23	9.23	0.433	0.140	0.004	2.68	0.020
RC-55	f10lm12	3	2	25	2.16	1.06	0.074	9.98	0.385	2.68	9.30	0.547	0.164	0.004	2.48	0.020
RC-28	f16lm12	3	2	26	1.86	0.932	0.061	8.71	0.745	2.28	9.69	0.466	0.141	<0.003	2.14	0.512
Batch 1	bchlm323	3	2	27	2.59	0.940	0.073	9.06	0.917	1.38	7.04	0.592	<0.017	0.426	<0.100	0.074
U_{std}	ustlm323	3	2	28	2.08	0.961	0.167	9.08	0.730	2.10	8.81	0.802	<0.017	0.580	1.96	<0.010

Table E.1: Measured Elemental Concentrations (wt%) for the RC Glasses Prepared Using Lithium Metaborate *(continued)*

SRTC-ML ID	Glass ID	Block	Sub-Block	Analytical Sequence	Al	Ca	Cr	Fe	Mg	Mn	Na	Ni	P	Si	Ti	U	Zr
Batch 1	BCHLM11	4	1	1	2.49	0.871	0.069	8.85	0.863	1.32	6.75	0.556	<0.017	23.9	0.398	<0.100	0.063
U_{std}	URLM1	4	1	2	1.95	0.919	0.182	8.60	0.665	2.03	8.28	0.742	<0.017	22.7	0.537	1.80	0.005
U_{std}	F36LM11	4	1	3	1.91	0.918	0.184	8.75	0.670	1.99	8.15	0.739	<0.017	22.5	0.532	1.88	0.007
Batch 1	F33LM21	4	1	4	2.47	0.891	0.109	8.80	0.857	1.31	6.74	0.559	<0.017	23.7	0.397	<0.100	0.066
Batch 1	F33LM11	4	1	5	2.52	0.900	0.103	8.96	0.873	1.33	6.91	0.567	<0.017	24.1	0.402	<0.100	0.071
RC-31	F35LM21	4	1	6	4.41	0.309	0.056	2.14	0.662	1.49	9.34	0.151	0.092	26.6	0.010	0.32	0.566
RC-31	F35LM11	4	1	7	4.41	0.311	0.055	1.78	0.674	1.48	9.31	0.152	0.087	26.7	0.007	0.322	0.566
U_{std}	F36LM21	4	1	8	1.83	0.883	0.169	8.17	0.655	1.92	7.83	0.710	<0.017	22.4	0.514	1.82	0.012
Batch 1	BCHLM12	4	1	9	2.46	0.887	0.071	8.67	0.884	1.29	6.69	0.560	<0.017	23.6	0.399	<0.100	0.063
U_{std}	URLM12	4	1	10	1.93	0.905	0.186	8.56	0.677	2.01	8.21	0.746	<0.017	22.6	0.539	1.87	0.006
Batch 1	BCHLM21	4	2	1	2.49	0.877	0.063	8.74	0.853	1.26	6.87	0.565	<0.017	23.7	0.401	<0.100	0.061
U_{std}	URLM21	4	2	2	1.94	0.905	0.177	8.59	0.652	1.98	8.26	0.747	<0.017	22.5	0.541	1.87	0.004
U_{std}	F36LM22	4	2	3	1.86	0.907	0.160	8.23	0.629	1.90	7.93	0.714	<0.017	22.4	0.518	1.83	0.007
Batch 1	F33LM12	4	2	4	2.53	0.904	0.097	9.02	0.846	1.31	6.97	0.570	<0.017	24.1	0.404	<0.100	0.070
RC-31	F35LM22	4	2	5	4.40	0.316	0.050	2.13	0.639	1.46	9.33	0.151	0.093	26.5	0.009	0.319	0.566
U_{std}	F36LM12	4	2	6	1.94	0.899	0.176	8.88	0.645	1.99	8.20	0.741	<0.017	22.6	0.536	1.89	0.009
Batch 1	F33LM22	4	2	7	2.48	0.918	0.103	8.89	0.835	1.29	6.83	0.564	<0.017	23.6	0.401	<0.100	0.066
RC-31	F35LM12	4	2	8	4.43	0.321	0.050	1.75	0.650	1.46	9.46	0.151	0.087	26.6	0.006	0.318	0.564
Batch 1	BCHLM22	4	2	9	2.47	0.885	0.065	8.79	0.864	1.28	6.83	0.565	<0.017	23.7	0.401	<0.100	0.065
U_{std}	URLM22	4	2	10	1.95	0.894	0.176	8.66	0.649	2.01	8.28	0.758	<0.017	22.6	0.543	1.89	0.005

Table E.2: Measured Elemental Concentrations (wt%) for the RC Glasses Prepared Using the SP Fusion

SRTC-ML ID	Glass ID	Block	Sub-Block	Analytical Sequence	B	Li	Si
bchsp111	Batch 1	1	1	1	2.48	2.05	23.7
ustsp111	U std	1	1	2	2.65	1.27	22.3
f33sp11	RC-53	1	1	3	1.45	2.13	21.2
f21sp11	RC-51	1	1	4	1.76	2.59	24.9
f18sp21	RC-41	1	1	5	2.67	1.71	24.1
f02sp21	RC-47	1	1	6	1.60	2.38	22.6
f33sp21	RC-53	1	1	7	1.43	2.14	21.4
f10sp11	RC-55	1	1	8	1.57	2.36	22.7
f04sp21	RC-25	1	1	9	1.95	2.06	21.3
f23sp21	RC-49	1	1	10	1.71	2.54	24.1
f29sp11	RC-38	1	1	11	2.45	1.53	23.4
f16sp11	RC-28	1	1	12	2.05	2.17	22.6
f25sp21	RC-52	1	1	13	1.81	2.72	25.4
bchsp112	Batch 1	1	1	14	2.43	2.05	23.7
ustsp112	U std	1	1	15	2.71	1.30	22.6
f25sp11	RC-52	1	1	16	1.83	2.72	25.4
f27sp21	RC-39	1	1	17	2.49	1.56	23.7
f20sp11	RC-46	1	1	18	1.53	2.28	21.8
f13sp11	RC-37	1	1	19	2.20	2.31	23.3
f18sp11	RC-41	1	1	20	2.74	1.75	24.7
f05sp21	RC-56	1	1	21	1.81	2.71	24.9
f07sp21	RC-45	1	1	22	1.53	2.27	21.4
f03sp11	RC-44	1	1	23	2.61	1.65	24.4
f11sp21	RC-32	1	1	24	2.05	2.15	22.5
f31sp21	RC-36	1	1	25	2.54	2.69	27.4
f17sp21	RC-35	1	1	26	2.16	2.28	23.5
bchsp113	Batch 1	1	1	27	2.46	2.08	24
ustsp113	U std	1	1	28	2.72	1.31	22.8
bchsp121	Batch 1	1	2	1	2.47	2.04	23.7
ustsp121	U std	1	2	2	2.67	1.29	22.6
f27sp22	RC-39	1	2	3	2.49	1.56	23.8
f29sp12	RC-38	1	2	4	2.45	1.54	23.4
f31sp22	RC-36	1	2	5	2.49	2.67	26.9
f11sp22	RC-32	1	2	6	1.99	2.12	22.1
f33sp12	RC-53	1	2	7	1.40	2.15	21.2
f05sp22	RC-56	1	2	8	1.75	2.68	24.6
f20sp12	RC-46	1	2	9	1.50	2.29	21.9
f18sp12	RC-41	1	2	10	2.67	1.72	24.3
f02sp22	RC-47	1	2	11	1.59	2.42	22.7
f23sp22	RC-49	1	2	12	1.69	2.57	24.2
f25sp12	RC-52	1	2	13	1.77	2.72	25.4
bchsp122	Batch 1	1	2	14	2.42	2.07	23.9
ustsp122	U std	1	2	15	2.71	1.30	22.8
f04sp22	RC-25	1	2	16	1.95	2.08	21.4
f25sp22	RC-52	1	2	17	1.80	2.76	25.5
f16sp12	RC-28	1	2	18	2.04	2.20	22.8
f21sp12	RC-51	1	2	19	1.75	2.61	25
f10sp12	RC-55	1	2	20	1.57	2.40	22.8
f18sp22	RC-41	1	2	21	2.70	1.74	24.3
f03sp12	RC-44	1	2	22	2.57	1.65	24.4
f13sp12	RC-37	1	2	23	2.20	2.34	23.5
f07sp22	RC-45	1	2	24	1.50	2.27	21.4
f17sp22	RC-35	1	2	25	2.17	2.30	23.8
f33sp22	RC-53	1	2	26	1.44	2.17	21.7
bchsp123	Batch 1	1	2	27	2.45	2.07	24
ustsp123	U std	1	2	28	2.71	1.30	22.9

Table E.2: Measured Elemental Concentrations (wt%) for the RC Glasses Prepared Using Peroxide Fusion *(continued)*

SRTC-ML ID	Glass ID	Block	Sub-Block	Analytical Sequence	B	Li	Si
bchsp211	Batch 1	2	1	1	2.46	2.04	23.6
ustsp211	U std	2	1	2	2.67	1.29	22.5
f07sp11	RC-45	2	1	3	1.56	2.31	21.9
f29sp21	RC-38	2	1	4	2.49	1.56	23.7
f09sp11	RC-26	2	1	5	1.88	1.99	21.8
f30sp21	RC-31	2	1	6	1.68	2.67	27
f19sp11	RC-50	2	1	7	1.56	2.34	22.2
f04sp11	RC-25	2	1	8	1.91	2.04	21.1
f27sp11	RC-39	2	1	9	2.48	1.56	23.6
f30sp11	RC-31	2	1	10	1.66	2.63	26.3
f21sp21	RC-51	2	1	11	1.72	2.56	24.7
f17sp11	RC-35	2	1	12	2.16	2.30	23.8
f03sp21	RC-44	2	1	13	2.57	1.65	24.4
bchsp212	Batch 1	2	1	14	2.42	2.06	23.7
ustsp212	U std	2	1	15	2.69	1.30	22.6
f20sp21	RC-46	2	1	16	1.53	2.28	21.8
f06sp21	RC-48	2	1	17	1.53	2.31	22.2
f14sp11	RC-54	2	1	18	1.68	2.56	23.9
f01sp11	RC-30	2	1	19	1.96	2.10	21.5
f24sp21	RC-33	2	1	20	1.91	2.04	21.6
f26sp11	RC-42	2	1	21	2.59	1.64	24
f31sp11	RC-36	2	1	22	2.55	2.74	27.6
f28sp11	RC-27	2	1	23	2.01	2.15	22.1
f01sp21	RC-30	2	1	24	1.97	2.11	21.2
f32sp11	RC-57	2	1	25	1.69	2.54	24.3
f09sp21	RC-26	2	1	26	1.90	2.03	21.7
bchsp213	Batch 1	2	1	27	2.40	2.05	23.6
ustsp213	U std	2	1	28	2.66	1.29	22.6
bchsp221	Batch 1	2	2	1	2.47	2.04	23.7
ustsp221	U std	2	2	2	2.69	1.29	22.6
f17sp12	RC-35	2	2	3	2.17	2.29	23.8
f32sp12	RC-57	2	2	4	1.70	2.54	24.7
f06sp22	RC-48	2	2	5	1.52	2.29	22.3
f28sp12	RC-27	2	2	6	2.00	2.13	22.2
f04sp12	RC-25	2	2	7	1.91	2.03	21.1
f09sp12	RC-26	2	2	8	1.87	1.99	21.9
f01sp12	RC-30	2	2	9	1.96	2.09	21.5
f24sp22	RC-33	2	2	10	1.92	2.04	21.8
f26sp12	RC-42	2	2	11	2.60	1.64	24.2
f30sp12	RC-31	2	2	12	1.66	2.64	26.5
f29sp22	RC-38	2	2	13	2.49	1.56	23.8
bchsp222	Batch 1	2	2	14	2.42	2.05	24
ustsp222	U std	2	2	15	2.72	1.30	22.9
f30sp22	RC-31	2	2	16	1.70	2.68	27.2
f21sp22	RC-51	2	2	17	1.72	2.56	24.8
f27sp12	RC-39	2	2	18	2.51	1.59	23.8
f01sp22	RC-30	2	2	19	1.98	2.11	21.5
f14sp12	RC-54	2	2	20	1.68	2.54	24.1
f20sp22	RC-46	2	2	21	1.51	2.28	22.1
f03sp22	RC-44	2	2	22	2.57	1.64	24.5
f31sp12	RC-36	2	2	23	2.56	2.73	27.9
f07sp12	RC-45	2	2	24	1.54	2.32	22.1
f19sp12	RC-50	2	2	25	1.55	2.34	22.5
f09sp22	RC-26	2	2	26	1.90	2.03	21.9
bchsp223	Batch 1	2	2	27	2.42	2.05	23.9
ustsp223	U std	2	2	28	2.73	1.31	23

Table E.2: Measured Elemental Concentrations (wt%) for the RC Glasses Prepared Using Peroxide Fusion *(continued)*

SRTC-ML ID	Glass ID	Block	Sub-Block	Analytical Sequence	B	Li	Si
ustsp311	U std	3	1	2	2.68	1.29	22.9
f02sp11	RC-47	3	1	3	1.54	2.35	22.3
f12sp21	RC-34	3	1	4	2.06	2.21	22.7
f26sp21	RC-42	3	1	5	2.44	1.55	23.1
f14sp21	RC-54	3	1	6	1.66	2.54	24.2
f15sp21	RC-29	3	1	7	2.10	2.25	23.2
f22sp11	RC-43	3	1	8	2.37	1.52	23.2
f11sp11	RC-32	3	1	9	1.96	2.10	21.8
f23sp11	RC-49	3	1	10	1.65	2.51	24.2
f06sp11	RC-48	3	1	11	1.47	2.27	22.2
f08sp21	RC-40	3	1	12	2.25	1.45	21.7
f12sp11	RC-34	3	1	13	2.07	2.25	22.7
bchsp312	Batch 1	3	1	14	2.41	2.05	24
ustsp312	U std	3	1	15	2.71	1.31	23
f19sp21	RC-50	3	1	16	1.54	2.33	22.6
f16sp21	RC-28	3	1	17	2.02	2.15	22.8
f10sp21	RC-55	3	1	18	1.48	2.28	22
f28sp21	RC-27	3	1	19	2.12	2.30	23.7
f13sp21	RC-37	3	1	20	2.21	2.37	23.8
f08sp11	RC-40	3	1	21	2.34	1.49	22.2
f32sp21	RC-57	3	1	22	1.67	2.53	24.8
f05sp11	RC-56	3	1	23	1.74	2.66	24.9
f24sp11	RC-33	3	1	24	1.87	2.02	21.9
f15sp11	RC-29	3	1	25	2.05	2.19	22.7
f22sp21	RC-43	3	1	26	2.36	1.51	23.9
bchsp313	Batch 1	3	1	27	2.42	2.06	24
ustsp313	U std	3	1	28	2.66	1.29	22.9
bchsp321	Batch 1	3	2	1	2.51	2.06	24
ustsp321	U std	3	2	2	2.73	1.30	22.9
f24sp12	RC-33	3	2	3	1.93	2.03	21.8
f08sp12	RC-40	3	2	4	2.41	1.53	22.7
f19sp22	RC-50	3	2	5	1.56	2.35	22.6
f23sp12	RC-49	3	2	6	1.68	2.53	24.3
f14sp22	RC-54	3	2	7	1.69	2.55	24.3
f32sp22	RC-57	3	2	8	1.69	2.54	24.7
f12sp12	RC-34	3	2	9	2.08	2.26	22.6
f12sp22	RC-34	3	2	10	2.07	2.21	22.7
f16sp22	RC-28	3	2	11	2.04	2.17	22.7
f15sp12	RC-29	3	2	12	2.06	2.20	22.6
f06sp12	RC-48	3	2	13	1.48	2.25	22
bchsp322	Batch 1	3	2	14	2.42	2.05	24
ustsp322	U std	3	2	15	2.70	1.30	22.9
f22sp12	RC-43	3	2	16	2.39	1.51	23.1
f10sp22	RC-55	3	2	17	1.50	2.27	22
f26sp22	RC-42	3	2	18	2.45	1.56	23
f22sp22	RC-43	3	2	19	2.37	1.50	23.7
f28sp22	RC-27	3	2	20	2.16	2.29	23.7
f05sp12	RC-56	3	2	21	1.75	2.66	24.9
f02sp12	RC-47	3	2	22	1.55	2.35	22.4
f11sp12	RC-32	3	2	23	2.00	2.12	22
f15sp22	RC-29	3	2	24	2.12	2.25	23.3
f13sp22	RC-37	3	2	25	2.24	2.37	23.9
f08sp22	RC-40	3	2	26	2.30	1.46	21.8
bchsp323	Batch 1	3	2	27	2.45	2.08	24.3
ustsp323	U std	3	2	28	2.71	1.31	23.3

Table E.3: Measured Elemental Concentrations (wt%) for RC-31.5 (Re-Batched RC31) Glass Prepared Using Lithium Metaborate

SRTC-ML ID	Glass ID	Block	Sub-Block	Analytical Sequence	Al	Ca	Cr	Fe	Mg	Mn	Na	Ni	P	Si	Ti	U	Zr
Batch 1	BCHLM11	4	1	1	2.49	0.871	0.069	8.85	0.863	1.32	6.75	0.556	<0.017	23.9	0.398	<0.100	0.063
U std	URLM1	4	1	2	1.95	0.919	0.182	8.60	0.665	2.03	8.28	0.742	<0.017	22.7	0.537	1.80	0.005
U std	F36LM11	4	1	3	1.91	0.918	0.184	8.75	0.670	1.99	8.15	0.739	<0.017	22.5	0.532	1.88	0.007
Batch 1	F33LM21	4	1	4	2.47	0.891	0.109	8.80	0.857	1.31	6.74	0.559	<0.017	23.7	0.397	<0.100	0.066
Batch 1	F33LM11	4	1	5	2.52	0.900	0.103	8.96	0.873	1.33	6.91	0.567	<0.017	24.1	0.402	<0.100	0.071
RC-31	F35LM21	4	1	6	4.41	0.309	0.056	2.14	0.662	1.49	9.34	0.151	0.092	26.6	0.010	0.32	0.566
RC-31	F35LM11	4	1	7	4.41	0.311	0.055	1.78	0.674	1.48	9.31	0.152	0.087	26.7	0.007	0.322	0.566
U std	F36LM21	4	1	8	1.83	0.883	0.169	8.17	0.655	1.92	7.83	0.710	<0.017	22.4	0.514	1.82	0.012
Batch 1	BCHLM12	4	1	9	2.46	0.887	0.071	8.67	0.884	1.29	6.69	0.560	<0.017	23.6	0.399	<0.100	0.063
U std	URLM12	4	1	10	1.93	0.905	0.186	8.56	0.677	2.01	8.21	0.746	<0.017	22.6	0.539	1.87	0.006
Batch 1	BCHLM21	4	2	1	2.49	0.877	0.063	8.74	0.853	1.26	6.87	0.565	<0.017	23.7	0.401	<0.100	0.061
U std	URLM21	4	2	2	1.94	0.905	0.177	8.59	0.652	1.98	8.26	0.747	<0.017	22.5	0.541	1.87	0.004
U std	F36LM22	4	2	3	1.86	0.907	0.160	8.23	0.629	1.90	7.93	0.714	<0.017	22.4	0.518	1.83	0.007
Batch 1	F33LM12	4	2	4	2.53	0.904	0.097	9.02	0.846	1.31	6.97	0.570	<0.017	24.1	0.404	<0.100	0.070
RC-31	F35LM22	4	2	5	4.40	0.316	0.050	2.13	0.639	1.46	9.33	0.151	0.093	26.5	0.009	0.319	0.566
U std	F36LM12	4	2	6	1.94	0.899	0.176	8.88	0.645	1.99	8.20	0.741	<0.017	22.6	0.536	1.89	0.009
Batch 1	F33LM22	4	2	7	2.48	0.918	0.103	8.89	0.835	1.29	6.83	0.564	<0.017	23.6	0.401	<0.100	0.066
RC-31	F35LM12	4	2	8	4.43	0.321	0.050	1.75	0.650	1.46	9.46	0.151	0.087	26.6	0.006	0.318	0.564
Batch 1	BCHLM22	4	2	9	2.47	0.885	0.065	8.79	0.864	1.28	6.83	0.565	<0.017	23.7	0.401	<0.100	0.065
U std	URLM22	4	2	10	1.95	0.894	0.176	8.66	0.649	2.01	8.28	0.758	<0.017	22.6	0.543	1.89	0.005

Table E.4: Measured Elemental Concentrations (wt%) for RC-31.5 (Re-Batched RC-31) Glass Prepared Using the SP Fusion

SRTC-ML ID	Glass ID	Block	Sub-Block	Analytical Sequence	B	Li
BCHSP11	Batch 1	4	1	1	2.48	2.01
URSP11	U std	4	1	2	2.75	1.27
F36SP21	U std	4	1	3	2.74	1.26
F33SP21	Batch 1	4	1	4	2.48	2.02
F36SP11	U std	4	1	5	2.77	1.28
F35SP21	RC-31	4	1	6	2.41	2.46
F35SP11	RC-31	4	1	7	2.42	2.47
F33SP11	Batch 1	4	1	8	2.45	2.01
BCHSP12	Batch 1	4	1	9	2.46	2.01
URSP12	U std	4	1	10	2.69	1.25
BCHSP21	Batch 1	4	2	1	2.49	2.02
URSP21	U std	4	2	2	2.70	1.27
F35SP12	RC-31	4	2	3	2.42	2.48
F33SP22	Batch 1	4	2	4	2.46	2.03
F36SP22	U std	4	2	5	2.69	1.27
F33SP12	Batch 1	4	2	6	2.44	2.01
F35SP22	RC-31	4	2	7	2.39	2.47
F36SP12	U std	4	2	8	2.69	1.28
BCHSP22	Batch 1	4	2	9	2.45	2.02
URSP22	U std	4	2	10	2.71	1.28

The values in the shaded row were reported by the SRTC-ML with the label F35SP12. This was an obvious mis-label and was corrected as indicated in Table E.3.

Table E.5: Average Measured and Bias-Corrected Chemical Compositions Versus Targeted Compositions by Oxide by Glass Number (0 – Batch 1 and 100 – U std)

Glass #	Oxide	Measured (wt%)	Measured Bias-Corrected (wt%)	Targeted (wt%)	Diff of Measured	Diff of Meas BC	% Diff of Measured	% Diff of Meas BC
0	Al2O3 (wt%)	4.7804	4.8791	4.8770	-0.0987	0.0021	-2.0%	0.0%
0	B2O3 (wt%)	7.8863	7.7770	7.7770	0.1093	0.0000	1.4%	0.0%
0	CaO (wt%)	1.2909	1.2276	1.2200	0.0632	0.0076	5.8%	0.6%
0	Cr2O3 (wt%)	0.1309	0.1173	0.1070	0.0136	0.0103	22.3%	9.6%
0	Fe2O3 (wt%)	12.7457	12.8706	12.8390	-0.1249	0.0316	-0.7%	0.2%
0	Li2O (wt%)	4.3994	4.4592	4.4290	-0.0598	0.0302	-0.7%	0.0%
0	MgO (wt%)	1.4551	1.4135	1.4190	0.0416	-0.0055	2.5%	-0.4%
0	MnO (wt%)	1.7221	1.7298	1.7260	-0.0078	0.0038	-0.2%	0.2%
0	Na2O (wt%)	9.2875	9.0147	9.0030	0.2728	0.0117	3.2%	0.1%
0	NiO (wt%)	0.7324	0.7516	0.7510	-0.0192	0.0006	-2.5%	0.1%
0	P2O5 (wt%)	0.0195	0.0195	0.0000	0.0000	0.0195		
0	SiO2 (wt%)	50.9926	50.2200	50.2200	0.7726	0.0000	1.5%	0.0%
0	TiO2 (wt%)	0.6839	0.6771	0.6770	0.0068	0.0001	1.0%	0.0%
0	U3O8 (wt%)	0.0590	0.0638	0.0000	-0.0049	0.0638		
0	ZrO2 (wt%)	0.0925	0.0925	0.0980	0.0000	-0.0055	-5.6%	-5.6%
0	Sum of Oxides (wt%)	96.2781	95.3134	95.1430	0.9647	0.1704	1.2%	0.1%
25	Al2O3 (wt%)	4.4687	4.4164	4.3820	0.0523	0.0344	2.0%	0.8%
25	B2O3 (wt%)	6.2144	6.1472	6.5140	0.0673	-0.3668	-4.6%	-5.6%
25	CaO (wt%)	1.6895	1.5517	1.5710	0.1378	-0.0193	7.5%	-1.2%
25	Cr2O3 (wt%)	0.1045	0.0987	0.1234	0.0058	-0.0247	-15.3%	-20.0%
25	Fe2O3 (wt%)	15.2978	15.2189	16.1910	0.0789	-0.9721	-5.5%	-6.0%
25	Li2O (wt%)	4.4188	4.6259	4.6190	-0.2071	0.0069	-4.3%	-4.2%
25	MgO (wt%)	1.0284	0.9674	1.0420	0.0610	-0.0746	-1.3%	-7.2%
25	MnO (wt%)	1.8303	1.7730	1.8320	0.0572	-0.0590	-0.1%	-3.2%
25	Na2O (wt%)	12.8700	12.3029	12.8290	0.5671	-0.5261	0.3%	-4.1%
25	NiO (wt%)	0.6553	0.6480	0.6592	0.0073	-0.0112	-0.6%	-1.7%
25	P2O5 (wt%)	0.3643	0.3643	0.4686	0.0000	-0.1043	-22.3%	-22.3%
25	SiO2 (wt%)	45.4066	44.8024	45.0120	0.6042	-0.2096	0.9%	-0.5%
25	TiO2 (wt%)	0.0292	0.0277	0.0140	0.0015	0.0137	108.5%	97.8%
25	U3O8 (wt%)	3.6585	3.8313	3.7326	-0.1729	0.0987	-2.0%	2.6%
25	ZrO2 (wt%)	0.6815	0.6815	0.6948	0.0000	-0.0133	-1.9%	-1.9%
25	Sum of Oxides (wt%)	98.7179	97.4574	99.6846	1.2605	-2.2272	-1.0%	-2.4%
26	Al2O3 (wt%)	4.0435	4.0256	4.1300	0.0179	-0.1044	-2.1%	-2.5%
26	B2O3 (wt%)	6.0776	6.0367	6.5140	0.0409	-0.4773	-6.7%	-7.3%
26	CaO (wt%)	1.5251	1.3773	1.4970	0.1478	-0.1197	1.9%	-8.0%
26	Cr2O3 (wt%)	0.0994	0.0963	0.1252	0.0031	-0.0289	-20.6%	-23.1%
26	Fe2O3 (wt%)	15.0833	15.0756	15.8430	0.0077	-0.7674	-4.8%	-4.8%
26	Li2O (wt%)	4.3273	4.6401	4.6200	-0.3127	0.0201	-6.3%	-5.9%
26	MgO (wt%)	1.0525	0.9934	1.1030	0.0591	-0.1096	-4.6%	-9.9%
26	MnO (wt%)	1.9142	1.8642	2.0090	0.0500	-0.1448	-4.7%	-7.2%
26	Na2O (wt%)	12.6105	12.0225	12.9180	0.5881	-0.8955	-2.4%	-6.9%
26	NiO (wt%)	0.8138	0.8083	0.8965	0.0055	-0.0882	-9.2%	-9.8%
26	P2O5 (wt%)	0.3540	0.3540	0.4751	0.0000	-0.1211	-25.5%	-25.5%
26	SiO2 (wt%)	46.6902	46.1498	44.9720	0.5404	1.1778	3.8%	2.6%
26	TiO2 (wt%)	0.0092	0.0087	0.0142	0.0005	-0.0055	-35.4%	-38.7%
26	U3O8 (wt%)	3.6555	3.8493	3.8667	-0.1938	-0.0174	-5.5%	-0.5%
26	ZrO2 (wt%)	0.6308	0.6308	0.6954	0.0000	-0.0646	-9.3%	-9.3%
26	Sum of Oxides (wt%)	98.8870	97.9327	99.6791	0.9544	-1.7464	-0.8%	-2.0%

Table E.5: Average Measured and Bias-Corrected Chemical Compositions Versus Targeted Compositions by Oxide by Glass Number (0 – Batch 1 and 100 – U std)

(continued)

Glass #	Oxide	Measured (wt%)	Measured Bias-Corrected (wt%)	Targeted (wt%)	Diff of Measured	Diff of Meas BC	% Diff of Measured	% Diff of Meas BC
27	Al2O3 (wt%)	3.1507	3.1359	3.1770	0.0148	-0.0411	-0.8%	-1.3%
27	B2O3 (wt%)	6.6732	6.6096	7.2610	0.0636	-0.6514	-8.1%	-9.0%
27	CaO (wt%)	1.3450	1.2440	1.1140	0.1009	0.1300	20.7%	11.7%
27	Cr2O3 (wt%)	0.0764	0.0773	0.0983	-0.0009	-0.0210	-22.3%	-21.4%
27	Fe2O3 (wt%)	11.6485	11.6425	11.5040	0.0060	0.1385	1.3%	1.2%
27	Li2O (wt%)	4.7741	5.1398	5.1300	-0.3657	0.0098	-6.9%	-6.8%
27	MgO (wt%)	1.2452	1.1598	1.2250	0.0854	-0.0652	1.7%	-5.3%
27	MnO (wt%)	2.6696	2.5828	2.7210	0.0868	-0.1382	-1.9%	-5.1%
27	Na2O (wt%)	12.8229	12.3080	12.9550	0.5149	-0.6470	-1.0%	-5.0%
27	NiO (wt%)	0.5341	0.5292	0.5613	0.0049	-0.0321	-4.8%	-5.7%
27	P2O5 (wt%)	0.2939	0.2939	0.3732	0.0000	-0.0793	-21.3%	-21.3%
27	SiO2 (wt%)	49.0435	48.1806	50.4960	0.8629	-2.3154	-2.9%	-4.6%
27	TiO2 (wt%)	0.0038	0.0036	0.0111	0.0002	-0.0075	-66.2%	-67.7%
27	U3O8 (wt%)	2.2818	2.4082	2.3589	-0.1264	0.0493	-3.3%	2.1%
27	ZrO2 (wt%)	0.7004	0.7004	0.7606	0.0000	-0.0602	-7.9%	-7.9%
27	Sum of Oxides (wt%)	97.2629	96.0155	99.7464	1.2473	-3.7309	-2.5%	-4.1%
28	Al2O3 (wt%)	3.4814	3.4784	3.4660	0.0030	0.0124	0.4%	0.4%
28	B2O3 (wt%)	6.5605	6.4720	7.0120	0.0885	-0.5400	-6.4%	-7.7%
28	CaO (wt%)	1.2925	1.1715	1.2160	0.1210	-0.0445	6.3%	-3.7%
28	Cr2O3 (wt%)	0.0888	0.0891	0.1073	-0.0003	-0.0182	-17.2%	-16.9%
28	Fe2O3 (wt%)	12.2668	12.2941	12.5500	-0.0273	-0.2559	-2.3%	-2.0%
28	Li2O (wt%)	4.6772	4.9553	4.9600	-0.2782	-0.0047	-5.7%	-5.8%
28	MgO (wt%)	1.2282	1.1536	1.2460	0.0747	-0.0924	-1.4%	-7.4%
28	MnO (wt%)	2.9181	2.8403	2.9690	0.0778	-0.1287	-1.7%	-4.3%
28	Na2O (wt%)	12.9846	12.4061	12.9510	0.5785	-0.5449	0.3%	-4.2%
28	NiO (wt%)	0.5930	0.5896	0.6124	0.0034	-0.0228	-3.2%	-3.7%
28	P2O5 (wt%)	0.3191	0.3191	0.4071	0.0000	-0.0880	-21.6%	-21.6%
28	SiO2 (wt%)	48.6156	47.6854	48.9040	0.9302	-1.2186	-0.6%	-2.5%
28	TiO2 (wt%)	0.0052	0.0050	0.0121	0.0002	-0.0071	-56.9%	-58.8%
28	U3O8 (wt%)	2.5087	2.6524	2.5733	-0.1436	0.0791	-2.5%	3.1%
28	ZrO2 (wt%)	0.6886	0.6886	0.7389	0.0000	-0.0503	-6.8%	-6.8%
28	Sum of Oxides (wt%)	98.2284	96.8003	99.7251	1.4281	-2.9248	-1.5%	-3.2%
29	Al2O3 (wt%)	3.7601	3.7714	3.7560	-0.0113	0.0154	0.1%	0.4%
29	B2O3 (wt%)	6.7054	6.6241	7.0120	0.0814	-0.3879	-4.4%	-5.5%
29	CaO (wt%)	1.4139	1.2550	1.3460	0.1589	-0.0910	5.0%	-6.8%
29	Cr2O3 (wt%)	0.0855	0.0851	0.1058	0.0004	-0.0207	-19.2%	-19.5%
29	Fe2O3 (wt%)	13.4320	13.4950	13.8780	-0.0630	-0.3830	-3.2%	-2.8%
29	Li2O (wt%)	4.7848	4.9564	4.9590	-0.1715	-0.0026	-3.5%	-3.6%
29	MgO (wt%)	1.0214	0.9675	1.0360	0.0539	-0.0685	-1.4%	-6.6%
29	MnO (wt%)	1.5656	1.5332	1.5700	0.0324	-0.0368	-0.3%	-2.3%
29	Na2O (wt%)	13.1295	12.4863	12.8530	0.6432	-0.3667	2.2%	-2.9%
29	NiO (wt%)	0.5386	0.5374	0.5650	0.0012	-0.0276	-4.7%	-4.9%
29	P2O5 (wt%)	0.3116	0.3116	0.4016	0.0000	-0.0900	-22.4%	-22.4%
29	SiO2 (wt%)	49.0969	47.9566	48.2960	1.1403	-0.3394	1.7%	-0.7%
29	TiO2 (wt%)	0.0079	0.0076	0.0120	0.0003	-0.0044	-34.0%	-36.8%
29	U3O8 (wt%)	3.1455	3.3312	3.1994	-0.1857	0.1318	-1.7%	4.1%
29	ZrO2 (wt%)	0.6913	0.6913	0.7384	0.0000	-0.0471	-6.4%	-6.4%
29	Sum of Oxides (wt%)	99.6901	98.0097	99.7282	1.6804	-1.7185	0.0%	-1.9%

Table E.5: Average Measured and Bias-Corrected Chemical Compositions Versus Targeted Compositions by Oxide by Glass Number (0 – Batch 1 and 100 – U std)
(continued)

Glass #	Oxide	Measured (wt%)	Measured Bias-Corrected (wt%)	Targeted (wt%)	Diff of Measured	Diff of Meas BC	% Diff of Measured	% Diff of Meas BC
30	Al2O3 (wt%)	3.2594	3.2456	3.1150	0.0138	0.1306	4.6%	4.2%
30	B2O3 (wt%)	6.3352	6.2925	6.5140	0.0426	-0.2215	-2.7%	-3.4%
30	CaO (wt%)	0.6723	0.6069	0.6130	0.0654	-0.0061	9.7%	-1.0%
30	Cr2O3 (wt%)	0.1060	0.1028	0.1260	0.0031	-0.0232	-15.9%	-18.4%
30	Fe2O3 (wt%)	11.3339	11.3324	12.0400	0.0015	-0.7076	-5.9%	-5.9%
30	Li2O (wt%)	4.5265	4.6401	4.6200	-0.1136	0.0201	-2.0%	-1.6%
30	MgO (wt%)	1.6469	1.5546	1.6630	0.0923	-0.1084	-1.0%	-6.5%
30	MnO (wt%)	3.8930	3.7921	3.9730	0.1009	-0.1809	-2.0%	-4.6%
30	Na2O (wt%)	13.2407	12.6235	12.9390	0.6172	-0.3155	2.3%	-2.4%
30	NiO (wt%)	2.7982	2.7797	2.9380	0.0185	-0.1583	-4.8%	-5.4%
30	P2O5 (wt%)	0.3844	0.3844	0.4782	0.0000	-0.0938	-19.6%	-19.6%
30	SiO2 (wt%)	45.8345	45.3040	44.5340	0.5305	0.7700	2.9%	1.7%
30	TiO2 (wt%)	0.0117	0.0111	0.0143	0.0006	-0.0032	-18.3%	-22.3%
30	U3O8 (wt%)	5.4656	5.7562	5.4138	-0.2906	0.3424	1.0%	6.3%
30	ZrO2 (wt%)	0.6838	0.6838	0.6957	0.0000	-0.0119	-1.7%	-1.7%
30	Sum of Oxides (wt%)	100.1921	99.1098	99.6770	1.0823	-0.5672	0.5%	-0.7%
31	Al2O3 (wt%)	8.8381	8.8307	8.7740	0.0074	0.0567	0.7%	0.6%
31	B2O3 (wt%)	5.3933	5.3570	8.0080	0.0363	-2.6510	-32.7%	-33.1%
31	CaO (wt%)	0.5544	0.5014	0.4190	0.0531	0.0824	32.3%	19.7%
31	Cr2O3 (wt%)	0.0555	0.0557	0.0709	-0.0002	-0.0152	-21.7%	-21.4%
31	Fe2O3 (wt%)	2.7808	2.7871	2.6990	-0.0063	0.0881	3.0%	3.3%
31	Li2O (wt%)	5.7159	5.6645	5.6400	0.0515	0.0245	1.3%	1.8%
31	MgO (wt%)	1.1814	1.1097	1.1480	0.0717	-0.0383	2.9%	-3.3%
31	MnO (wt%)	2.0659	2.0109	1.9860	0.0550	0.0249	4.0%	1.3%
31	Na2O (wt%)	13.6350	13.0266	12.9490	0.6084	0.0776	5.3%	0.6%
31	NiO (wt%)	0.2176	0.2164	0.2148	0.0012	0.0016	1.3%	0.7%
31	P2O5 (wt%)	0.2142	0.2142	0.2693	0.0000	-0.0551	-20.4%	-20.4%
31	SiO2 (wt%)	57.2263	56.5639	56.3990	0.6624	0.1649	1.5%	0.3%
31	TiO2 (wt%)	0.0044	0.0042	0.0080	0.0002	-0.0038	-45.3%	-47.7%
31	U3O8 (wt%)	0.4251	0.4494	0.4088	-0.0243	0.0406	4.0%	9.9%
31	ZrO2 (wt%)	0.8199	0.8199	0.8257	0.0000	-0.0058	-0.7%	-0.7%
31	Sum of Oxides (wt%)	99.1280	97.6116	99.8195	1.5164	-2.2079	-0.7%	-2.1%
31.5	Al2O3 (wt%)	8.3374	8.6468	8.7740	-0.3094	-0.1272	-5.0%	-1.4%
31.5	B2O3 (wt%)	8.0015	7.8444	8.0080	0.1570	-0.1636	-3.1%	-5.0%
31.5	CaO (wt%)	0.4397	0.4300	0.4190	0.0097	0.0110	4.9%	2.6%
31.5	Cr2O3 (wt%)	0.0771	0.0664	0.0709	0.0107	-0.0045	8.7%	-6.4%
31.5	Fe2O3 (wt%)	2.7879	2.8322	2.6990	-0.0443	0.1332	3.3%	4.9%
31.5	Li2O (wt%)	4.6772	5.7546	5.6400	-1.0775	0.1146	-5.7%	-3.8%
31.5	MgO (wt%)	1.0881	1.0835	1.1480	0.0046	-0.0645	-5.2%	-5.6%
31.5	MnO (wt%)	1.9013	1.9570	1.9860	-0.0557	-0.0290	-4.3%	-1.5%
31.5	Na2O (wt%)	12.6173	12.3496	12.9490	0.2677	-0.5994	-2.6%	-4.6%
31.5	NiO (wt%)	0.1925	0.2017	0.2148	-0.0092	-0.0131	-10.4%	-6.1%
31.5	P2O5 (wt%)	0.2057	0.2057	0.2693	0.0000	-0.0636	-23.6%	-23.6%
31.5	SiO2 (wt%)	56.9054	56.1282	56.3990	0.7772	-0.2708	0.9%	-0.5%
31.5	TiO2 (wt%)	0.0133	0.0135	0.0080	-0.0002	0.0055	66.8%	69.1%
31.5	U3O8 (wt%)	0.3770	0.4145	0.4088	-0.0374	0.0057	-7.8%	1.4%
31.5	ZrO2 (wt%)	0.7639	0.7639	0.8257	0.0000	-0.0618	-7.5%	-7.5%
31.5	Sum of Oxides (wt%)	98.3852	98.6919	99.8195	-0.3066	-1.1276	-1.0%	-1.7%

Table E.5: Average Measured and Bias-Corrected Chemical Compositions Versus Targeted Compositions by Oxide by Glass Number (0 – Batch 1 and 100 – U std)
(continued)

Glass #	Oxide	Measured (wt%)	Measured Bias-Corrected (wt%)	Targeted (wt%)	Diff of Measured	Diff of Meas BC	% Diff of Measured	% Diff of Meas BC
32	Al2O3 (wt%)	4.1286	4.1249	4.0440	0.0036	0.0809	2.1%	2.0%
32	B2O3 (wt%)	6.4398	6.3527	6.5140	0.0871	-0.1613	-1.1%	-2.5%
32	CaO (wt%)	1.5636	1.4173	1.4180	0.1463	-0.0007	10.3%	-0.1%
32	Cr2O3 (wt%)	0.0994	0.0998	0.1251	-0.0004	-0.0253	-20.6%	-20.2%
32	Fe2O3 (wt%)	14.0861	14.1149	14.6420	-0.0288	-0.5271	-3.8%	-3.6%
32	Li2O (wt%)	4.5695	4.6157	4.6200	-0.0461	-0.0043	-1.1%	-1.2%
32	MgO (wt%)	1.2034	1.1301	1.2870	0.0733	-0.1569	-6.5%	-12.2%
32	MnO (wt%)	0.7118	0.6927	3.4630	0.0190	-2.7703	-79.4%	-80.0%
32	Na2O (wt%)	13.1194	12.5345	12.9430	0.5849	-0.4085	1.4%	-3.2%
32	NiO (wt%)	0.6773	0.6734	0.7144	0.0039	-0.0410	-5.2%	-5.7%
32	P2O5 (wt%)	0.3729	0.3729	0.4750	0.0000	-0.1021	-21.5%	-21.5%
32	SiO2 (wt%)	47.2785	46.3759	45.7220	0.9027	0.6539	3.4%	1.4%
32	TiO2 (wt%)	0.0851	0.0813	0.0142	0.0038	0.0671	499.1%	472.5%
32	U3O8 (wt%)	2.9067	3.0729	3.0022	-0.1662	0.0707	-3.2%	2.4%
32	ZrO2 (wt%)	0.6565	0.6565	0.6954	0.0000	-0.0389	-5.6%	-5.6%
32	Sum of Oxides (wt%)	97.8986	96.3153	99.6793	1.5833	-3.3640	-1.8%	-3.4%
33	Al2O3 (wt%)	4.2372	4.2330	4.3330	0.0042	-0.1000	-2.2%	-2.3%
33	B2O3 (wt%)	6.1420	6.0839	6.2650	0.0581	-0.1811	-2.0%	-2.9%
33	CaO (wt%)	1.5671	1.4215	1.5190	0.1456	-0.0975	3.2%	-6.4%
33	Cr2O3 (wt%)	0.1005	0.1009	0.1341	-0.0004	-0.0332	-25.1%	-24.7%
33	Fe2O3 (wt%)	14.8939	14.9269	15.6870	-0.0330	-0.7601	-5.1%	-4.8%
33	Li2O (wt%)	4.3758	4.4585	4.4500	-0.0827	0.0085	-1.7%	-1.5%
33	MgO (wt%)	1.2983	1.2188	1.3070	0.0795	-0.0882	-0.7%	-6.7%
33	MnO (wt%)	0.7702	0.7495	3.7110	0.0207	-2.9615	-79.2%	-79.8%
33	Na2O (wt%)	12.8801	12.3081	12.9390	0.5720	-0.6309	-0.5%	-4.9%
33	NiO (wt%)	0.7031	0.6989	0.7654	0.0042	-0.0665	-8.1%	-8.7%
33	P2O5 (wt%)	0.3861	0.3861	0.5089	0.0000	-0.1228	-24.1%	-24.1%
33	SiO2 (wt%)	46.5833	45.7718	44.1300	0.8114	1.6418	5.6%	3.7%
33	TiO2 (wt%)	0.0158	0.0151	0.0152	0.0007	-0.0001	4.2%	-0.5%
33	U3O8 (wt%)	3.0866	3.2629	3.2167	-0.1764	0.0462	-4.0%	1.4%
33	ZrO2 (wt%)	0.6143	0.6143	0.6736	0.0000	-0.0593	-8.8%	-8.8%
33	Sum of Oxides (wt%)	97.6541	96.2501	99.6549	1.4040	-3.4048	-2.0%	-3.5%
34	Al2O3 (wt%)	3.5570	3.5677	3.5400	-0.0107	0.0277	0.5%	0.8%
34	B2O3 (wt%)	6.6652	6.5844	7.0120	0.0808	-0.4276	-4.9%	-6.1%
34	CaO (wt%)	1.3677	1.2140	1.2830	0.1537	-0.0690	6.6%	-5.4%
34	Cr2O3 (wt%)	0.0862	0.0859	0.1073	0.0003	-0.0214	-19.6%	-19.9%
34	Fe2O3 (wt%)	12.7208	12.7795	13.5790	-0.0588	-0.7995	-6.3%	-5.9%
34	Li2O (wt%)	4.8063	4.9574	4.9600	-0.1510	-0.0026	-3.1%	-3.1%
34	MgO (wt%)	1.0570	1.0013	1.0890	0.0558	-0.0877	-2.9%	-8.1%
34	MnO (wt%)	1.6850	1.6502	1.7220	0.0349	-0.0718	-2.1%	-4.2%
34	Na2O (wt%)	12.9071	12.2722	12.9300	0.6349	-0.6578	-0.2%	-5.1%
34	NiO (wt%)	0.7304	0.7288	0.7684	0.0016	-0.0396	-4.9%	-5.2%
34	P2O5 (wt%)	0.3174	0.3174	0.4072	0.0000	-0.0898	-22.1%	-22.1%
34	SiO2 (wt%)	48.5086	47.3821	48.2620	1.1265	-0.8799	0.5%	-1.8%
34	TiO2 (wt%)	0.0100	0.0096	0.0121	0.0004	-0.0025	-17.3%	-20.8%
34	U3O8 (wt%)	3.2074	3.3968	3.3143	-0.1894	0.0825	-3.2%	2.5%
34	ZrO2 (wt%)	0.6946	0.6946	0.7389	0.0000	-0.0443	-6.0%	-6.0%
34	Sum of Oxides (wt%)	98.3209	96.6419	99.7252	1.6790	-3.0833	-1.4%	-3.2%

Table E.5: Average Measured and Bias-Corrected Chemical Compositions Versus Targeted Compositions by Oxide by Glass Number (0 – Batch 1 and 100 – U std)
(continued)

Glass #	Oxide	Measured (wt%)	Measured Bias-Corrected (wt%)	Targeted (wt%)	Diff of Measured	Diff of Meas BC	% Diff of Measured	% Diff of Meas BC
35	Al2O3 (wt%)	3.3019	3.2632	3.2450	0.0387	0.0182	1.8%	0.6%
35	B2O3 (wt%)	6.9711	6.8959	7.2610	0.0752	-0.3651	-4.0%	-5.0%
35	CaO (wt%)	1.3331	1.2243	1.1760	0.1088	0.0483	13.4%	4.1%
35	Cr2O3 (wt%)	0.0895	0.0846	0.0983	0.0050	-0.0137	-8.9%	-14.0%
35	Fe2O3 (wt%)	12.1632	12.1005	12.4480	0.0626	-0.3475	-2.3%	-2.8%
35	Li2O (wt%)	4.9355	5.1377	5.1300	-0.2022	0.0077	-3.8%	-3.6%
35	MgO (wt%)	1.0786	1.0146	1.0810	0.0640	-0.0664	-0.2%	-6.1%
35	MnO (wt%)	1.5559	1.5072	1.5780	0.0487	-0.0708	-1.4%	-4.5%
35	Na2O (wt%)	13.0251	12.4510	12.9350	0.5740	-0.4840	0.7%	-3.7%
35	NiO (wt%)	0.6515	0.6443	0.7044	0.0072	-0.0601	-7.5%	-8.5%
35	P2O5 (wt%)	0.2893	0.2893	0.3733	0.0000	-0.0840	-22.5%	-22.5%
35	SiO2 (wt%)	50.7549	50.0801	49.9070	0.6748	0.1731	1.7%	0.3%
35	TiO2 (wt%)	0.0425	0.0404	0.0111	0.0021	0.0293	283.2%	263.9%
35	U3O8 (wt%)	2.9952	3.1365	3.0381	-0.1413	0.0984	-1.4%	3.2%
35	ZrO2 (wt%)	0.7561	0.7561	0.7607	0.0000	-0.0046	-0.6%	-0.6%
35	Sum of Oxides (wt%)	99.9433	98.6257	99.7469	1.3176	-1.1212	0.2%	-1.3%
36	Al2O3 (wt%)	6.4668	6.3910	6.5810	0.0758	-0.1900	-1.7%	-2.9%
36	B2O3 (wt%)	8.1624	8.0746	8.5060	0.0878	-0.4314	-4.0%	-5.1%
36	CaO (wt%)	0.3725	0.3422	0.3140	0.0304	0.0282	18.6%	9.0%
36	Cr2O3 (wt%)	0.0475	0.0448	0.0532	0.0027	-0.0084	-10.7%	-15.7%
36	Fe2O3 (wt%)	2.0659	2.0553	2.0240	0.0107	0.0313	2.1%	1.5%
36	Li2O (wt%)	5.8290	5.9890	5.9800	-0.1600	0.0090	-2.5%	-2.4%
36	MgO (wt%)	1.0885	1.0240	1.1110	0.0646	-0.0870	-2.0%	-7.8%
36	MnO (wt%)	1.4913	1.4446	1.4890	0.0467	-0.0444	0.2%	-3.0%
36	Na2O (wt%)	13.0149	12.4413	12.9610	0.5736	-0.5197	0.4%	-4.0%
36	NiO (wt%)	0.1603	0.1585	0.1611	0.0018	-0.0026	-0.5%	-1.6%
36	P2O5 (wt%)	0.1598	0.1598	0.2019	0.0000	-0.0421	-20.8%	-20.8%
36	SiO2 (wt%)	58.7238	57.9437	59.2990	0.7801	-1.3553	-1.0%	-2.3%
36	TiO2 (wt%)	0.0071	0.0067	0.0060	0.0004	0.0007	18.2%	11.3%
36	U3O8 (wt%)	0.3567	0.3735	0.3066	-0.0168	0.0669	16.3%	21.8%
36	ZrO2 (wt%)	0.8230	0.8230	0.8693	0.0000	-0.0463	-5.3%	-5.3%
36	Sum of Oxides (wt%)	98.7697	97.2721	99.8631	1.4977	-2.5910	-1.1%	-2.7%
37	Al2O3 (wt%)	3.1649	3.1500	3.1300	0.0149	0.0200	1.1%	0.6%
37	B2O3 (wt%)	7.1240	7.0280	7.5100	0.0961	-0.4820	-5.1%	-6.4%
37	CaO (wt%)	1.2908	1.1941	1.1220	0.0967	0.0721	15.0%	6.4%
37	Cr2O3 (wt%)	0.0734	0.0743	0.0882	-0.0009	-0.0139	-16.7%	-15.7%
37	Fe2O3 (wt%)	11.4197	11.4138	11.5650	0.0059	-0.1512	-1.3%	-1.3%
37	Li2O (wt%)	5.0539	5.2940	5.2990	-0.2401	-0.0050	-4.6%	-4.7%
37	MgO (wt%)	1.0168	0.9471	1.0300	0.0698	-0.0829	-1.3%	-8.1%
37	MnO (wt%)	1.3009	1.2586	1.3090	0.0423	-0.0504	-0.6%	-3.9%
37	Na2O (wt%)	12.8094	12.2944	12.8780	0.5150	-0.5836	-0.5%	-4.5%
37	NiO (wt%)	0.4578	0.4536	0.4708	0.0042	-0.0172	-2.8%	-3.7%
37	P2O5 (wt%)	0.2624	0.2624	0.3347	0.0000	-0.0723	-21.6%	-21.6%
37	SiO2 (wt%)	50.5410	49.5719	51.5800	0.9691	-2.0081	-2.0%	-3.9%
37	TiO2 (wt%)	0.0033	0.0032	0.0100	0.0002	-0.0068	-66.6%	-68.2%
37	U3O8 (wt%)	2.6149	2.7597	2.6662	-0.1448	0.0935	-1.9%	3.5%
37	ZrO2 (wt%)	0.7399	0.7399	0.7820	0.0000	-0.0421	-5.4%	-5.4%
37	Sum of Oxides (wt%)	97.8731	96.4448	99.7749	1.4283	-3.3301	-1.9%	-3.6%

Table E.5: Average Measured and Bias-Corrected Chemical Compositions Versus Targeted Compositions by Oxide by Glass Number (0 – Batch 1 and 100 – U std)

(continued)

Glass #	Oxide	Measured (wt%)	Measured Bias-Corrected (wt%)	Targeted (wt%)	Diff of Measured	Diff of Meas BC	% Diff of Measured	% Diff of Meas BC
38	Al2O3 (wt%)	3.5428	3.5536	3.5400	-0.0108	0.0136	0.1%	0.4%
38	B2O3 (wt%)	7.9532	7.8677	8.4120	0.0855	-0.5443	-5.5%	-6.5%
38	CaO (wt%)	1.3145	1.1670	1.2830	0.1476	-0.1160	2.5%	-9.0%
38	Cr2O3 (wt%)	0.0972	0.0969	0.1073	0.0003	-0.0104	-9.4%	-9.7%
38	Fe2O3 (wt%)	12.7315	12.7982	13.5790	-0.0667	-0.7808	-6.2%	-5.8%
38	Li2O (wt%)	3.3316	3.5653	3.5600	-0.2337	0.0053	-6.4%	-6.3%
38	MgO (wt%)	1.7410	1.6491	1.7890	0.0919	-0.1399	-2.7%	-7.8%
38	MnO (wt%)	1.7012	1.6659	1.7220	0.0352	-0.0561	-1.2%	-3.3%
38	Na2O (wt%)	11.3333	10.7787	11.5300	0.5546	-0.7513	-1.7%	-6.5%
38	NiO (wt%)	0.7269	0.7253	0.7684	0.0016	-0.0431	-5.4%	-5.6%
38	P2O5 (wt%)	0.3151	0.3151	0.4072	0.0000	-0.0921	-22.6%	-22.6%
38	SiO2 (wt%)	50.4340	49.7638	49.6620	0.6702	0.1018	1.6%	0.2%
38	TiO2 (wt%)	0.0100	0.0096	0.0121	0.0004	-0.0025	-17.3%	-20.9%
38	U3O8 (wt%)	3.1426	3.3283	3.3143	-0.1857	0.0140	-5.2%	0.4%
38	ZrO2 (wt%)	0.0270	0.0270	0.0389	0.0000	-0.0119	-30.6%	-30.6%
38	Sum of Oxides (wt%)	98.4018	97.3114	99.7252	1.0904	-2.4138	-1.3%	-2.6%
39	Al2O3 (wt%)	3.4767	3.4738	3.4660	0.0029	0.0078	0.3%	0.2%
39	B2O3 (wt%)	8.0256	7.9391	8.4120	0.0865	-0.4729	-4.6%	-5.6%
39	CaO (wt%)	1.2544	1.1370	1.2160	0.1174	-0.0790	3.2%	-6.5%
39	Cr2O3 (wt%)	0.0979	0.0984	0.1073	-0.0004	-0.0089	-8.7%	-8.3%
39	Fe2O3 (wt%)	12.5385	12.5688	12.5500	-0.0303	0.0188	-0.1%	0.1%
39	Li2O (wt%)	3.3747	3.5653	3.5600	-0.1907	0.0053	-5.2%	-5.1%
39	MgO (wt%)	1.9524	1.8339	1.9460	0.1185	-0.1121	0.3%	-5.8%
39	MnO (wt%)	3.0117	2.9316	2.9690	0.0801	-0.0374	1.4%	-1.3%
39	Na2O (wt%)	11.4412	10.9316	11.5510	0.5096	-0.6194	-1.0%	-5.4%
39	NiO (wt%)	0.5987	0.5953	0.6124	0.0034	-0.0171	-2.2%	-2.8%
39	P2O5 (wt%)	0.3191	0.3191	0.4071	0.0000	-0.0880	-21.6%	-21.6%
39	SiO2 (wt%)	50.7549	50.0794	50.3040	0.6755	-0.2246	0.9%	-0.4%
39	TiO2 (wt%)	0.0058	0.0056	0.0121	0.0003	-0.0065	-51.8%	-53.9%
39	U3O8 (wt%)	2.4940	2.6368	2.5733	-0.1428	0.0635	-3.1%	2.5%
39	ZrO2 (wt%)	0.0176	0.0176	0.0389	0.0000	-0.0213	-54.9%	-54.9%
39	Sum of Oxides (wt%)	99.3631	98.1332	99.7251	1.2299	-1.5919	-0.4%	-1.8%
40	Al2O3 (wt%)	3.1933	3.1669	3.1150	0.0263	0.0519	2.5%	1.7%
40	B2O3 (wt%)	7.4863	7.3950	7.8140	0.0913	-0.4190	-4.2%	-5.4%
40	CaO (wt%)	0.7143	0.6584	0.6130	0.0559	0.0454	16.5%	7.4%
40	Cr2O3 (wt%)	0.1001	0.0978	0.1260	0.0023	-0.0282	-20.5%	-22.4%
40	Fe2O3 (wt%)	11.6056	11.5725	12.0400	0.0331	-0.4675	-3.6%	-3.9%
40	Li2O (wt%)	3.1917	3.3182	3.3200	-0.1266	-0.0018	-3.9%	-3.9%
40	MgO (wt%)	2.2335	2.0905	2.3130	0.1430	-0.2225	-3.4%	-9.6%
40	MnO (wt%)	3.8607	3.7374	3.9730	0.1233	-0.2356	-2.8%	-5.9%
40	Na2O (wt%)	11.7883	11.2917	11.6390	0.4966	-0.3473	1.3%	-3.0%
40	NiO (wt%)	2.7139	2.6862	2.9380	0.0277	-0.2518	-7.6%	-8.6%
40	P2O5 (wt%)	0.3844	0.3844	0.4782	0.0000	-0.0938	-19.6%	-19.6%
40	SiO2 (wt%)	47.2785	46.1796	45.8340	1.0989	0.3456	3.2%	0.8%
40	TiO2 (wt%)	0.0183	0.0174	0.0143	0.0009	0.0031	28.3%	21.9%
40	U3O8 (wt%)	5.3713	5.6465	5.4138	-0.2753	0.2327	-0.8%	4.3%
40	ZrO2 (wt%)	0.0365	0.0365	0.0457	0.0000	-0.0092	-20.2%	-20.2%
40	Sum of Oxides (wt%)	99.9765	98.2790	99.6770	1.6975	-1.3980	0.3%	-1.5%

Table E.5: Average Measured and Bias-Corrected Chemical Compositions Versus Targeted Compositions by Oxide by Glass Number (0 – Batch 1 and 100 – U std)

(continued)

Glass #	Oxide	Measured (wt%)	Measured Bias-Corrected (wt%)	Targeted (wt%)	Diff of Measured	Diff of Meas BC	% Diff of Measured	% Diff of Meas BC
41	Al2O3 (wt%)	3.2074	3.1811	3.1300	0.0264	0.0511	2.5%	1.6%
41	B2O3 (wt%)	8.6776	8.5489	9.0100	0.1288	-0.4611	-3.7%	-5.1%
41	CaO (wt%)	1.2498	1.1520	1.1220	0.0978	0.0300	11.4%	2.7%
41	Cr2O3 (wt%)	0.0705	0.0689	0.0882	0.0017	-0.0193	-20.0%	-21.9%
41	Fe2O3 (wt%)	11.3768	11.3446	11.5650	0.0322	-0.2204	-1.6%	-1.9%
41	Li2O (wt%)	3.7245	3.7939	3.7990	-0.0694	-0.0051	-2.0%	-2.1%
41	MgO (wt%)	1.7534	1.6412	1.7800	0.1123	-0.1388	-1.5%	-7.8%
41	MnO (wt%)	1.3719	1.3280	1.3090	0.0439	0.0190	4.8%	1.5%
41	Na2O (wt%)	11.4749	10.9914	11.3780	0.4835	-0.3866	0.9%	-3.4%
41	NiO (wt%)	0.4750	0.4701	0.4708	0.0049	-0.0007	0.9%	-0.1%
41	P2O5 (wt%)	0.2538	0.2538	0.3347	0.0000	-0.0809	-24.2%	-24.2%
41	SiO2 (wt%)	52.0920	51.3089	53.0800	0.7830	-1.7711	-1.9%	-3.3%
41	TiO2 (wt%)	0.0663	0.0631	0.0100	0.0032	0.0531	563.0%	530.9%
41	U3O8 (wt%)	2.6355	2.7706	2.6662	-0.1351	0.1044	-1.2%	3.9%
41	ZrO2 (wt%)	0.0436	0.0436	0.0320	0.0000	0.0116	36.1%	36.1%
41	Sum of Oxides (wt%)	98.4730	96.9600	99.7749	1.5131	-2.8149	-1.3%	-2.9%
42	Al2O3 (wt%)	3.8451	3.8136	3.7560	0.0316	0.0576	2.4%	1.5%
42	B2O3 (wt%)	8.1141	8.0383	8.4120	0.0759	-0.3737	-3.5%	-4.4%
42	CaO (wt%)	1.4307	1.3187	1.3460	0.1120	-0.0273	6.3%	-2.0%
42	Cr2O3 (wt%)	0.0873	0.0854	0.1058	0.0020	-0.0204	-17.5%	-19.3%
42	Fe2O3 (wt%)	13.2855	13.2480	13.8780	0.0375	-0.6300	-4.3%	-4.5%
42	Li2O (wt%)	3.4393	3.5658	3.5590	-0.1265	0.0068	-3.4%	-3.2%
42	MgO (wt%)	1.7037	1.5946	1.7360	0.1091	-0.1414	-1.9%	-8.1%
42	MnO (wt%)	1.6043	1.5531	1.5700	0.0512	-0.0169	2.2%	-1.1%
42	Na2O (wt%)	11.6669	11.1753	11.4530	0.4916	-0.2777	1.9%	-2.4%
42	NiO (wt%)	0.5580	0.5523	0.5650	0.0057	-0.0127	-1.2%	-2.2%
42	P2O5 (wt%)	0.3174	0.3174	0.4016	0.0000	-0.0842	-21.0%	-21.0%
42	SiO2 (wt%)	50.4340	49.5631	49.6960	0.8709	-0.1329	1.5%	-0.3%
42	TiO2 (wt%)	0.0077	0.0073	0.0120	0.0004	-0.0047	-35.7%	-39.2%
42	U3O8 (wt%)	3.1838	3.3472	3.1994	-0.1634	0.1478	-0.5%	4.6%
42	ZrO2 (wt%)	0.0284	0.0284	0.0384	0.0000	-0.0100	-26.1%	-26.1%
42	Sum of Oxides (wt%)	99.7063	98.2083	99.7282	1.4979	-1.5199	0.0%	-1.6%
43	Al2O3 (wt%)	3.7648	3.7616	3.7550	0.0033	0.0066	0.3%	0.2%
43	B2O3 (wt%)	7.6392	7.5465	8.1130	0.0927	-0.5665	-5.8%	-7.0%
43	CaO (wt%)	1.3856	1.2556	1.3170	0.1300	-0.0614	5.2%	-4.7%
43	Cr2O3 (wt%)	0.0906	0.0910	0.1162	-0.0004	-0.0252	-22.0%	-21.7%
43	Fe2O3 (wt%)	12.8923	12.9200	13.5960	-0.0276	-0.6760	-5.2%	-5.0%
43	Li2O (wt%)	3.2509	3.4382	3.4400	-0.1873	-0.0018	-5.5%	-5.5%
43	MgO (wt%)	1.8363	1.7246	1.9410	0.1117	-0.2164	-5.4%	-11.1%
43	MnO (wt%)	3.0989	3.0162	3.2160	0.0827	-0.1998	-3.6%	-6.2%
43	Na2O (wt%)	11.5658	11.0490	11.5970	0.5169	-0.5480	-0.3%	-4.7%
43	NiO (wt%)	0.6273	0.6237	0.6634	0.0036	-0.0397	-5.4%	-6.0%
43	P2O5 (wt%)	0.3340	0.3340	0.4410	0.0000	-0.1070	-24.3%	-24.3%
43	SiO2 (wt%)	50.2201	49.0541	48.6630	1.1659	0.3911	3.2%	0.8%
43	TiO2 (wt%)	0.0067	0.0064	0.0132	0.0003	-0.0068	-49.5%	-51.7%
43	U3O8 (wt%)	2.7181	2.8735	2.7878	-0.1555	0.0857	-2.5%	3.1%
43	ZrO2 (wt%)	0.0301	0.0301	0.0421	0.0000	-0.0120	-28.6%	-28.6%
43	Sum of Oxides (wt%)	99.4606	97.7244	99.7017	1.7363	-1.9773	-0.2%	-2.2%

Table E.5: Average Measured and Bias-Corrected Chemical Compositions Versus Targeted Compositions by Oxide by Glass Number (0 – Batch 1 and 100 – U std)
(continued)

Glass #	Oxide	Measured (wt%)	Measured Bias-Corrected (wt%)	Targeted (wt%)	Diff of Measured	Diff of Meas BC	% Diff of Measured	% Diff of Meas BC
44	Al2O3 (wt%)	3.1980	3.1716	3.2450	0.0264	-0.0734	-1.4%	-2.3%
44	B2O3 (wt%)	8.3073	8.2176	8.7110	0.0898	-0.4934	-4.6%	-5.7%
44	CaO (wt%)	1.2309	1.1346	1.1760	0.0963	-0.0414	4.7%	-3.5%
44	Cr2O3 (wt%)	0.0811	0.0793	0.0983	0.0018	-0.0190	-17.5%	-19.4%
44	Fe2O3 (wt%)	12.1989	12.1640	12.4480	0.0349	-0.2840	-2.0%	-2.3%
44	Li2O (wt%)	3.5469	3.6855	3.6800	-0.1386	0.0055	-3.6%	-3.5%
44	MgO (wt%)	1.8115	1.6955	1.8060	0.1160	-0.1105	0.3%	-6.1%
44	MnO (wt%)	1.5882	1.5375	1.5780	0.0507	-0.0405	0.6%	-2.6%
44	Na2O (wt%)	11.3771	10.8976	11.4850	0.4795	-0.5874	-0.9%	-5.1%
44	NiO (wt%)	0.6735	0.6666	0.7044	0.0069	-0.0378	-4.4%	-5.4%
44	P2O5 (wt%)	0.2853	0.2853	0.3733	0.0000	-0.0880	-23.6%	-23.6%
44	SiO2 (wt%)	52.2524	51.5575	51.3570	0.6949	0.2005	1.7%	0.4%
44	TiO2 (wt%)	0.0063	0.0059	0.0111	0.0003	-0.0052	-43.6%	-46.7%
44	U3O8 (wt%)	2.9568	3.1085	3.0381	-0.1517	0.0704	-2.7%	2.3%
44	ZrO2 (wt%)	0.0240	0.0240	0.0357	0.0000	-0.0117	-32.8%	-32.8%
44	Sum of Oxides (wt%)	99.5382	98.2310	99.7469	1.3072	-1.5159	-0.2%	-1.7%
45	Al2O3 (wt%)	4.1427	4.1242	4.1300	0.0185	-0.0058	0.3%	-0.1%
45	B2O3 (wt%)	4.9345	4.8815	5.2140	0.0530	-0.3325	-5.4%	-6.4%
45	CaO (wt%)	1.5916	1.4379	1.4970	0.1537	-0.0591	6.3%	-3.9%
45	Cr2O3 (wt%)	0.1019	0.0988	0.1252	0.0032	-0.0264	-18.6%	-21.1%
45	Fe2O3 (wt%)	14.3077	14.3031	15.8430	0.0046	-1.5399	-9.7%	-9.7%
45	Li2O (wt%)	4.9355	5.2779	5.2700	-0.3424	0.0079	-6.3%	-6.2%
45	MgO (wt%)	0.4203	0.3967	0.4530	0.0236	-0.0563	-7.2%	-12.4%
45	MnO (wt%)	1.9336	1.8830	2.0090	0.0505	-0.1260	-3.8%	-6.3%
45	Na2O (wt%)	12.0916	11.5291	12.2680	0.5624	-0.7389	-1.4%	-6.0%
45	NiO (wt%)	0.8233	0.8177	0.8965	0.0056	-0.0788	-8.2%	-8.8%
45	P2O5 (wt%)	0.3643	0.3643	0.4751	0.0000	-0.1108	-23.3%	-23.3%
45	SiO2 (wt%)	46.4228	45.8062	47.5720	0.6166	-1.7658	-2.4%	-3.7%
45	TiO2 (wt%)	0.0096	0.0091	0.0142	0.0005	-0.0051	-32.5%	-35.8%
45	U3O8 (wt%)	3.7174	3.9145	3.8667	-0.1971	0.0478	-3.9%	1.2%
45	ZrO2 (wt%)	0.0344	0.0344	0.0454	0.0000	-0.0110	-24.1%	-24.1%
45	Sum of Oxides (wt%)	95.8314	94.8786	99.6791	0.9528	-4.8005	-3.9%	-5.2%
46	Al2O3 (wt%)	3.1413	3.1265	3.0600	0.0148	0.0665	2.7%	2.2%
46	B2O3 (wt%)	4.8862	4.8335	5.0150	0.0527	-0.1815	-2.6%	-3.6%
46	CaO (wt%)	1.2957	1.1987	1.2270	0.0970	-0.0283	5.6%	-2.3%
46	Cr2O3 (wt%)	0.1085	0.1098	0.1357	-0.0013	-0.0259	-20.0%	-19.1%
46	Fe2O3 (wt%)	14.2434	14.2356	15.4780	0.0078	-1.2424	-8.0%	-8.0%
46	Li2O (wt%)	4.9140	5.0836	5.0760	-0.1696	0.0076	-3.2%	-3.0%
46	MgO (wt%)	0.6972	0.6494	0.7070	0.0478	-0.0576	-1.4%	-8.1%
46	MnO (wt%)	3.8187	3.6945	3.9930	0.1242	-0.2985	-4.4%	-7.5%
46	Na2O (wt%)	12.5802	12.0745	12.4550	0.5058	-0.3805	1.0%	-3.1%
46	NiO (wt%)	1.7338	1.7178	1.9021	0.0160	-0.1843	-8.8%	-9.7%
46	P2O5 (wt%)	0.4027	0.4027	0.5152	0.0000	-0.1125	-21.8%	-21.8%
46	SiO2 (wt%)	46.8507	46.2271	45.6330	0.6236	0.5941	2.7%	1.3%
46	TiO2 (wt%)	0.0075	0.0072	0.0154	0.0003	-0.0082	-51.3%	-53.5%
46	U3O8 (wt%)	4.3188	4.5581	4.3894	-0.2393	0.1687	-1.6%	3.8%
46	ZrO2 (wt%)	0.0334	0.0334	0.0492	0.0000	-0.0158	-32.0%	-32.0%
46	Sum of Oxides (wt%)	99.0321	97.9524	99.6510	1.0797	-1.6986	-0.6%	-1.9%

Table E.5: Average Measured and Bias-Corrected Chemical Compositions Versus Targeted Compositions by Oxide by Glass Number (0 – Batch 1 and 100 – U std)
(continued)

Glass #	Oxide	Measured (wt%)	Measured Bias-Corrected (wt%)	Targeted (wt%)	Diff of Measured	Diff of Meas BC	% Diff of Measured	% Diff of Meas BC
47	Al2O3 (wt%)	4.5112	4.4916	4.3820	0.0196	0.1096	2.9%	2.5%
47	B2O3 (wt%)	5.0552	4.9870	5.2140	0.0683	-0.2270	-3.0%	-4.4%
47	CaO (wt%)	1.7140	1.5477	1.5710	0.1663	-0.0233	9.1%	-1.5%
47	Cr2O3 (wt%)	0.1049	0.1017	0.1234	0.0032	-0.0217	-15.0%	-17.6%
47	Fe2O3 (wt%)	15.0833	15.0820	16.1910	0.0014	-1.1090	-6.8%	-6.8%
47	Li2O (wt%)	5.1131	5.2641	5.2690	-0.1509	-0.0049	-3.0%	-3.0%
47	MgO (wt%)	0.3718	0.3509	0.3920	0.0209	-0.0411	-5.1%	-10.5%
47	MnO (wt%)	1.8045	1.7574	1.8320	0.0471	-0.0746	-1.5%	-4.1%
47	Na2O (wt%)	12.3915	11.8148	12.1790	0.5767	-0.3642	1.7%	-3.0%
47	NiO (wt%)	0.6245	0.6203	0.6592	0.0042	-0.0389	-5.3%	-5.9%
47	P2O5 (wt%)	0.3655	0.3655	0.4686	0.0000	-0.1031	-22.0%	-22.0%
47	SiO2 (wt%)	48.1343	47.2145	47.6120	0.9197	-0.3975	1.1%	-0.8%
47	TiO2 (wt%)	0.0150	0.0143	0.0140	0.0007	0.0003	7.2%	2.0%
47	U3O8 (wt%)	3.6349	3.8280	3.7326	-0.1931	0.0954	-2.6%	2.6%
47	ZrO2 (wt%)	0.0358	0.0358	0.0448	0.0000	-0.0090	-20.1%	-20.1%
47	Sum of Oxides (wt%)	98.9595	97.4755	99.6846	1.4840	-2.2091	-0.7%	-2.4%
48	Al2O3 (wt%)	4.4687	4.4320	4.4250	0.0367	0.0070	1.0%	0.2%
48	B2O3 (wt%)	4.8299	4.7845	5.0150	0.0453	-0.2305	-3.7%	-4.6%
48	CaO (wt%)	1.6860	1.5541	1.6040	0.1320	-0.0499	5.1%	-3.1%
48	Cr2O3 (wt%)	0.1107	0.1082	0.1341	0.0026	-0.0259	-17.4%	-19.3%
48	Fe2O3 (wt%)	15.6195	15.5749	16.9740	0.0445	-1.3991	-8.0%	-8.2%
48	Li2O (wt%)	4.9086	5.0847	5.0750	-0.1761	0.0097	-3.3%	-3.1%
48	MgO (wt%)	0.4701	0.4400	0.4860	0.0301	-0.0460	-3.3%	-9.5%
48	MnO (wt%)	2.1143	2.0469	2.1520	0.0675	-0.1051	-1.8%	-4.9%
48	Na2O (wt%)	12.2904	11.7725	12.2870	0.5178	-0.5145	0.0%	-4.2%
48	NiO (wt%)	0.8930	0.8839	0.9605	0.0091	-0.0766	-7.0%	-8.0%
48	P2O5 (wt%)	0.3987	0.3987	0.5090	0.0000	-0.1103	-21.7%	-21.7%
48	SiO2 (wt%)	47.4390	46.6149	45.8270	0.8240	0.7879	3.5%	1.7%
48	TiO2 (wt%)	0.0100	0.0095	0.0152	0.0005	-0.0057	-34.2%	-37.6%
48	U3O8 (wt%)	4.0889	4.2986	4.1429	-0.2098	0.1557	-1.3%	3.8%
48	ZrO2 (wt%)	0.0469	0.0469	0.0486	0.0000	-0.0017	-3.4%	-3.4%
48	Sum of Oxides (wt%)	99.3746	98.0503	99.6553	1.3243	-1.6050	-0.3%	-1.8%
49	Al2O3 (wt%)	3.5286	3.5256	3.4660	0.0030	0.0596	1.8%	1.7%
49	B2O3 (wt%)	5.4175	5.3442	5.6120	0.0732	-0.2678	-3.5%	-4.8%
49	CaO (wt%)	1.2978	1.1761	1.2160	0.1216	-0.0399	6.7%	-3.3%
49	Cr2O3 (wt%)	0.0870	0.0873	0.1073	-0.0004	-0.0200	-19.0%	-18.6%
49	Fe2O3 (wt%)	11.9880	12.0124	12.5500	-0.0244	-0.5376	-4.5%	-4.3%
49	Li2O (wt%)	5.4630	5.6547	5.6600	-0.1917	-0.0053	-3.5%	-3.6%
49	MgO (wt%)	0.5434	0.5104	0.5460	0.0331	-0.0356	-0.5%	-6.5%
49	MnO (wt%)	2.9149	2.8370	2.9690	0.0779	-0.1320	-1.8%	-4.4%
49	Na2O (wt%)	12.2365	11.6904	12.2510	0.5461	-0.5606	-0.1%	-4.6%
49	NiO (wt%)	0.5917	0.5883	0.6124	0.0034	-0.0241	-3.4%	-3.9%
49	P2O5 (wt%)	0.3174	0.3174	0.4071	0.0000	-0.0897	-22.0%	-22.0%
49	SiO2 (wt%)	51.7711	50.7800	51.7040	0.9910	-0.9240	0.1%	-1.8%
49	TiO2 (wt%)	0.0056	0.0054	0.0121	0.0002	-0.0067	-53.5%	-55.5%
49	U3O8 (wt%)	2.5353	2.6802	2.5733	-0.1449	0.1069	-1.5%	4.2%
49	ZrO2 (wt%)	0.0230	0.0230	0.0389	0.0000	-0.0159	-41.0%	-41.0%
49	Sum of Oxides (wt%)	98.7207	97.2323	99.7251	1.4883	-2.4928	-1.0%	-2.7%

Table E.5: Average Measured and Bias-Corrected Chemical Compositions Versus Targeted Compositions by Oxide by Glass Number (0 – Batch 1 and 100 – U std)
(continued)

Glass #	Oxide	Measured (wt%)	Measured Bias-Corrected (wt%)	Targeted (wt%)	Diff of Measured	Diff of Meas BC	% Diff of Measured	% Diff of Meas BC
50	Al2O3 (wt%)	3.2358	3.1978	3.1150	0.0379	0.0828	3.9%	2.7%
50	B2O3 (wt%)	4.9989	4.9517	5.2140	0.0472	-0.2623	-4.1%	-5.0%
50	CaO (wt%)	0.7034	0.6461	0.6130	0.0574	0.0331	14.8%	5.4%
50	Cr2O3 (wt%)	0.1144	0.1080	0.1260	0.0063	-0.0180	-9.2%	-14.3%
50	Fe2O3 (wt%)	11.3125	11.2544	12.0400	0.0581	-0.7856	-6.0%	-6.5%
50	Li2O (wt%)	5.0378	5.2800	5.2700	-0.2423	0.0100	-4.4%	-4.2%
50	MgO (wt%)	0.9932	0.9342	1.0130	0.0590	-0.0788	-2.0%	-7.8%
50	MnO (wt%)	3.8349	3.7147	3.9730	0.1201	-0.2583	-3.5%	-6.5%
50	Na2O (wt%)	12.5263	11.9745	12.2890	0.5517	-0.3145	1.9%	-2.6%
50	NiO (wt%)	2.7550	2.7242	2.9380	0.0308	-0.2138	-6.2%	-7.3%
50	P2O5 (wt%)	0.3781	0.3781	0.4782	0.0000	-0.1001	-20.9%	-20.9%
50	SiO2 (wt%)	48.0808	47.2423	47.1340	0.8385	0.1083	2.0%	0.2%
50	TiO2 (wt%)	0.0117	0.0110	0.0143	0.0006	-0.0033	-18.3%	-22.9%
50	U3O8 (wt%)	5.3536	5.6062	5.4138	-0.2527	0.1924	-1.1%	3.6%
50	ZrO2 (wt%)	0.0358	0.0358	0.0457	0.0000	-0.0099	-21.7%	-21.7%
50	Sum of Oxides (wt%)	99.3720	98.0592	99.6770	1.3128	-1.6178	-0.3%	-1.9%
51	Al2O3 (wt%)	3.2688	3.2305	3.1770	0.0384	0.0535	2.9%	1.7%
51	B2O3 (wt%)	5.5946	5.5340	5.8110	0.0606	-0.2770	-3.7%	-4.8%
51	CaO (wt%)	1.2093	1.1106	1.1140	0.0987	-0.0034	8.6%	-0.3%
51	Cr2O3 (wt%)	0.0862	0.0815	0.0983	0.0048	-0.0168	-12.3%	-17.1%
51	Fe2O3 (wt%)	10.8514	10.7955	11.5040	0.0559	-0.7085	-5.7%	-6.2%
51	Li2O (wt%)	5.5545	5.8638	5.8550	-0.3093	0.0088	-5.1%	-5.0%
51	MgO (wt%)	0.4908	0.4617	0.5000	0.0291	-0.0383	-1.8%	-7.7%
51	MnO (wt%)	2.6405	2.5579	2.7210	0.0826	-0.1631	-3.0%	-6.0%
51	Na2O (wt%)	12.1286	11.5940	12.2300	0.5346	-0.6360	-0.8%	-5.2%
51	NiO (wt%)	0.5469	0.5408	0.5613	0.0061	-0.0205	-2.6%	-3.7%
51	P2O5 (wt%)	0.2922	0.2922	0.3732	0.0000	-0.0810	-21.7%	-21.7%
51	SiO2 (wt%)	53.1616	52.4541	53.3960	0.7075	-0.9419	-0.4%	-1.8%
51	TiO2 (wt%)	0.0098	0.0092	0.0111	0.0006	-0.0019	-11.7%	-16.8%
51	U3O8 (wt%)	2.3260	2.4357	2.3589	-0.1098	0.0768	-1.4%	3.3%
51	ZrO2 (wt%)	0.0304	0.0304	0.0356	0.0000	-0.0052	-14.6%	-14.6%
51	Sum of Oxides (wt%)	98.1915	96.9918	99.7464	1.1997	-2.7546	-1.6%	-3.1%
52	Al2O3 (wt%)	3.2452	3.2185	3.1300	0.0268	0.0885	3.7%	2.8%
52	B2O3 (wt%)	5.8039	5.7177	6.0100	0.0862	-0.2923	-3.4%	-4.9%
52	CaO (wt%)	1.2030	1.1088	1.1220	0.0942	-0.0132	7.2%	-1.2%
52	Cr2O3 (wt%)	0.0734	0.0717	0.0882	0.0017	-0.0165	-16.7%	-18.7%
52	Fe2O3 (wt%)	10.8550	10.8242	11.5650	0.0308	-0.7408	-6.1%	-6.4%
52	Li2O (wt%)	5.8774	6.0409	6.0490	-0.1634	-0.0081	-2.8%	-3.0%
52	MgO (wt%)	0.2707	0.2534	0.2800	0.0173	-0.0266	-3.3%	-9.5%
52	MnO (wt%)	1.3170	1.2749	1.3090	0.0421	-0.0341	0.6%	-2.6%
52	Na2O (wt%)	12.2264	11.7116	12.1280	0.5148	-0.4164	0.8%	-3.4%
52	NiO (wt%)	0.4578	0.4531	0.4708	0.0047	-0.0177	-2.8%	-3.8%
52	P2O5 (wt%)	0.2647	0.2647	0.3347	0.0000	-0.0700	-20.9%	-20.9%
52	SiO2 (wt%)	54.3917	53.5739	54.5800	0.8178	-1.0061	-0.3%	-1.8%
52	TiO2 (wt%)	0.0065	0.0061	0.0100	0.0004	-0.0039	-35.4%	-38.9%
52	U3O8 (wt%)	2.6444	2.7800	2.6662	-0.1356	0.1138	-0.8%	4.3%
52	ZrO2 (wt%)	0.0267	0.0267	0.0320	0.0000	-0.0053	-16.6%	-16.6%
52	Sum of Oxides (wt%)	98.6636	97.3259	99.7749	1.3377	-2.4490	-1.1%	-2.6%

Table E.5: Average Measured and Bias-Corrected Chemical Compositions Versus Targeted Compositions by Oxide by Glass Number (0 – Batch 1 and 100 – U std)
(continued)

Glass #	Oxide	Measured (wt%)	Measured Bias-Corrected (wt%)	Targeted (wt%)	Diff of Measured	Diff of Meas BC	% Diff of Measured	% Diff of Meas BC
53	Al2O3 (wt%)	4.5206	4.5004	4.6220	0.0202	-0.1216	-2.2%	-2.6%
53	B2O3 (wt%)	4.6045	4.5361	4.8160	0.0684	-0.2799	-4.4%	-5.8%
53	CaO (wt%)	1.6511	1.4913	1.6210	0.1598	-0.1297	1.9%	-8.0%
53	Cr2O3 (wt%)	0.1162	0.1127	0.1430	0.0035	-0.0303	-18.7%	-21.2%
53	Fe2O3 (wt%)	15.6552	15.6519	16.7330	0.0033	-1.0811	-6.4%	-6.5%
53	Li2O (wt%)	4.6234	4.8734	4.8800	-0.2501	-0.0066	-5.3%	-5.4%
53	MgO (wt%)	0.7001	0.6609	0.7280	0.0393	-0.0671	-3.8%	-9.2%
53	MnO (wt%)	3.7090	3.6123	3.9580	0.0967	-0.3457	-6.3%	-8.7%
53	Na2O (wt%)	12.2466	11.6773	12.3350	0.5693	-0.6577	-0.7%	-5.3%
53	NiO (wt%)	0.7288	0.7239	0.8165	0.0049	-0.0926	-10.7%	-11.3%
53	P2O5 (wt%)	0.4136	0.4136	0.5428	0.0000	-0.1292	-23.8%	-23.8%
53	SiO2 (wt%)	45.7275	45.0398	44.9390	0.6877	0.1008	1.8%	0.2%
53	TiO2 (wt%)	0.0113	0.0107	0.0162	0.0006	-0.0055	-30.5%	-33.9%
53	U3O8 (wt%)	3.2870	3.4612	3.4311	-0.1741	0.0301	-4.2%	0.9%
53	ZrO2 (wt%)	0.0419	0.0419	0.0518	0.0000	-0.0099	-19.2%	-19.2%
53	Sum of Oxides (wt%)	98.0367	96.8074	99.6334	1.2293	-2.8260	-1.6%	-3.1%
54	Al2O3 (wt%)	3.8168	3.8135	3.7560	0.0033	0.0575	1.6%	1.5%
54	B2O3 (wt%)	5.4014	5.3504	5.6120	0.0510	-0.2616	-3.8%	-4.7%
54	CaO (wt%)	1.4303	1.2968	1.3460	0.1335	-0.0492	6.3%	-3.7%
54	Cr2O3 (wt%)	0.0859	0.0862	0.1058	-0.0004	-0.0196	-18.8%	-18.5%
54	Fe2O3 (wt%)	12.9459	12.9715	13.8780	-0.0256	-0.9065	-6.7%	-6.5%
54	Li2O (wt%)	5.4845	5.6698	5.6590	-0.1853	0.0108	-3.1%	-2.9%
54	MgO (wt%)	0.3150	0.2959	0.3360	0.0191	-0.0401	-6.2%	-11.9%
54	MnO (wt%)	1.5753	1.5333	1.5700	0.0420	-0.0367	0.3%	-2.3%
54	Na2O (wt%)	12.1758	11.6320	12.1530	0.5438	-0.5210	0.2%	-4.3%
54	NiO (wt%)	0.5491	0.5459	0.5650	0.0032	-0.0191	-2.8%	-3.4%
54	P2O5 (wt%)	0.3197	0.3197	0.4016	0.0000	-0.0819	-20.4%	-20.4%
54	SiO2 (wt%)	51.6106	50.7108	51.0960	0.8998	-0.3852	1.0%	-0.8%
54	TiO2 (wt%)	0.0100	0.0096	0.0120	0.0004	-0.0024	-16.6%	-20.3%
54	U3O8 (wt%)	3.1514	3.3316	3.1994	-0.1802	0.1322	-1.5%	4.1%
54	ZrO2 (wt%)	0.0247	0.0247	0.0384	0.0000	-0.0137	-35.8%	-35.8%
54	Sum of Oxides (wt%)	98.8964	97.5916	99.7282	1.3047	-2.1366	-0.8%	-2.3%
55	Al2O3 (wt%)	4.0577	4.0386	4.0440	0.0191	-0.0054	0.3%	-0.1%
55	B2O3 (wt%)	4.9264	4.8598	5.2140	0.0666	-0.3542	-5.5%	-6.8%
55	CaO (wt%)	1.4622	1.3527	1.4180	0.1095	-0.0653	3.1%	-4.6%
55	Cr2O3 (wt%)	0.1049	0.1061	0.1251	-0.0013	-0.0190	-16.2%	-15.2%
55	Fe2O3 (wt%)	14.0575	14.0497	14.6420	0.0078	-0.5923	-4.0%	-4.0%
55	Li2O (wt%)	5.0109	5.2651	5.2700	-0.2542	-0.0049	-4.9%	-5.0%
55	MgO (wt%)	0.6309	0.5876	0.6370	0.0433	-0.0494	-1.0%	-7.8%
55	MnO (wt%)	3.4281	3.3167	3.4630	0.1115	-0.1463	-1.0%	-4.2%
55	Na2O (wt%)	12.2668	11.7734	12.2930	0.4934	-0.5196	-0.2%	-4.2%
55	NiO (wt%)	0.6891	0.6827	0.7144	0.0063	-0.0317	-3.5%	-4.4%
55	P2O5 (wt%)	0.3712	0.3712	0.4750	0.0000	-0.1038	-21.9%	-21.9%
55	SiO2 (wt%)	47.8668	46.9544	48.3220	0.9125	-1.3676	-0.9%	-2.8%
55	TiO2 (wt%)	0.0067	0.0064	0.0142	0.0003	-0.0078	-53.0%	-55.2%
55	U3O8 (wt%)	2.9008	3.0615	3.0022	-0.1607	0.0593	-3.4%	2.0%
55	ZrO2 (wt%)	0.0284	0.0284	0.0454	0.0000	-0.0170	-37.5%	-37.5%
55	Sum of Oxides (wt%)	97.8084	96.4541	99.6793	1.3543	-3.2252	-1.9%	-3.5%

Table E.5: Average Measured and Bias-Corrected Chemical Compositions Versus Targeted Compositions by Oxide by Glass Number (0 – Batch 1 and 100 – U std)
(continued)

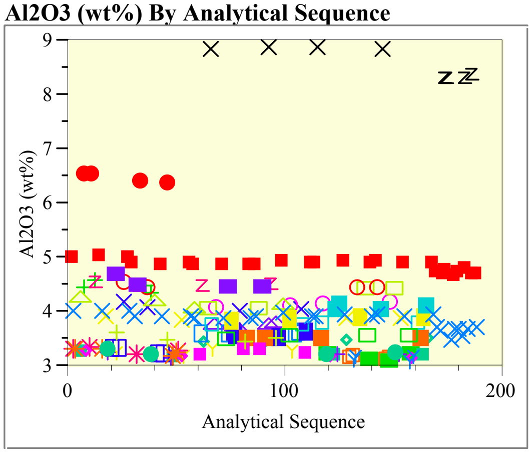
Glass #	Oxide	Measured (wt%)	Measured Bias-Corrected (wt%)	Targeted (wt%)	Diff of Measured	Diff of Meas BC	% Diff of Measured	% Diff of Meas BC
56	Al2O3 (wt%)	3.2405	3.2503	3.2450	-0.0098	0.0053	-0.1%	0.2%
56	B2O3 (wt%)	5.6751	5.5984	5.8110	0.0767	-0.2126	-2.3%	-3.7%
56	CaO (wt%)	1.2320	1.0935	1.1760	0.1385	-0.0825	4.8%	-7.0%
56	Cr2O3 (wt%)	0.0753	0.0750	0.0983	0.0003	-0.0233	-23.4%	-23.7%
56	Fe2O3 (wt%)	11.8558	11.9118	12.4480	-0.0561	-0.5362	-4.8%	-4.3%
56	Li2O (wt%)	5.7644	5.8495	5.8550	-0.0851	-0.0055	-1.5%	-1.6%
56	MgO (wt%)	0.3337	0.3161	0.3560	0.0176	-0.0399	-6.3%	-11.2%
56	MnO (wt%)	1.5688	1.5363	1.5780	0.0325	-0.0417	-0.6%	-2.6%
56	Na2O (wt%)	12.2634	11.6616	12.2100	0.6018	-0.5484	0.4%	-4.5%
56	NiO (wt%)	0.6677	0.6663	0.7044	0.0015	-0.0381	-5.2%	-5.4%
56	P2O5 (wt%)	0.2813	0.2813	0.3733	0.0000	-0.0920	-24.7%	-24.7%
56	SiO2 (wt%)	53.1081	52.0917	52.8070	1.0164	-0.7153	0.6%	-1.4%
56	TiO2 (wt%)	0.0100	0.0096	0.0111	0.0004	-0.0015	-9.8%	-13.6%
56	U3O8 (wt%)	2.8772	3.0471	3.0381	-0.1698	0.0090	-5.3%	0.3%
56	ZrO2 (wt%)	0.0216	0.0216	0.0357	0.0000	-0.0141	-39.5%	-39.5%
56	Sum of Oxides (wt%)	98.9749	97.4101	99.7469	1.5649	-2.3368	-0.8%	-2.4%
57	Al2O3 (wt%)	3.5192	3.5035	3.5400	0.0156	-0.0365	-0.6%	-1.0%
57	B2O3 (wt%)	5.4336	5.3823	5.6120	0.0512	-0.2297	-3.2%	-4.1%
57	CaO (wt%)	1.3327	1.2035	1.2830	0.1292	-0.0795	3.9%	-6.2%
57	Cr2O3 (wt%)	0.0884	0.0857	0.1073	0.0027	-0.0216	-17.6%	-20.1%
57	Fe2O3 (wt%)	12.7065	12.7021	13.5790	0.0043	-0.8769	-6.4%	-6.5%
57	Li2O (wt%)	5.4630	5.6708	5.6600	-0.2078	0.0108	-3.5%	-3.3%
57	MgO (wt%)	0.3660	0.3455	0.3890	0.0205	-0.0435	-5.9%	-11.2%
57	MnO (wt%)	1.6818	1.6380	1.7220	0.0438	-0.0840	-2.3%	-4.9%
57	Na2O (wt%)	12.1084	11.5445	12.2300	0.5639	-0.6855	-1.0%	-5.6%
57	NiO (wt%)	0.7295	0.7246	0.7684	0.0049	-0.0438	-5.1%	-5.7%
57	P2O5 (wt%)	0.3099	0.3099	0.4072	0.0000	-0.0973	-23.9%	-23.9%
57	SiO2 (wt%)	52.6803	51.7616	51.0620	0.9186	0.6996	3.2%	1.4%
57	TiO2 (wt%)	0.0113	0.0107	0.0121	0.0006	-0.0014	-7.0%	-11.5%
57	U3O8 (wt%)	3.2693	3.4426	3.3143	-0.1733	0.1283	-1.4%	3.9%
57	ZrO2 (wt%)	0.0287	0.0287	0.0389	0.0000	-0.0102	-26.2%	-26.2%
57	Sum of Oxides (wt%)	99.7285	98.3542	99.7252	1.3743	-1.3710	0.0%	-1.6%
100	Al2O3 (wt%)	3.7125	3.7867	4.1000	-0.0743	-0.3133	-9.5%	-7.6%
100	B2O3 (wt%)	8.6640	8.5442	9.2090	0.1199	-0.6648	-5.5%	-6.8%
100	CaO (wt%)	1.2963	1.2306	1.3010	0.0656	-0.0704	-0.4%	-5.4%
100	Cr2O3 (wt%)	0.2473	0.2278	0.0000	0.0195	0.2278		
100	Fe2O3 (wt%)	12.4551	12.5617	13.1960	-0.1067	-0.6343	-5.6%	-4.8%
100	Li2O (wt%)	2.8733	3.0779	3.0570	-0.2046	0.0209	-9.2%	-8.6%
100	MgO (wt%)	1.1159	1.0915	1.2100	0.0244	-0.1185	-7.8%	-9.8%
100	MnO (wt%)	2.5832	2.6137	2.8920	-0.0305	-0.2783	-10.7%	-9.6%
100	Na2O (wt%)	11.1915	10.8158	11.7950	0.3757	-0.9792	-5.1%	-8.3%
100	NiO (wt%)	0.9621	0.9848	1.1200	-0.0227	-0.1352	-14.1%	-12.1%
100	P2O5 (wt%)	0.0195	0.0195	0.0000	0.0000	0.0195		
100	SiO2 (wt%)	48.4774	47.7425	45.3530	0.7349	2.3895	6.9%	5.3%
100	TiO2 (wt%)	0.9112	0.9009	1.0490	0.0104	-0.1481	-13.1%	-14.1%
100	U3O8 (wt%)	2.2262	2.4001	2.4060	-0.1739	-0.0059	-7.5%	-0.2%
100	ZrO2 (wt%)	0.0090	0.0090	0.0000	0.0000	0.0090		
100	Sum of Oxides (wt%)	96.7444	96.0066	96.6880	0.7378	-0.6814	0.0%	-1.0%

Table E.6: Average Measured and Bias-Corrected Chemical Compositions Versus the As-Batched, Targeted Compositions by Oxide of RC-31

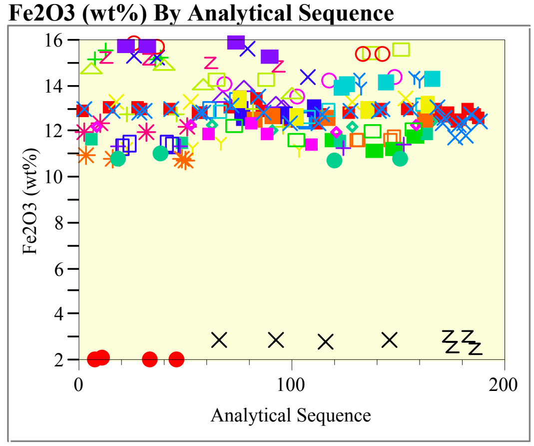
Glass #	Oxide	Measured (wt%)	Measured Bias-Corrected (wt%)	Targeted (wt%)	Diff of Measured	Diff of Meas BC	% Diff of Measured	% Diff of Meas BC
31	Al2O3 (wt%)	8.8381	8.8307	9.0300	0.0074	-0.1993	-2.1%	-2.2%
31	B2O3 (wt%)	5.3933	5.3570	5.4980	0.0363	-0.1410	-1.9%	-2.6%
31	CaO (wt%)	0.5544	0.5014	0.4360	0.0531	0.0654	27.2%	15.0%
31	Cr2O3 (wt%)	0.0555	0.0557	0.0670	-0.0002	-0.0113	-17.1%	-16.8%
31	Fe2O3 (wt%)	2.7808	2.7871	2.7800	-0.0063	0.0071	0.0%	0.3%
31	Li2O (wt%)	5.7159	5.6645	5.8380	0.0515	-0.1735	-2.1%	-1.7%
31	MgO (wt%)	1.1814	1.1097	1.1800	0.0717	-0.0703	0.1%	-6.0%
31	MnO (wt%)	2.0659	2.0109	2.0400	0.0550	-0.0291	1.3%	-1.4%
31	Na2O (wt%)	13.6350	13.0266	13.2000	0.6084	-0.1734	3.3%	-1.3%
31	NiO (wt%)	0.2176	0.2164	0.2200	0.0012	-0.0036	-1.1%	-1.7%
31	P2O5 (wt%)	0.2142	0.2142	0.2560	0.0000	-0.0418	-16.3%	-16.3%
31	SiO2 (wt%)	57.2263	56.5639	58.0100	0.6624	-1.4461	-1.4%	-2.5%
31	TiO2 (wt%)	0.0044	0.0042	0.0070	0.0002	-0.0028	-37.5%	-40.2%
31	U3O8 (wt%)	0.4251	0.4494	0.4200	-0.0243	0.0294	1.2%	7.0%
31	ZrO2 (wt%)	0.8199	0.8199	0.8440	0.0000	-0.0241	-2.9%	-2.9%
31	Sum of Oxides (wt%)	99.1280	97.6116	99.8260	1.5164	-2.2144	-0.7%	-2.1%

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

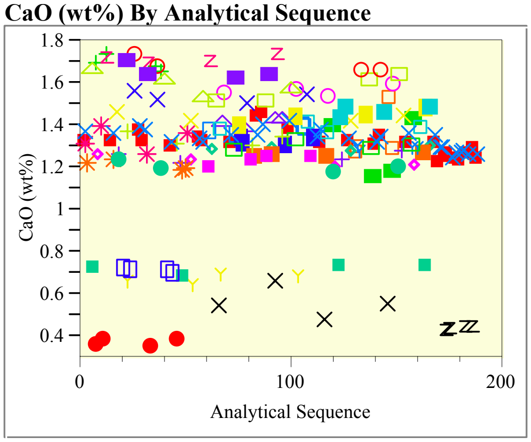
Al2O3 (wt%) By Analytical Sequence



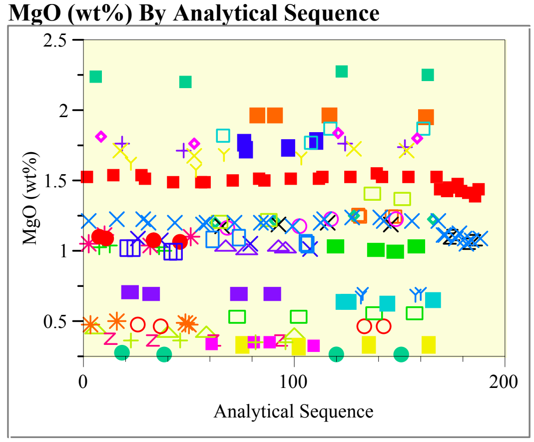
Fe2O3 (wt%) By Analytical Sequence



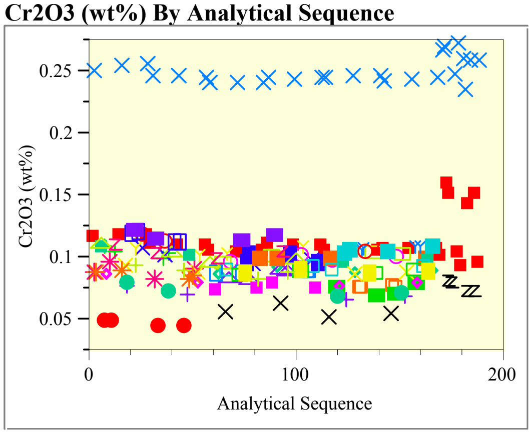
CaO (wt%) By Analytical Sequence



MgO (wt%) By Analytical Sequence



Cr2O3 (wt%) By Analytical Sequence



MnO (wt%) By Analytical Sequence

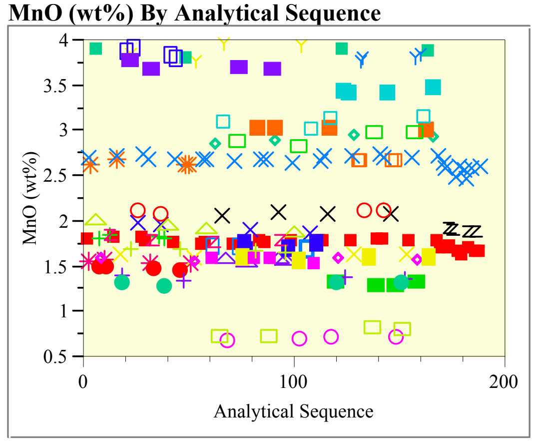
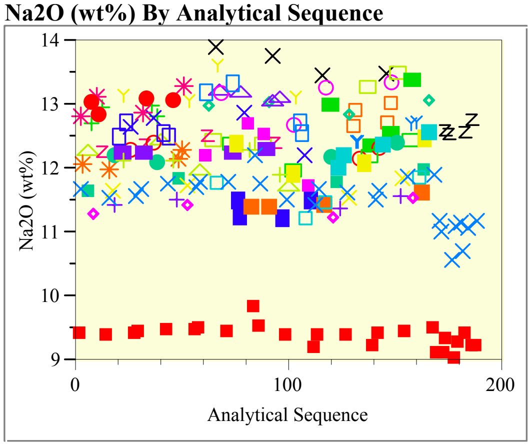
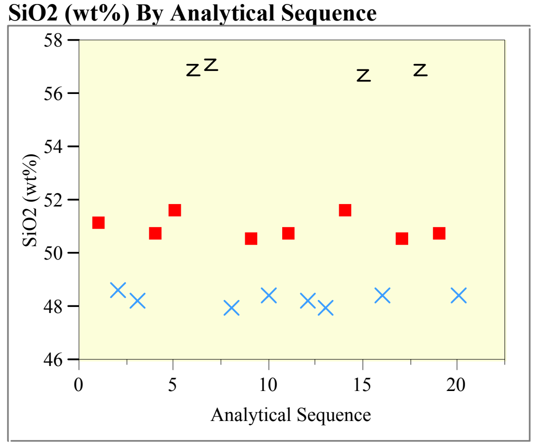


Exhibit E.1: SRTC-ML Measurements for Samples Prepared Using the LM Method *(continued)*

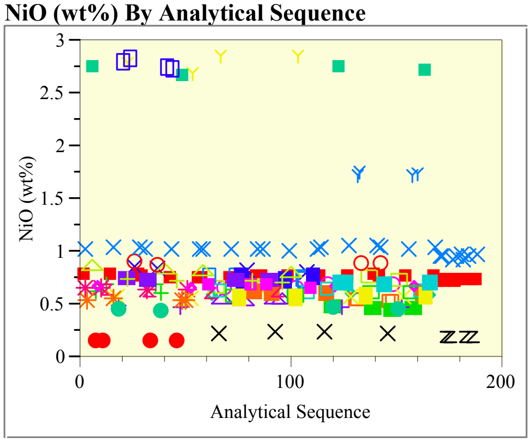
Na2O (wt%) By Analytical Sequence



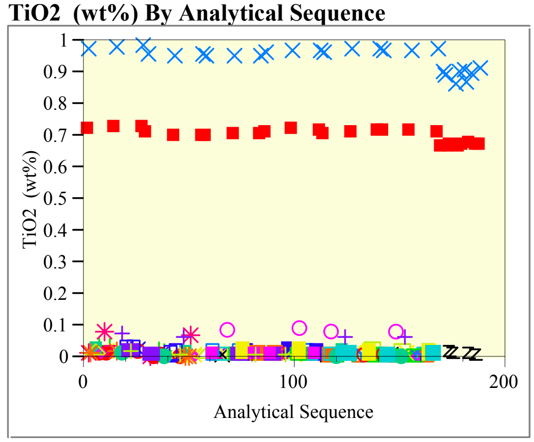
SiO2 (wt%) By Analytical Sequence



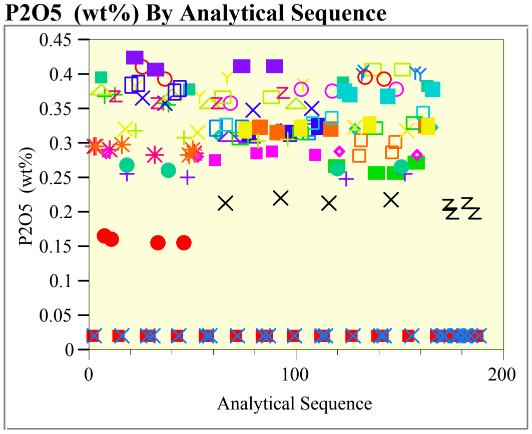
NiO (wt%) By Analytical Sequence



TiO2 (wt%) By Analytical Sequence



P2O5 (wt%) By Analytical Sequence



U3O8 (wt%) By Analytical Sequence

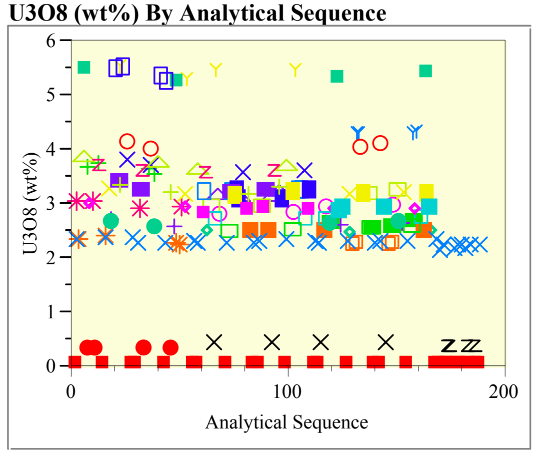


Exhibit E.1: SRTC-ML Measurements for Samples Prepared Using the LM Method
(continued)

ZrO2 (wt%) By Analytical Sequence

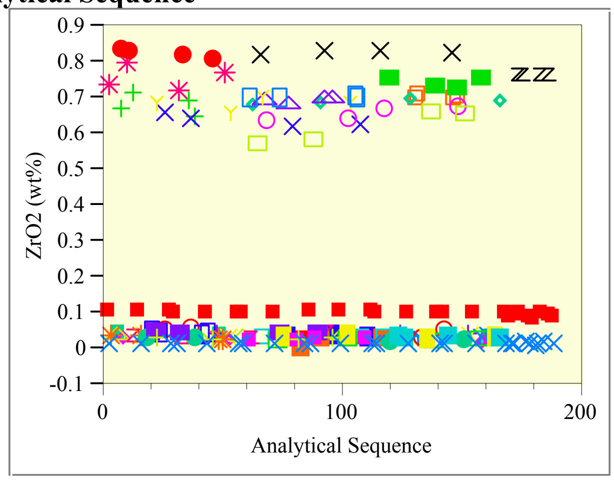
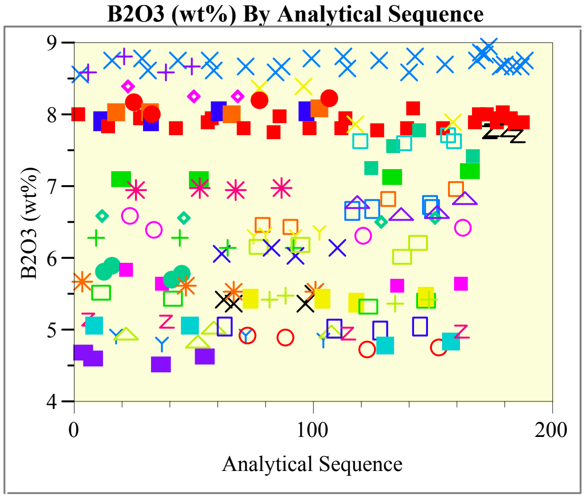
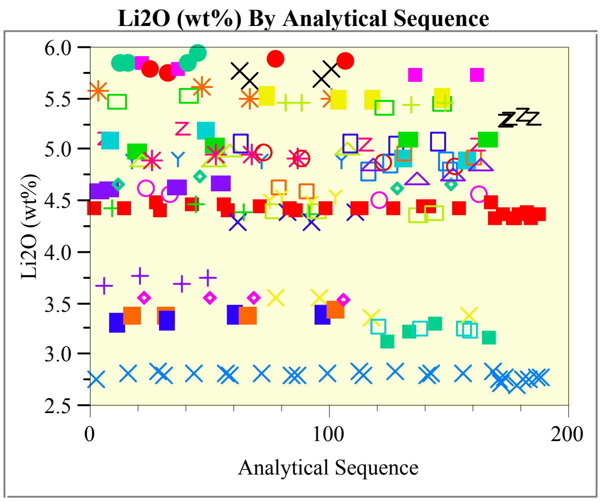


Exhibit E.2: SRTC-ML Measurements for Samples Prepared Using the SP Fusion





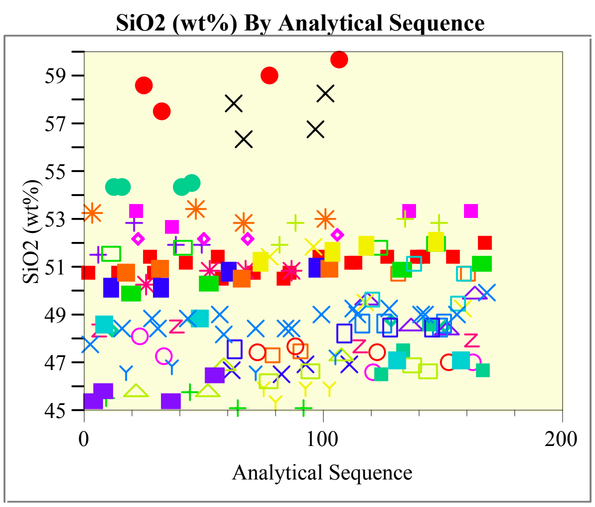
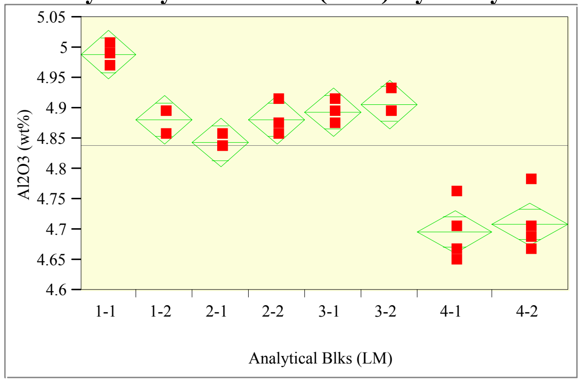


Exhibit E.3: SRTC-ML Measurements by Analytical Block for Samples of the Standard Glasses Prepared Using the LM Method

Batch 1 – reference value 4.8777 wt%

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



Oneway Anova

Summary of Fit

Rsquare	0.92536
Adj Rsquare	0.896333
Root Mean Square Error	0.033451
Mean of Response	4.838573
Observations (or Sum Wgts)	26

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	7	0.24971103	0.035673	31.8795	<.0001
Error	18	0.02014194	0.001119		
C. Total	25	0.26985297			

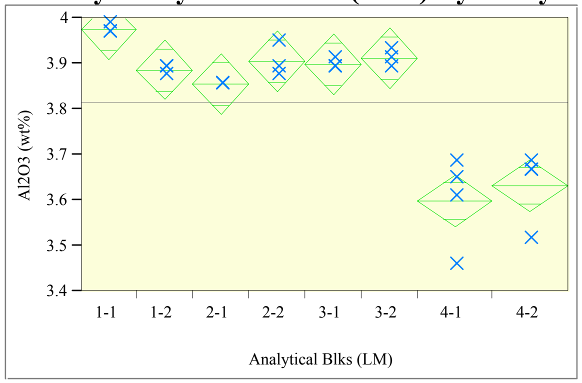
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	4.98828	0.01931	4.9477	5.0289
1-2	3	4.88121	0.01931	4.8406	4.9218
2-1	3	4.84342	0.01931	4.8028	4.8840
2-2	3	4.88121	0.01931	4.8406	4.9218
3-1	3	4.89381	0.01931	4.8532	4.9344
3-2	3	4.90640	0.01931	4.8658	4.9470
4-1	4	4.69541	0.01673	4.6603	4.7305
4-2	4	4.70958	0.01673	4.6744	4.7447

Std Error uses a pooled estimate of error variance

U std – reference value 4.1 wt%

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



Oneway Anova

Summary of Fit

Rsquare	0.902033
Adj Rsquare	0.863934
Root Mean Square Error	0.054257
Mean of Response	3.816063
Observations (or Sum Wgts)	26

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	7	0.48788525	0.069698	23.6764	<.0001
Error	18	0.05298787	0.002944		
C. Total	25	0.54087312			

Means for Oneway Anova

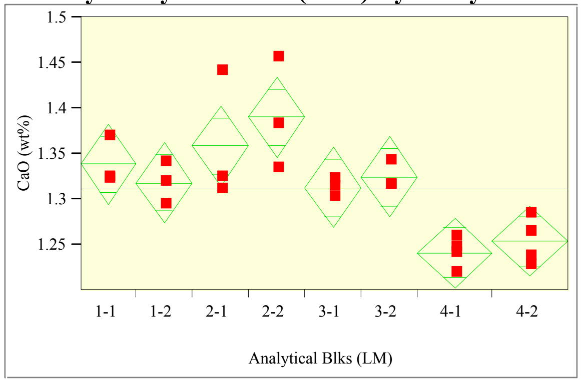
Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	3.97425	0.03133	3.9084	4.0401
1-2	3	3.88607	0.03133	3.8203	3.9519
2-1	3	3.85458	0.03133	3.7888	3.9204
2-2	3	3.90497	0.03133	3.8392	3.9708
3-1	3	3.89867	0.03133	3.8329	3.9645
3-2	3	3.91127	0.03133	3.8455	3.9771
4-1	4	3.59950	0.02713	3.5425	3.6565
4-2	4	3.63256	0.02713	3.5756	3.6896

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 – reference value 1.22 wt%

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



Oneway Anova

Summary of Fit

Rsquare	0.718711
Adj Rsquare	0.609321
Root Mean Square Error	0.036465
Mean of Response	1.311911
Observations (or Sum Wgts)	26

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	7	0.06115405	0.008736	6.5702	0.0006
Error	18	0.02393444	0.001330		
C. Total	25	0.08508849			

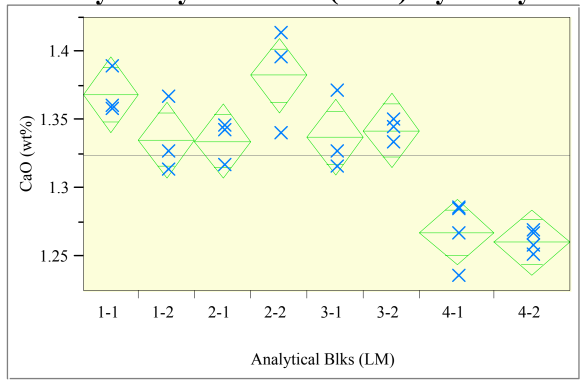
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	1.33857	0.02105	1.2943	1.3828
1-2	3	1.31805	0.02105	1.2738	1.3623
2-1	3	1.35862	0.02105	1.3144	1.4029
2-2	3	1.39034	0.02105	1.3461	1.4346
3-1	3	1.31292	0.02105	1.2687	1.3571
3-2	3	1.32458	0.02105	1.2803	1.3688
4-1	4	1.24144	0.01823	1.2031	1.2797
4-2	4	1.25368	0.01823	1.2154	1.2920

Std Error uses a pooled estimate of error variance

U std – reference value 1.301 wt%

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



Oneway Anova

Summary of Fit

Rsquare	0.835343
Adj Rsquare	0.771309
Root Mean Square Error	0.022739
Mean of Response	1.32402
Observations (or Sum Wgts)	26

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	7	0.04721913	0.006746	13.0454	<.0001
Error	18	0.00930752	0.000517		
C. Total	25	0.05652665			

Means for Oneway Anova

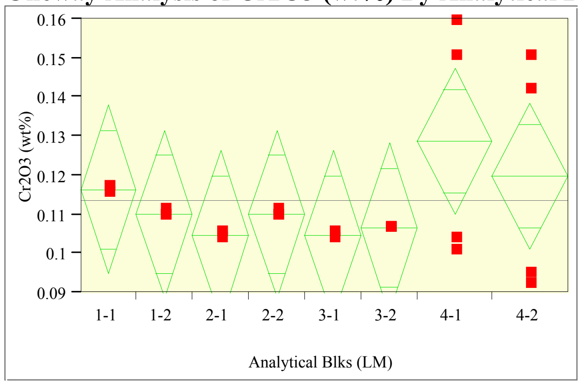
Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	1.36888	0.01313	1.3413	1.3965
1-2	3	1.33577	0.01313	1.3082	1.3634
2-1	3	1.33484	0.01313	1.3073	1.3624
2-2	3	1.38288	0.01313	1.3553	1.4105
3-1	3	1.33764	0.01313	1.3101	1.3652
3-2	3	1.34277	0.01313	1.3152	1.3703
4-1	4	1.26803	0.01137	1.2441	1.2919
4-2	4	1.26103	0.01137	1.2371	1.2849

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 – reference value 0.107 wt%

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



Oneway Anova

Summary of Fit

Rsquare	0.239121
Adj Rsquare	-0.05678
Root Mean Square Error	0.017685
Mean of Response	0.113555
Observations (or Sum Wgts)	26

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	7	0.00176927	0.000253	0.8081	0.5918
Error	18	0.00562980	0.000313		
C. Total	25	0.00739907			

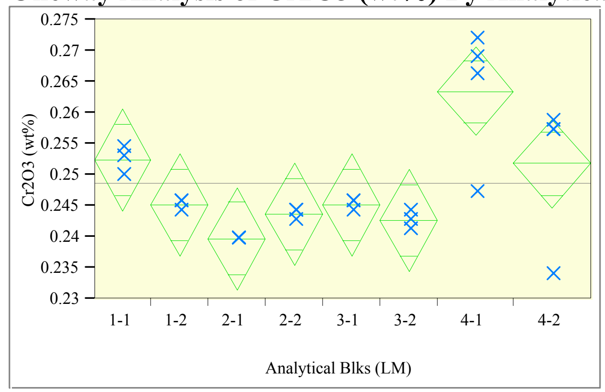
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.116441	0.01021	0.09499	0.13789
1-2	3	0.110107	0.01021	0.08866	0.13156
2-1	3	0.104748	0.01021	0.08330	0.12620
2-2	3	0.110107	0.01021	0.08866	0.13156
3-1	3	0.104748	0.01021	0.08330	0.12620
3-2	3	0.106697	0.01021	0.08525	0.12815
4-1	4	0.128621	0.00884	0.11004	0.14720
4-2	4	0.119851	0.00884	0.10127	0.13843

Std Error uses a pooled estimate of error variance

U std – reference value no defined

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



Oneway Anova

Summary of Fit

Rsquare	0.638889
Adj Rsquare	0.498457
Root Mean Square Error	0.00677
Mean of Response	0.248697
Observations (or Sum Wgts)	26

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	7	0.00145954	0.000209	4.5495	0.0045
Error	18	0.00082496	0.000046		
C. Total	25	0.00228450			

Means for Oneway Anova

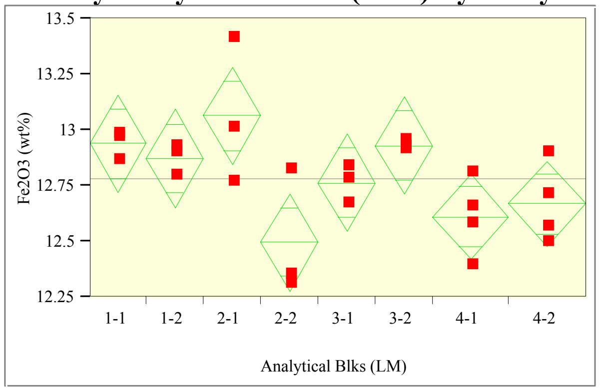
Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.252370	0.00391	0.24416	0.26058
1-2	3	0.245062	0.00391	0.23685	0.25327
2-1	3	0.239702	0.00391	0.23149	0.24791
2-2	3	0.243600	0.00391	0.23539	0.25181
3-1	3	0.245062	0.00391	0.23685	0.25327
3-2	3	0.242626	0.00391	0.23441	0.25084
4-1	4	0.263453	0.00338	0.25634	0.27056
4-2	4	0.251761	0.00338	0.24465	0.25887

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 – reference value 12.839 wt%

Oneway Analysis of Fe2O3 (wt%) By Analytical Blks (LM)



Oneway Anova

Summary of Fit

Rsquare	0.581073
Adj Rsquare	0.418157
Root Mean Square Error	0.180991
Mean of Response	12.78042
Observations (or Sum Wgts)	26

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	7	0.8178579	0.116837	3.5667	0.0139
Error	18	0.5896380	0.032758		
C. Total	25	1.4074959			

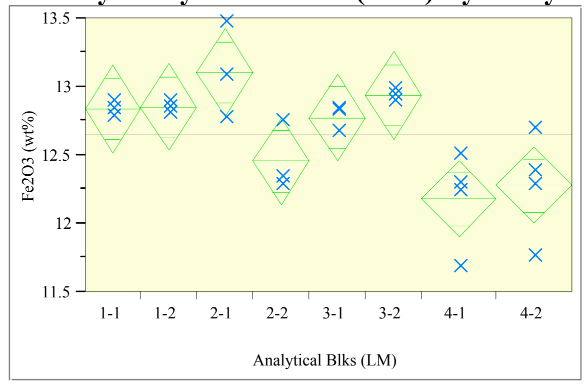
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	12.9388	0.10450	12.719	13.158
1-2	3	12.8721	0.10450	12.653	13.092
2-1	3	13.0627	0.10450	12.843	13.282
2-2	3	12.4956	0.10450	12.276	12.715
3-1	3	12.7625	0.10450	12.543	12.982
3-2	3	12.9293	0.10450	12.710	13.149
4-1	4	12.6100	0.09050	12.420	12.800
4-2	4	12.6671	0.09050	12.477	12.857

Std Error uses a pooled estimate of error variance

U std – reference value 13.196 wt%

Oneway Analysis of Fe2O3 (wt%) By Analytical Blks (LM)



Oneway Anova

Summary of Fit

Rsquare	0.685452
Adj Rsquare	0.563127
Root Mean Square Error	0.261678
Mean of Response	12.6446
Observations (or Sum Wgts)	26

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	7	2.6859421	0.383706	5.6036	0.0015
Error	18	1.2325574	0.068475		
C. Total	25	3.9184994			

Means for Oneway Anova

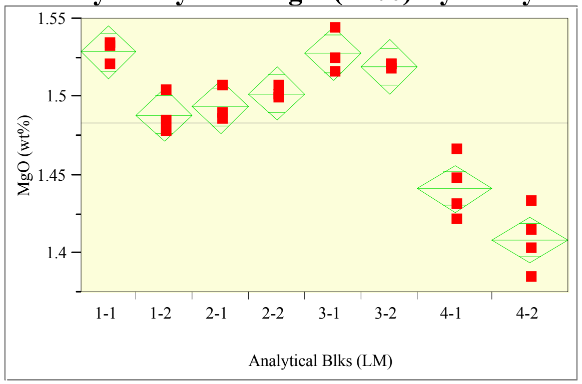
Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	12.8387	0.15108	12.521	13.156
1-2	3	12.8530	0.15108	12.536	13.170
2-1	3	13.1056	0.15108	12.788	13.423
2-2	3	12.4575	0.15108	12.140	12.775
3-1	3	12.7768	0.15108	12.459	13.094
3-2	3	12.9388	0.15108	12.621	13.256
4-1	4	12.1810	0.13084	11.906	12.456
4-2	4	12.2811	0.13084	12.006	12.556

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 – reference value 1.419 wt%

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



Oneway Anova

Summary of Fit

Rsquare	0.928693
Adj Rsquare	0.900963
Root Mean Square Error	0.014144
Mean of Response	1.483872
Observations (or Sum Wgts)	26

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	7	0.04689775	0.006700	33.4901	<.0001
Error	18	0.00360089	0.000200		
C. Total	25	0.05049864			

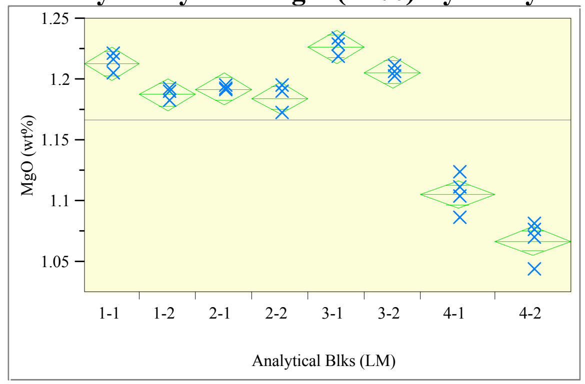
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	1.52877	0.00817	1.5116	1.5459
1-2	3	1.48842	0.00817	1.4713	1.5056
2-1	3	1.49395	0.00817	1.4768	1.5111
2-2	3	1.50224	0.00817	1.4851	1.5194
3-1	3	1.52766	0.00817	1.5105	1.5448
3-2	3	1.51937	0.00817	1.5022	1.5365
4-1	4	1.44130	0.00707	1.4264	1.4562
4-2	4	1.40856	0.00707	1.3937	1.4234

Std Error uses a pooled estimate of error variance

U std – reference value 1.21 wt%

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



Oneway Anova

Summary of Fit

Rsquare	0.973721
Adj Rsquare	0.963501
Root Mean Square Error	0.011
Mean of Response	1.166346
Observations (or Sum Wgts)	26

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	7	0.08069782	0.011528	95.2792	<.0001
Error	18	0.00217790	0.000121		
C. Total	25	0.08287572			

Means for Oneway Anova

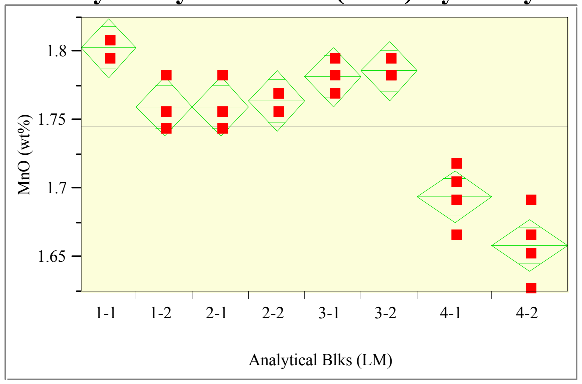
Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	1.21318	0.00635	1.1998	1.2265
1-2	3	1.18775	0.00635	1.1744	1.2011
2-1	3	1.19217	0.00635	1.1788	1.2055
2-2	3	1.18499	0.00635	1.1716	1.1983
3-1	3	1.22699	0.00635	1.2137	1.2403
3-2	3	1.20599	0.00635	1.1926	1.2193
4-1	4	1.10554	0.00550	1.0940	1.1171
4-2	4	1.06740	0.00550	1.0558	1.0790

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 – reference value 1.726 wt%

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



Oneway Anova

Summary of Fit

Rsquare	0.913168
Adj Rsquare	0.8794
Root Mean Square Error	0.018026
Mean of Response	1.745603
Observations (or Sum Wgts)	26

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	7	0.06151210	0.008787	27.0425	<.0001
Error	18	0.00584908	0.000325		
C. Total	25	0.06736119			

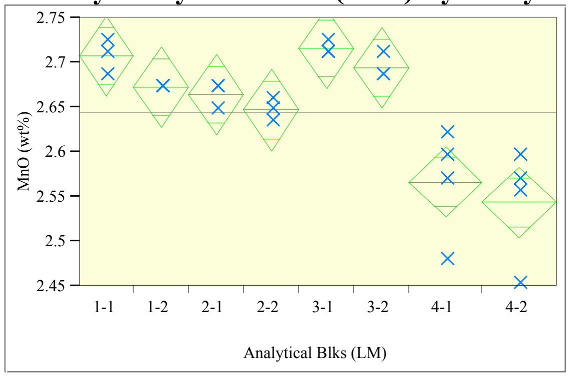
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	1.80338	0.01041	1.7815	1.8252
1-2	3	1.76034	0.01041	1.7385	1.7822
2-1	3	1.76034	0.01041	1.7385	1.7822
2-2	3	1.76464	0.01041	1.7428	1.7865
3-1	3	1.78186	0.01041	1.7600	1.8037
3-2	3	1.78616	0.01041	1.7643	1.8080
4-1	4	1.69470	0.00901	1.6758	1.7136
4-2	4	1.65919	0.00901	1.6403	1.6781

Std Error uses a pooled estimate of error variance

U std – reference value 2.892 wt%

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



Oneway Anova

Summary of Fit

Rsquare	0.803512
Adj Rsquare	0.7271
Root Mean Square Error	0.037449
Mean of Response	2.64398
Observations (or Sum Wgts)	26

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	7	0.10323265	0.014748	10.5155	<.0001
Error	18	0.02524415	0.001402		
C. Total	25	0.12847680			

Means for Oneway Anova

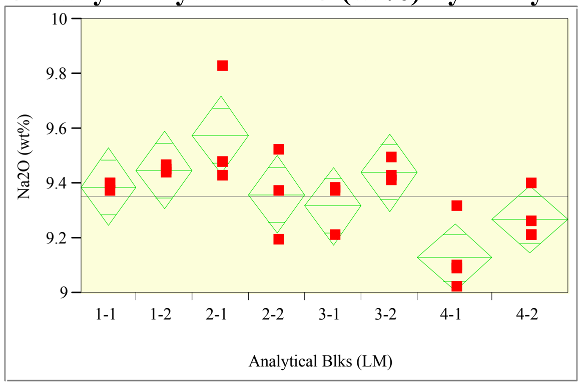
Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	2.70722	0.02162	2.6618	2.7526
1-2	3	2.67278	0.02162	2.6274	2.7182
2-1	3	2.66418	0.02162	2.6188	2.7096
2-2	3	2.64696	0.02162	2.6015	2.6924
3-1	3	2.71582	0.02162	2.6704	2.7612
3-2	3	2.69430	0.02162	2.6489	2.7397
4-1	4	2.56626	0.01872	2.5269	2.6056
4-2	4	2.54366	0.01872	2.5043	2.5830

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 – reference value 9.003 wt%

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



Oneway Anova

Summary of Fit

Rsquare	0.639119
Adj Rsquare	0.498776
Root Mean Square Error	0.116873
Mean of Response	9.353046
Observations (or Sum Wgts)	26

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	7	0.43543286	0.062205	4.5540	0.0044
Error	18	0.24586931	0.013659		
C. Total	25	0.68130218			

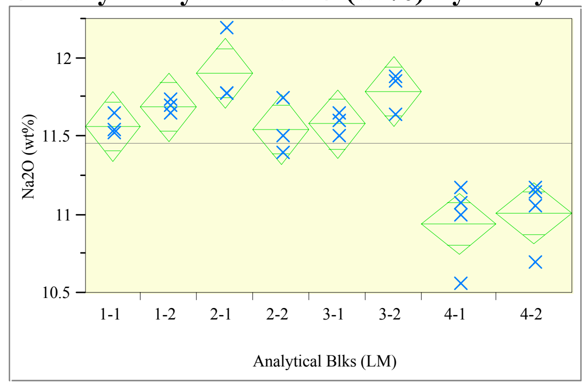
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	9.38657	0.06748	9.2448	9.5283
1-2	3	9.44948	0.06748	9.3077	9.5912
2-1	3	9.57529	0.06748	9.4335	9.7171
2-2	3	9.35961	0.06748	9.2178	9.5014
3-1	3	9.31917	0.06748	9.1774	9.4609
3-2	3	9.44049	0.06748	9.2987	9.5823
4-1	4	9.12933	0.05844	9.0066	9.2521
4-2	4	9.26750	0.05844	9.1447	9.3903

Std Error uses a pooled estimate of error variance

U std – reference value 11.795 wt%

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



Oneway Anova

Summary of Fit

Rsquare	0.835875
Adj Rsquare	0.772048
Root Mean Square Error	0.182506
Mean of Response	11.46215
Observations (or Sum Wgts)	26

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	7	3.0534686	0.436210	13.0960	<.0001
Error	18	0.5995535	0.033309		
C. Total	25	3.6530220			

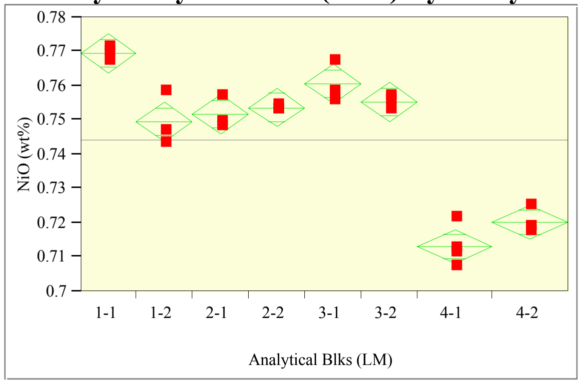
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	11.5658	0.10537	11.344	11.787
1-2	3	11.6872	0.10537	11.466	11.909
2-1	3	11.9073	0.10537	11.686	12.129
2-2	3	11.5434	0.10537	11.322	11.765
3-1	3	11.5793	0.10537	11.358	11.801
3-2	3	11.7860	0.10537	11.565	12.007
4-1	4	10.9424	0.09125	10.751	11.134
4-2	4	11.0098	0.09125	10.818	11.202

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 – reference 0.751 wt%
Oneway Analysis of NiO (wt%) By Analytical Blks (LM)



Oneway Anova
Summary of Fit

Rsquare	0.960368
Adj Rsquare	0.944956
Root Mean Square Error	0.004726
Mean of Response	0.744412
Observations (or Sum Wgts)	26

Analysis of Variance

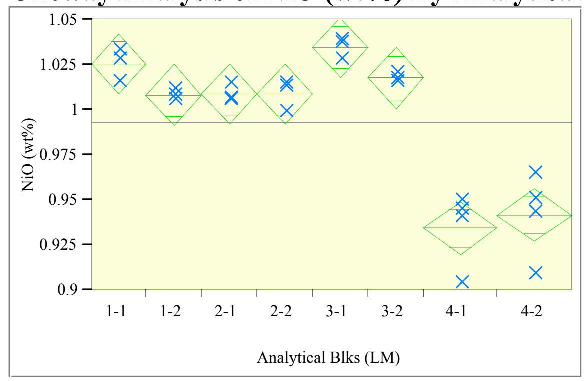
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	7	0.00974414	0.001392	62.3114	<.0001
Error	18	0.00040212	0.000022		
C. Total	25	0.01014626			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.769438	0.00273	0.76371	0.77517
1-2	3	0.749502	0.00273	0.74377	0.75524
2-1	3	0.751623	0.00273	0.74589	0.75736
2-2	3	0.753744	0.00273	0.74801	0.75948
3-1	3	0.760531	0.00273	0.75480	0.76626
3-2	3	0.755441	0.00273	0.74971	0.76117
4-1	4	0.713236	0.00236	0.70827	0.71820
4-2	4	0.720235	0.00236	0.71527	0.72520

Std Error uses a pooled estimate of error variance

U std – reference value 1.12 wt%
Oneway Analysis of NiO (wt%) By Analytical Blks (LM)



Oneway Anova
Summary of Fit

Rsquare	0.91368
Adj Rsquare	0.880111
Root Mean Square Error	0.013873
Mean of Response	0.992844
Observations (or Sum Wgts)	26

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	7	0.03666838	0.005238	27.2179	<.0001
Error	18	0.00346426	0.000192		
C. Total	25	0.04013264			

Means for Oneway Anova

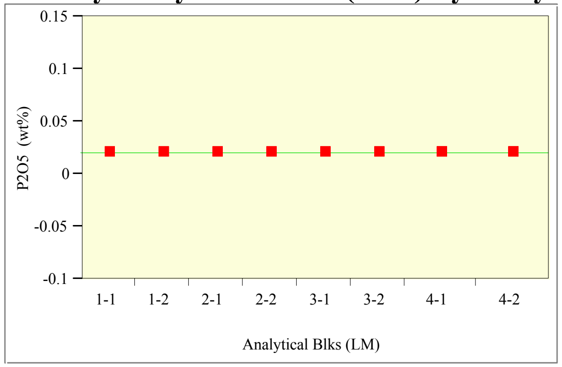
Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	1.02564	0.00801	1.0088	1.0425
1-2	3	1.00824	0.00801	0.9914	1.0251
2-1	3	1.00867	0.00801	0.9918	1.0255
2-2	3	1.00867	0.00801	0.9918	1.0255
3-1	3	1.03454	0.00801	1.0177	1.0514
3-2	3	1.01758	0.00801	1.0007	1.0344
4-1	4	0.93433	0.00694	0.9198	0.9489
4-2	4	0.94165	0.00694	0.9271	0.9562

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 – reference value ~0 wt%

Oneway Analysis of P2O5 (wt%) By Analytical Blks (LM)



Oneway Anova

Summary of Fit

Rsquare	.
Adj Rsquare	.
Root Mean Square Error	0
Mean of Response	0.019477
Observations (or Sum Wgts)	26

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	7	0	0	.	.
Error	18	0	0		
C. Total	25	0			

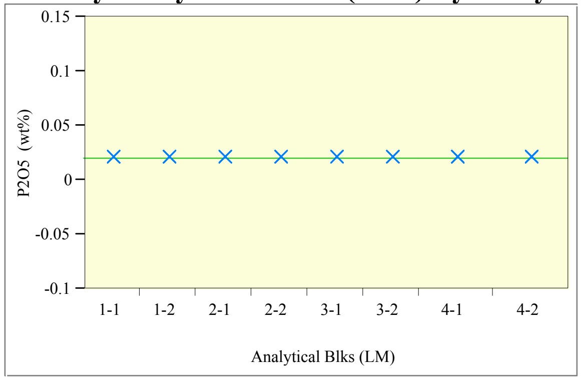
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.019477	0	0.01948	0.01948
1-2	3	0.019477	0	0.01948	0.01948
2-1	3	0.019477	0	0.01948	0.01948
2-2	3	0.019477	0	0.01948	0.01948
3-1	3	0.019477	0	0.01948	0.01948
3-2	3	0.019477	0	0.01948	0.01948
4-1	4	0.019477	0	0.01948	0.01948
4-2	4	0.019477	0	0.01948	0.01948

Std Error uses a pooled estimate of error variance

U std – reference value ~0 wt%

Oneway Analysis of P2O5 (wt%) By Analytical Blks (LM)



Oneway Anova

Summary of Fit

Rsquare	.
Adj Rsquare	.
Root Mean Square Error	0
Mean of Response	0.019477
Observations (or Sum Wgts)	26

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	7	0	0	.	.
Error	18	0	0		
C. Total	25	0			

Means for Oneway Anova

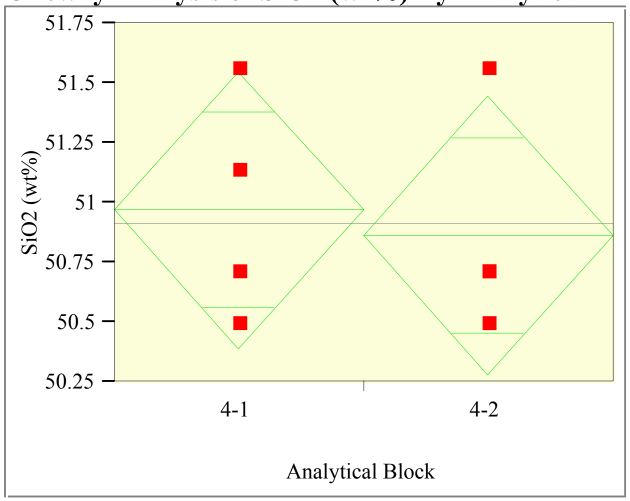
Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.019477	0	0.01948	0.01948
1-2	3	0.019477	0	0.01948	0.01948
2-1	3	0.019477	0	0.01948	0.01948
2-2	3	0.019477	0	0.01948	0.01948
3-1	3	0.019477	0	0.01948	0.01948
3-2	3	0.019477	0	0.01948	0.01948
4-1	4	0.019477	0	0.01948	0.01948
4-2	4	0.019477	0	0.01948	0.01948

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 – reference value 50.22 wt %

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



Oneway Anova

Summary of Fit

Rsquare	0.016667
Adj Rsquare	-0.14722
Root Mean Square Error	0.474359
Mean of Response	50.91534
Observations (or Sum Wgts)	8

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Block	1	0.0228830	0.022883	0.1017	0.7606
Error	6	1.3500983	0.225016		
C. Total	7	1.3729813			

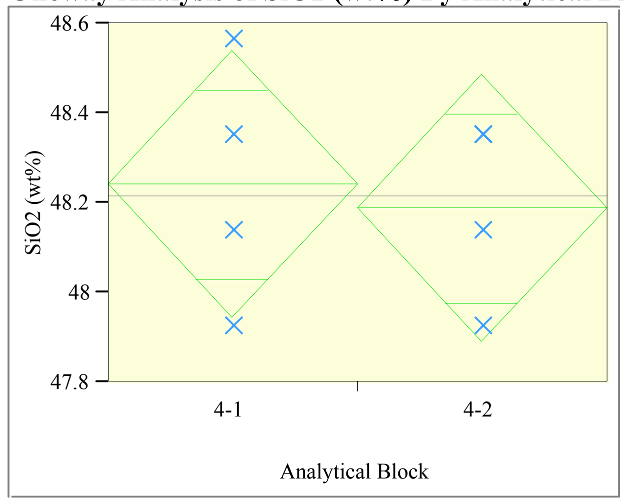
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
4-1	4	50.9688	0.23718	50.388	51.549
4-2	4	50.8619	0.23718	50.282	51.442

Std Error uses a pooled estimate of error variance

U std – reference value 45.353 wt%

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



Oneway Anova

Summary of Fit

Rsquare	0.015873
Adj Rsquare	-0.14815
Root Mean Square Error	0.243135
Mean of Response	48.21447
Observations (or Sum Wgts)	8

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Block	1	0.00572076	0.005721	0.0968	0.7663
Error	6	0.35468685	0.059114		
C. Total	7	0.36040760			

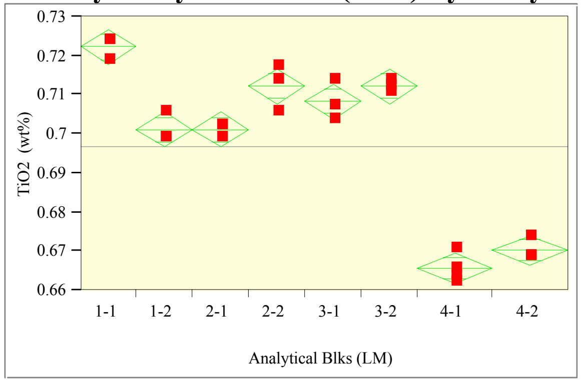
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
4-1	4	48.2412	0.12157	47.944	48.539
4-2	4	48.1877	0.12157	47.890	48.485

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 – reference value 0.677 wt%
Oneway Analysis of TiO2 (wt%) By Analytical Blks (LM)



Oneway Anova
Summary of Fit

Rsquare	0.977822
Adj Rsquare	0.969197
Root Mean Square Error	0.003662
Mean of Response	0.696711
Observations (or Sum Wgts)	26

Analysis of Variance

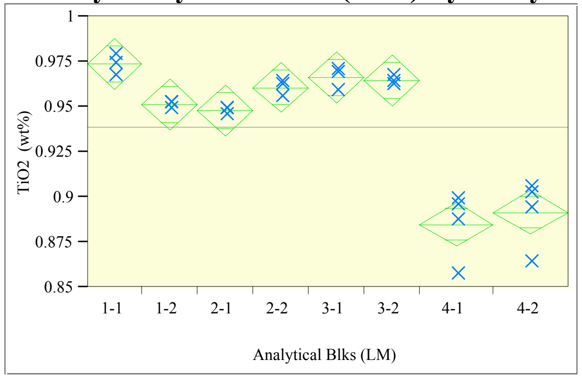
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	7	0.01064142	0.001520	113.3737	<.0001
Error	18	0.00024136	0.000013		
C. Total	25	0.01088278			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.722244	0.00211	0.71780	0.72669
1-2	3	0.701116	0.00211	0.69667	0.70556
2-1	3	0.701116	0.00211	0.69667	0.70556
2-2	3	0.712236	0.00211	0.70779	0.71668
3-1	3	0.708344	0.00211	0.70390	0.71279
3-2	3	0.712236	0.00211	0.70779	0.71668
4-1	4	0.665532	0.00183	0.66169	0.66938
4-2	4	0.670119	0.00183	0.66627	0.67397

Std Error uses a pooled estimate of error variance

U std – reference value 1.049 wt%
Oneway Analysis of TiO2 (wt%) By Analytical Blks (LM)



Oneway Anova
Summary of Fit

Rsquare	0.927918
Adj Rsquare	0.899886
Root Mean Square Error	0.011498
Mean of Response	0.938442
Observations (or Sum Wgts)	26

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	7	0.03063457	0.004376	33.1023	<.0001
Error	18	0.00237973	0.000132		
C. Total	25	0.03301430			

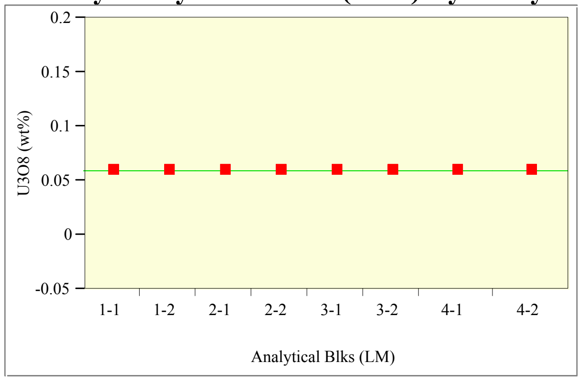
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.973556	0.00664	0.95961	0.98750
1-2	3	0.951316	0.00664	0.93737	0.96526
2-1	3	0.947980	0.00664	0.93403	0.96193
2-2	3	0.960768	0.00664	0.94682	0.97471
3-1	3	0.966328	0.00664	0.95238	0.98027
3-2	3	0.964660	0.00664	0.95071	0.97861
4-1	4	0.884874	0.00575	0.87280	0.89695
4-2	4	0.891546	0.00575	0.87947	0.90362

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 – reference value 0 wt%
Oneway Analysis of U3O8 (wt%) By Analytical Blks (LM)



Oneway Anova
Summary of Fit

Rsquare	.
Adj Rsquare	.
Root Mean Square Error	0
Mean of Response	0.05896
Observations (or Sum Wgts)	26

Analysis of Variance

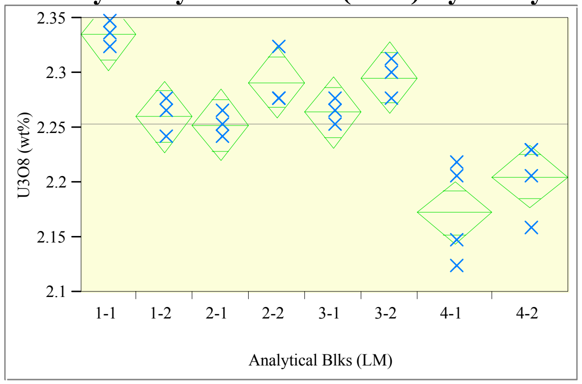
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	7	0	0	.	.
Error	18	0	0		
C. Total	25	0			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.058960	0	0.05896	0.05896
1-2	3	0.058960	0	0.05896	0.05896
2-1	3	0.058960	0	0.05896	0.05896
2-2	3	0.058960	0	0.05896	0.05896
3-1	3	0.058960	0	0.05896	0.05896
3-2	3	0.058960	0	0.05896	0.05896
4-1	4	0.058960	0	0.05896	0.05896
4-2	4	0.058960	0	0.05896	0.05896

Std Error uses a pooled estimate of error variance

U std – reference value 2.406 wt%
Oneway Analysis of U3O8 (wt%) By Analytical Blks (LM)



Oneway Anova
Summary of Fit

Rsquare	0.832415
Adj Rsquare	0.767243
Root Mean Square Error	0.027055
Mean of Response	2.254086
Observations (or Sum Wgts)	26

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	7	0.06544234	0.009349	12.7726	<.0001
Error	18	0.01317511	0.000732		
C. Total	25	0.07861745			

Means for Oneway Anova

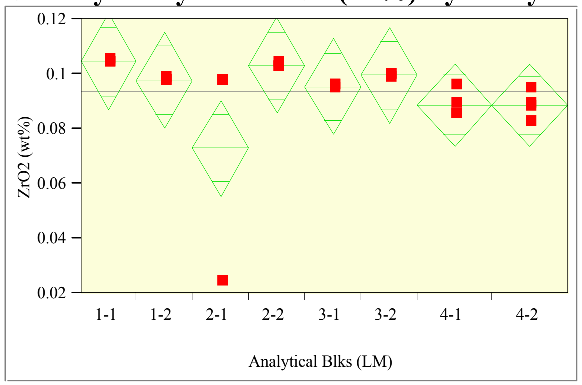
Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	2.33482	0.01562	2.3020	2.3676
1-2	3	2.26013	0.01562	2.2273	2.2929
2-1	3	2.25227	0.01562	2.2195	2.2851
2-2	3	2.29158	0.01562	2.2588	2.3244
3-1	3	2.26406	0.01562	2.2312	2.2969
3-2	3	2.29551	0.01562	2.2627	2.3283
4-1	4	2.17268	0.01353	2.1443	2.2011
4-2	4	2.20510	0.01353	2.1767	2.2335

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 – reference value 0.098 wt%

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



Oneway Anova

Summary of Fit

Rsquare	0.379516
Adj Rsquare	0.138216
Root Mean Square Error	0.014349
Mean of Response	0.093413
Observations (or Sum Wgts)	26

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	7	0.00226678	0.000324	1.5728	0.2067
Error	18	0.00370604	0.000206		
C. Total	25	0.00597282			

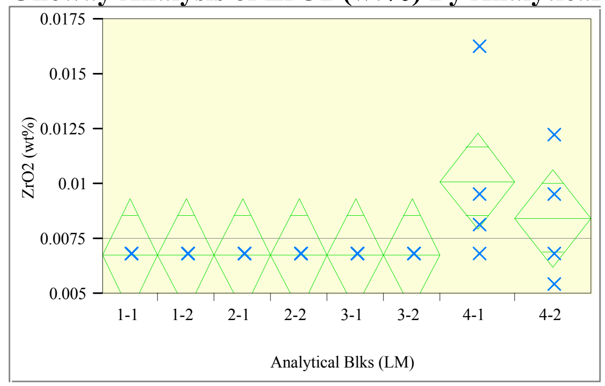
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.104462	0.00828	0.08706	0.12187
1-2	3	0.097708	0.00828	0.08030	0.11511
2-1	3	0.072943	0.00828	0.05554	0.09035
2-2	3	0.103111	0.00828	0.08571	0.12052
3-1	3	0.095457	0.00828	0.07805	0.11286
3-2	3	0.099509	0.00828	0.08210	0.11691
4-1	4	0.088815	0.00717	0.07374	0.10389
4-2	4	0.088477	0.00717	0.07340	0.10355

Std Error uses a pooled estimate of error variance

U std – reference value ~0 wt%

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



Oneway Anova

Summary of Fit

Rsquare	0.34058
Adj Rsquare	0.084138
Root Mean Square Error	0.002106
Mean of Response	0.007533
Observations (or Sum Wgts)	26

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	7	0.00004123	0.0000059	1.3281	0.2936
Error	18	0.00007983	0.0000044		
C. Total	25	0.00012106			

Means for Oneway Anova

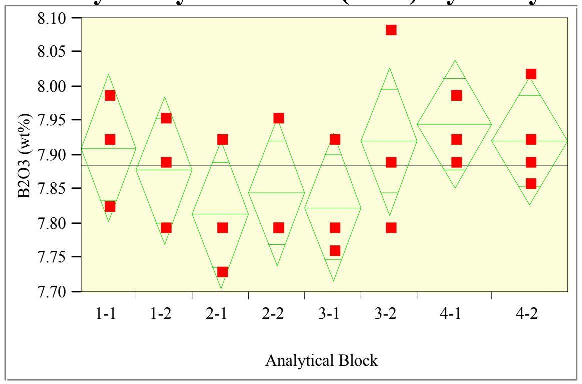
Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.006754	0.00122	0.00420	0.00931
1-2	3	0.006754	0.00122	0.00420	0.00931
2-1	3	0.006754	0.00122	0.00420	0.00931
2-2	3	0.006754	0.00122	0.00420	0.00931
3-1	3	0.006754	0.00122	0.00420	0.00931
3-2	3	0.006754	0.00122	0.00420	0.00931
4-1	4	0.010131	0.00105	0.00792	0.01234
4-2	4	0.008443	0.00105	0.00623	0.01065

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 SP Fusion

Batch 1 – reference value 7.777 wt%

Oneway Analysis of B2O3 (wt%) By Analytical Block



Oneway Anova

Summary of Fit

Rsquare	0.283714
Adj Rsquare	0.005159
Root Mean Square Error	0.088966
Mean of Response	7.886278
Observations (or Sum Wgts)	26

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Block	7	0.05643116	0.008062	1.0185	0.4514
Error	18	0.14247025	0.007915		
C. Total	25	0.19890141			

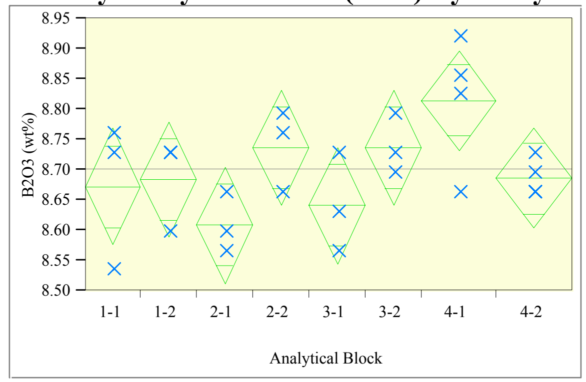
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	7.91022	0.05136	7.8023	8.0181
1-2	3	7.87802	0.05136	7.7701	7.9859
2-1	3	7.81362	0.05136	7.7057	7.9215
2-2	3	7.84582	0.05136	7.7379	7.9537
3-1	3	7.82436	0.05136	7.7164	7.9323
3-2	3	7.92095	0.05136	7.8130	8.0289
4-1	4	7.94510	0.04448	7.8516	8.0386
4-2	4	7.92095	0.04448	7.8275	8.0144

Std Error uses a pooled estimate of error variance

U std – reference value 9.209 wt%

Oneway Analysis of B2O3 (wt%) By Analytical Block



Oneway Anova

Summary of Fit

Rsquare	0.474624
Adj Rsquare	0.270311
Root Mean Square Error	0.078688
Mean of Response	8.701161
Observations (or Sum Wgts)	26

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Block	7	0.10068686	0.014384	2.3230	0.0709
Error	18	0.11145338	0.006192		
C. Total	25	0.21214024			

Means for Oneway Anova

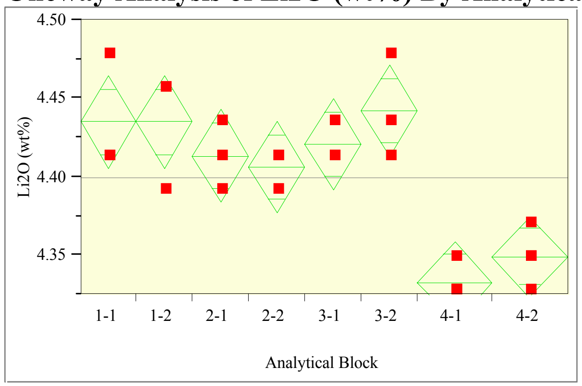
Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	8.67226	0.04543	8.5768	8.7677
1-2	3	8.68300	0.04543	8.5876	8.7784
2-1	3	8.60787	0.04543	8.5124	8.7033
2-2	3	8.73666	0.04543	8.6412	8.8321
3-1	3	8.64006	0.04543	8.5446	8.7355
3-2	3	8.73666	0.04543	8.6412	8.8321
4-1	4	8.81448	0.03934	8.7318	8.8971
4-2	4	8.68568	0.03934	8.6030	8.7683

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 SP Method *(continued)*

Batch 1 – reference value 4.429 wt%

Oneway Analysis of Li2O (wt%) By Analytical Block



Oneway Anova

Summary of Fit

Rsquare	0.803684
Adj Rsquare	0.727339
Root Mean Square Error	0.024204
Mean of Response	4.399368
Observations (or Sum Wgts)	26

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Block	7	0.04316769	0.006167	10.5270	<.0001
Error	18	0.01054458	0.000586		
C. Total	25	0.05371227			

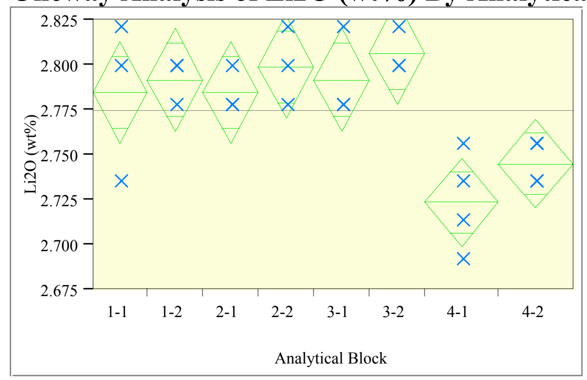
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	4.43497	0.01397	4.4056	4.4643
1-2	3	4.43497	0.01397	4.4056	4.4643
2-1	3	4.41344	0.01397	4.3841	4.4428
2-2	3	4.40627	0.01397	4.3769	4.4356
3-1	3	4.42062	0.01397	4.3913	4.4500
3-2	3	4.44215	0.01397	4.4128	4.4715
4-1	4	4.33271	0.01210	4.3073	4.3581
4-2	4	4.34886	0.01210	4.3234	4.3743

Std Error uses a pooled estimate of error variance

U std – reference value 3.057 wt%

Oneway Analysis of Li2O (wt%) By Analytical Block



Oneway Anova

Summary of Fit

Rsquare	0.679938
Adj Rsquare	0.55547
Root Mean Square Error	0.023438
Mean of Response	2.774757
Observations (or Sum Wgts)	26

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Block	7	0.02100596	0.003001	5.4627	0.0017
Error	18	0.00988795	0.000549		
C. Total	25	0.03089391			

Means for Oneway Anova

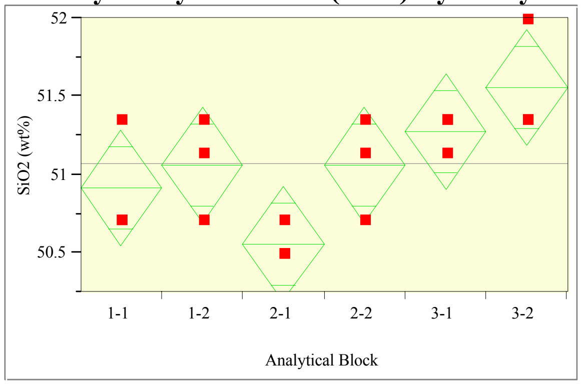
Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	2.78442	0.01353	2.7560	2.8128
1-2	3	2.79159	0.01353	2.7632	2.8200
2-1	3	2.78442	0.01353	2.7560	2.8128
2-2	3	2.79877	0.01353	2.7703	2.8272
3-1	3	2.79159	0.01353	2.7632	2.8200
3-2	3	2.80595	0.01353	2.7775	2.8344
4-1	4	2.72342	0.01172	2.6988	2.7480
4-2	4	2.74495	0.01172	2.7203	2.7696

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 SP Method *(continued)*

Batch 1 – reference value 50.22 wt %

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



Oneway Anova

Summary of Fit

Rsquare	0.619758
Adj Rsquare	0.461323
Root Mean Square Error	0.294019
Mean of Response	51.06985
Observations (or Sum Wgts)	18

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Block	5	1.6908011	0.338160	3.9118	0.0246
Error	12	1.0373637	0.086447		
C. Total	17	2.7281648			

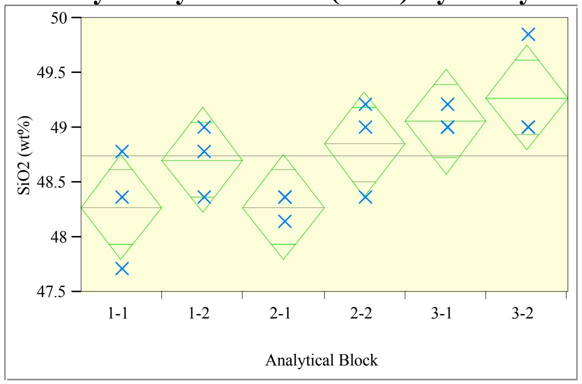
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	50.9153	0.16975	50.545	51.285
1-2	3	51.0580	0.16975	50.688	51.428
2-1	3	50.5588	0.16975	50.189	50.929
2-2	3	51.0580	0.16975	50.688	51.428
3-1	3	51.2719	0.16975	50.902	51.642
3-2	3	51.5571	0.16975	51.187	51.927
4-1	0	.	.	.	.
4-2	0	.	.	.	.

Std Error uses a pooled estimate of error variance

U std – reference value 45.353 wt%

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



Oneway Anova

Summary of Fit

Rsquare	0.589189
Adj Rsquare	0.418018
Root Mean Square Error	0.380691
Mean of Response	48.74038
Observations (or Sum Wgts)	18

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Block	5	2.4942494	0.498850	3.4421	0.0368
Error	12	1.7391097	0.144926		
C. Total	17	4.2333592			

Means for Oneway Anova

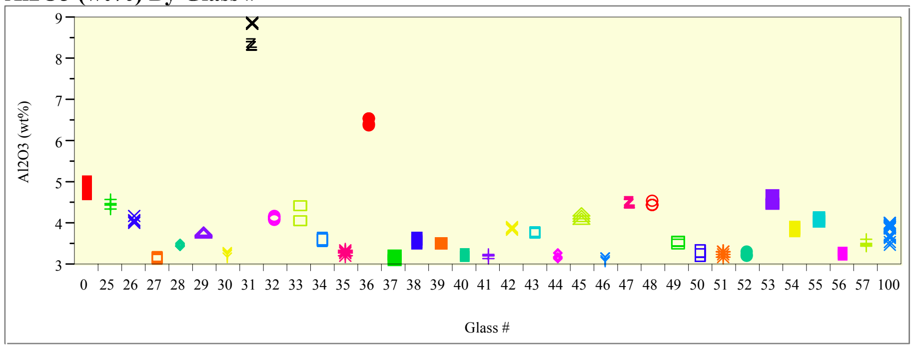
Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	48.2769	0.21979	47.798	48.756
1-2	3	48.7047	0.21979	48.226	49.184
2-1	3	48.2769	0.21979	47.798	48.756
2-2	3	48.8473	0.21979	48.368	49.326
3-1	3	49.0613	0.21979	48.582	49.540
3-2	3	49.2752	0.21979	48.796	49.754
4-1	0	.	.	.	.
4-2	0	.	.	.	.

Std Error uses a pooled estimate of error variance

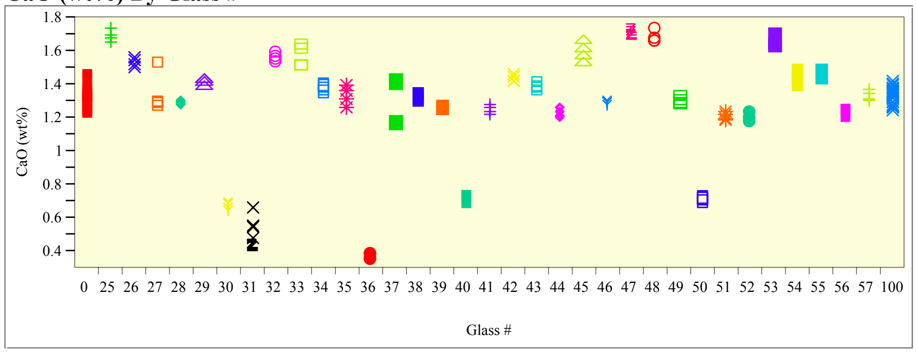
Exhibit E.5: SRTC-ML Measurements by Glass Number for Samples Prepared Using the LM Method

(0 – Batch 1 and 100 – U std)

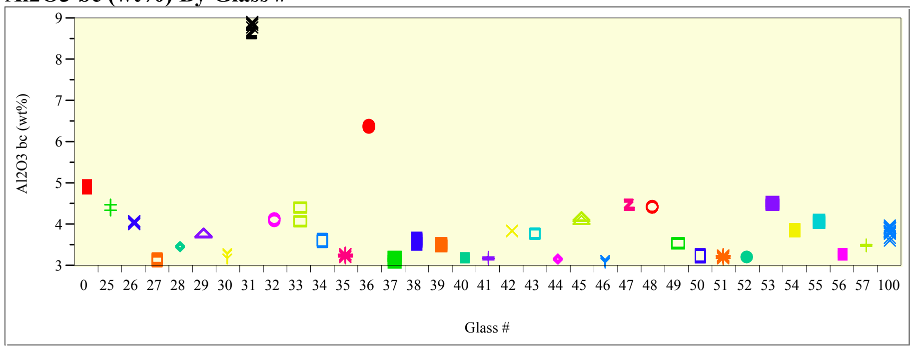
Al2O3 (wt%) By Glass #



CaO (wt%) By Glass #



Al2O3 bc (wt%) By Glass #



CaO bc (wt%) By Glass #

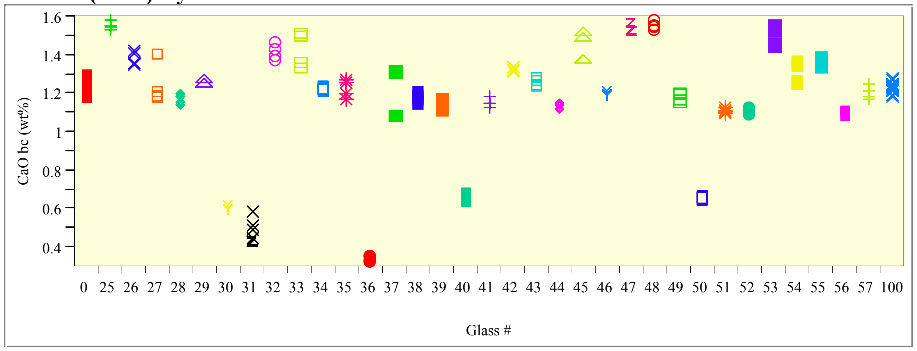
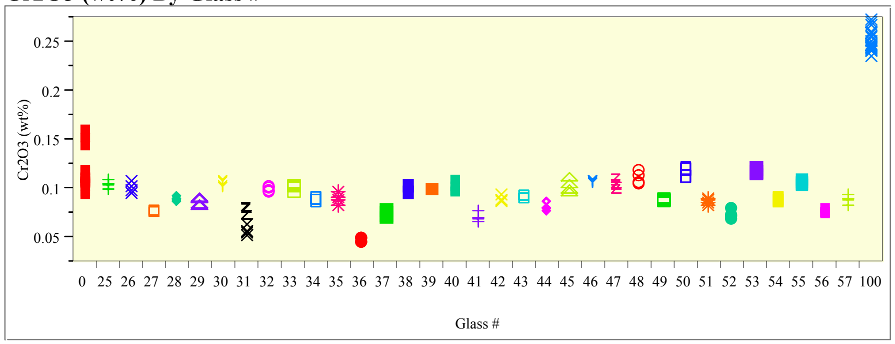
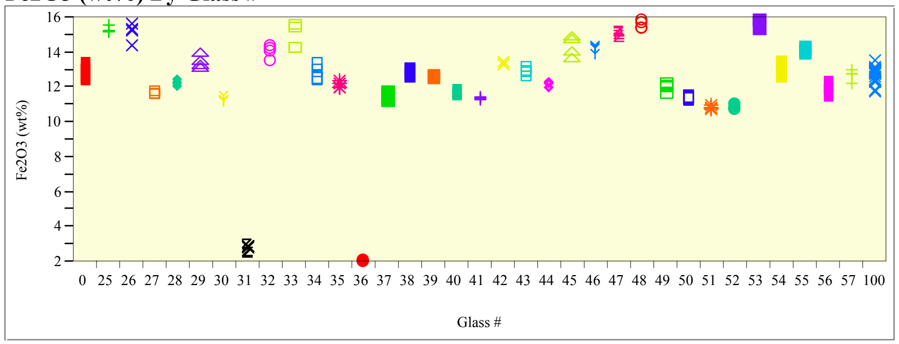


Exhibit E.5: SRTC-ML Measurements by Glass Number for Samples Prepared Using the LM Method *(continued)*
(0 – Batch 1 and 100 – U std)

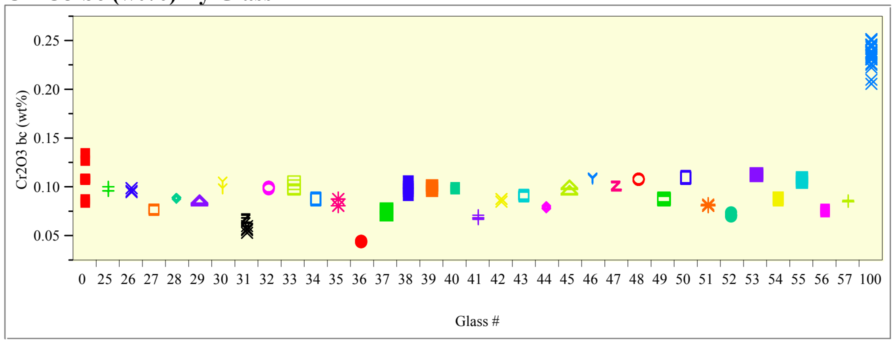
Cr2O3 (wt%) By Glass #



Fe2O3 (wt%) By Glass #



Cr2O3 bc (wt%) By Glass #



Fe2O3 bc (wt%) By Glass #

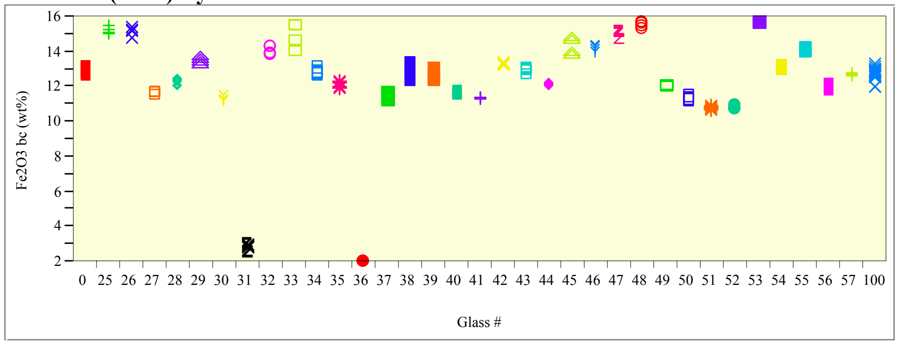
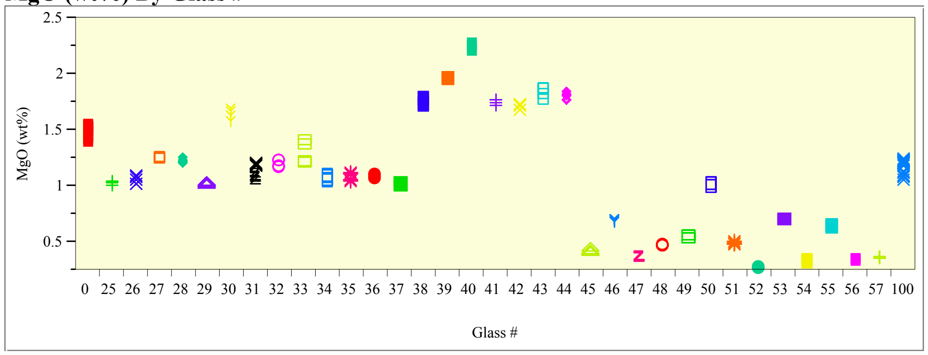
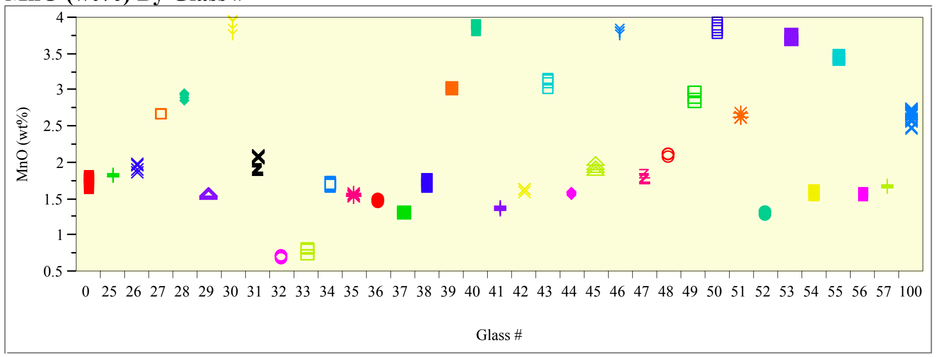


Exhibit E.5: SRTC-ML Measurements by Glass Number for Samples Prepared Using the LM Method *(continued)*
(0 – Batch 1 and 100 – U std)

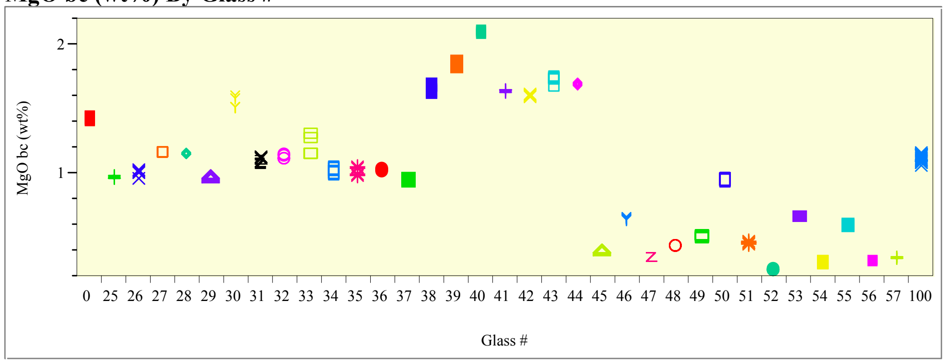
MgO (wt%) By Glass #



MnO (wt%) By Glass #



MgO bc (wt%) By Glass #



MnO bc (wt%) By Glass #

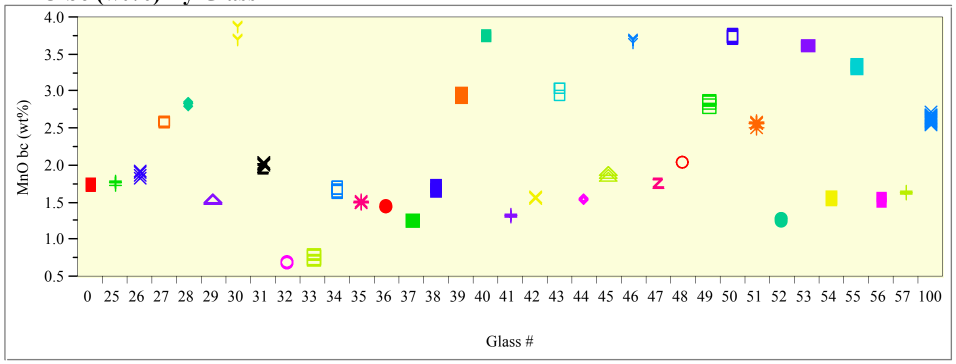
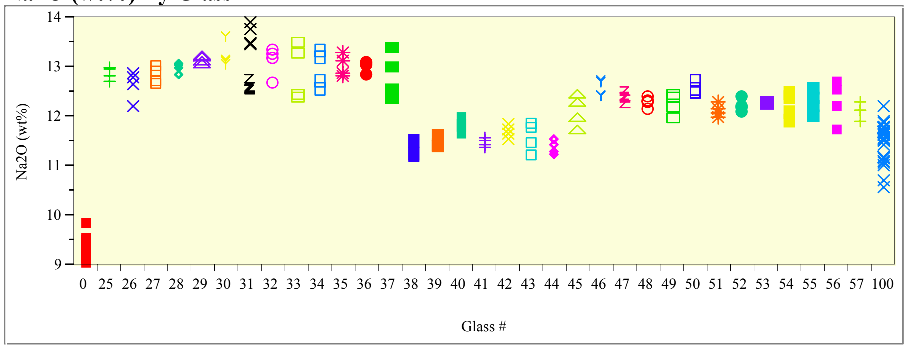
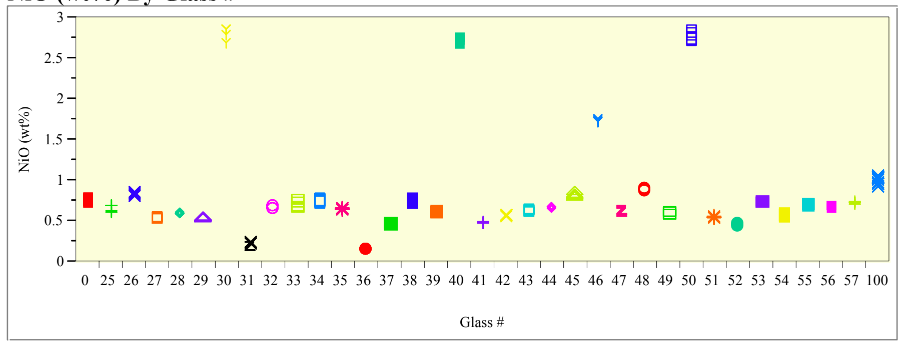


Exhibit E.5: SRTC-ML Measurements by Glass Number for Samples Prepared Using the LM Method *(continued)*
(0 – Batch 1 and 100 – U std)

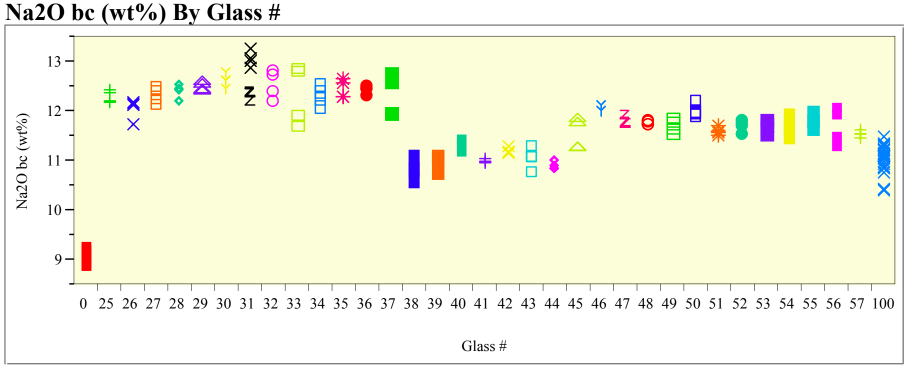
Na2O (wt%) By Glass #



NiO (wt%) By Glass #



Na2O bc (wt%) By Glass #



NiO bc (wt%) By Glass #

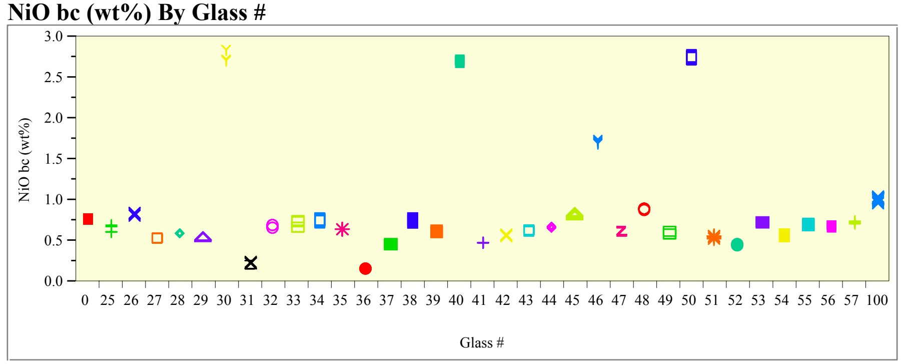
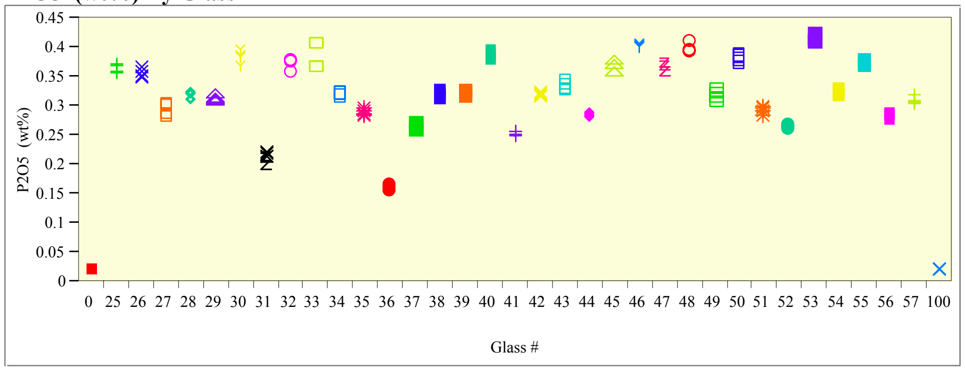
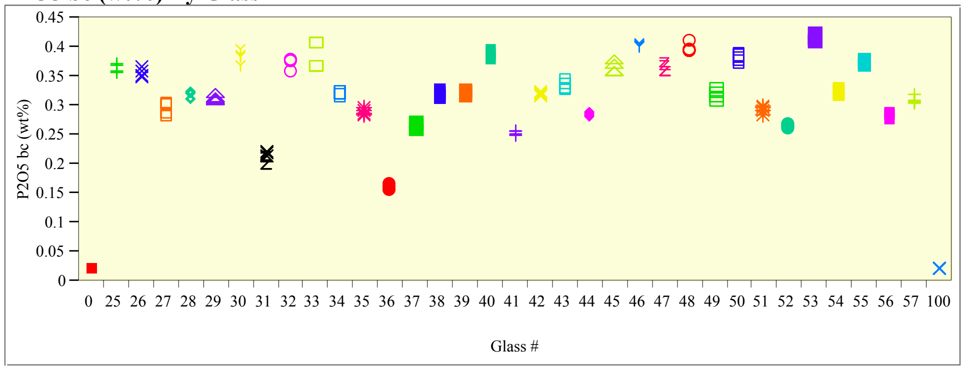


Exhibit E.5: SRTC-ML Measurements by Glass Number for Samples Prepared Using the LM Method *(continued)*
(0 – Batch 1 and 100 – U std)

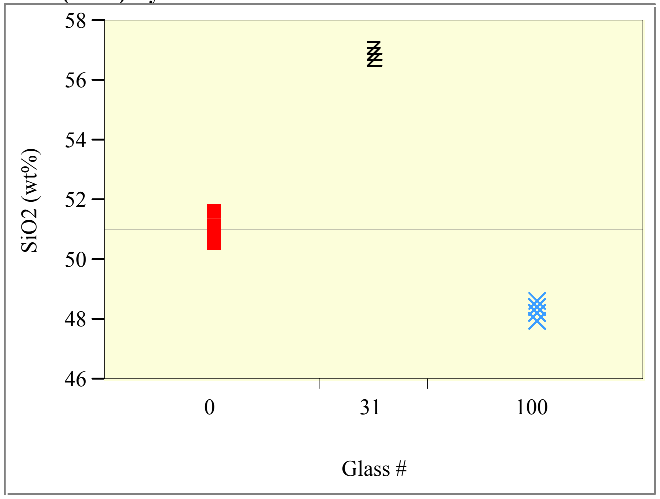
P2O5 (wt%) By Glass #



P2O5 bc (wt%) By Glass #



SiO2 (wt%) By Glass #



SiO2 bc (wt%) By Glass #

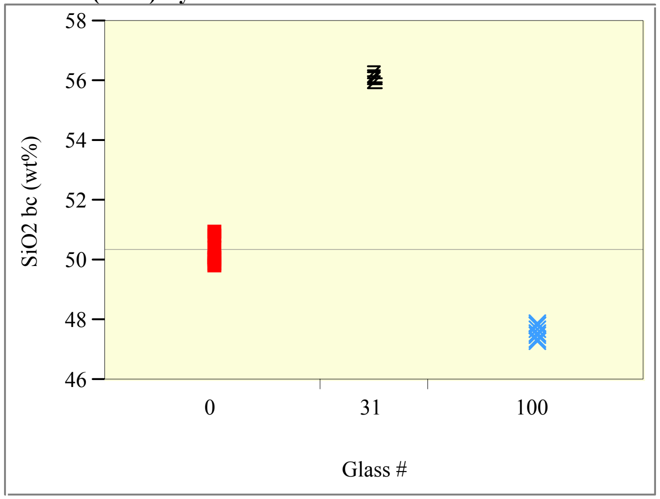
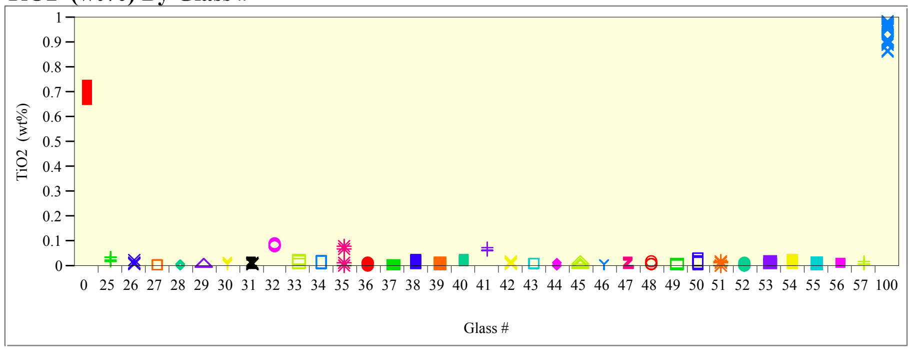
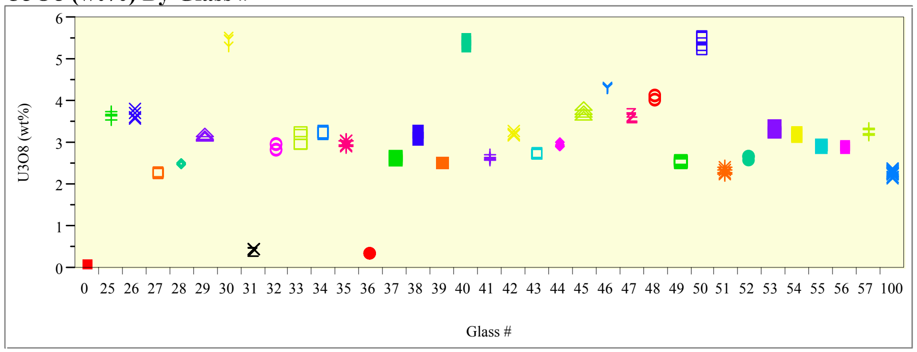


Exhibit E.5: SRTC-ML Measurements by Glass Number for Samples Prepared Using the LM Method *(continued)*
(0 – Batch 1 and 100 – U std)

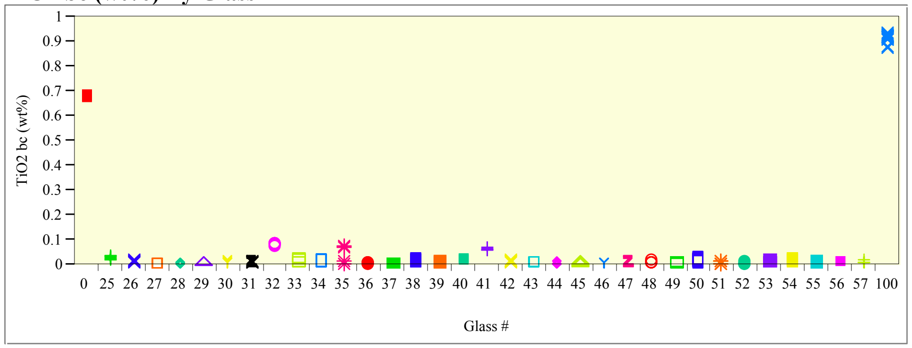
TiO2 (wt%) By Glass #



U3O8 (wt%) By Glass #



TiO2 bc (wt%) By Glass #



U3O8 bc (wt%) By Glass #

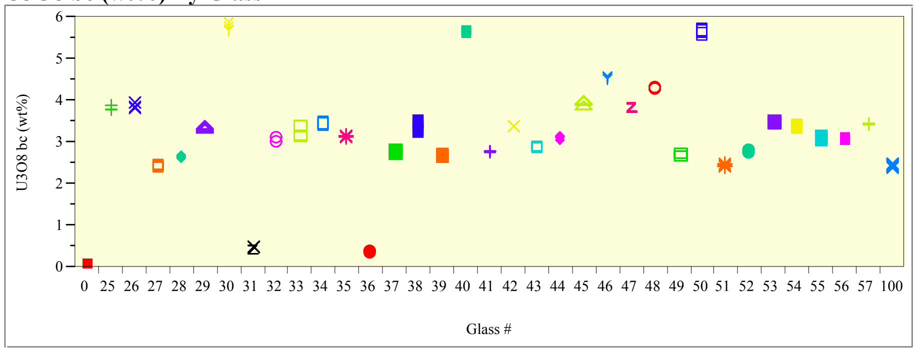
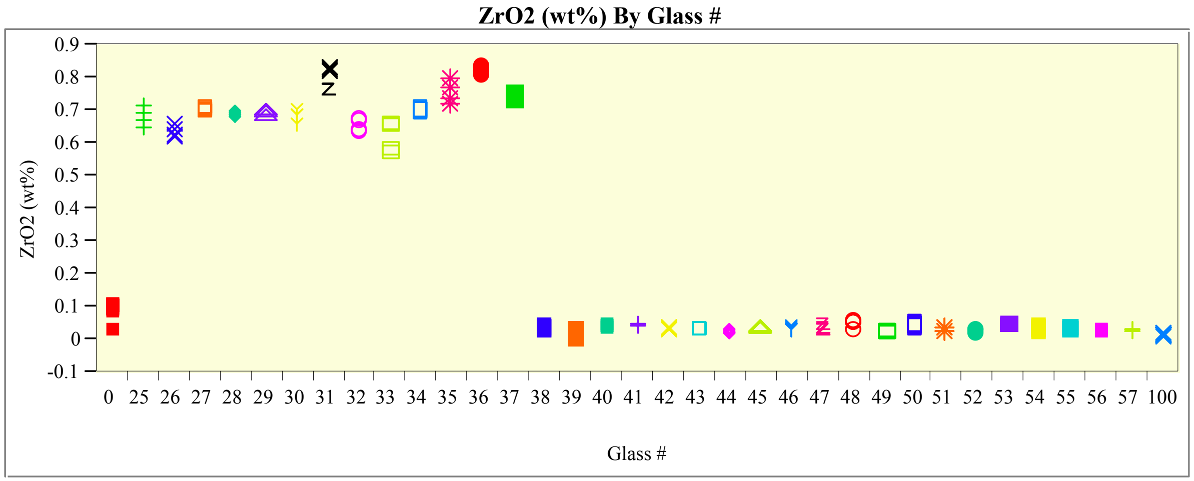


Exhibit E.5: SRTC-ML Measurements by Glass Number for Samples Prepared Using the LM Method *(continued)*
(0 – Batch 1 and 100 – U std)



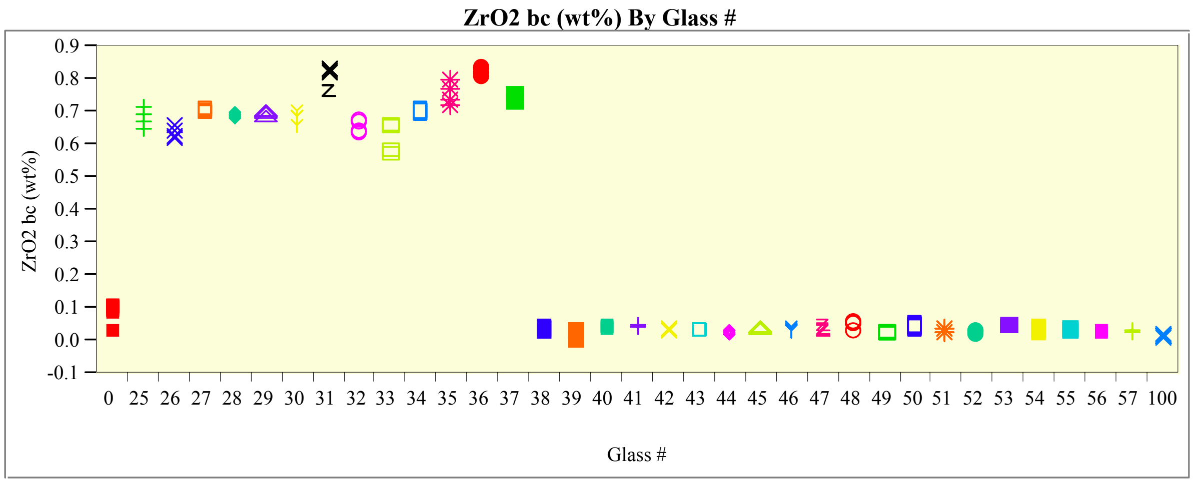
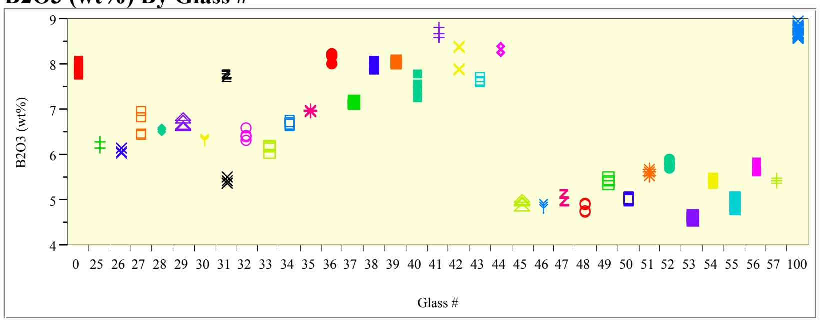


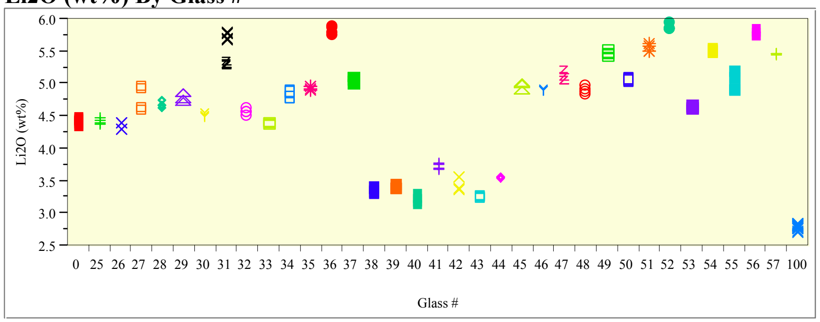
Exhibit E.6: SRTC-ML Measurements by Glass Number for Samples Prepared Using the SP Fusion

(0 – Batch 1 and 100 – U std)

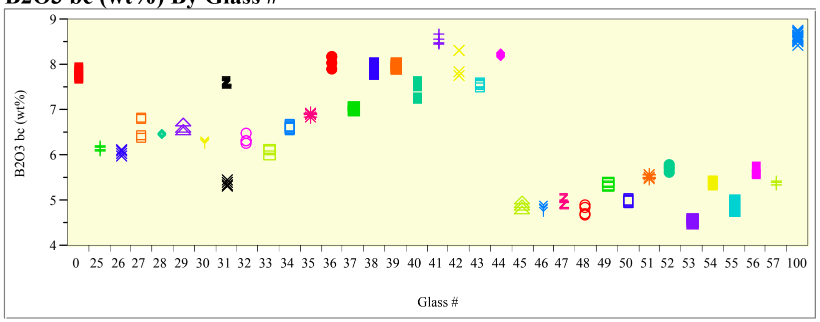
B2O3 (wt%) By Glass #



Li2O (wt%) By Glass #



B2O3 bc (wt%) By Glass #



Li2O bc (wt%) By Glass #

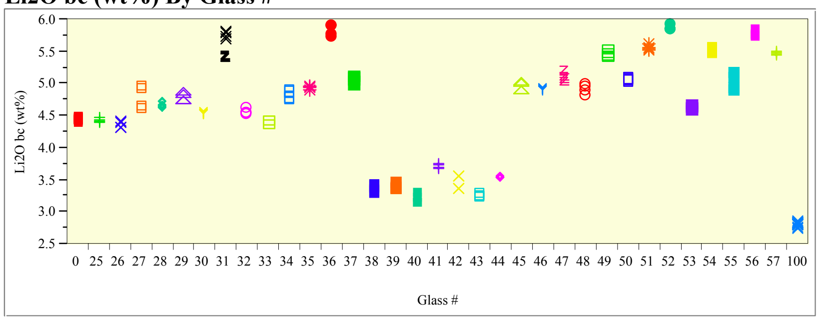
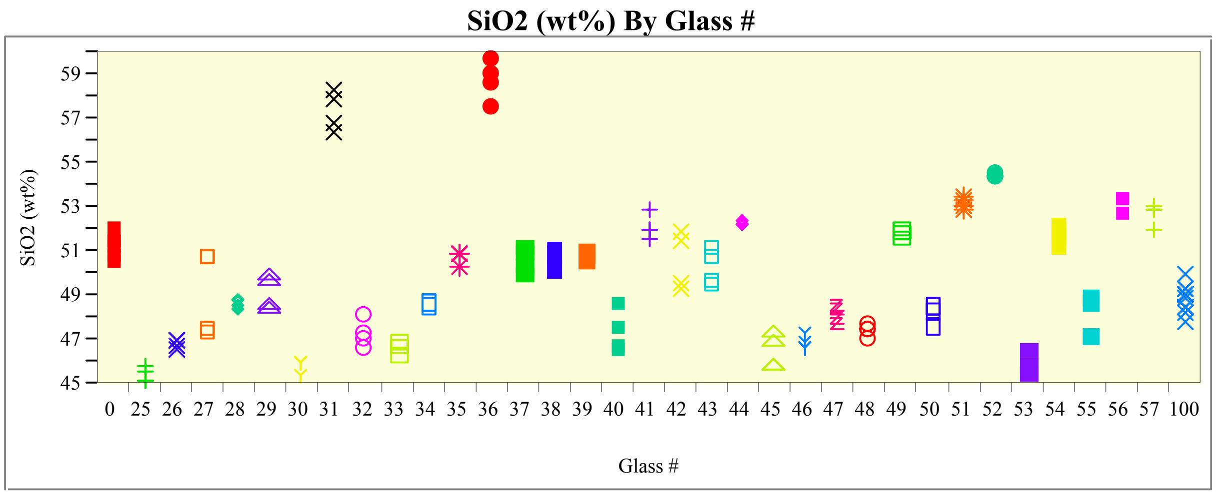


Exhibit E.6: SRTC-ML Measurements by Glass Number for Samples Prepared Using the SP Method *(continued)*
(0 – Batch 1 and 100 – U std)



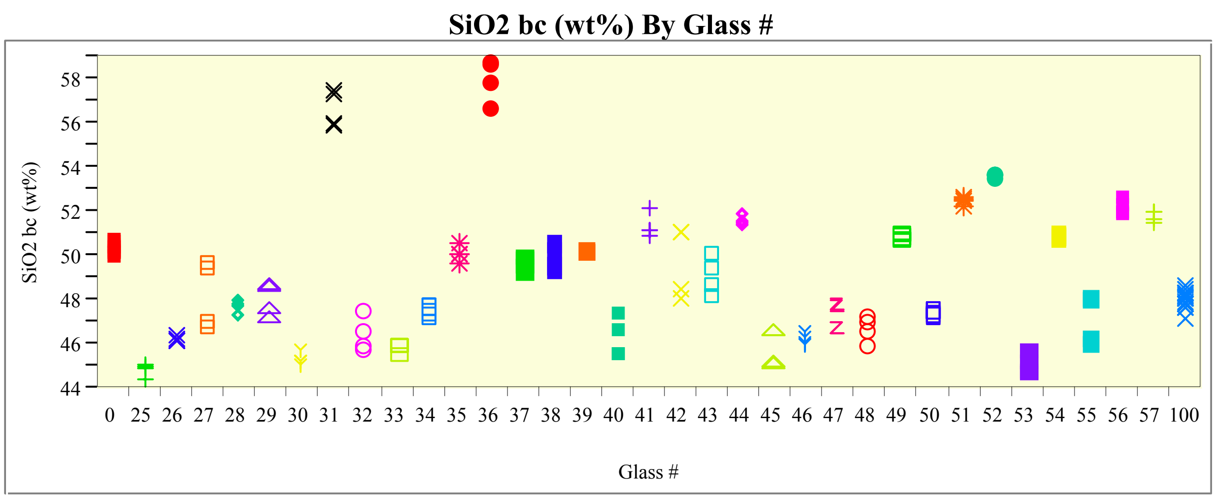
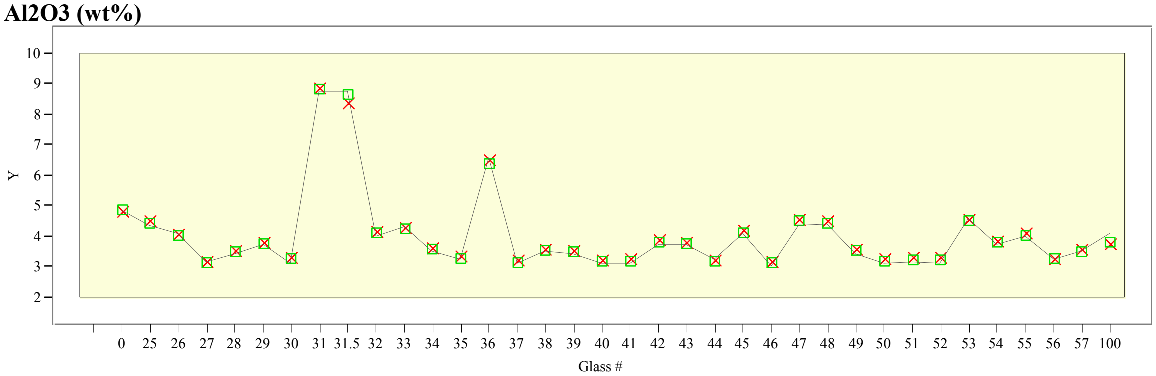
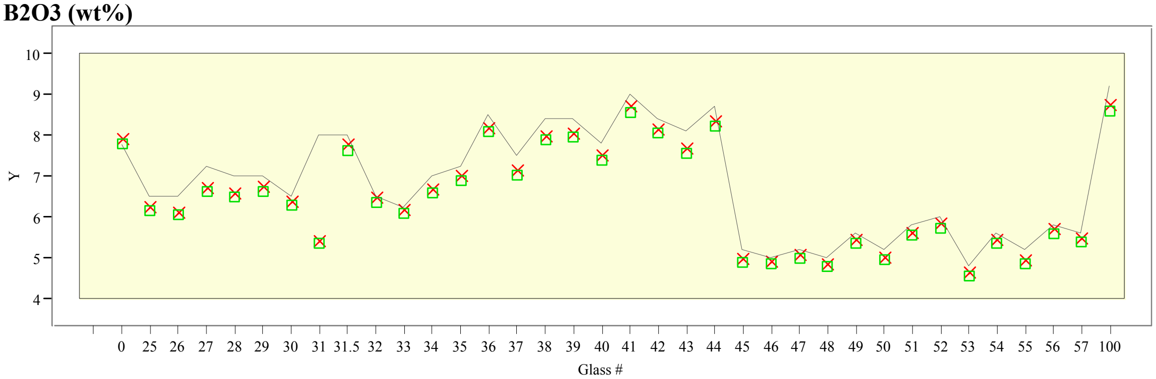


Exhibit E.7: Average Measured and Bias-Corrected (bc) Versus Targeted Compositions by Glass by Oxide
(0 – Batch 1 and 100 – U std)

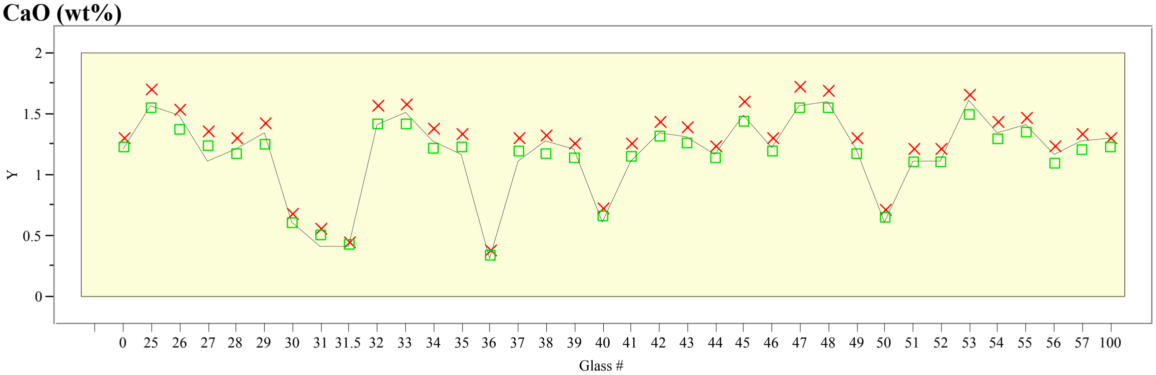
Al2O3 (wt%)



B2O3 (wt%)



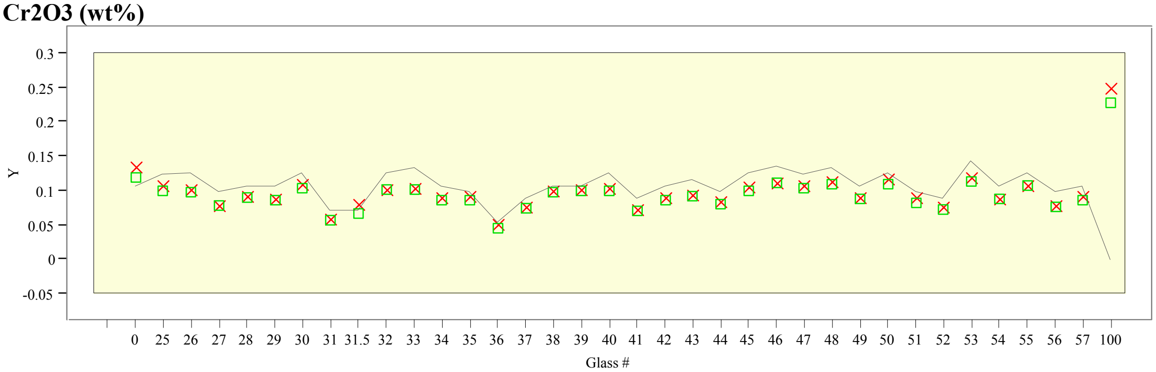
CaO (wt%)



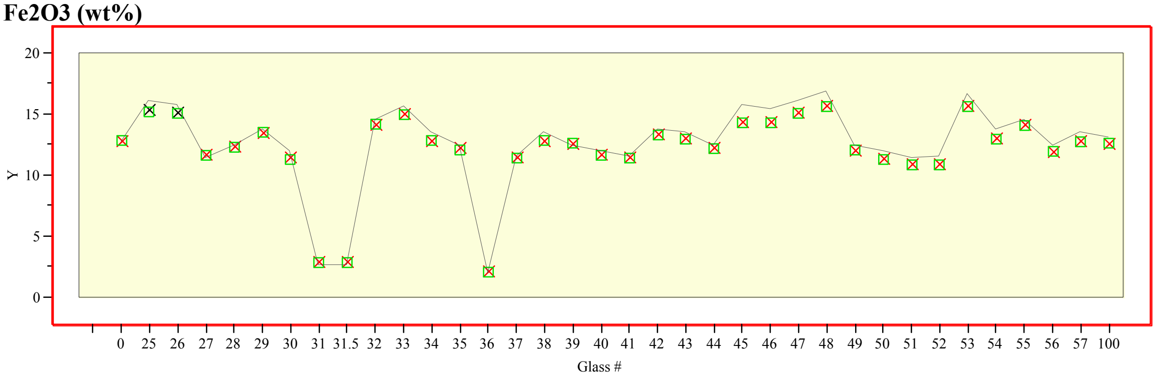
Y ✕ Measured ▫ Measured bc — Targeted

Exhibit E.7: Average Measured and Bias-Corrected (bc) Versus Targeted Compositions by Glass by Oxide *(continued)*
(0 – Batch 1 and 100 – U std)

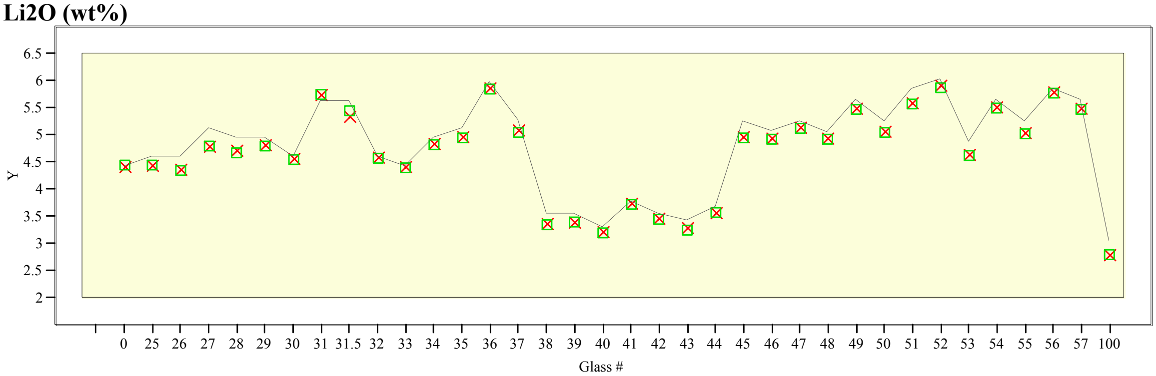
Cr2O3 (wt%)



Fe2O3 (wt%)



Li2O (wt%)

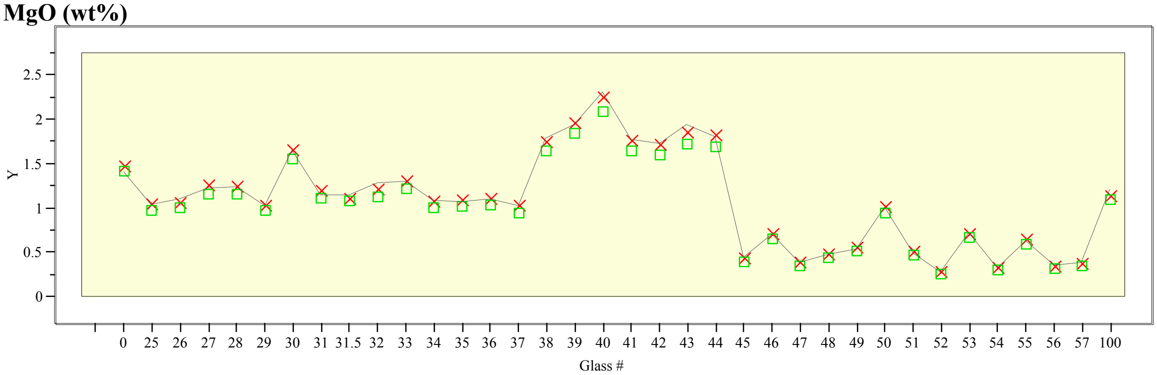


Y ✕ Measured ▫ Measured bc — Targeted

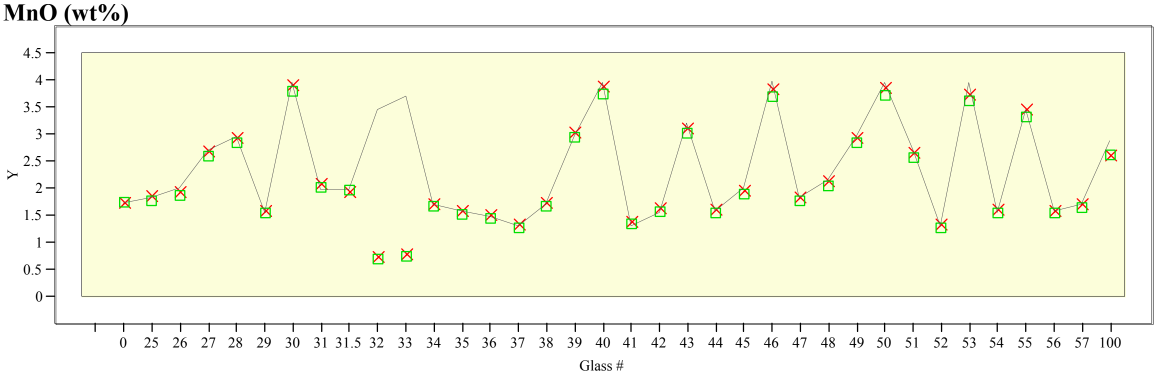
Exhibit E.7: Average Measured and Bias-Corrected (bc) Versus Targeted Compositions by Glass by Oxide *(continued)*

(0 – Batch 1 and 100 – U std)

MgO (wt%)



MnO (wt%)



Na2O (wt%)

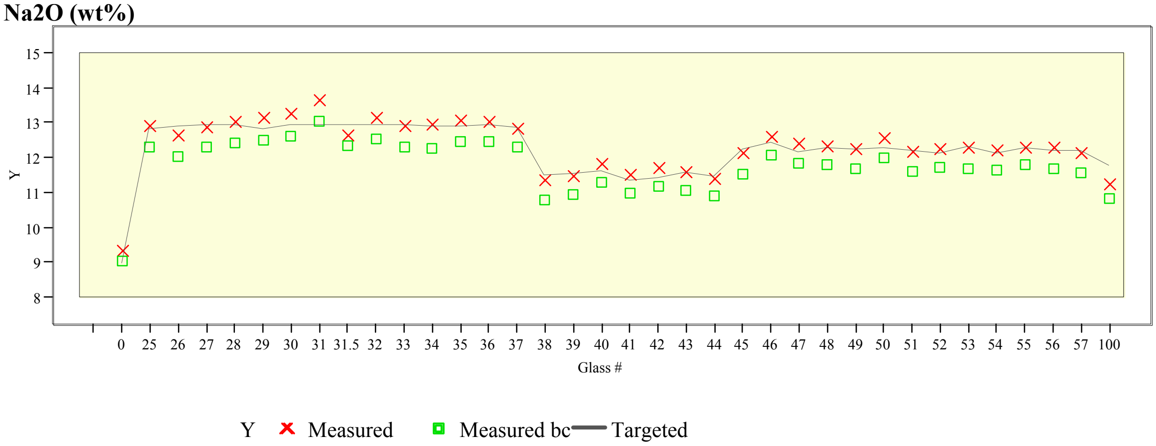
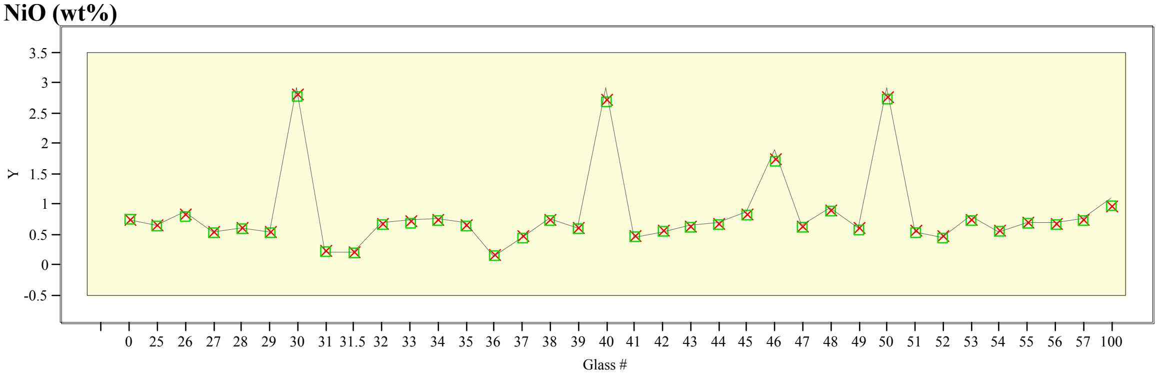


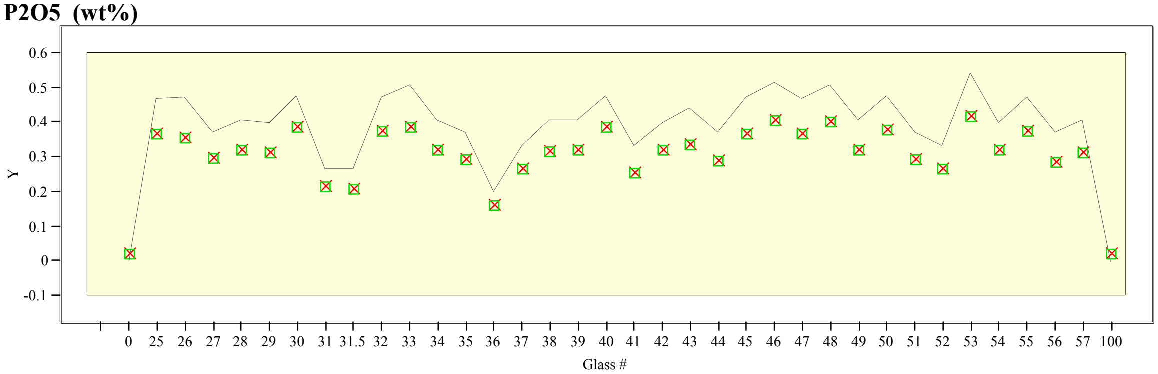
Exhibit E.7: Average Measured and Bias-Corrected (bc) Versus Targeted Compositions by Glass by Oxide *(continued)*

(0 – Batch 1 and 100 – U std)

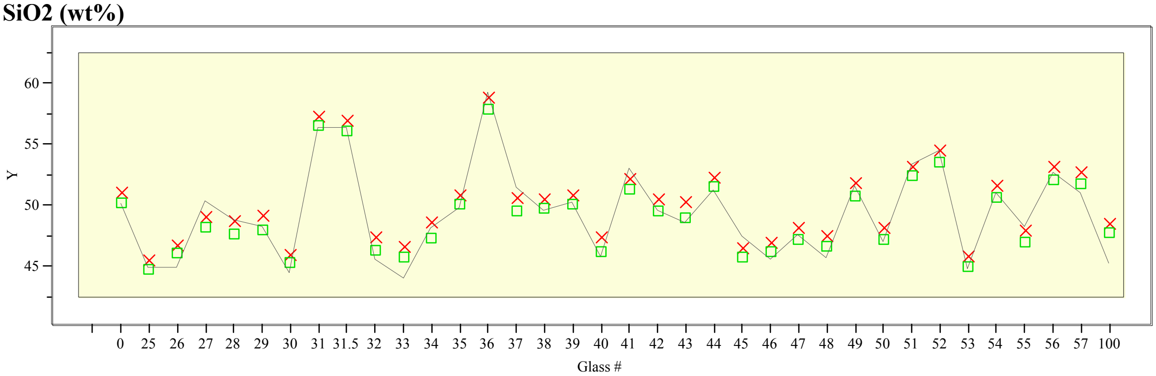
NiO (wt%)



P2O5 (wt%)



SiO2 (wt%)

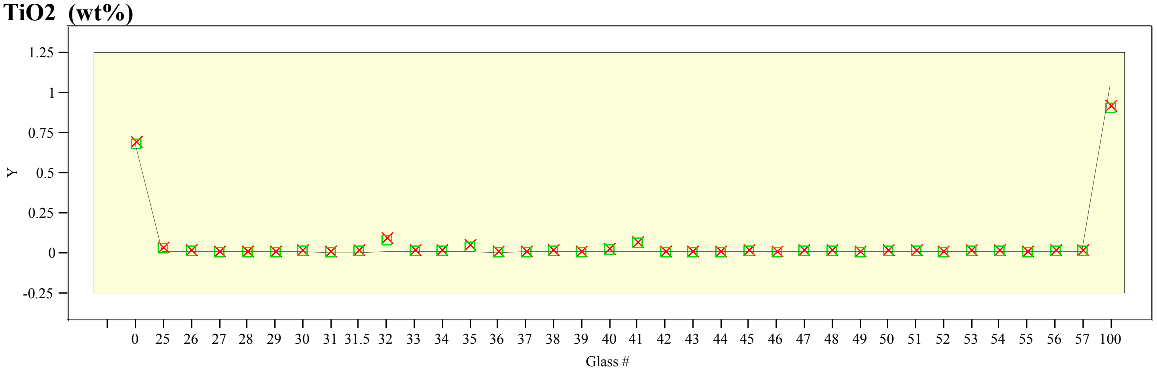


Y ✕ Measured ▫ Measured bc — Targeted

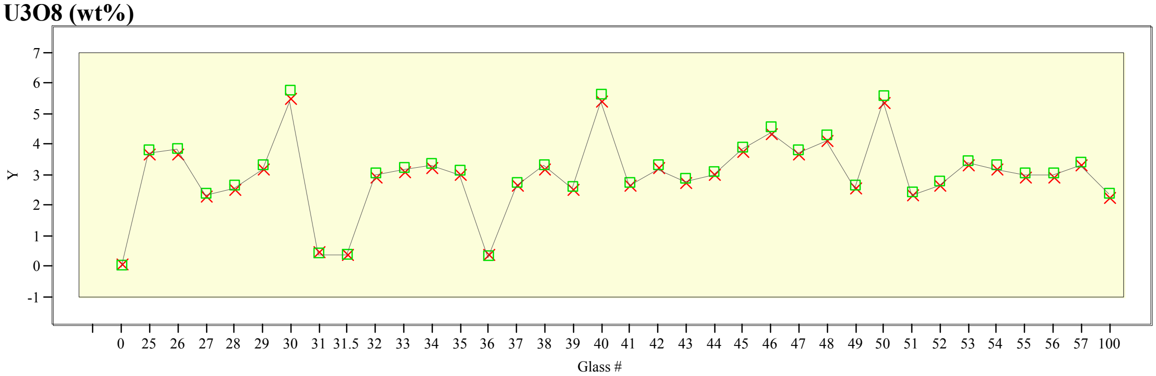
Exhibit E.7: Average Measured and Bias-Corrected (bc) Versus Targeted Compositions by Glass by Oxide *(continued)*

(0 – Batch 1 and 100 – U std)

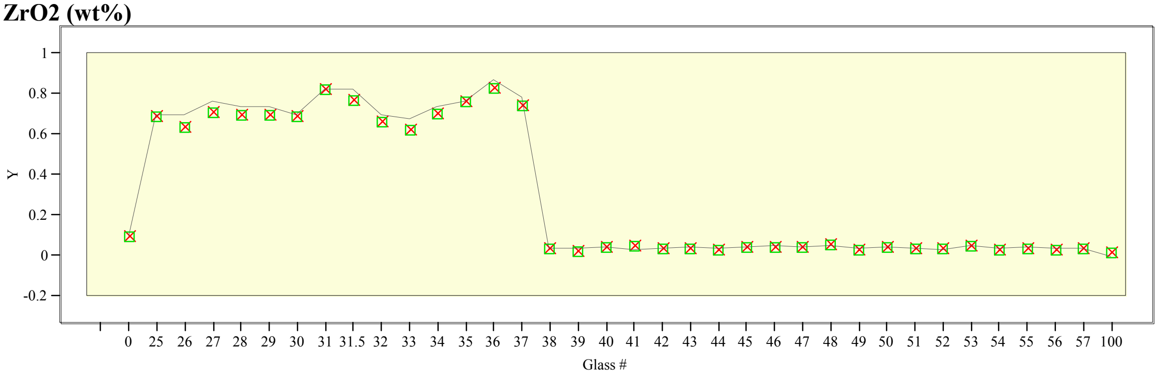
TiO2 (wt%)



U3O8 (wt%)



ZrO2 (wt%)

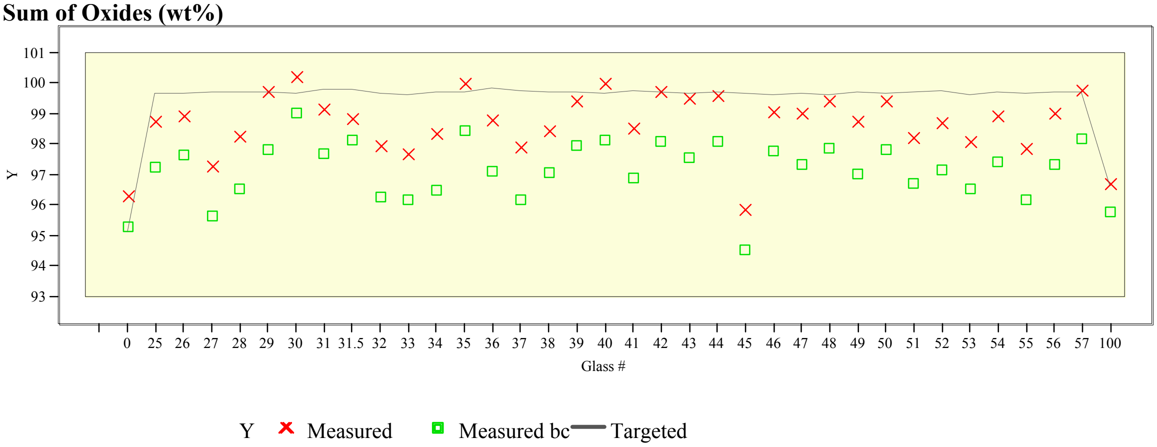


Y × Measured ▫ Measured bc — Targeted

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

(0 – Batch 1 and 100 – U std)

Sum of Oxides (wt%)



Appendix F

XRD PATTERNS OF QUENCHED AND CCC RC GLASSES

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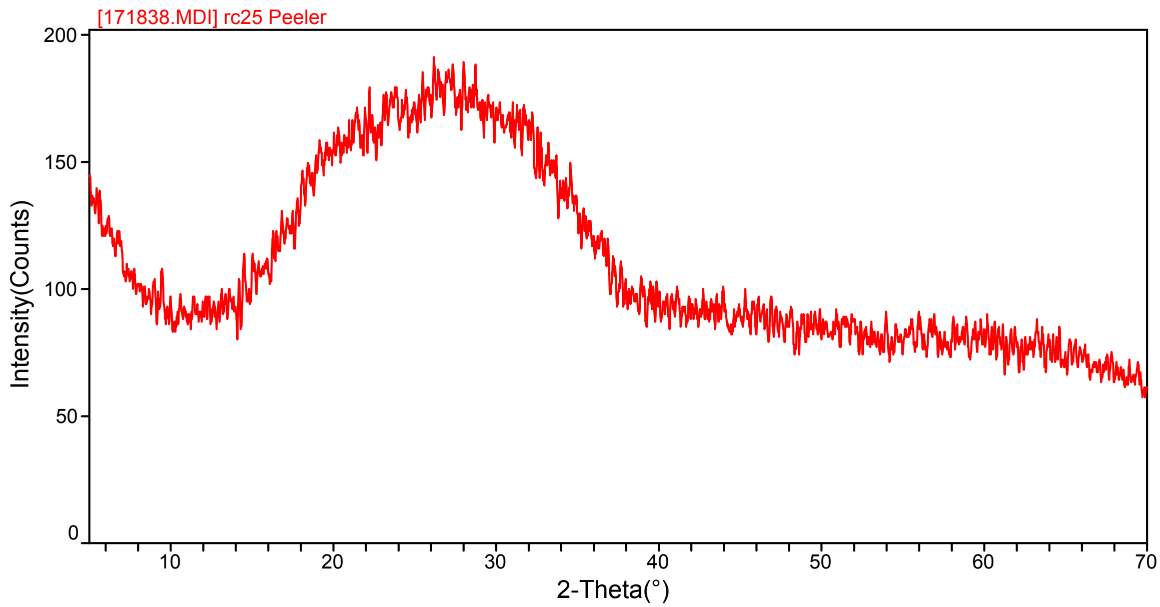

Figure F.1. XRD Pattern of RC-25Q.

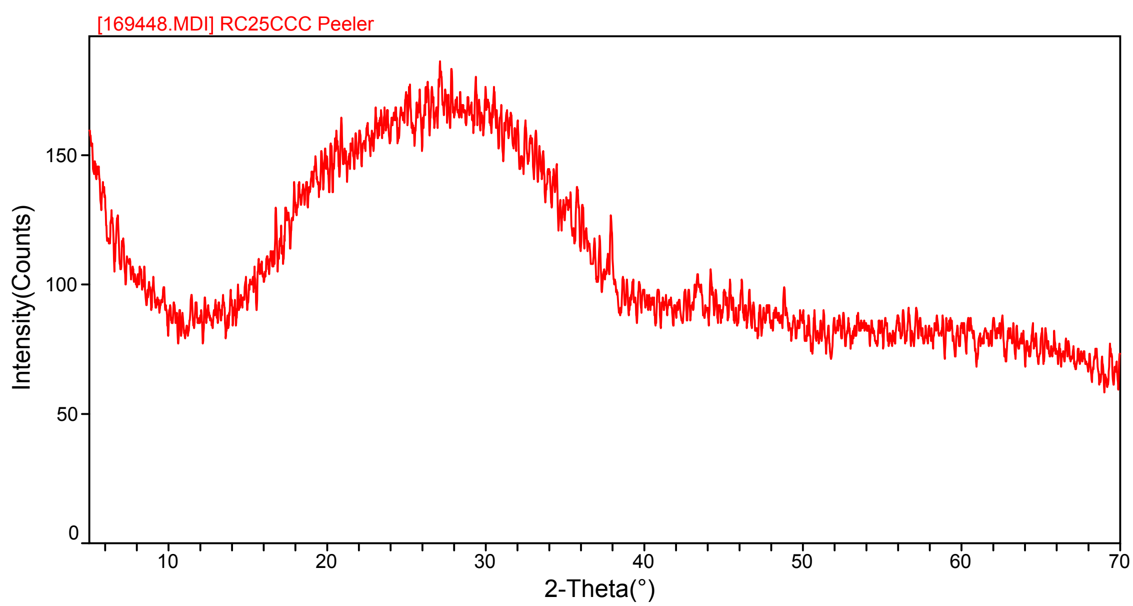

Figure F.2. XRD Pattern of RC-25ccc.

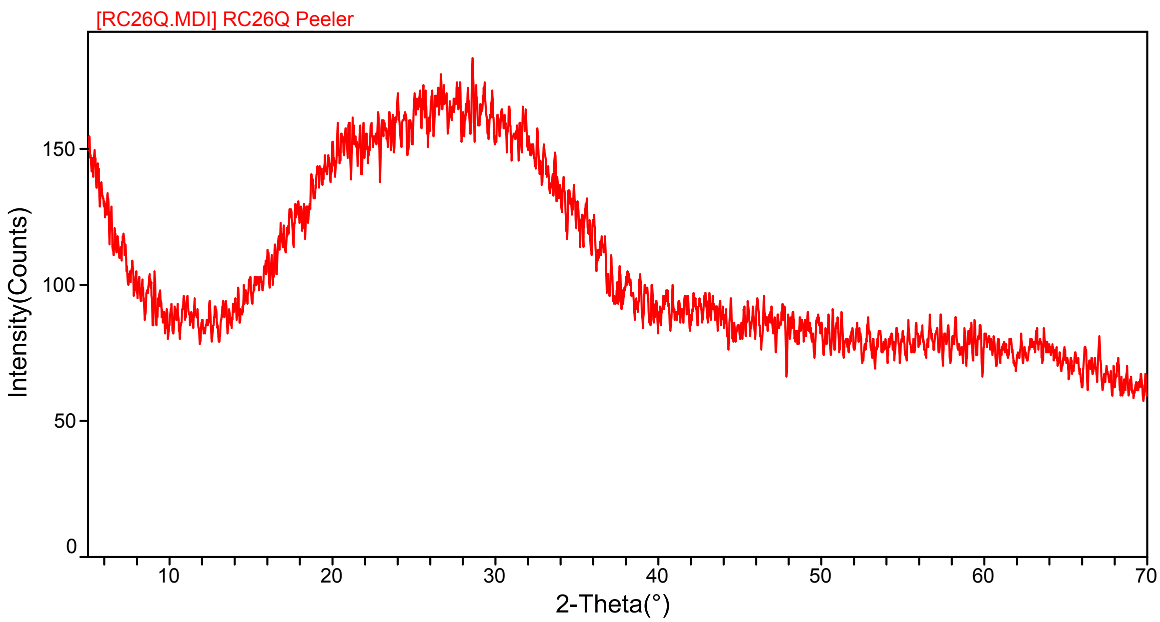

Figure F.3. XRD Pattern of RC-26Q.

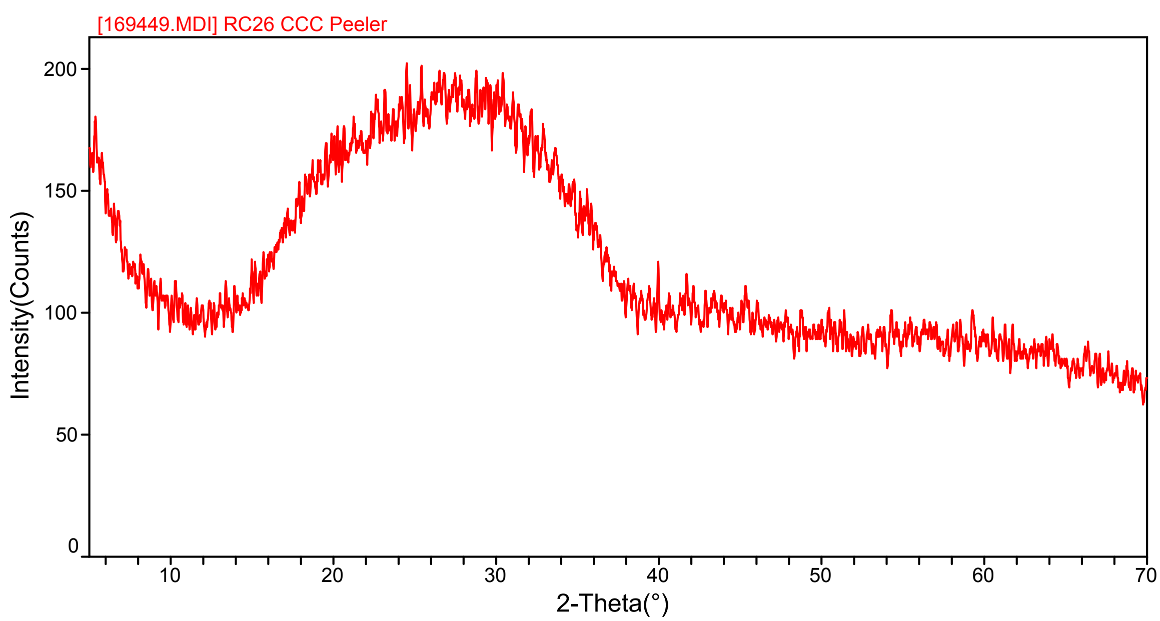

Figure F.4. XRD Pattern of RC-26ccc.

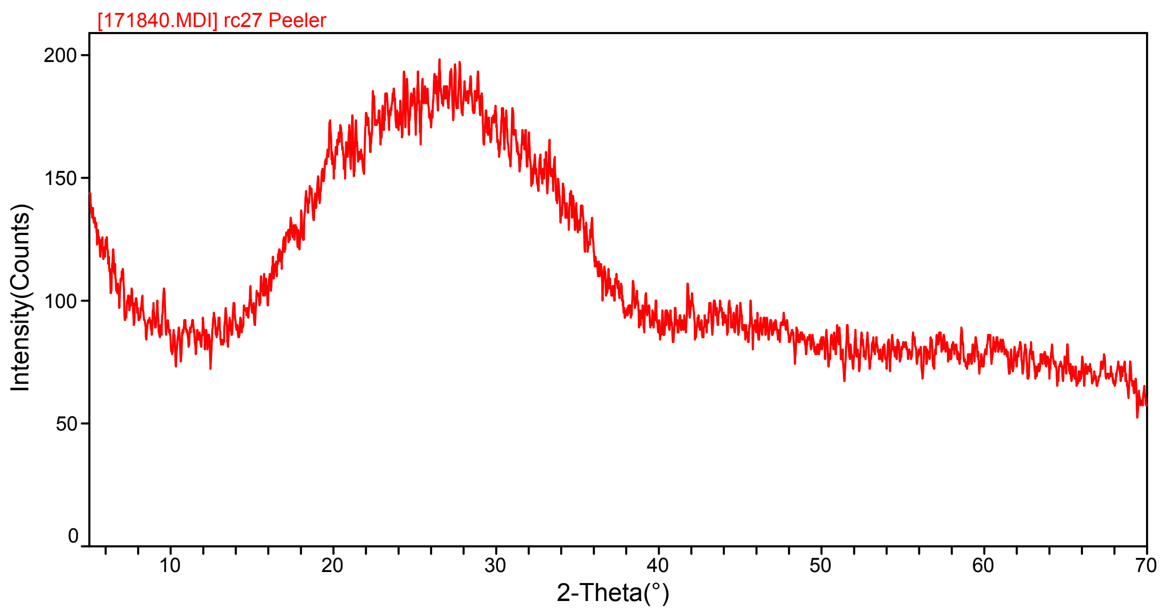

Figure F.5. XRD Pattern of RC-27Q.

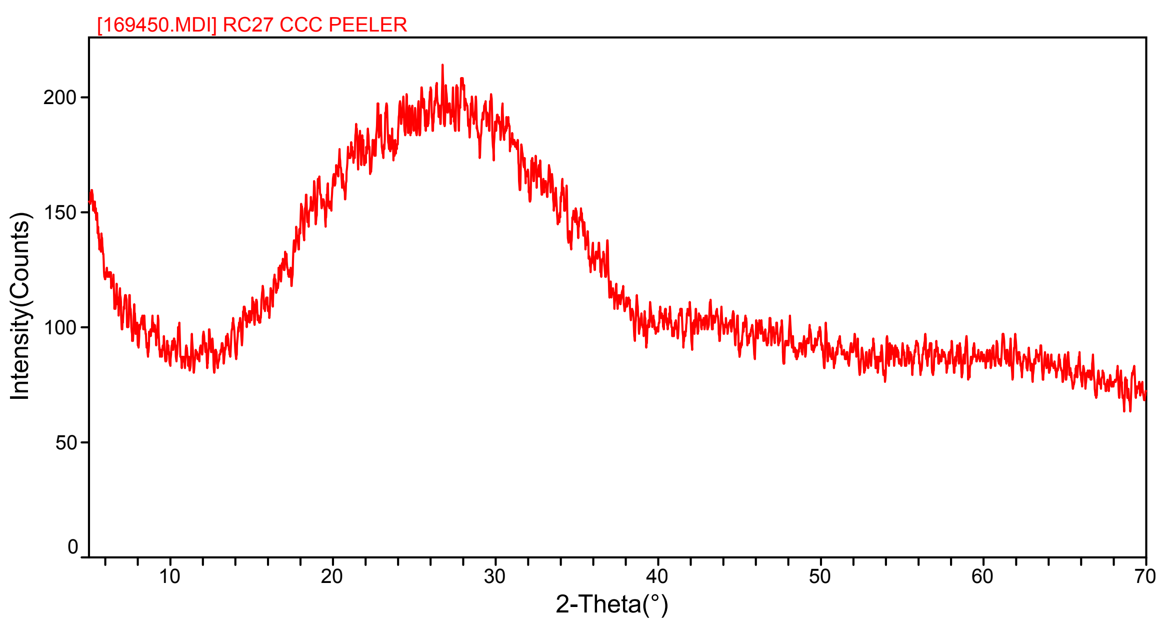

Figure F.6. XRD Pattern of RC-27ccc.

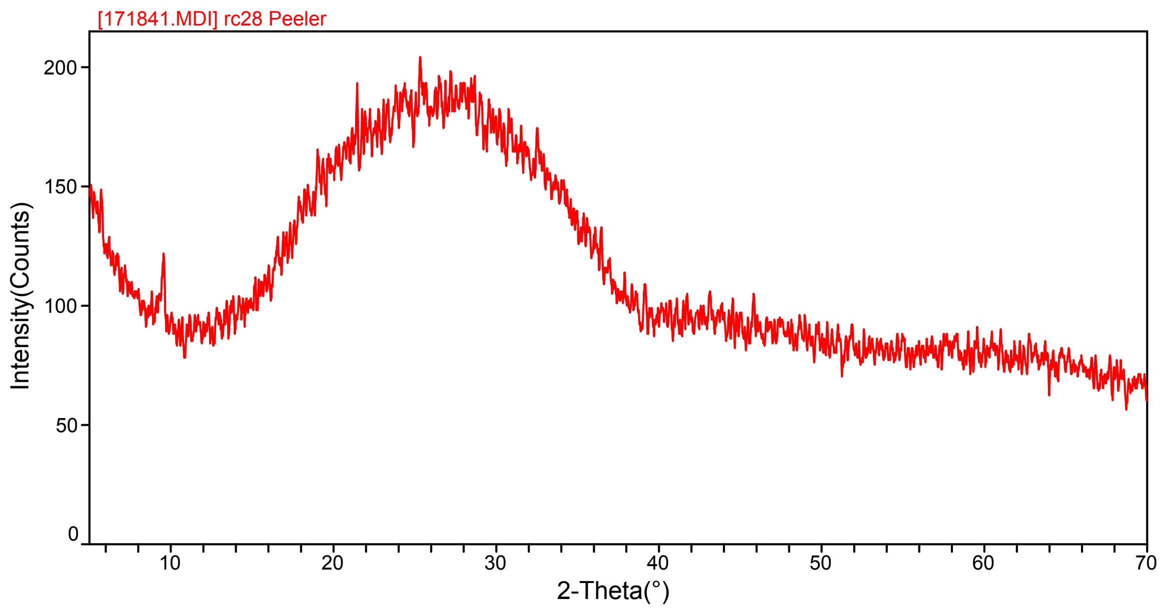

Figure F.7. XRD Pattern of RC-28Q.

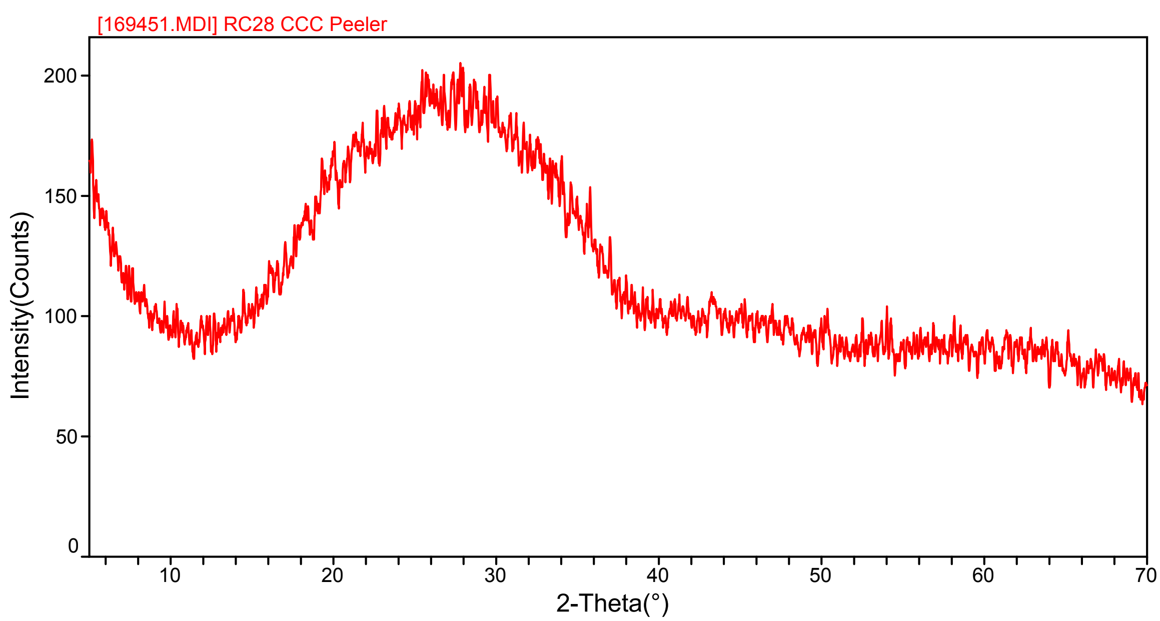

Figure F.8. XRD Pattern of RC-28ccc.

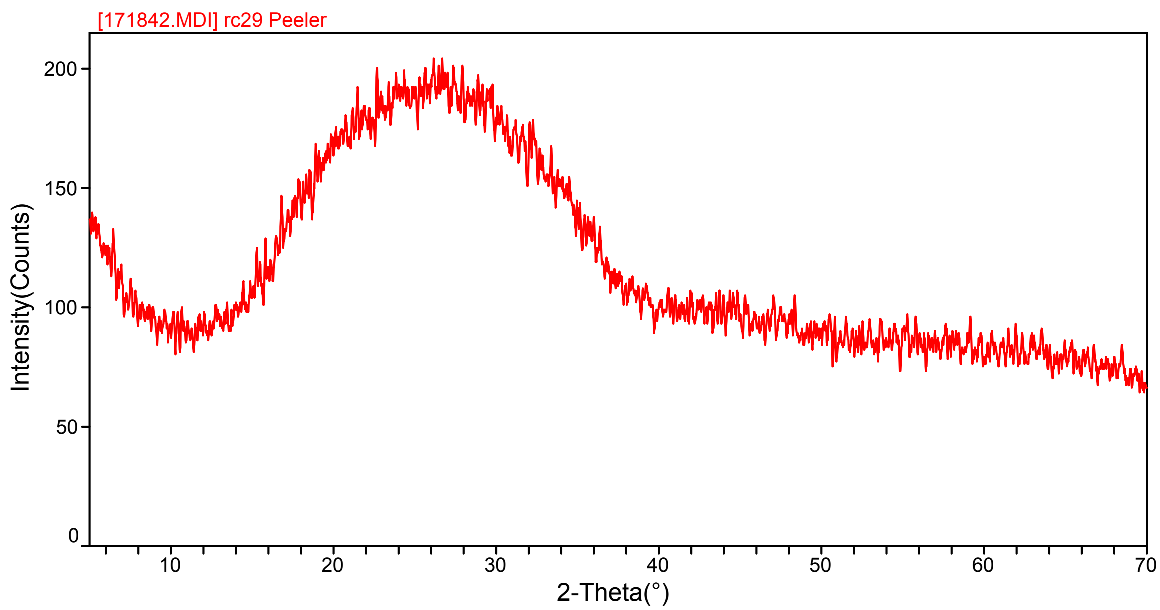

Figure F.9. XRD Pattern of RC-29Q.

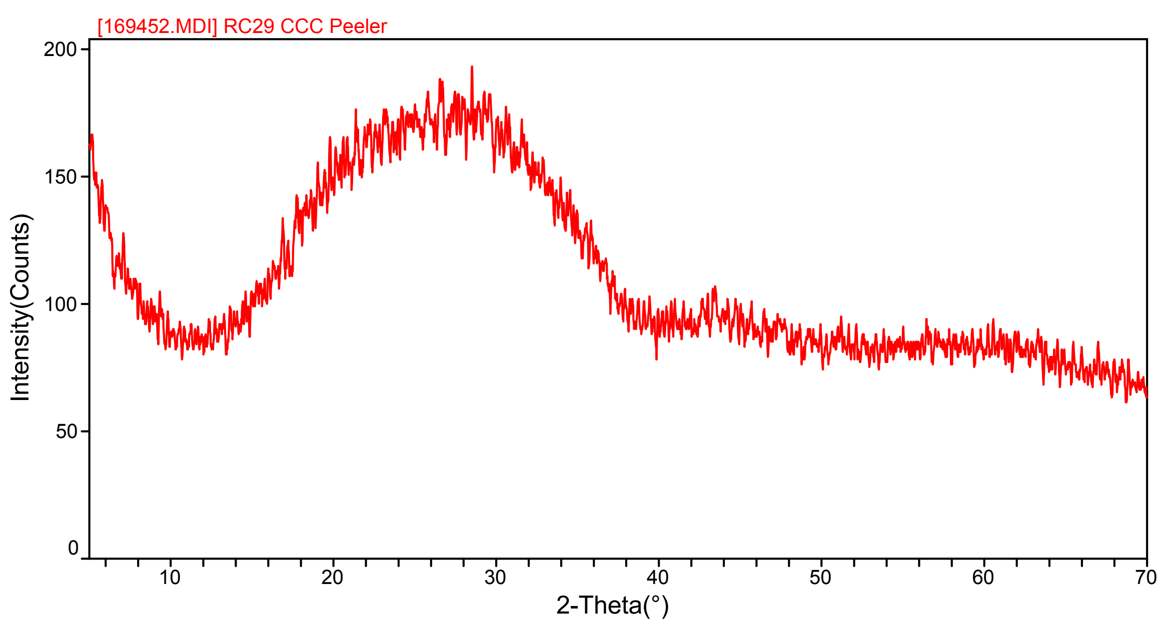

Figure F.10. XRD Pattern of RC-29ccc.

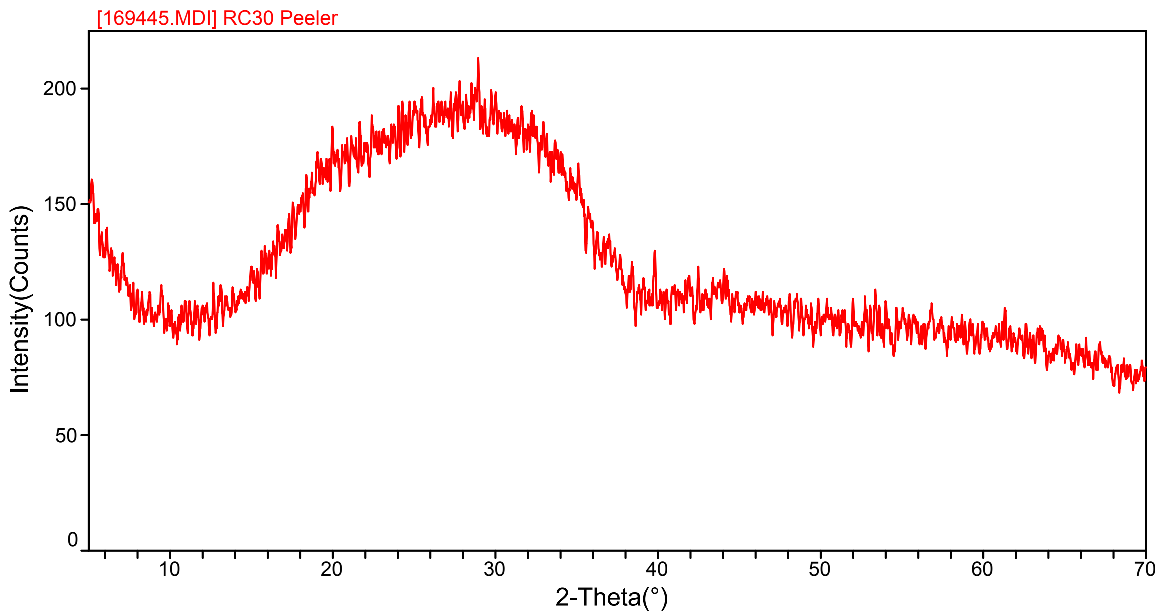

Figure F.11. XRD Pattern of RC-30Q.

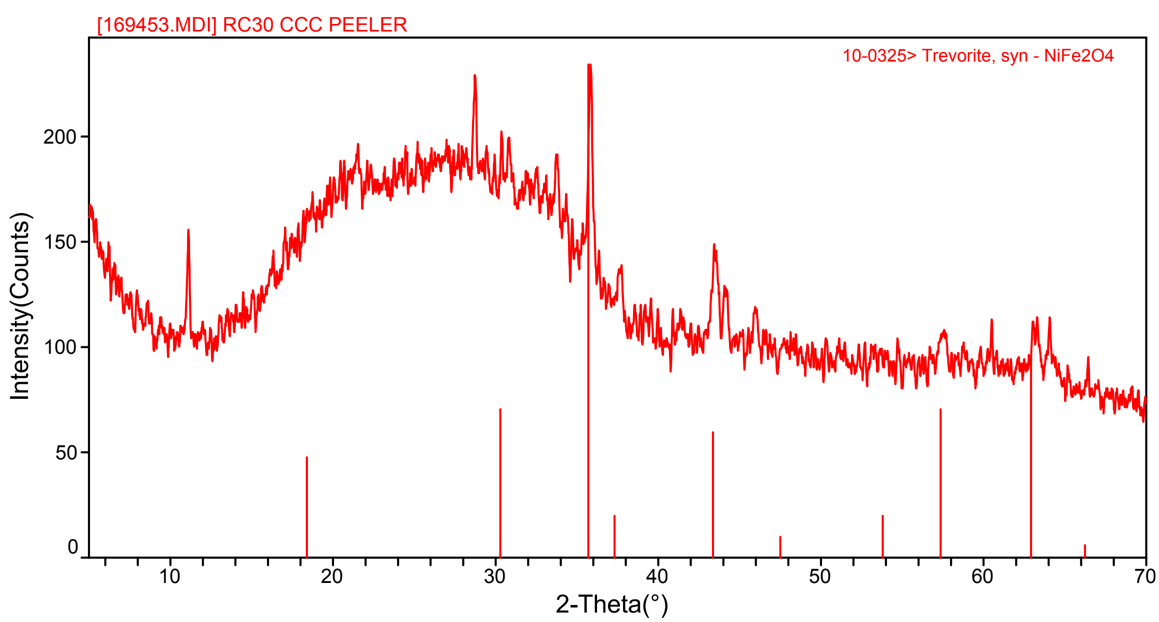

Figure F.12. XRD Pattern of RC-30ccc.

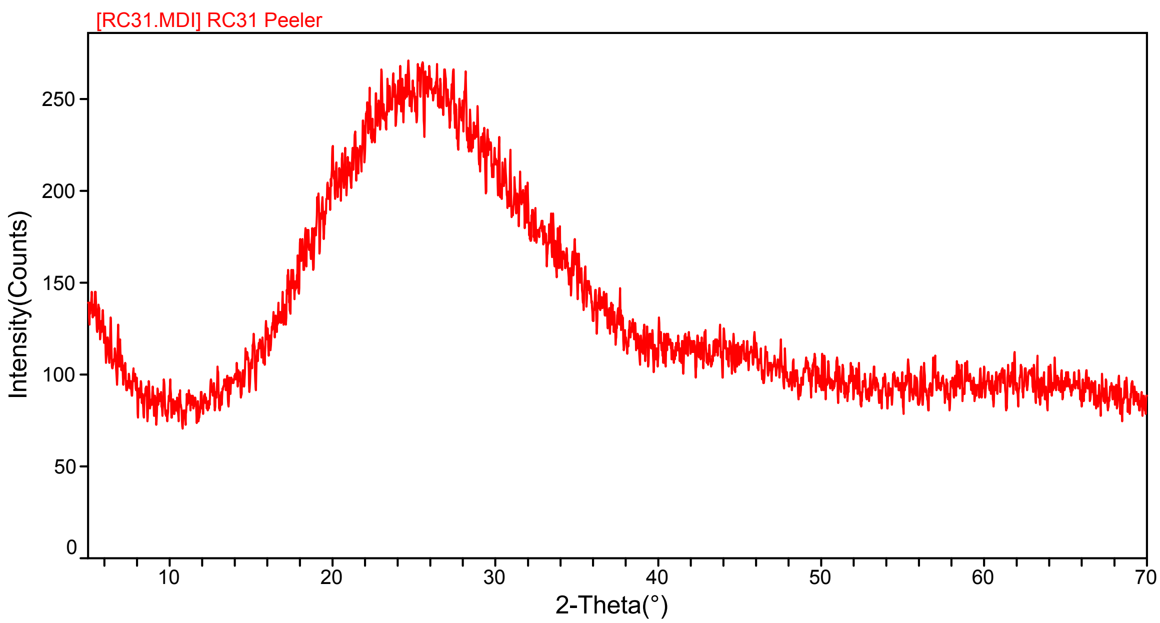

Figure F.13. XRD Pattern of RC-31Q.

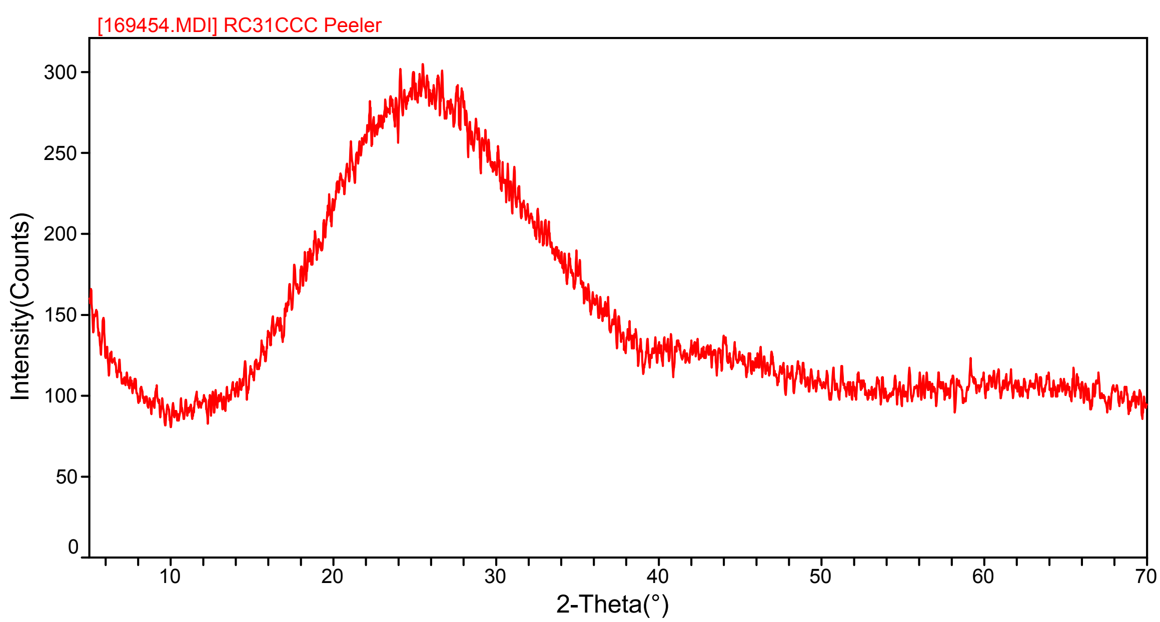

Figure F.14. XRD Pattern of RC-31ccc.

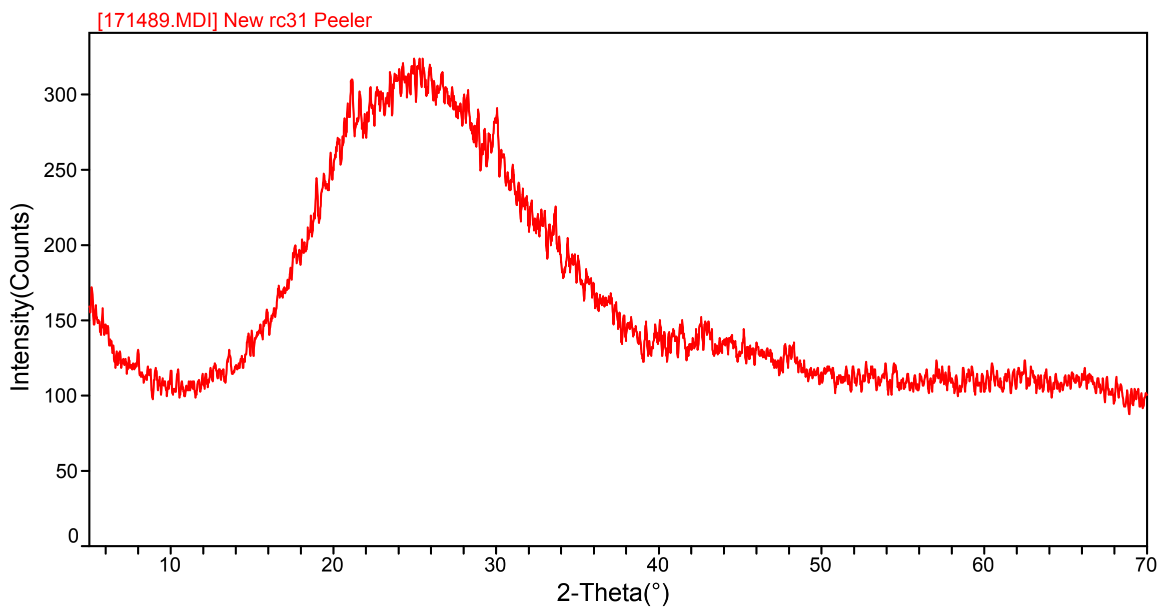

Figure F.15. XRD Pattern of RC-31.5Q.

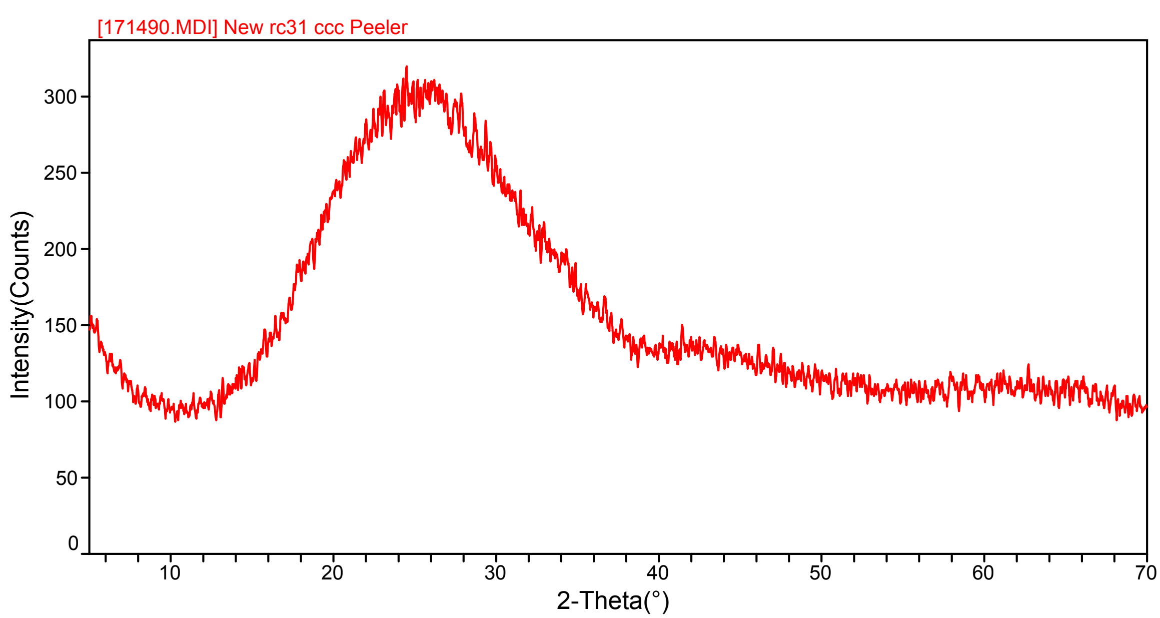

Figure F.16. XRD Pattern of RC-31.5ccc.

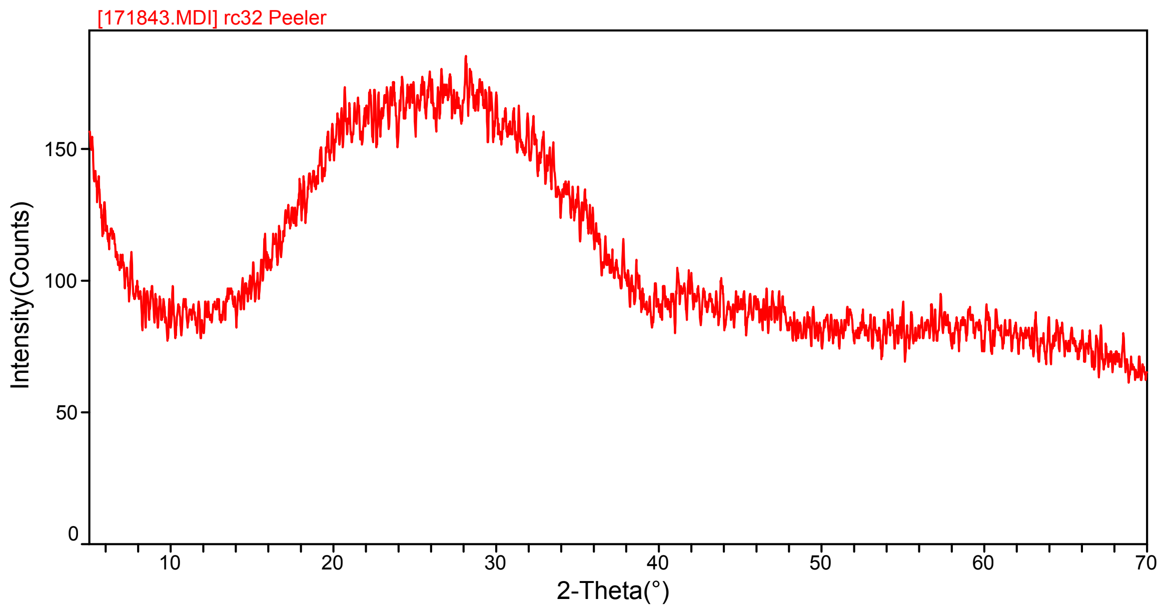

Figure F.17. XRD Pattern of RC-32Q.

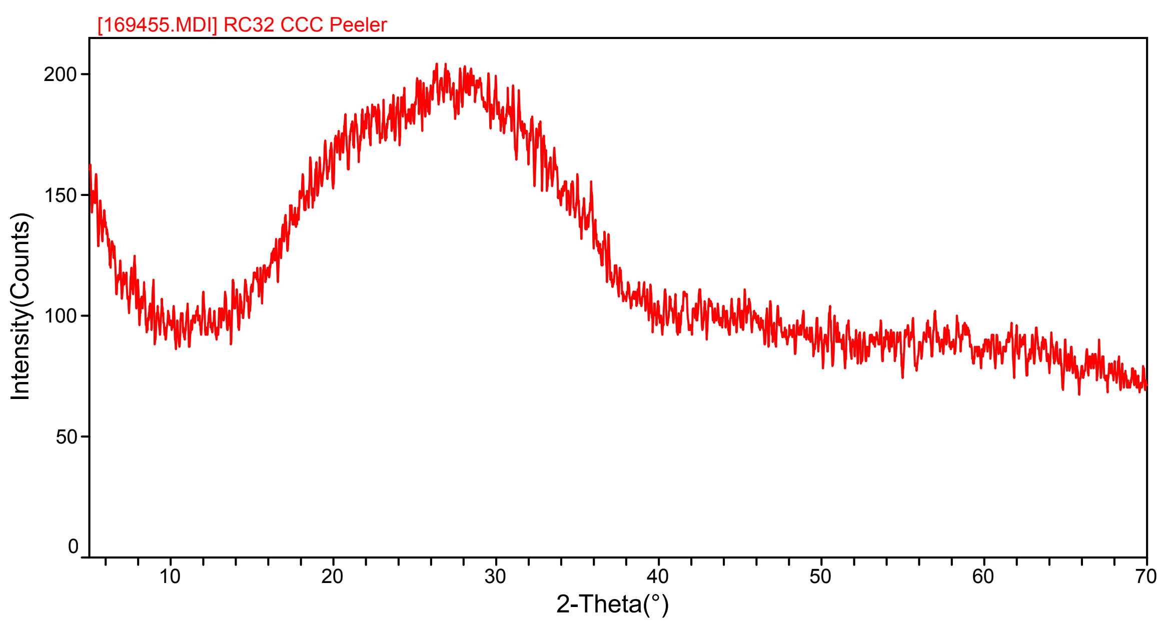

Figure F.18. XRD Pattern of RC-32ccc.

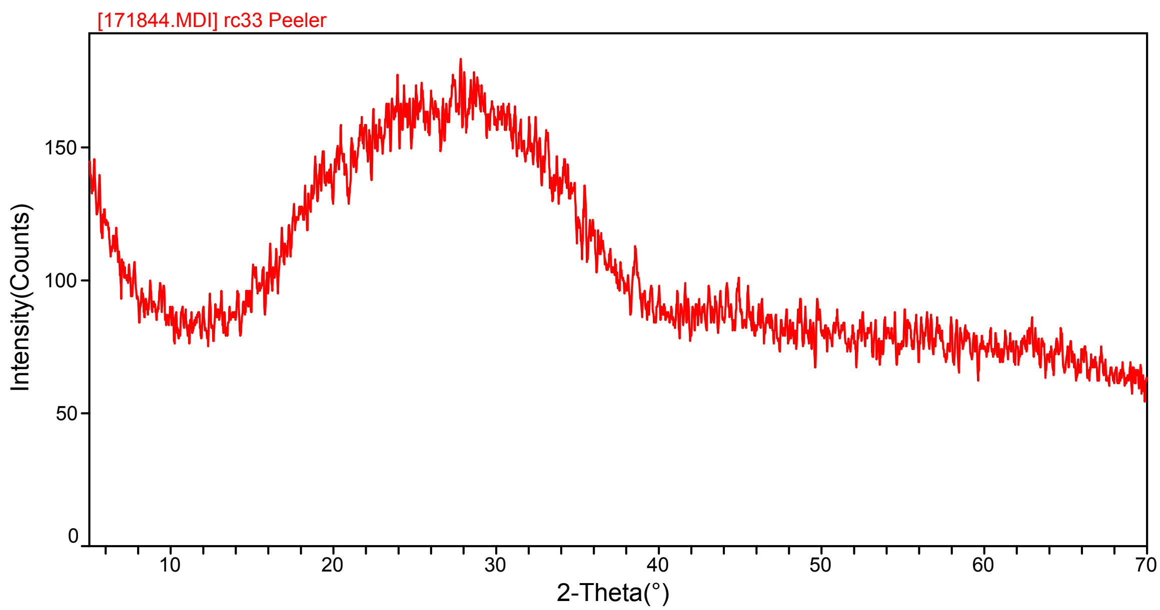

Figure F.19. XRD Pattern of RC-33Q.

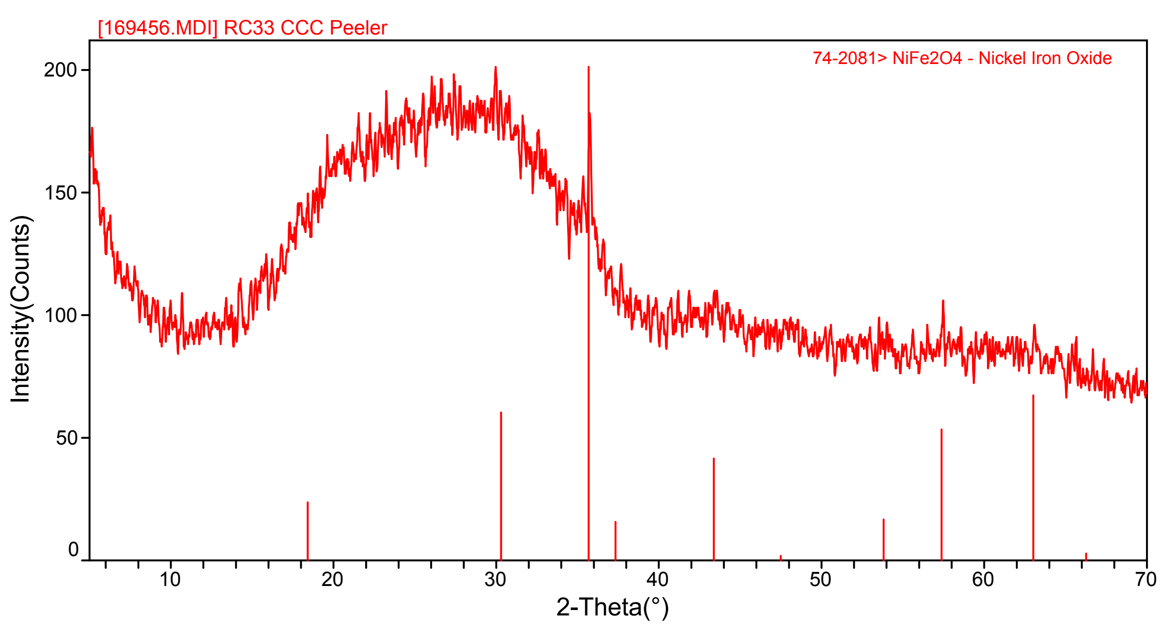

Figure F.20. XRD Pattern of RC-33ccc.

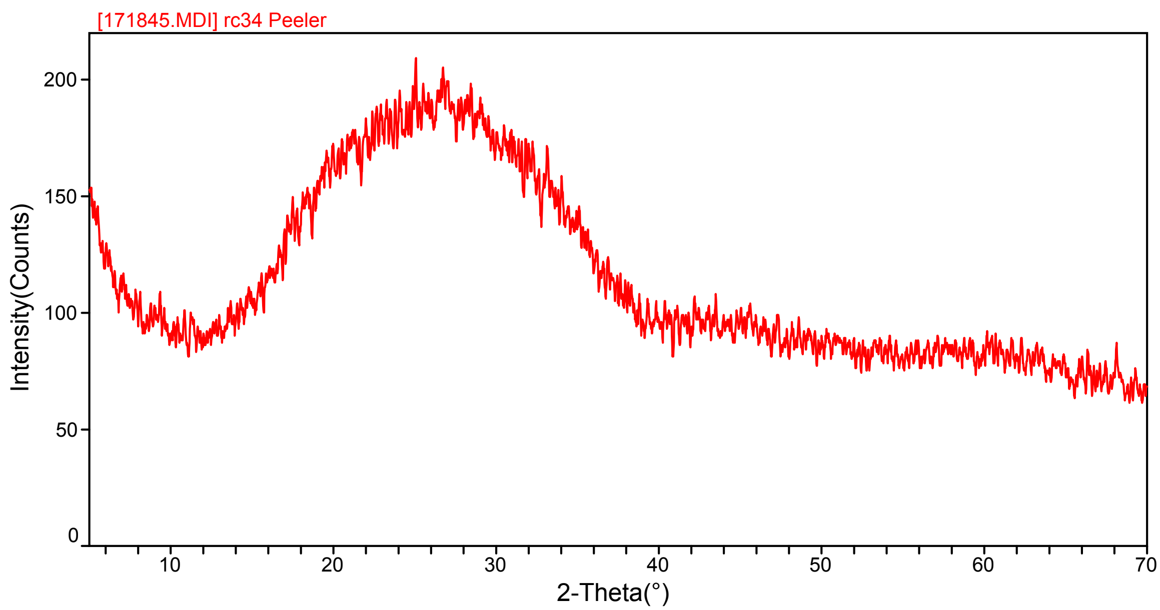

Figure F.21. XRD Pattern of RC-34Q.

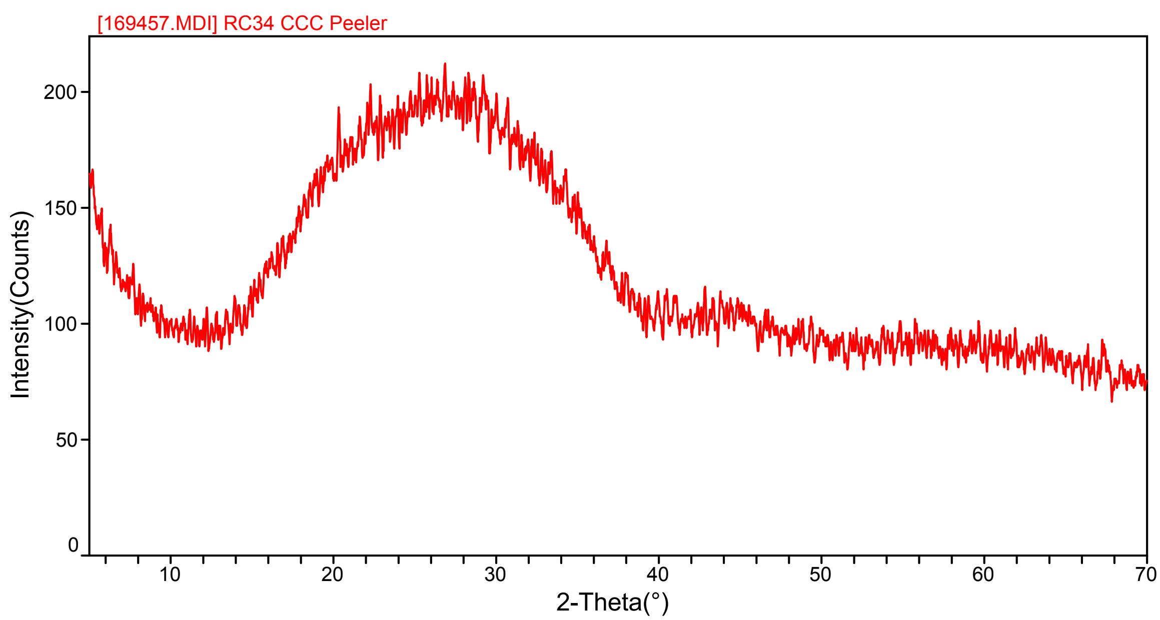

Figure F.22. XRD Pattern of RC-34ccc.

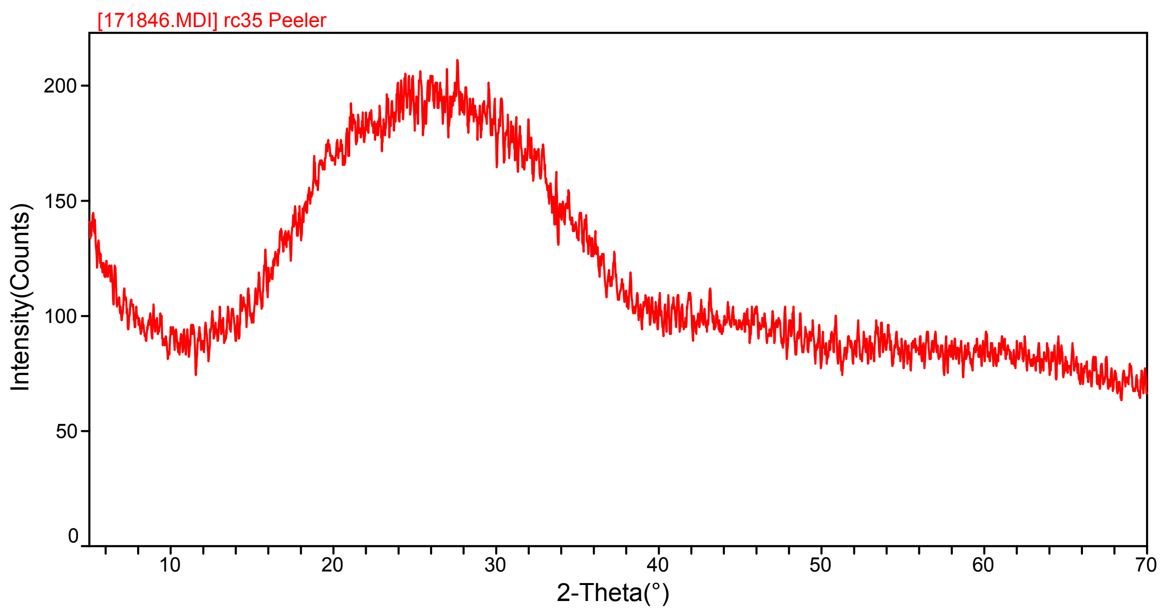

Figure F.23. XRD Pattern of RC-35Q.

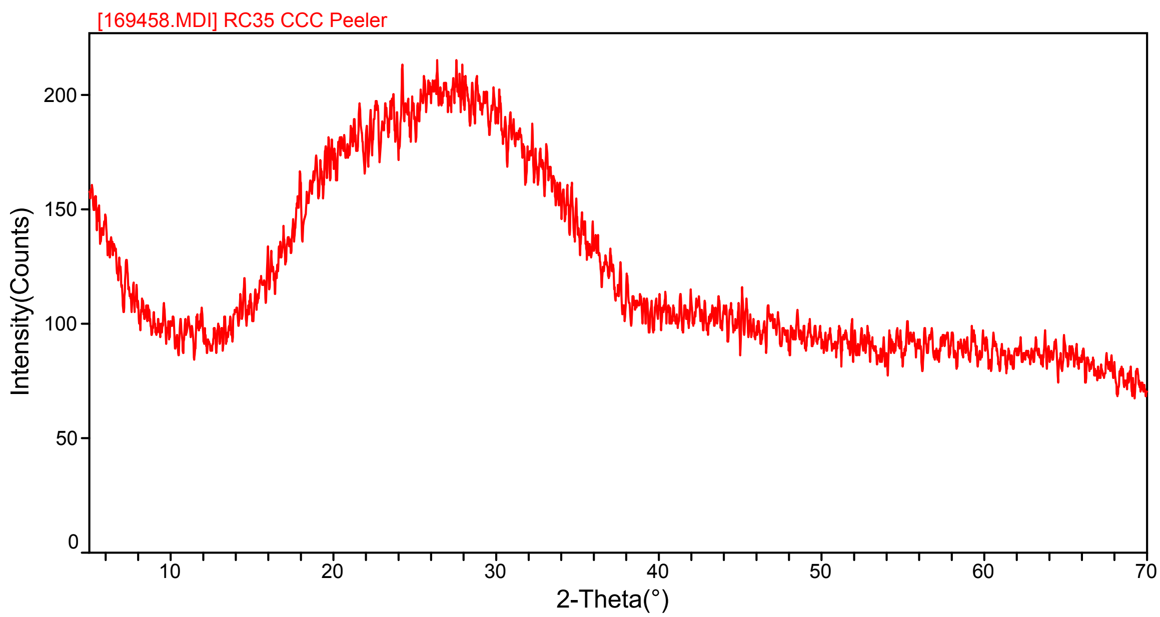

Figure F.24. XRD Pattern of RC-35ccc.

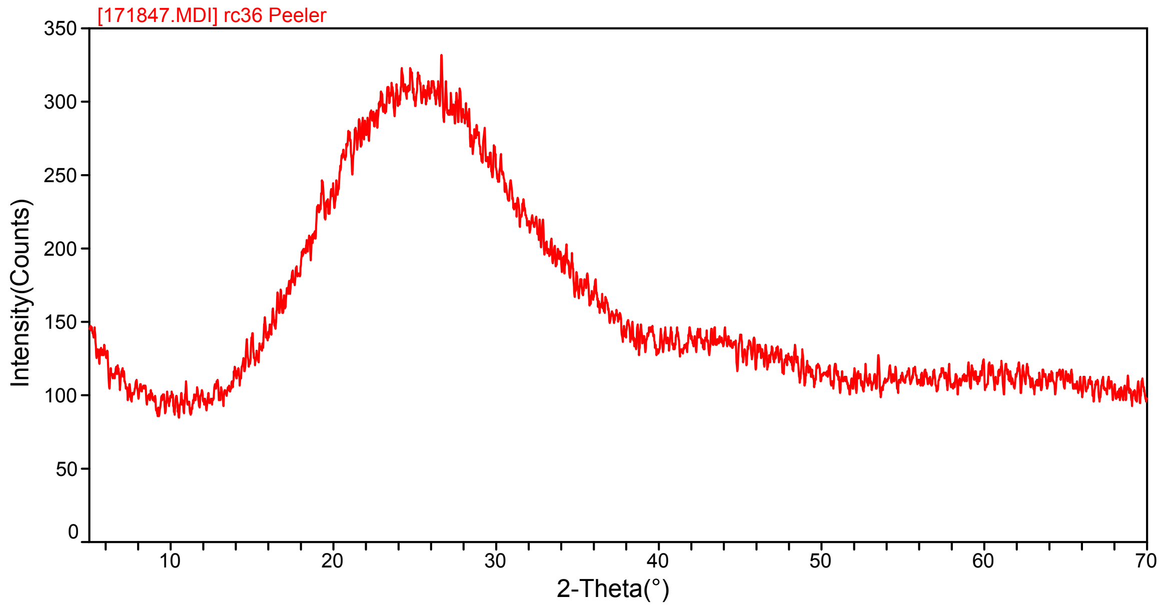

Figure F.25. XRD Pattern of RC-36Q.

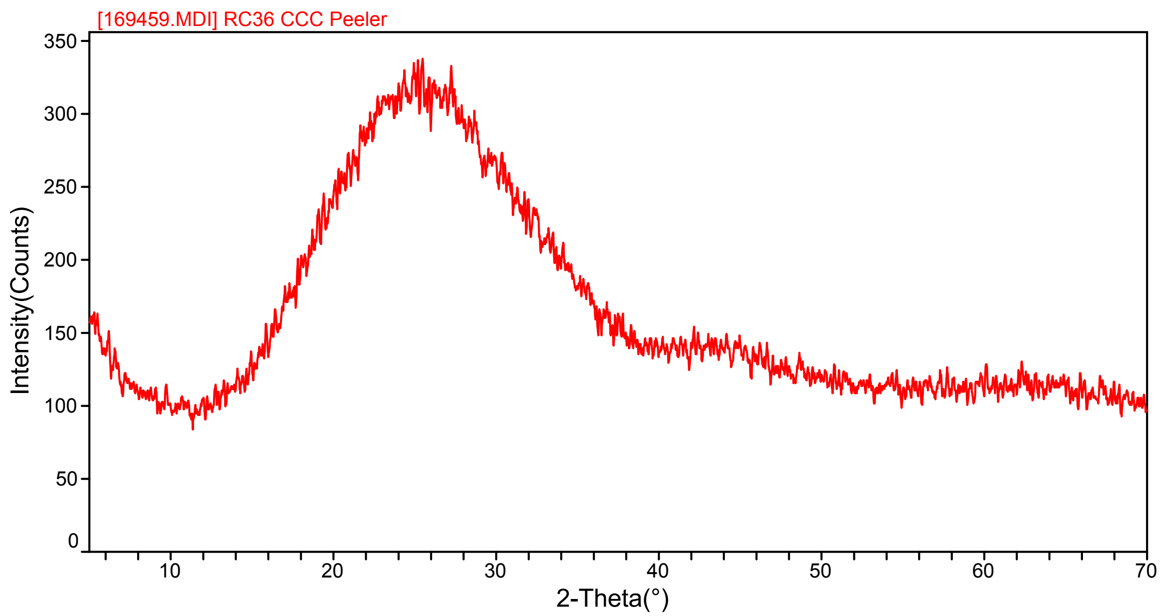

Figure F.26. XRD Pattern of RC-36ccc.

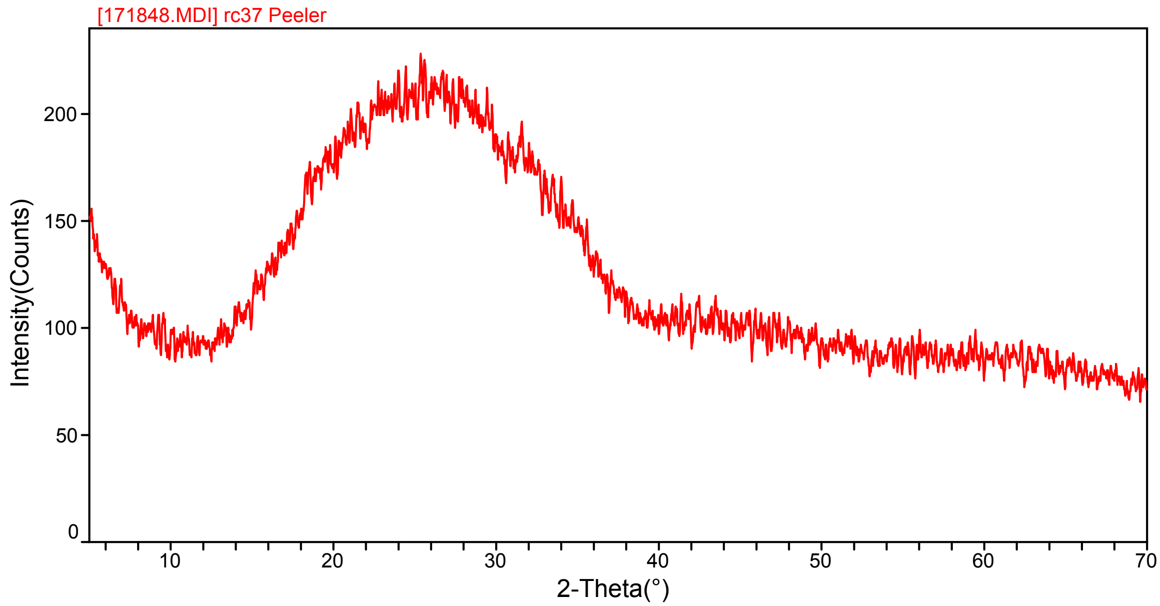

Figure F.27. XRD Pattern of RC-37Q.

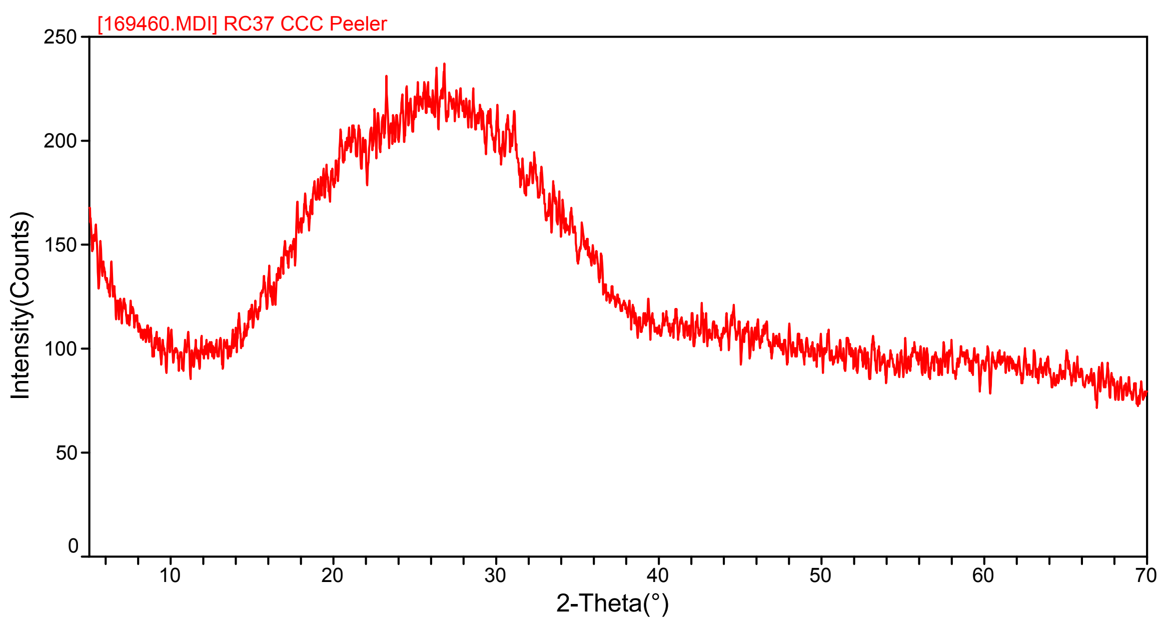

Figure F.28. XRD Pattern of RC-37ccc.

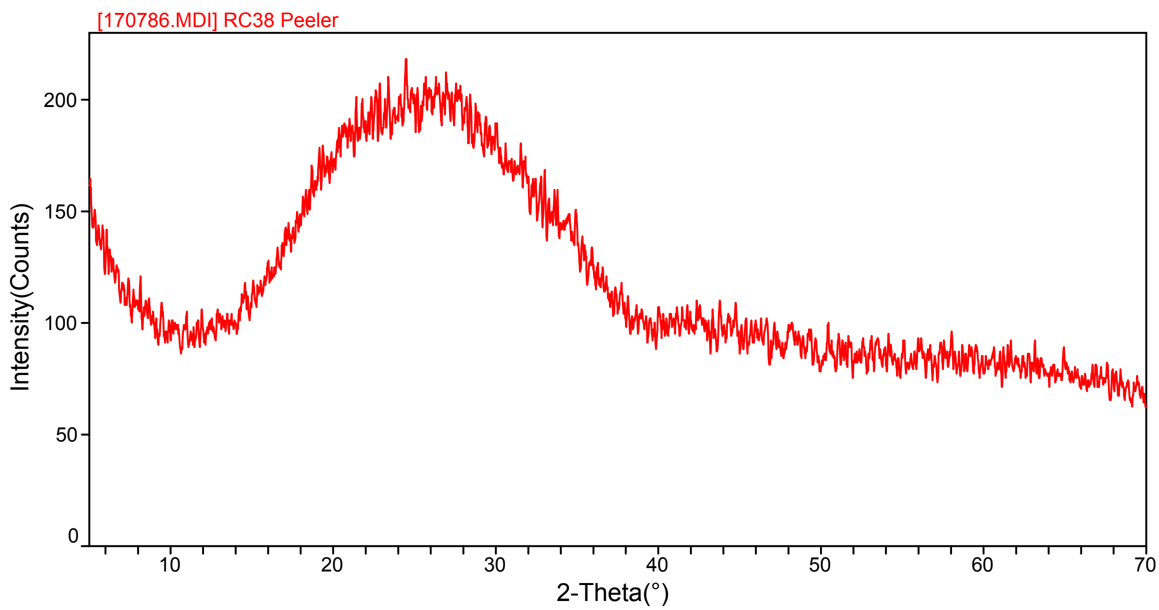

Figure F.29. XRD Pattern of RC-38Q.

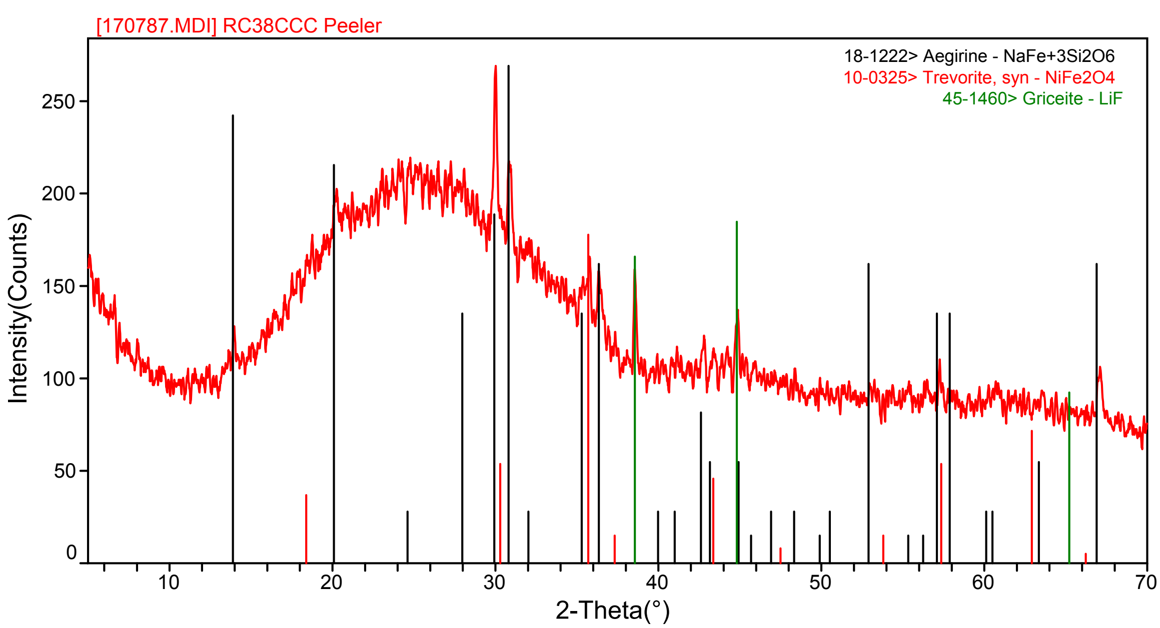

Figure F.30. XRD Pattern of RC-38ccc.

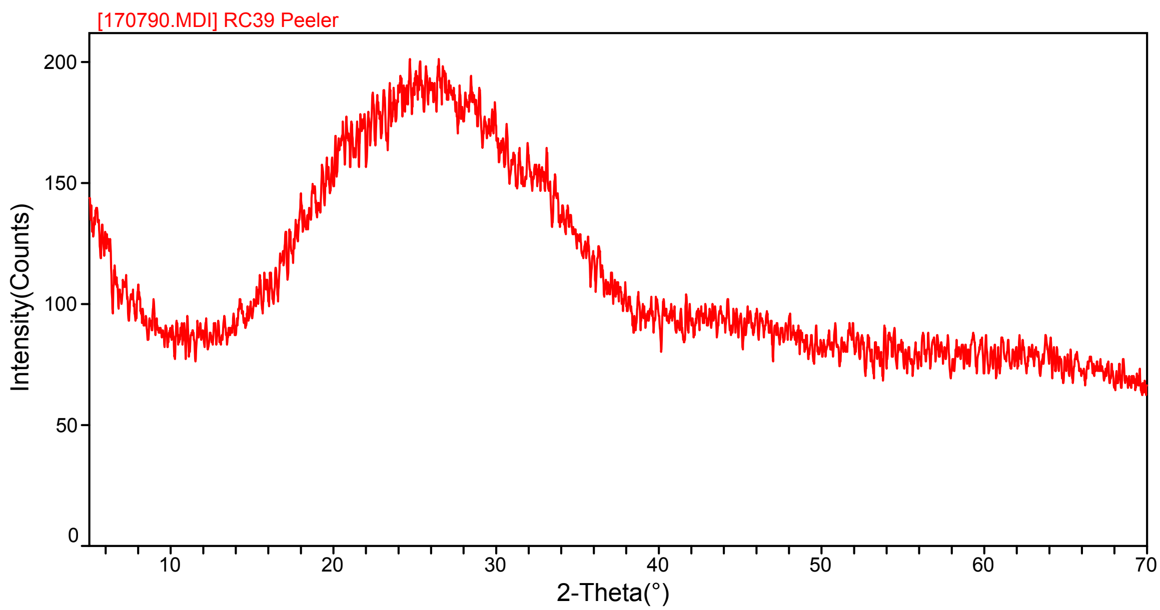

Figure F.31. XRD Pattern of RC-39Q.

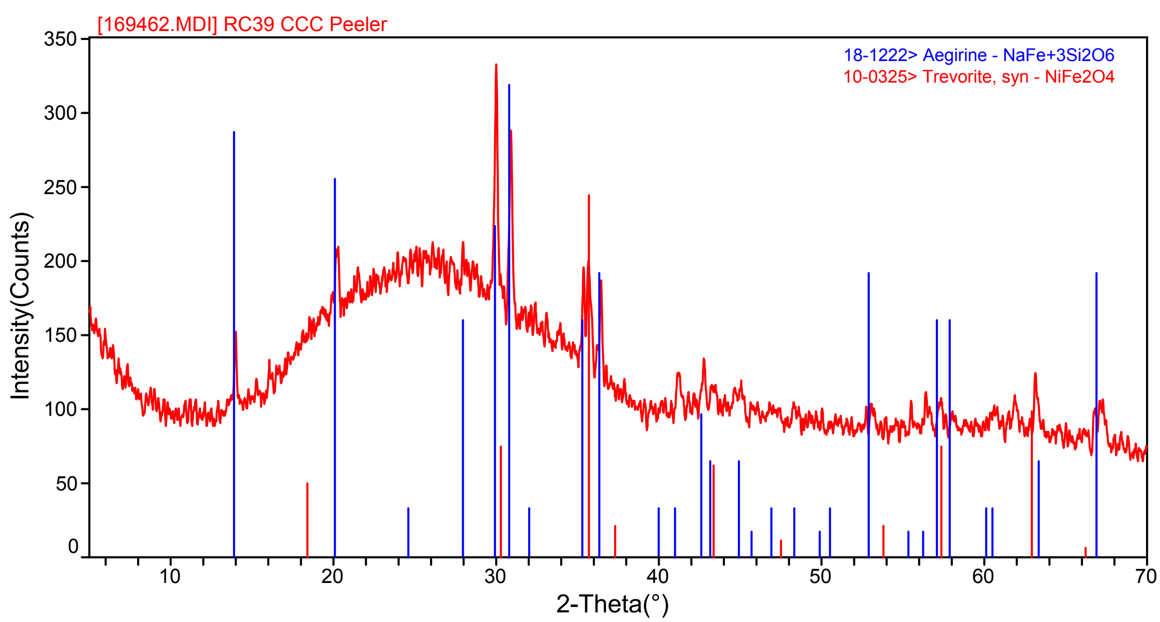

Figure F.32. XRD Pattern of RC-39ccc.

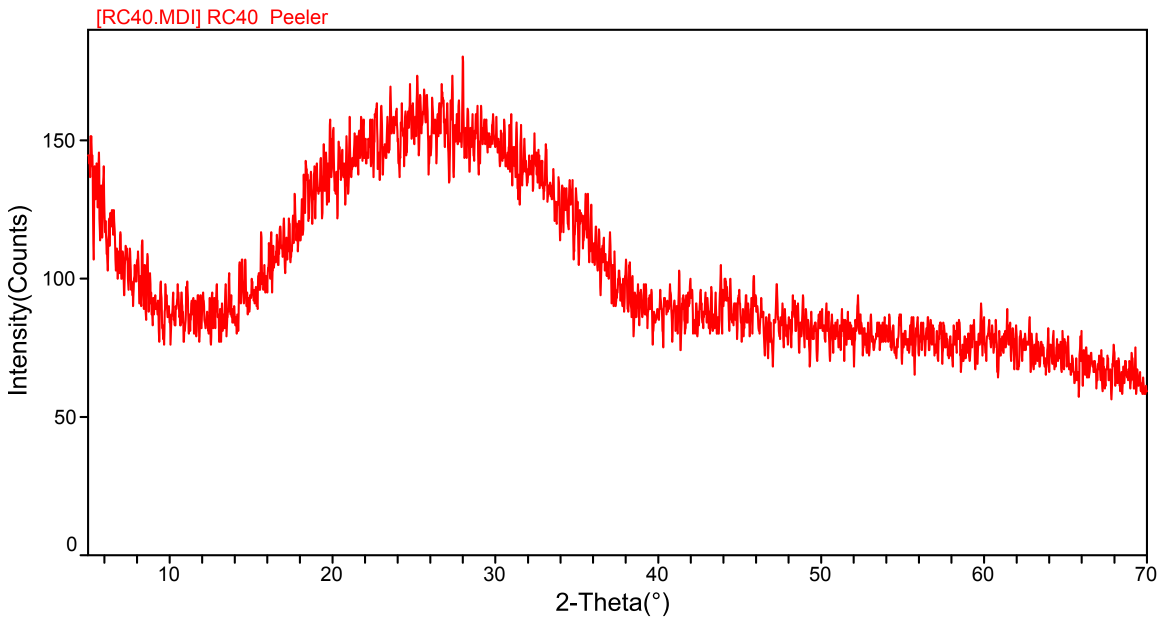

Figure F.33. XRD Pattern of RC-40Q.

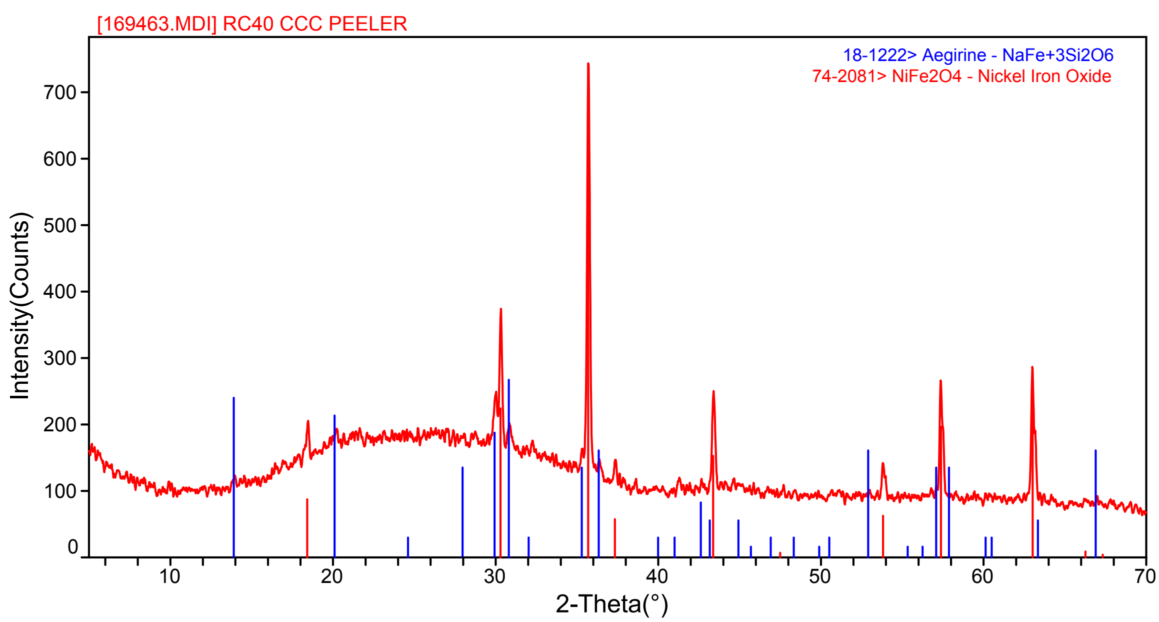

Figure F.34. XRD Pattern of RC-40ccc.

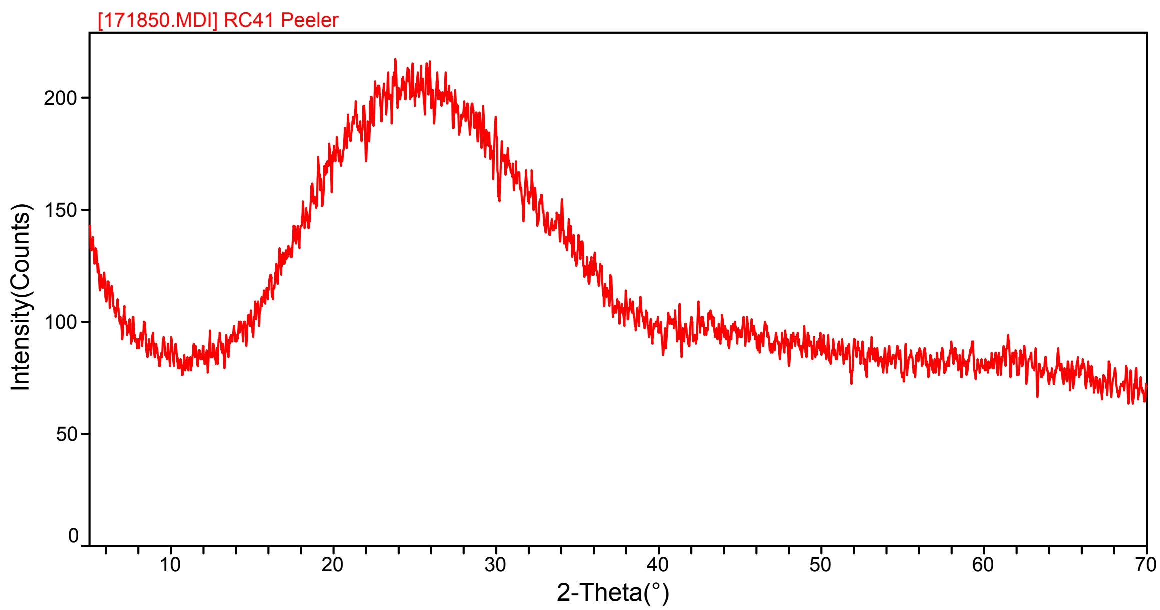

Figure F.35. XRD Pattern of RC-41Q.

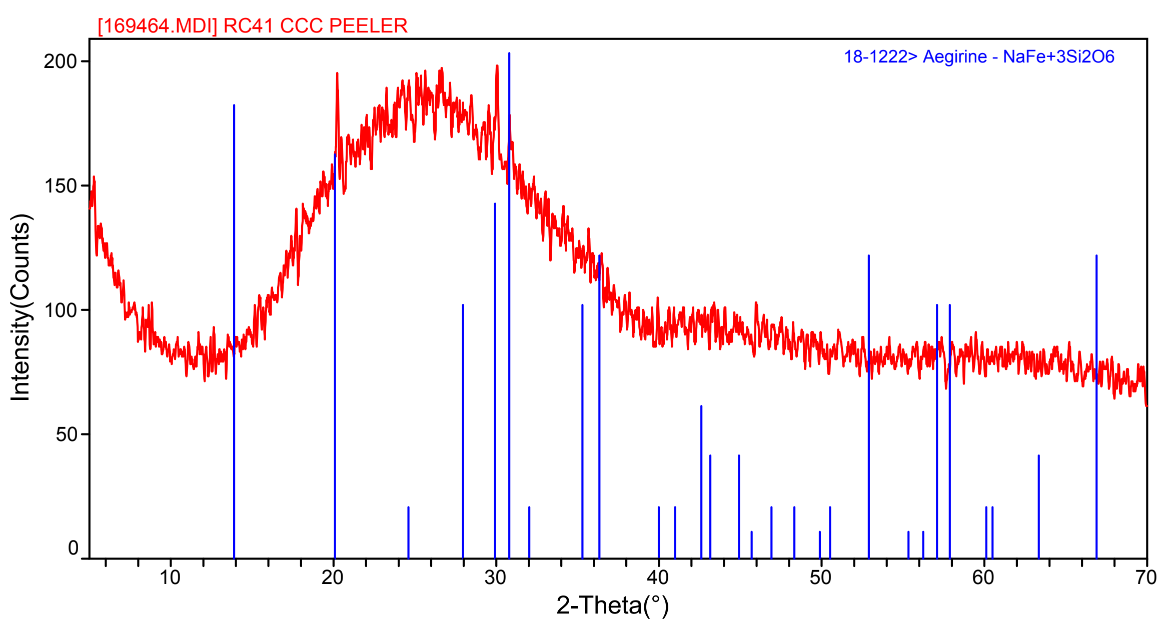

Figure F.36. XRD Pattern of RC-41ccc.

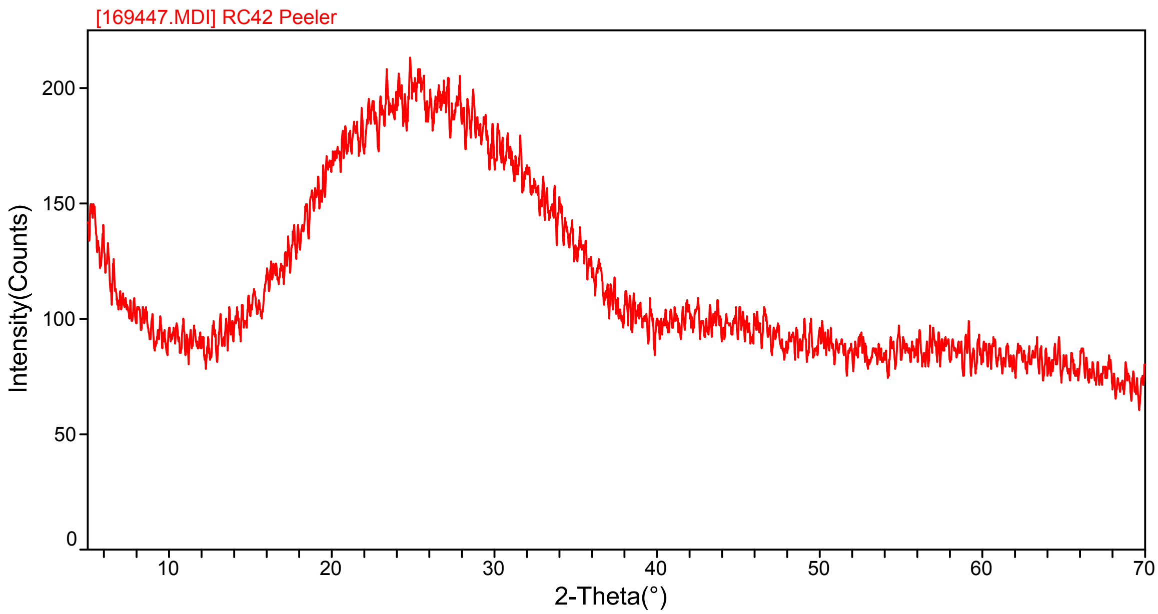

Figure F.37. XRD Pattern of RC-42Q.

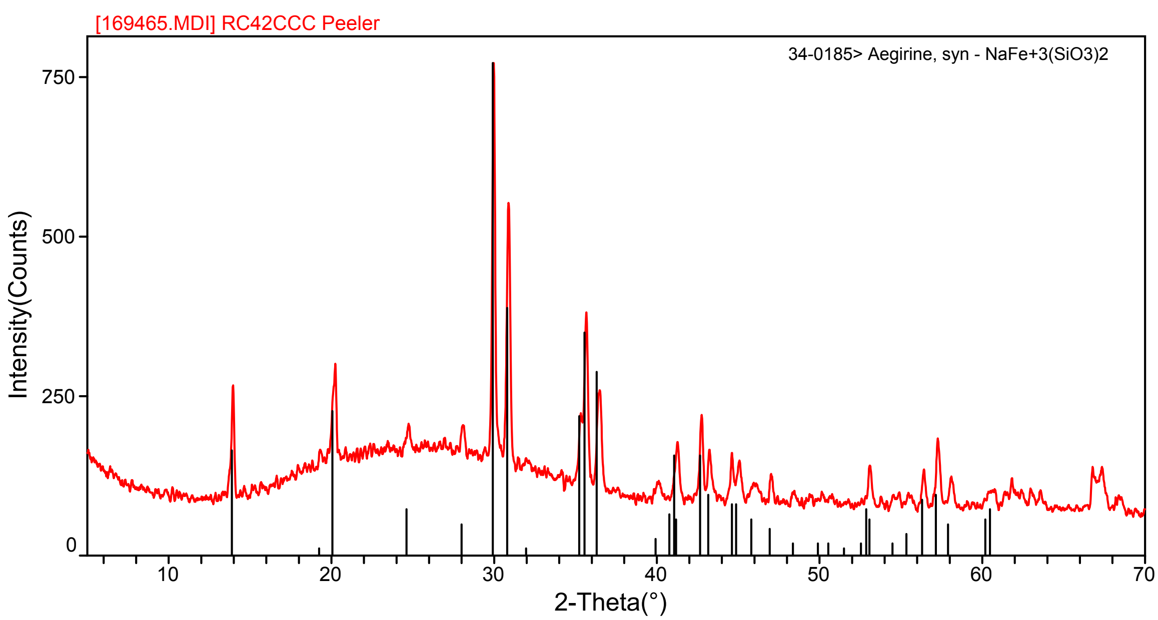

Figure F.38. XRD Pattern of RC-42ccc.

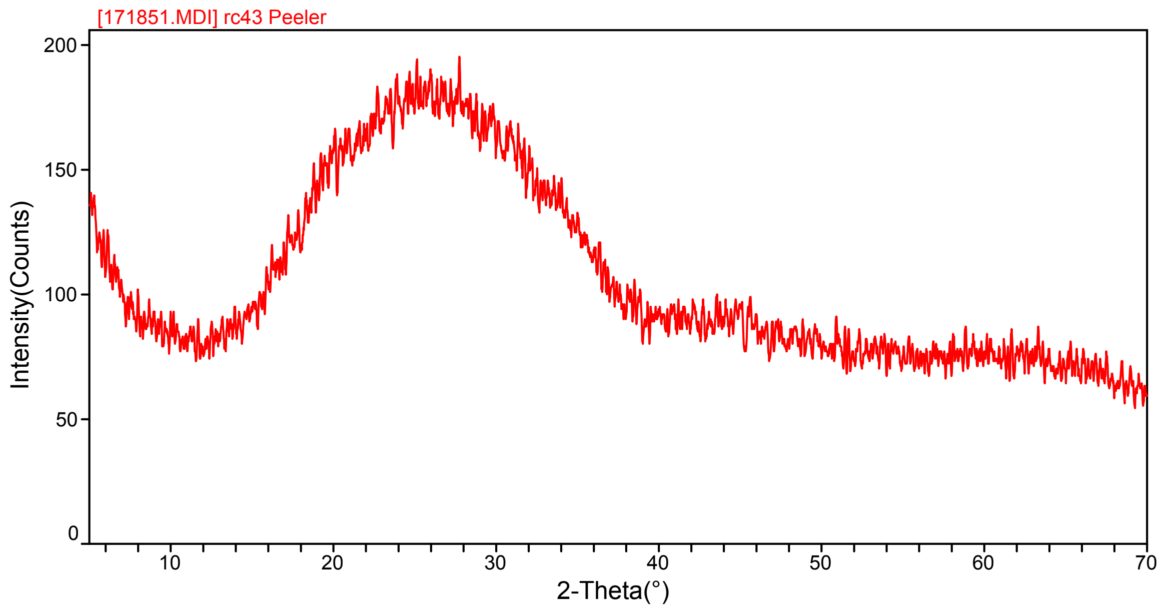

Figure F.39. XRD Pattern of RC-43Q.

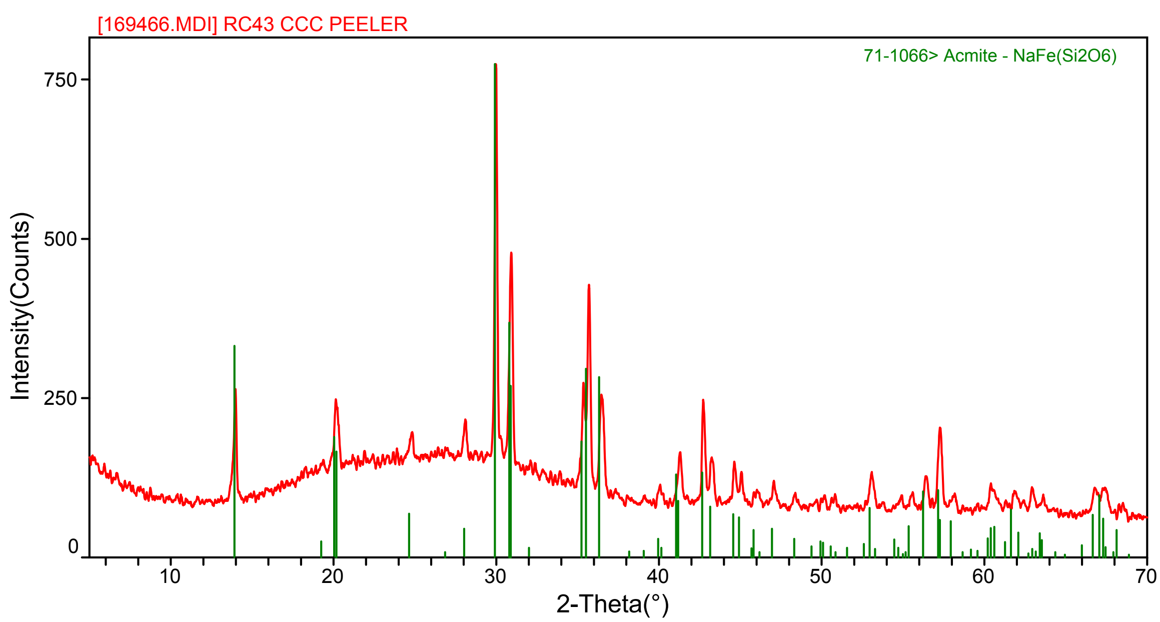

Figure F.40. XRD Pattern of RC-43ccc.

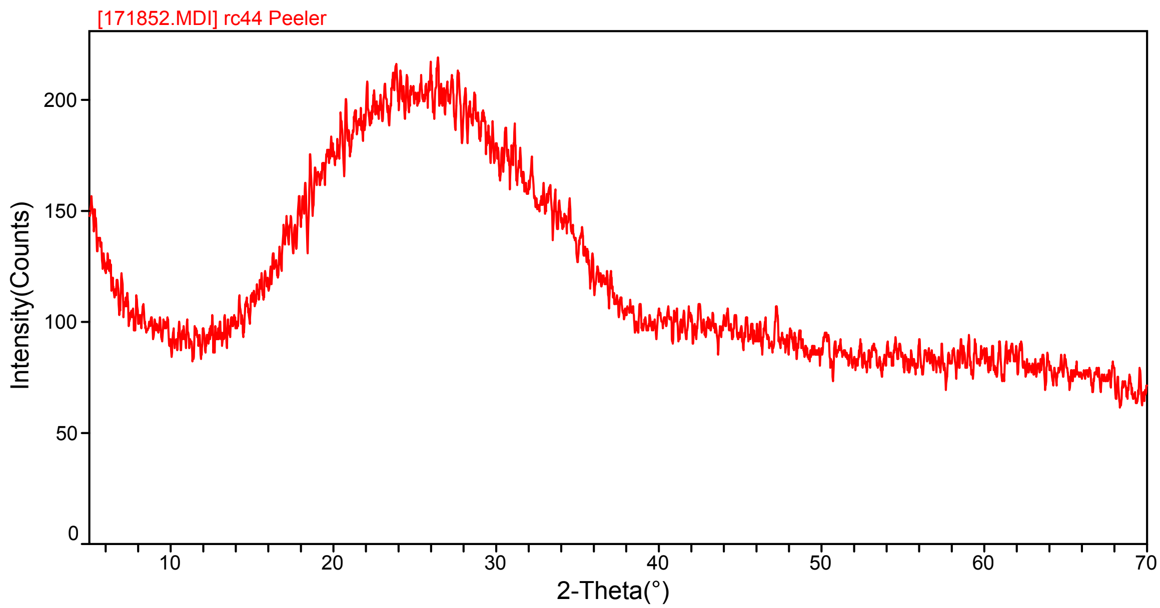

Figure F.41. XRD Pattern of RC-44Q.

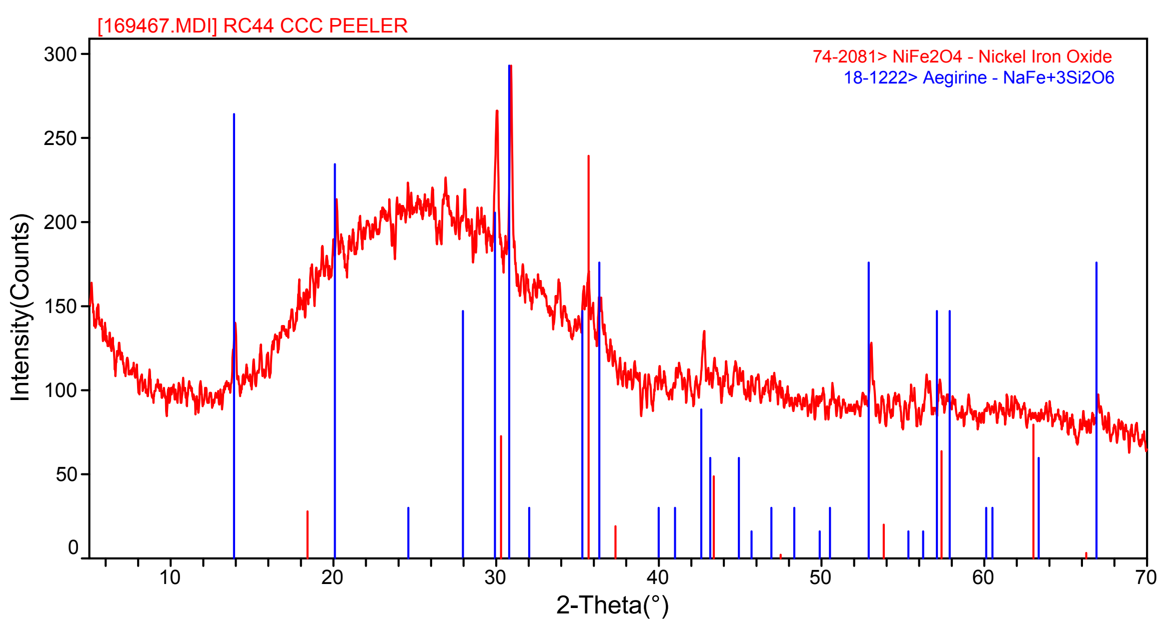

Figure F.42. XRD Pattern of RC-44ccc.

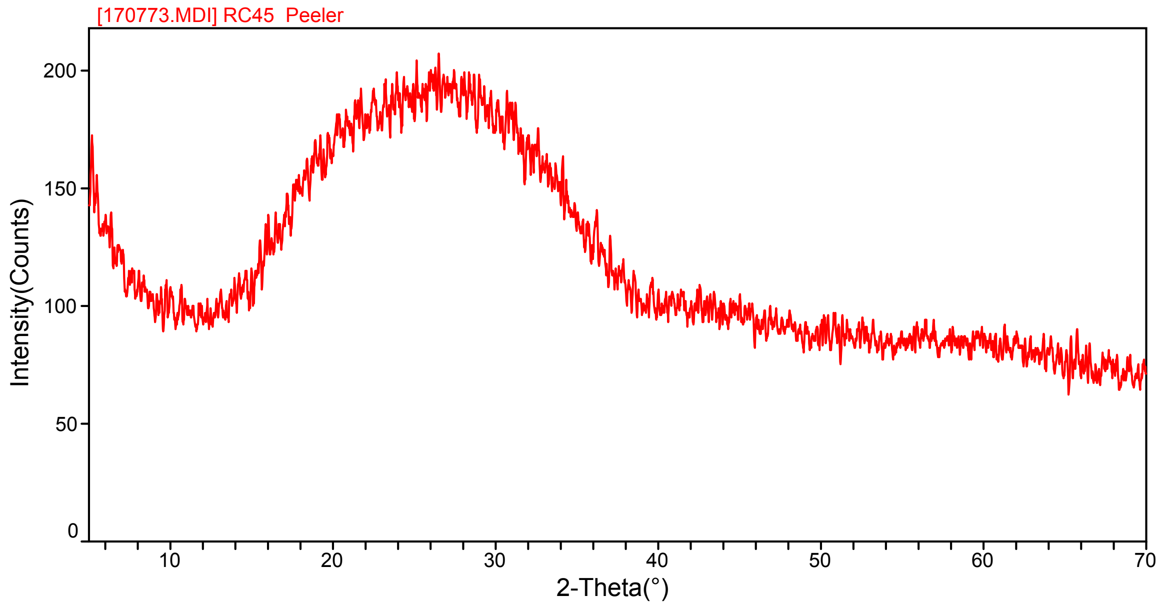

Figure F.43. XRD Pattern of RC-45Q.

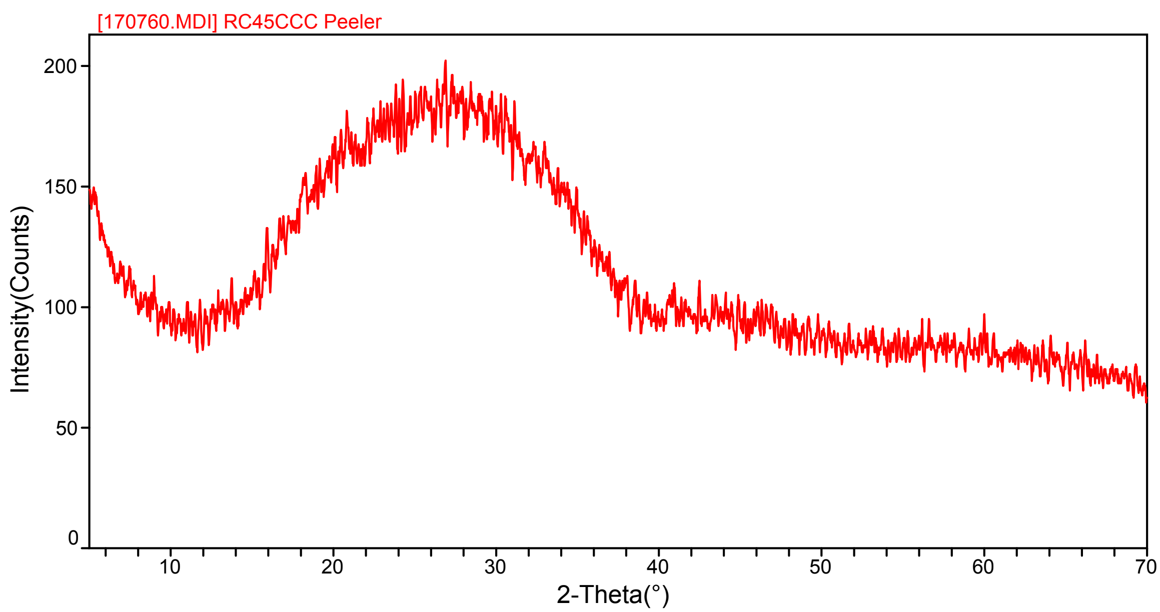

Figure F.44. XRD Pattern of RC-45ccc.

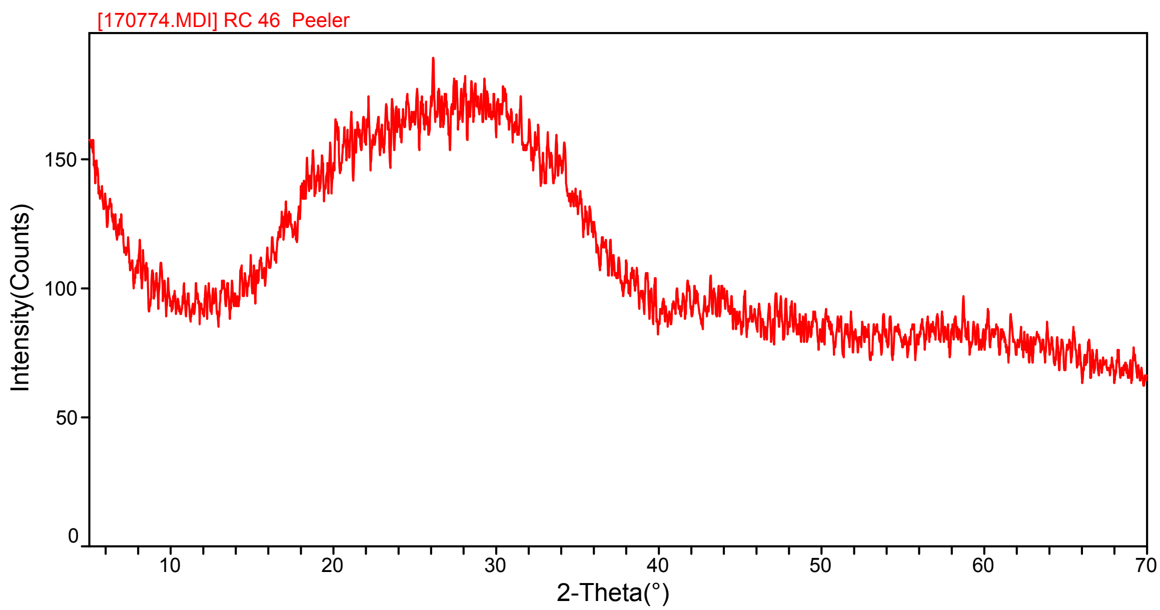

Figure F.45. XRD Pattern of RC-46Q.

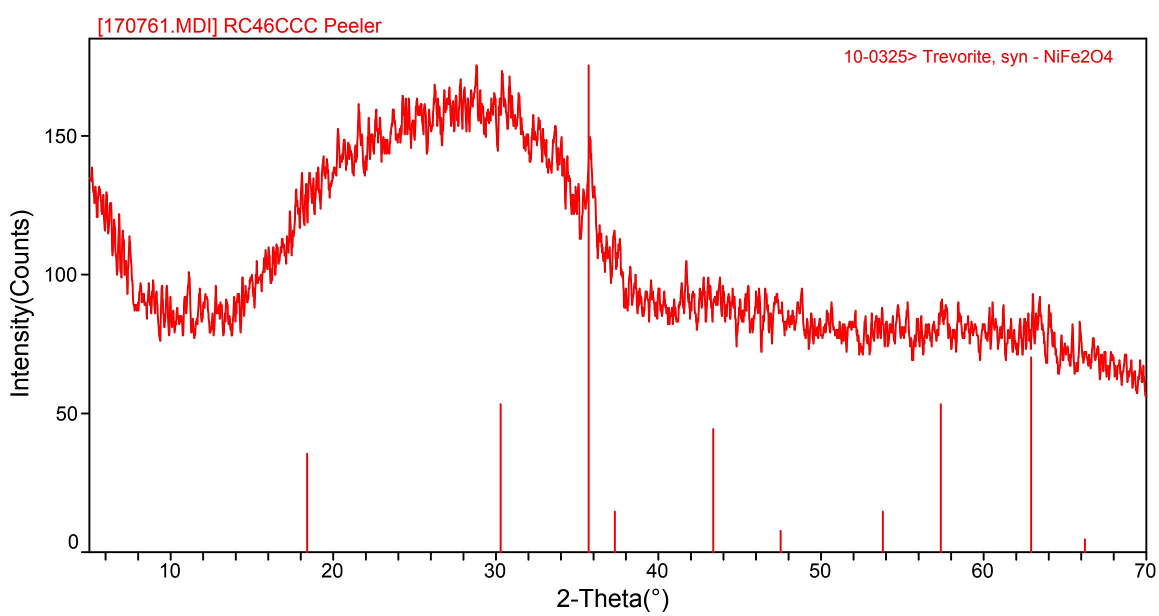

Figure F.46. XRD Pattern of RC-46ccc.

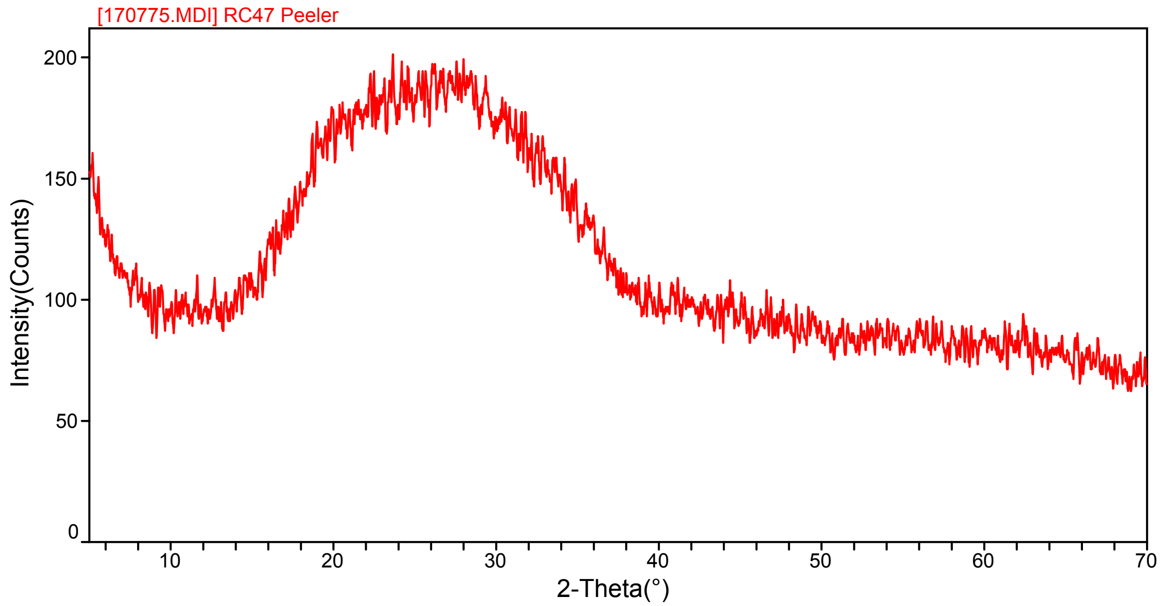

Figure F.47. XRD Pattern of RC-47Q.

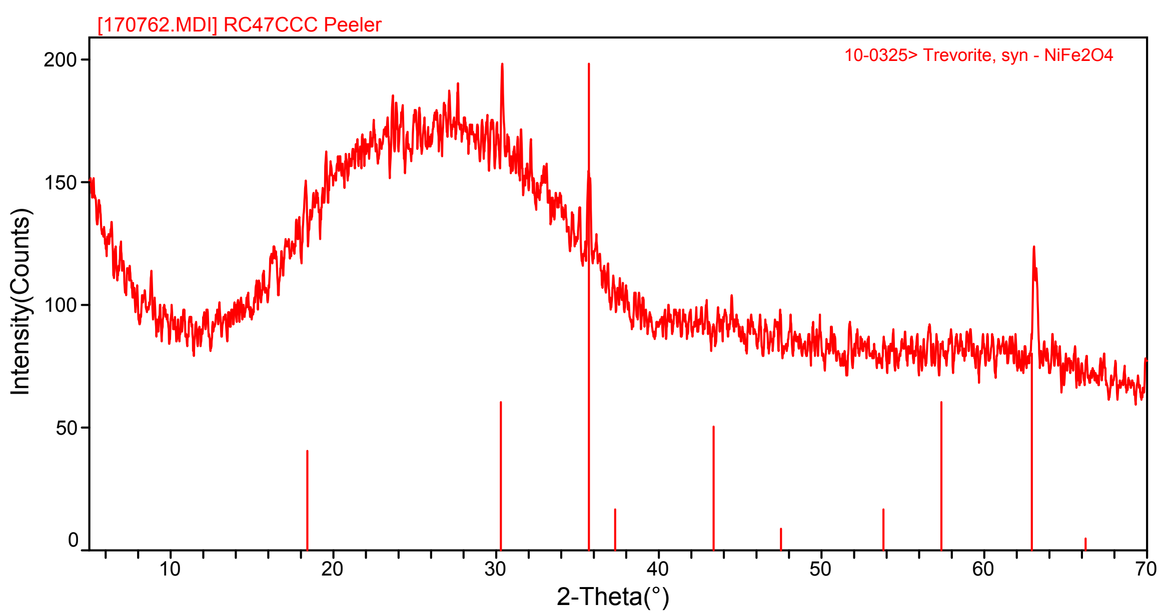

Figure F.48. XRD Pattern of RC-47ccc.

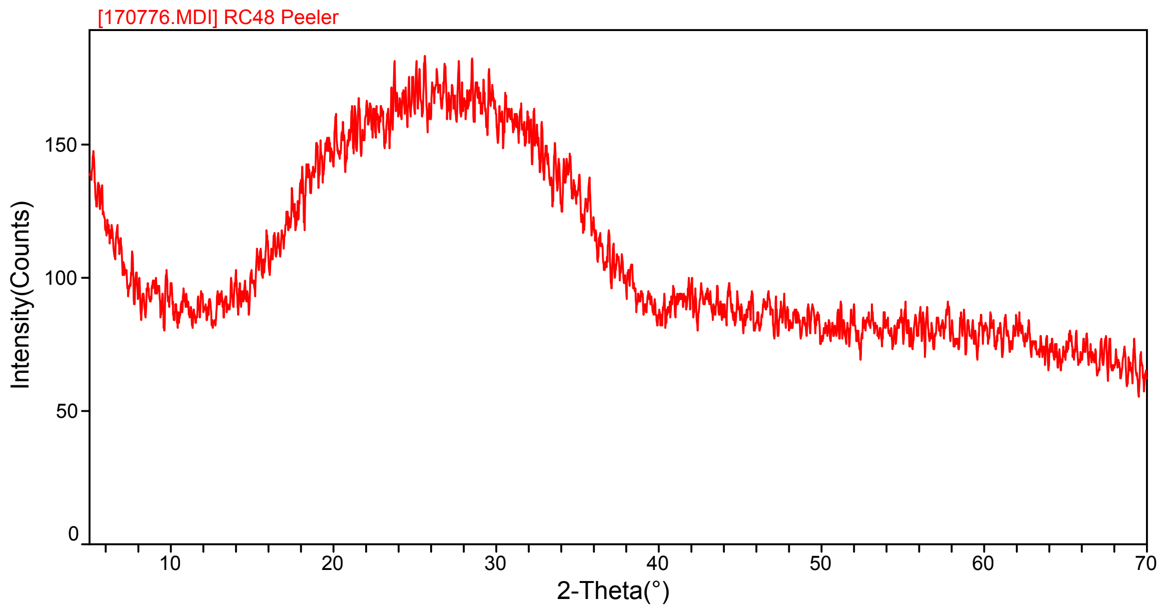

Figure F.49. XRD Pattern of RC-48Q.

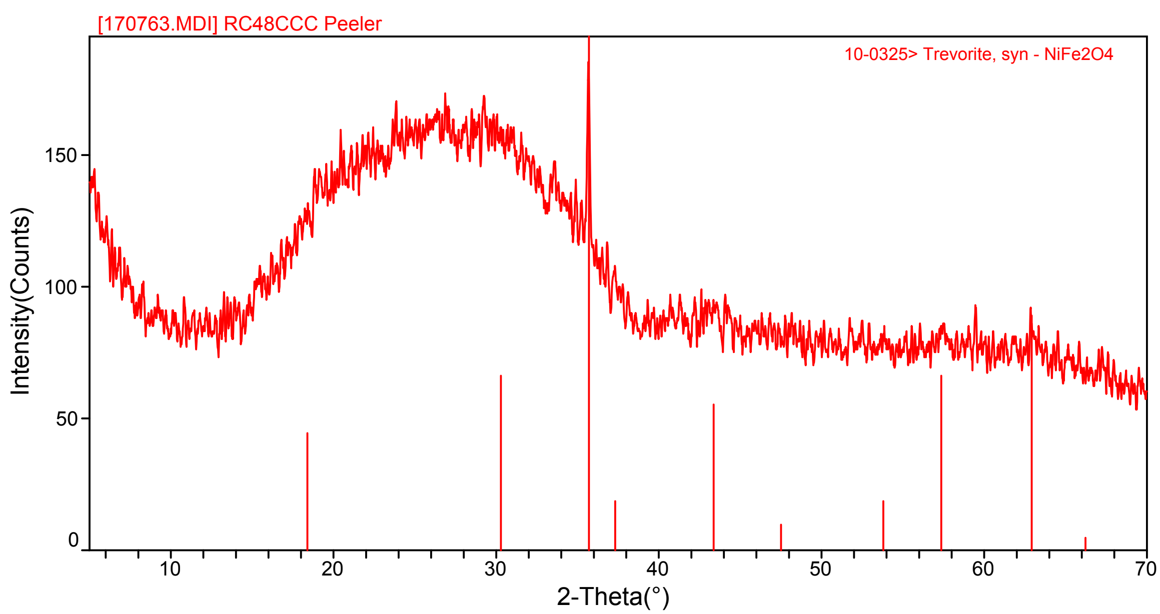

Figure F.50. XRD Pattern of RC-48ccc.

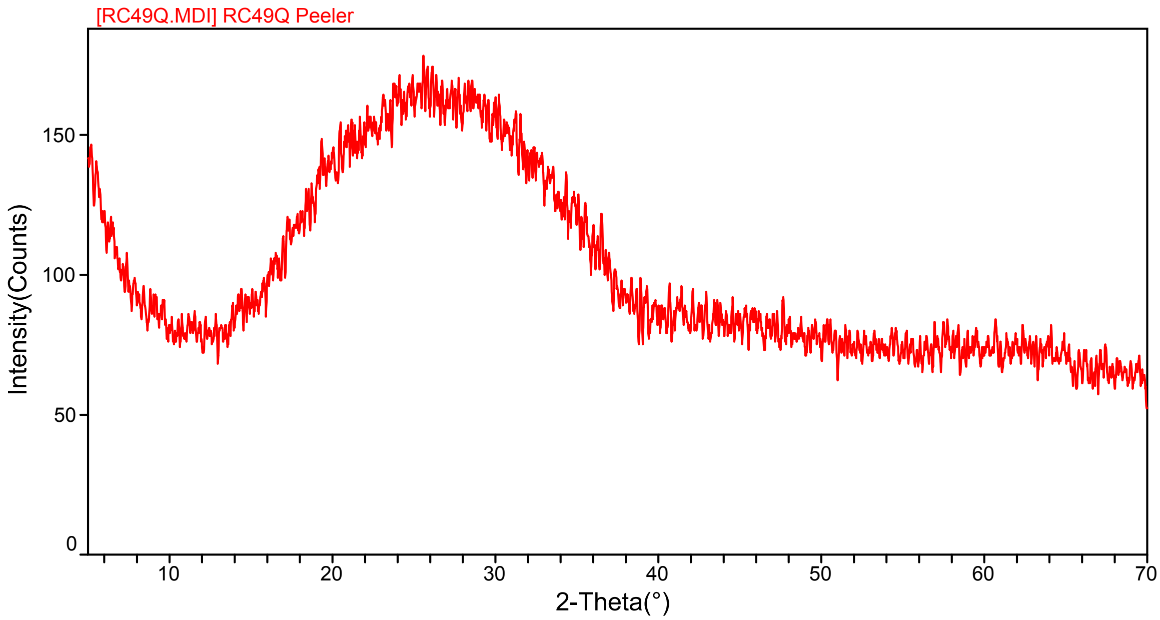

Figure F.51. XRD Pattern of RC-49Q.

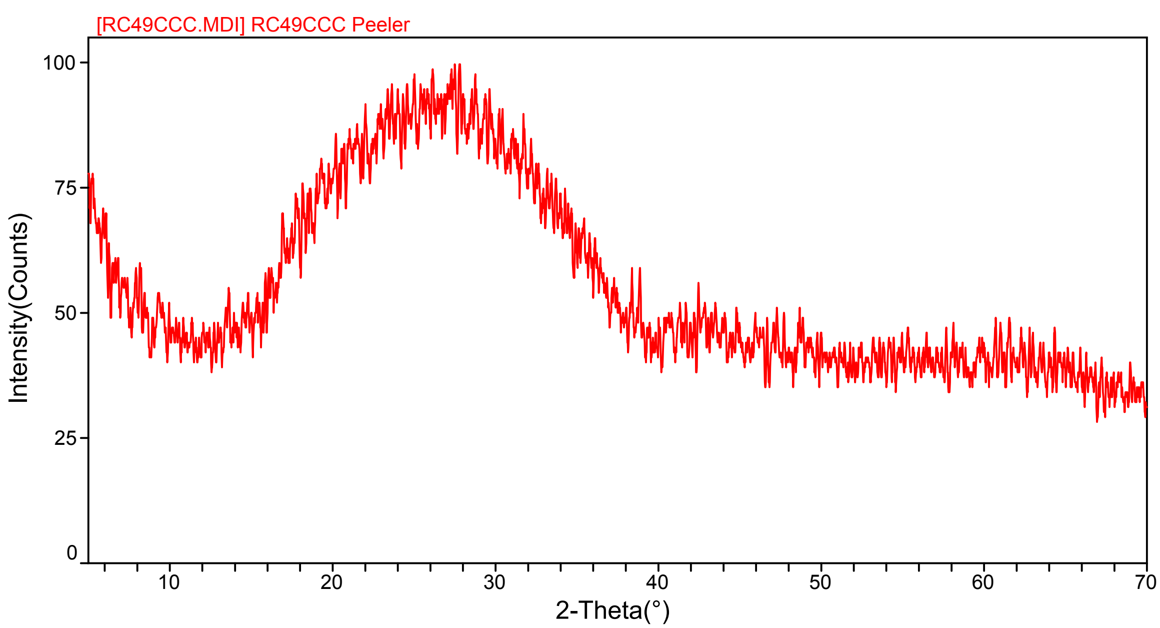

Figure F.52. XRD Pattern of RC-49ccc.

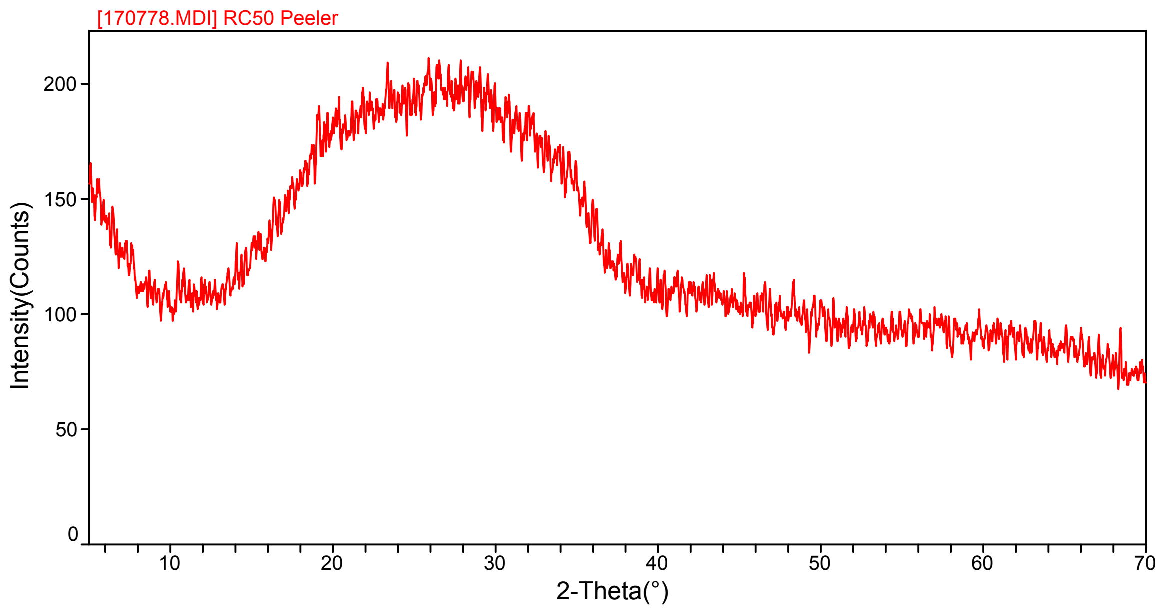

Figure F.53. XRD Pattern of RC-50Q.

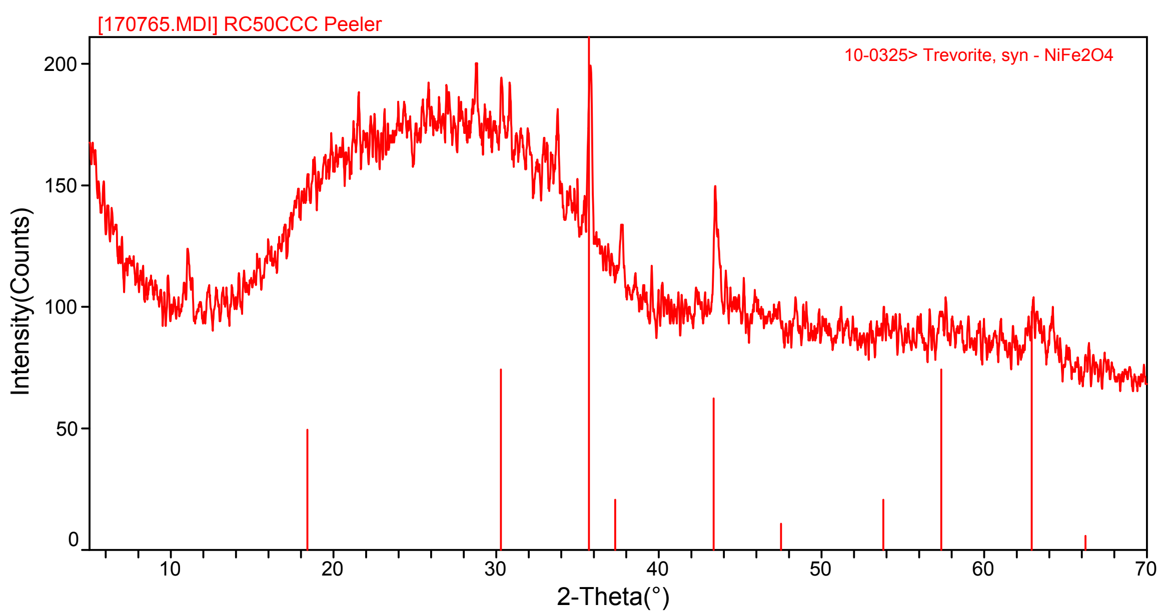

Figure F.54. XRD Pattern of RC-50ccc.

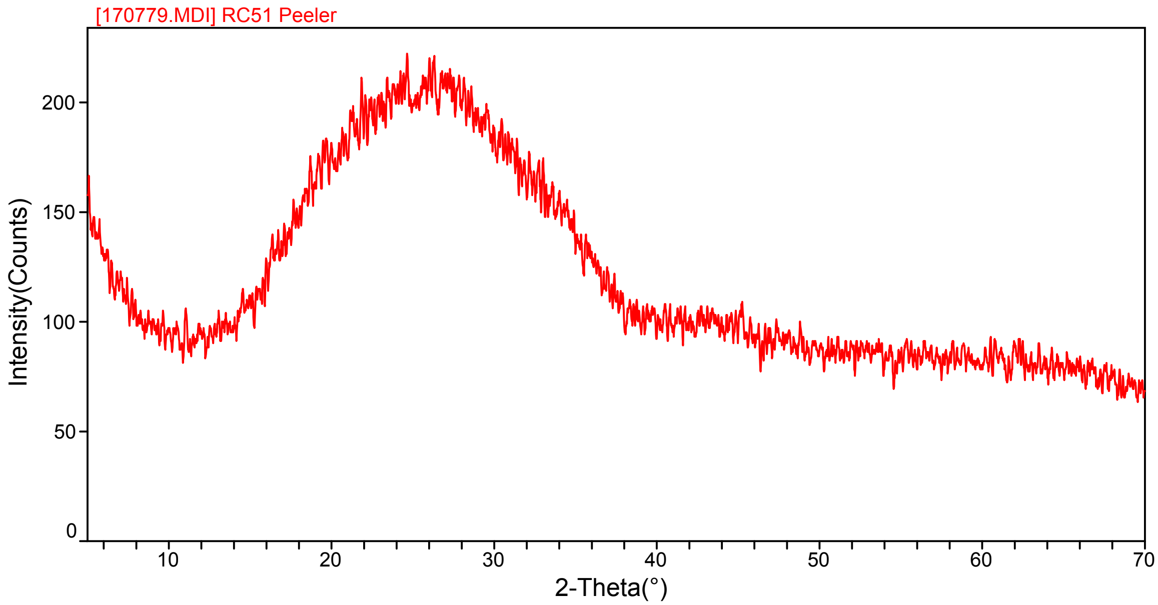

Figure F.55. XRD Pattern of RC-51Q.

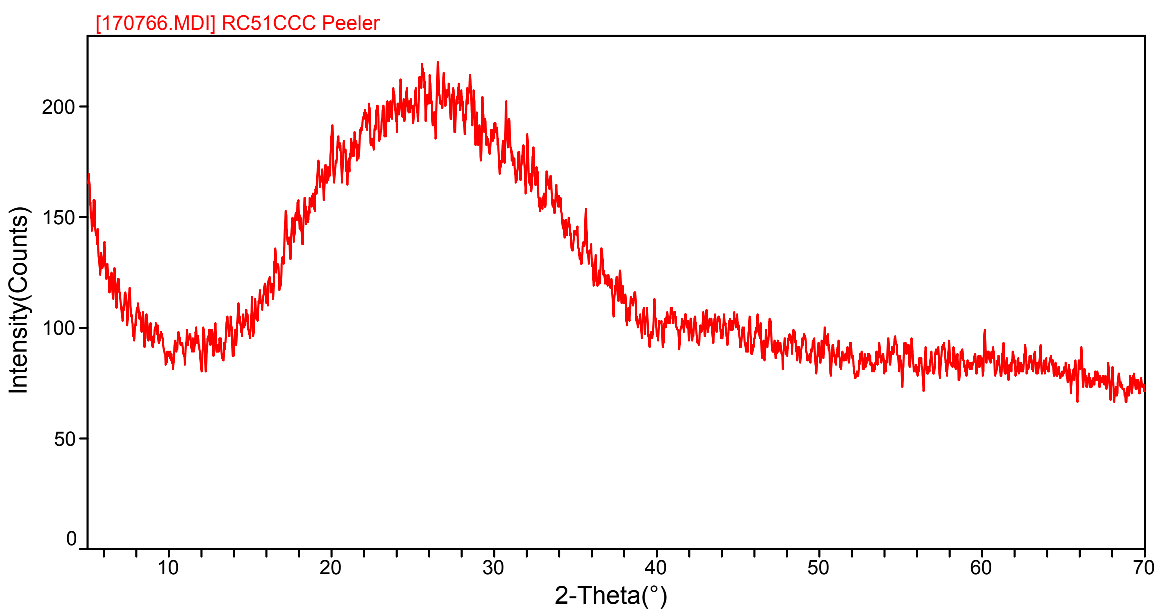

Figure F.56. XRD Pattern of RC-51ccc.

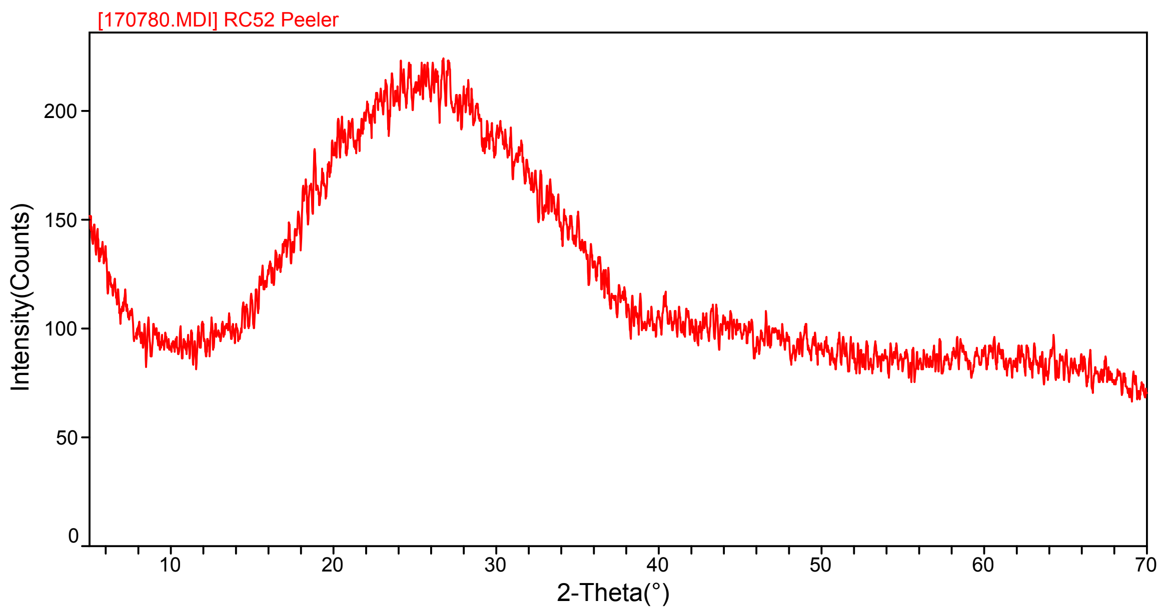

Figure F.57. XRD Pattern of RC-52Q.

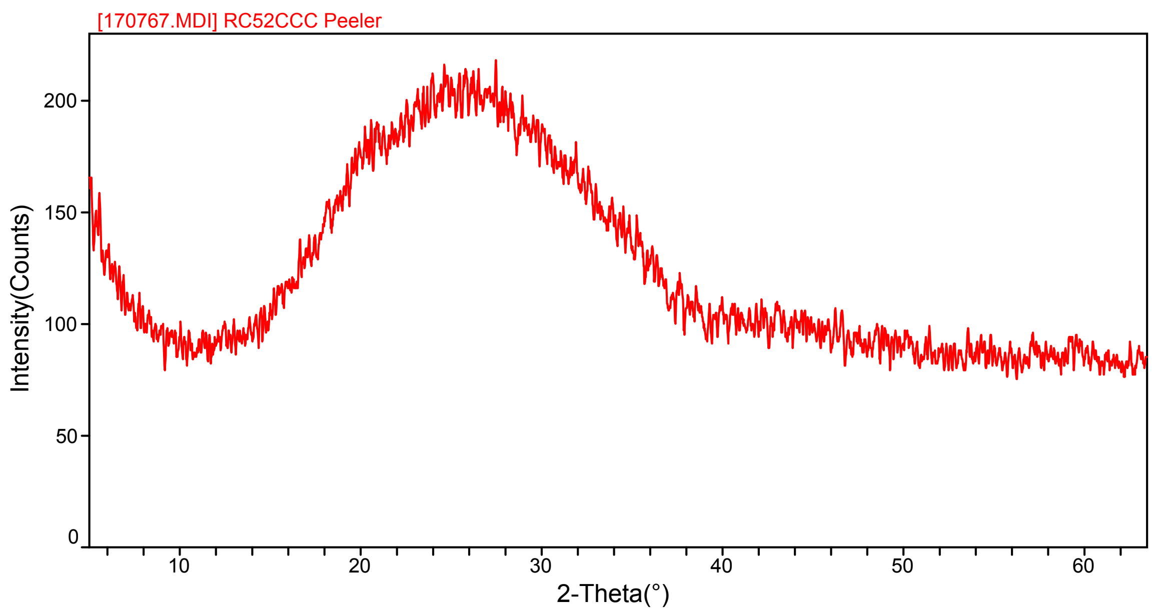

Figure F.58. XRD Pattern of RC-52ccc.

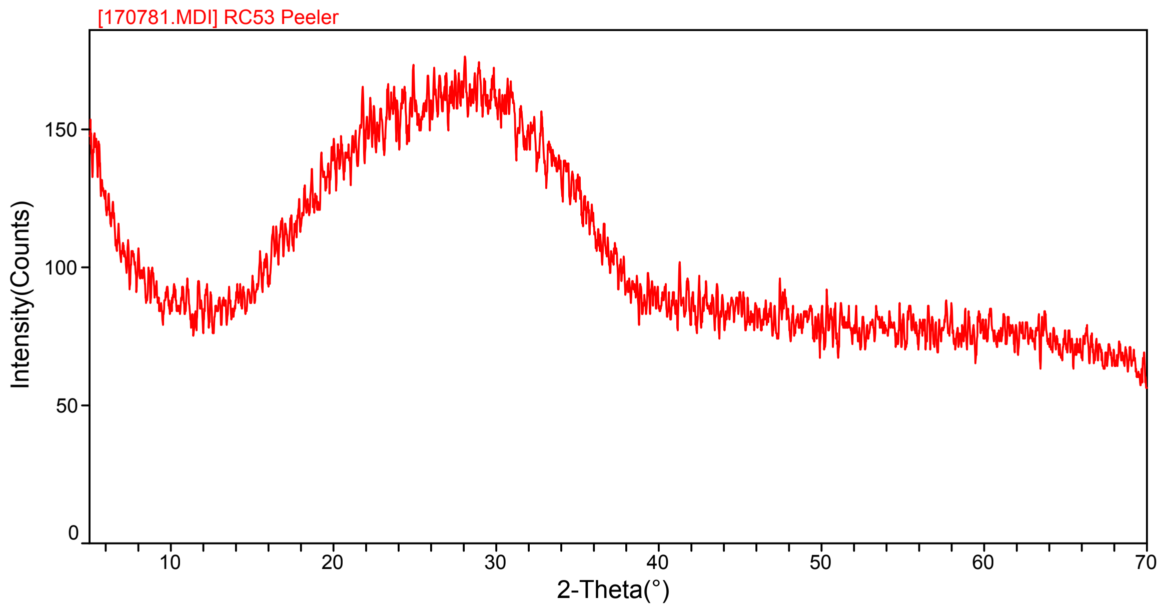

Figure F.59. XRD Pattern of RC-53Q.

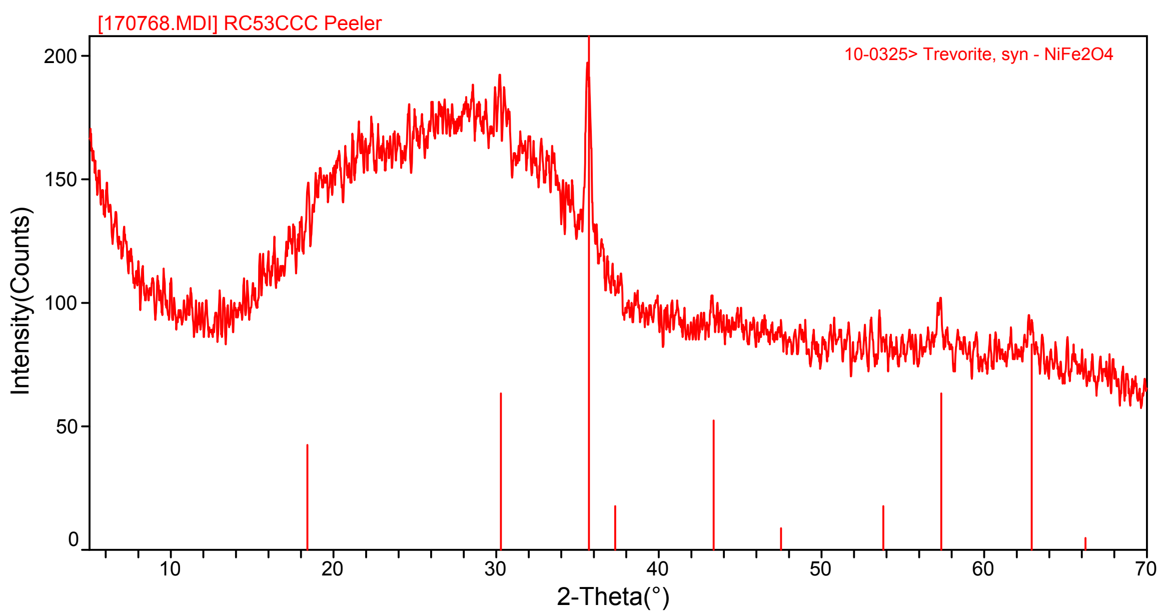

Figure F.60. XRD Pattern of RC-53ccc.

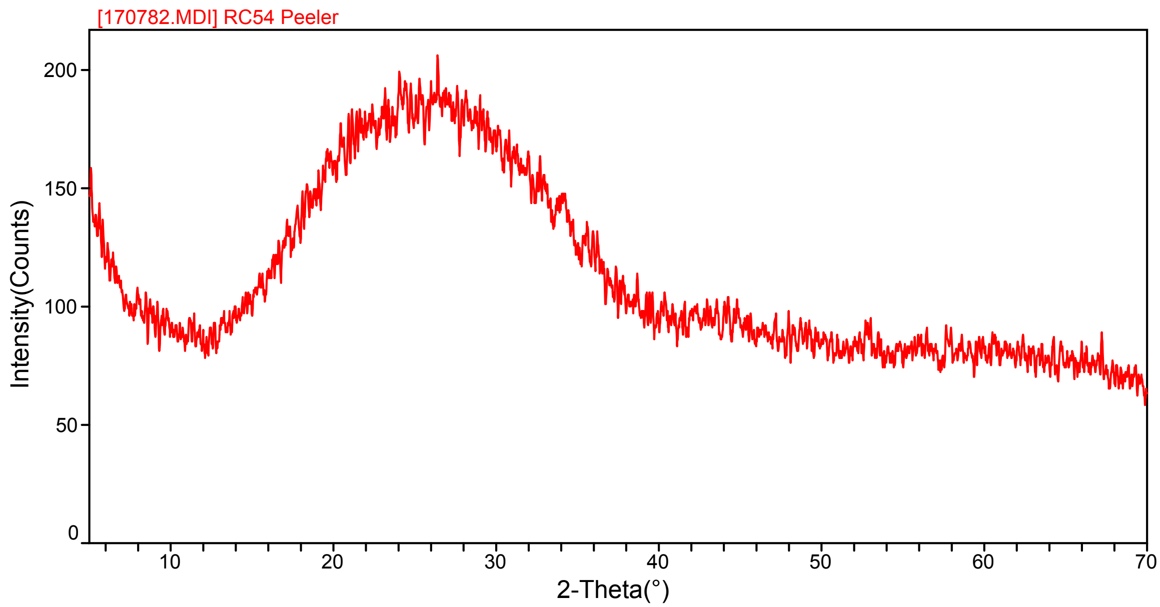

Figure F.61. XRD Pattern of RC-54Q.

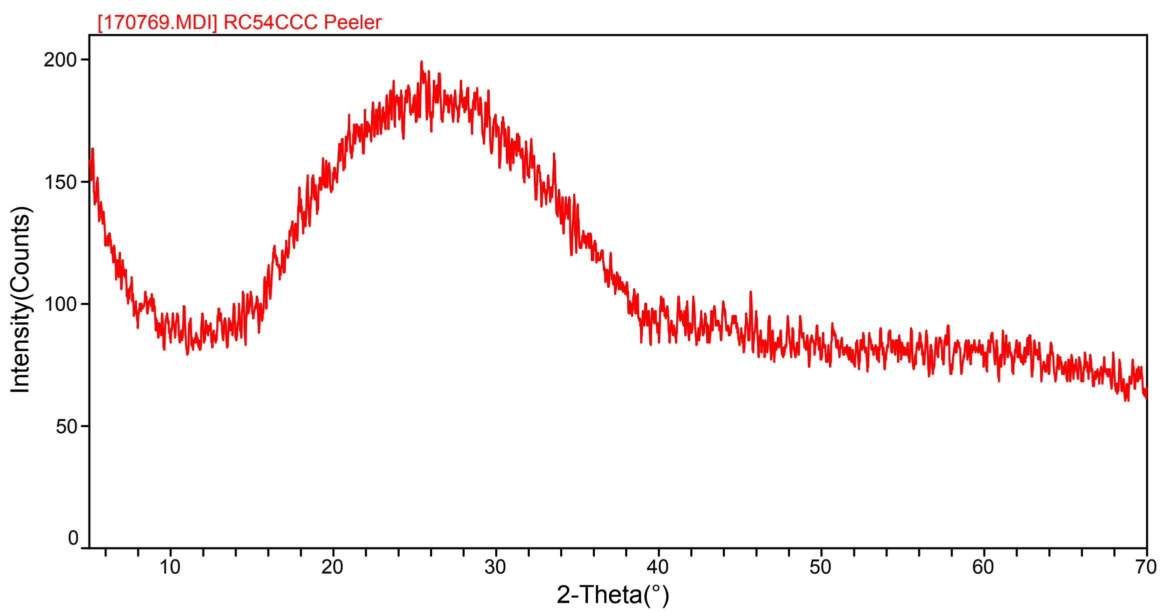

Figure F.62. XRD Pattern of RC-54ccc.

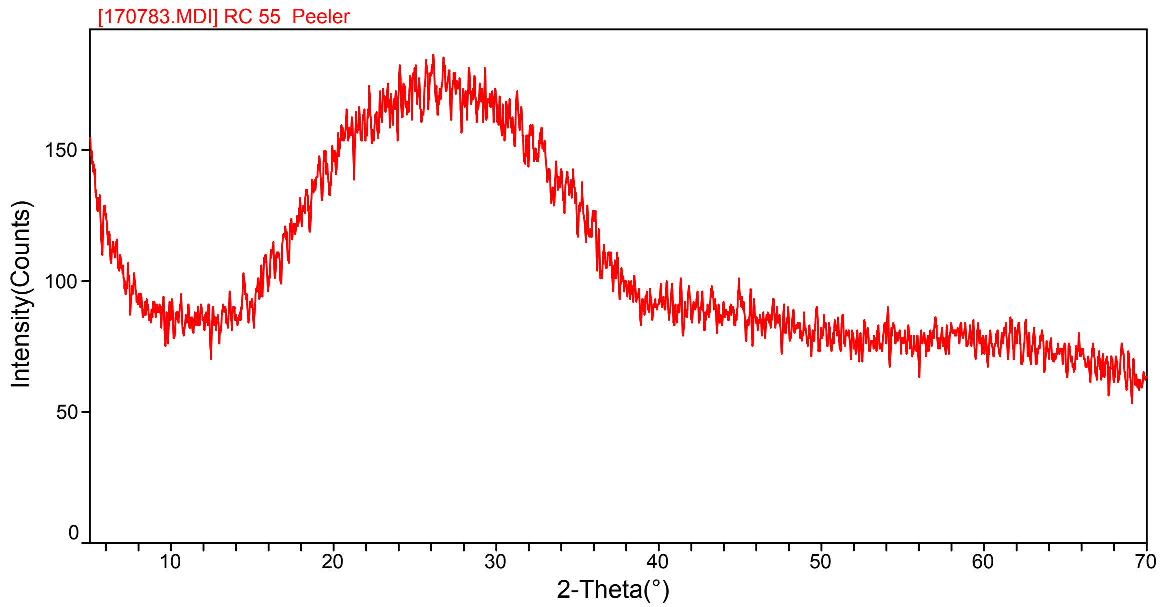

Figure F.63. XRD Pattern of RC-55Q.

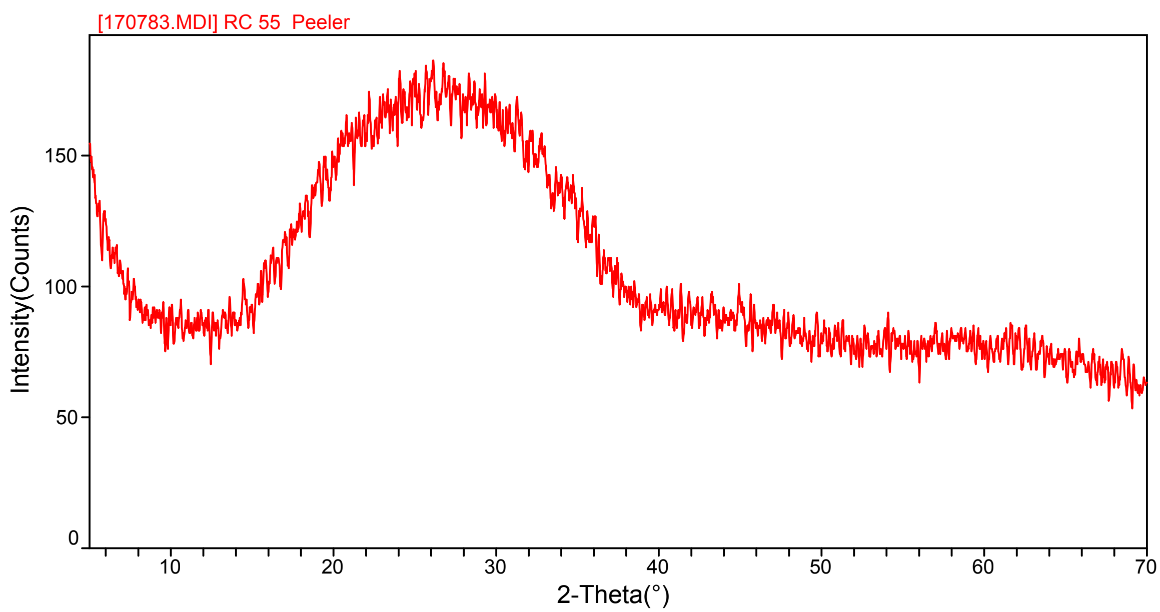

Figure F.64. XRD Pattern of RC-55ccc.

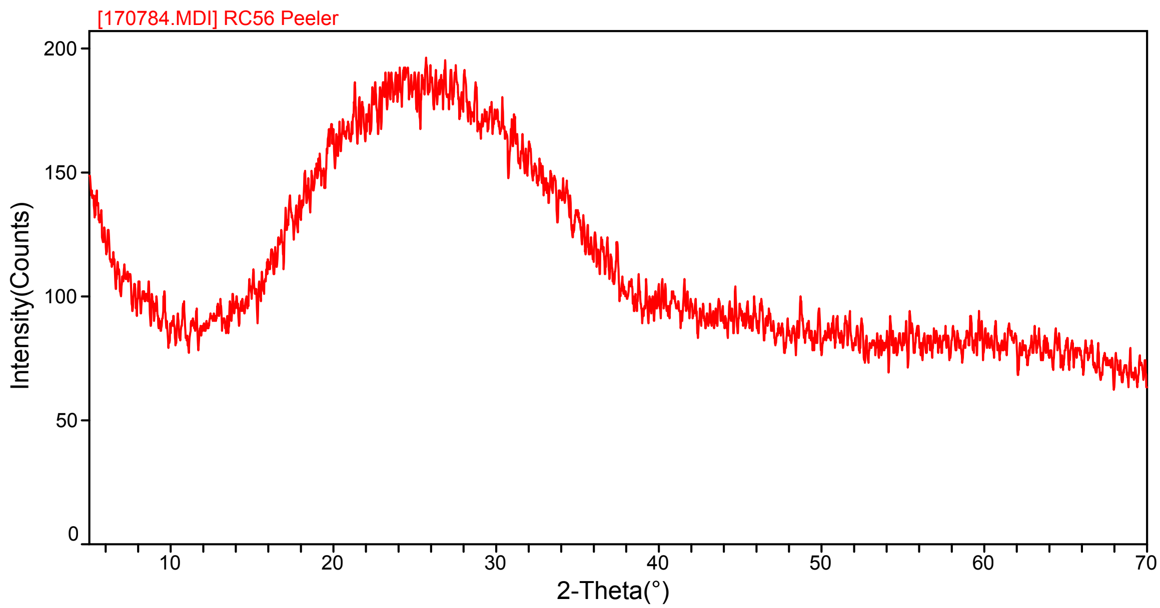

Figure F.65. XRD Pattern of RC-56Q.

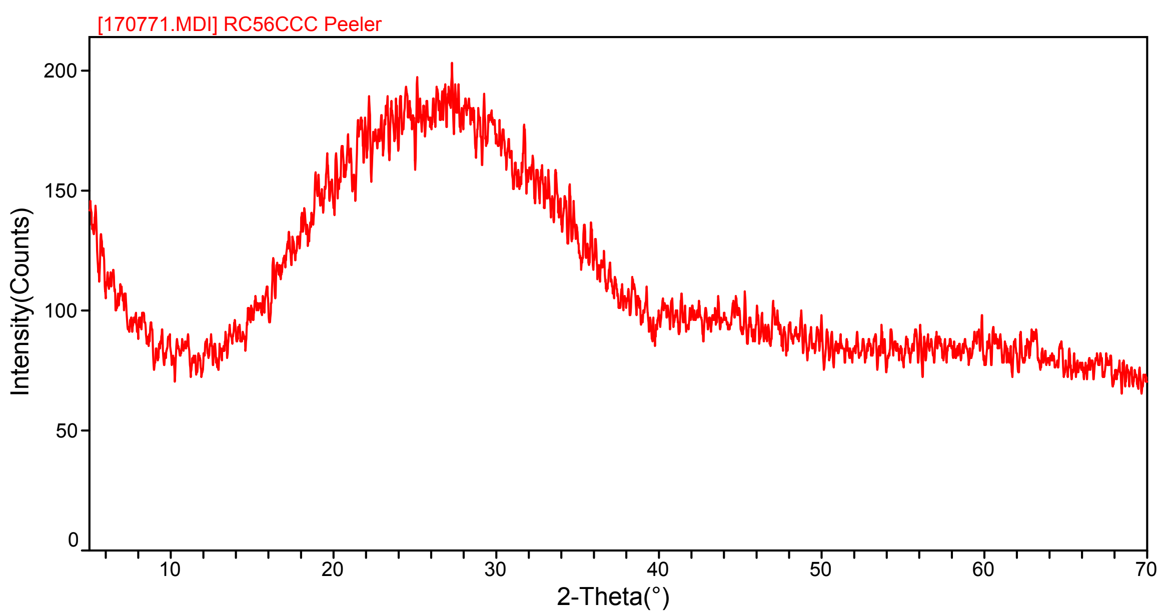

Figure F.66. XRD Pattern of RC-56ccc.

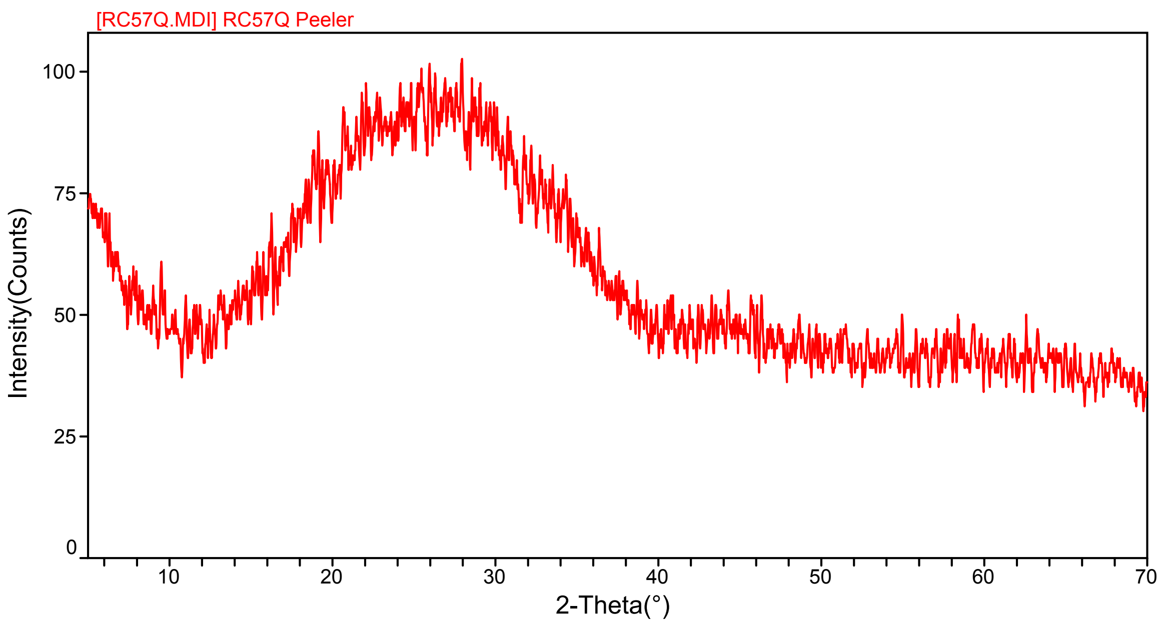

Figure F.67. XRD Pattern of RC-57Q.

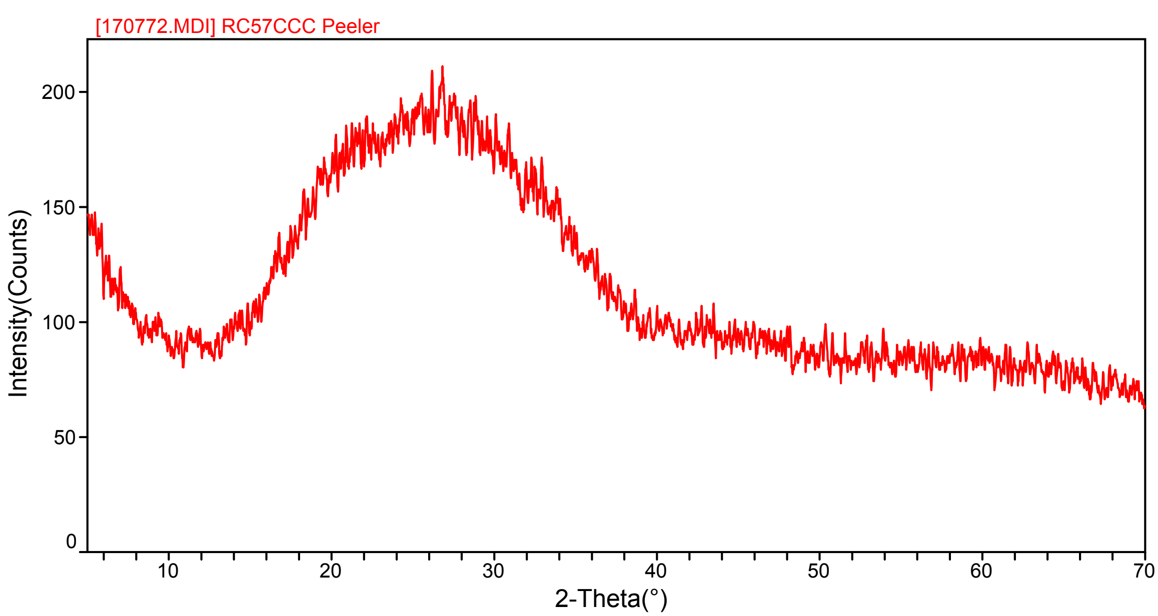

Figure F.68. XRD Pattern of RC-57ccc.

Appendix G

TABLES AND EXHIBITS SUPPORTING THE ANALYSIS OF THE PCT RESULTS FOR THE RC GLASSES

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Table G.1: SRTC-ML Measurements of the PCT Solutions for the RC Glasses

Study	Water-Loss Problem	Glass ID	Glass #	SRTC-ML ID	Heat Treatment	Block	Seq. #	Planning ID	As-Reported (ppm)				Adjusted for Dilutions (ppm)			
									B	Li	Na	Si	B	Li	Na	Si
1	No	std	0	std-b1-1		1	1	soln std	20.1	9.6	80	50	20.100	9.600	80.000	50.000
1	Yes	RC	41	k07	quenched	1	2	RC-41	16.8	10.5	45.1	84.5	28.001	17.500	75.168	140.836
1	No	RC	44	k06	quenched	1	3	RC-44	15.6	9.79	44.7	80.1	26.001	16.317	74.501	133.503
1	No	blank	102	k31		1	4	blank	<0.150	0.554	<0.100	<0.790	0.125	0.923	0.083	0.658
1	No	RC	42	k05	quenched	1	5	RC-42	14.2	9.22	43.4	75.7	23.667	15.367	72.335	126.169
1	No	RC	39	k22	quenched	1	6	RC-39	15	9.42	46.2	77.5	25.001	15.700	77.002	129.169
1	No	EA	100	k18		1	7	EA	32.8	10.2	92.5	50.7	546.678	170.003	1541.698	845.017
1	No	ARM	101	k46		1	8	ARM	11.6	9.08	23.7	40.4	19.334	15.134	39.501	67.335
1	No	RC	41	k21	ccc	1	9	RC-41ccc	16.5	10.4	44.6	84.5	27.501	17.334	74.335	140.836
1	No	std	0	std-b1-2		1	10	soln std	20.2	9.64	80.4	50.6	20.200	9.640	80.400	50.600
1	No	RC	39	k41	ccc	1	11	RC-39ccc	24.5	13	57.1	84.4	40.834	21.667	95.169	140.670
1	No	RC	43	k48	ccc	1	12	RC-43ccc	37.1	18.7	80.2	94.5	61.835	31.167	133.669	157.503
1	No	RC	40	k38	ccc	1	13	RC-40ccc	45.1	25.2	122	159	75.168	42.001	203.337	265.005
1	No	RC	43	k02	quenched	1	14	RC-43	17	10.1	52.3	82.3	28.334	16.834	87.168	137.169
1	No	RC	38	k50	quenched	1	15	RC-38	14.8	9.31	44.7	77.5	24.667	15.517	74.501	129.169
1	No	RC	42	k37	ccc	1	16	RC-42ccc	27.9	14.8	59.5	82.9	46.501	24.667	99.169	138.169
1	No	RC	44	k40	ccc	1	17	RC-44ccc	17.1	10.4	45.2	81.6	28.501	17.334	75.335	136.003
1	No	RC	40	k24	quenched	1	18	RC-40	29.5	15.8	87	110	49.168	26.334	145.003	183.337
1	Yes	RC	38	k32	ccc	1	19	RC-38ccc	17.1	10.2	46.5	80.7	28.501	17.000	77.502	134.503
1	No	std	0	std-b1-3		1	20	soln std	20.9	9.75	80.3	51.6	20.900	9.750	80.300	51.600
1	No	std	0	sb-b2-1		2	1	soln std	20.7	9.65	80.3	50.4	20.700	9.650	80.300	50.400
1	No	RC	40	k14	quenched	2	2	RC-40	28.7	15	84.2	104	47.834	25.001	140.336	173.337
1	No	RC	40	k11	ccc	2	3	RC-40ccc	45.7	25.2	124	156	76.168	42.001	206.671	260.005
1	No	RC	41	k10	quenched	2	4	RC-41	17	10.5	45.8	84.8	28.334	17.500	76.335	141.336
1	No	RC	39	k30	quenched	2	5	RC-39	15.7	9.59	47.7	78.8	26.167	15.984	79.502	131.336
1	No	RC	38	k08	quenched	2	6	RC-38	14.8	9.35	45.1	76.3	24.667	15.584	75.168	127.169
1	No	ARM	101	k34		2	7	ARM	10.8	8.63	22.5	39	18.000	14.384	37.501	65.001
1	No	RC	43	k15	ccc	2	8	RC-43ccc	36.1	18.3	79.2	94.5	60.168	30.501	132.003	157.503
1	No	RC	42	k09	ccc	2	9	RC-42ccc	29.3	15.2	61.9	83.2	48.834	25.334	103.169	138.669
1	No	std	0	std-b2-2		2	10	soln std	20.7	9.66	79.8	50.4	20.700	9.660	79.800	50.400
1	No	RC	44	k43	ccc	2	11	RC-44ccc	17.5	10.4	45	80.2	29.167	17.334	75.002	133.669
1	No	blank	102	k26		2	12	blank	<0.150	0.651	<0.100	<0.790	0.125	1.085	0.083	0.658
1	No	RC	42	k19	quenched	2	13	RC-42	14.6	9.34	43.5	76.2	24.334	15.567	72.501	127.003
1	No	RC	38	k25	ccc	2	14	RC-38ccc	15.9	9.48	43.6	75	26.501	15.800	72.668	125.003
1	No	RC	44	k39	quenched	2	15	RC-44	16.4	10.3	47	82.3	27.334	17.167	78.335	137.169
1	No	RC	39	k45	ccc	2	16	RC-39ccc	24.4	13	57.7	85.9	40.667	21.667	96.169	143.170
1	Yes	RC	41	k42	ccc	2	17	RC-41ccc	17.6	10.9	46.6	87.5	29.334	18.167	77.668	145.836

Table G.1: SRTC-ML Measurements of the PCT Solutions for the RC Glasses

Study	Water-Loss Problem	Glass ID	Glass #	SRTC-ML ID	Heat Treatment	Block	Seq. #	Planning ID	As-Reported (ppm) B	Li	Na	Si	Adjusted for Dilutions (ppm) B	Li	Na	Si
1	No	EA	100	k13		2	18	EA	35.2	10.9	99.2	53.9	586.678	181.670	1653.366	898.351
1	No	RC	43	k44	quenched	2	19	RC-43	16.9	10	52	81.8	28.167	16.667	86.668	136.336
1	No	std	0	std-b2-3		2	20	soln std	21	9.77	81.2	51.3	21.000	9.770	81.200	51.300
1	No	std	0	std-b3-1		3	1	soln std	20.4	9.67	79.4	50.6	20.400	9.670	79.400	50.600
1	No	RC	44	k17	ccc	3	2	RC-44ccc	16.9	10.2	43.4	78.9	28.167	17.000	72.335	131.503
1	No	RC	39	k35	ccc	3	3	RC-39ccc	24.9	13.1	57.1	84.7	41.501	21.834	95.169	141.170
1	No	RC	41	k23	quenched	3	4	RC-41	16.6	10.4	44	85.1	27.667	17.334	73.335	141.836
1	No	RC	42	k16	ccc	3	5	RC-42ccc	29.1	15.1	59.9	83	48.501	25.167	99.835	138.336
1	No	RC	41	k01	ccc	3	6	RC-41ccc	17	10.4	44.6	83.7	28.334	17.334	74.335	139.503
1	No	RC	38	k29	quenched	3	7	RC-38	15	9.42	44.6	77.3	25.001	15.700	74.335	128.836
1	No	EA	100	k28		3	8	EA	33.2	10.3	90.5	50.5	553.344	171.670	1508.364	841.684
1	No	RC	43	k49	quenched	3	9	RC-43	17.1	10.1	52.6	82.6	28.501	16.834	87.668	137.669
1	No	std	0	std-b3-2		3	10	soln std	20.5	9.61	78.8	50.5	20.500	9.610	78.800	50.500
1	No	RC	40	k12	quenched	3	11	RC-40	26.9	14.2	78	102	44.834	23.667	130.003	170.003
1	No	RC	38	k36	ccc	3	12	RC-38ccc	16.3	9.54	44	76.9	27.167	15.900	73.335	128.169
1	No	ARM	101	k33		3	13	ARM	11.8	8.93	22.9	39.8	19.667	14.884	38.167	66.335
1	No	RC	44	k04	quenched	3	14	RC-44	16.8	10.3	47	84.2	28.001	17.167	78.335	140.336
1	No	RC	43	k27	ccc	3	15	RC-43ccc	36.9	18.3	77.9	93.8	61.501	30.501	129.836	156.337
1	No	RC	40	k20	ccc	3	16	RC-40ccc	45.1	25.2	121	156	75.168	42.001	201.671	260.005
1	No	RC	42	k03	quenched	3	17	RC-42	14.8	9.17	42.6	76.4	24.667	15.284	71.001	127.336
1	No	RC	39	k47	quenched	3	18	RC-39	15.8	9.53	46.2	79.1	26.334	15.884	77.002	131.836
1	No	std	0	std-b3-3		3	19	soln std	20.8	9.6	78.9	50.2	20.800	9.600	78.900	50.200
2	No	std	0	std-b1-1		1	1	soln std	20.9	9.69	82.6	51.9	20.900	9.690	82.600	51.900
2	No	RC	27	n43	ccc	1	2	RC-27ccc	25.6	24.5	92.8	131	42.668	40.834	154.670	218.338
2	No	RC	37	n41	ccc	1	3	RC-37ccc	22.2	22	78	123	37.001	36.667	130.003	205.004
2	No	RC	25	n37	quenched	1	4	RC-25	16.7	15.8	70.8	89.7	27.834	26.334	118.002	149.503
2	No	RC	35	n74	quenched	1	5	RC-35	19.8	18.9	74.9	110	33.001	31.501	124.836	183.337
2	No	RC	29	n85	quenched	1	6	RC-29	15.7	15.6	63.6	92.3	26.167	26.001	106.002	153.836
2	No	RC	37	n61	quenched	1	7	RC-37	24.8	23.6	86.1	131	41.334	39.334	143.503	218.338
2	No	RC	35	n50	ccc	1	8	RC-35ccc	18.9	19.4	70.1	111	31.501	32.334	116.836	185.004
2	No	std	0	std-b1-2		1	9	soln std	21.2	9.7	80.5	52.6	21.200	9.700	80.500	52.600
2	No	RC	33	n75	ccc	1	10	RC-33ccc	16.9	16.4	73.8	94.6	28.167	27.334	123.003	157.670
2	Yes	RC	29	n73	ccc	1	11	RC-29ccc	16.4	16.8	62.8	97	27.334	28.001	104.669	161.670
2	No	RC	25	n16	ccc	1	12	RC-25ccc	17.3	17.2	69.2	94.5	28.834	28.667	115.336	157.503
2	No	RC	27	n32	quenched	1	13	RC-27	30.7	28.4	106	155	51.168	47.334	176.670	258.339
2	No	RC	31	n31	ccc	1	14	RC-31ccc	5.99	12.4	40.7	75.6	9.984	20.667	67.835	126.003
2	No	RC	31	n69	quenched	1	15	RC-31	6.37	12.7	45.3	77.9	10.617	21.167	75.502	129.836

Table G.1: SRTC-ML Measurements of the PCT Solutions for the RC Glasses

Study	Water-Loss Problem	Glass ID	Glass #	SRTC-ML ID	Heat Treatment	Block	Seq. #	Planning ID	As-Reported (ppm)				Adjusted for Dilutions (ppm)			
									B	Li	Na	Si	B	Li	Na	Si
2	Yes	RC	33	n68	quenched	1	16	RC-33	19.2	17.5	83.3	101	32.001	29.167	138.836	168.337
2	No	blank	102	n55		1	17	blank	0.338	0.501	0.108	0.14	0.563	0.835	0.180	0.233
2	No	std	0	std-b1-3		1	18	soln std	21.4	9.92	81.2	54.1	21.400	9.920	81.200	54.100
2	No	std	0	std-b2-1		2	1	soln std	20.3	9.57	82.6	51.1	20.300	9.570	82.600	51.100
2	No	RC	33	n77	quenched	2	2	RC-33	17.4	16.4	81.6	94.1	29.001	27.334	136.003	156.837
2	Yes	RC	33	n26	ccc	2	3	RC-33ccc	16.8	16.6	77.5	93.1	28.001	27.667	129.169	155.170
2	No	RC	31	n53	quenched	2	4	RC-31	5.79	12.5	46.8	73.8	9.650	20.834	78.002	123.003
2	No	RC	25	n46	quenched	2	5	RC-25	16	15.5	70.5	86.5	26.667	25.834	117.502	144.170
2	No	RC	29	n28	quenched	2	6	RC-29	14.3	14.8	63	88.9	23.834	24.667	105.002	148.170
2	No	RC	27	n14	quenched	2	7	RC-27	27	25.6	101	139	45.001	42.668	168.337	231.671
2	No	RC	31	n19	ccc	2	8	RC-31ccc	5.16	11.8	40.6	71.1	8.600	19.667	67.668	118.502
2	No	std	0	std-b2-2		2	9	soln std	20.6	9.75	83.4	51.8	20.600	9.750	83.400	51.800
2	No	RC	35	n36	quenched	2	10	RC-35	19.7	19.3	79.1	111	32.834	32.167	131.836	185.004
2	No	RC	37	n38	quenched	2	11	RC-37	23.3	22.6	86.5	127	38.834	37.667	144.170	211.671
2	No	RC	29	n81	ccc	2	12	RC-29ccc	15.3	16.6	64.5	93.8	25.501	27.667	107.502	156.337
2	No	RC	25	n76	ccc	2	13	RC-25ccc	16.1	17	70.7	90.3	26.834	28.334	117.836	150.503
2	No	RC	27	n63	ccc	2	14	RC-27ccc	25.4	24.8	94.8	133	42.334	41.334	158.003	221.671
2	Yes	RC	37	n70	ccc	2	15	RC-37ccc	22.2	22.6	80.4	123	37.001	37.667	134.003	205.004
2	No	RC	35	n01	ccc	2	16	RC-35ccc	19.2	20	75.8	112	32.001	33.334	126.336	186.670
2	No	blank	102	n80		2	17	blank	< 0.015	0.7	< 0.010	< 0.079	0.013	1.167	0.008	0.066
2	No	std	0	std-b2-3		2	18	soln std	20.6	9.8	83.8	52	20.600	9.800	83.800	52.000
2	No	std	0	std-b3-1		3	1	soln std	20.8	9.73	84	50.8	20.800	9.730	84.000	50.800
2	No	RC	25	n11	quenched	3	2	RC-25	16.1	15.7	70.8	85	26.834	26.167	118.002	141.670
2	Spilled[a]	RC	37	n65	quenched	3	3	RC-37	< 0.015	0.64	< 0.010	< 0.079	0.013	Not Available due to Spilled Sample		
2	No	RC	27	n15	ccc	3	4	RC-27ccc	24	23.7	91.1	126	40.001	39.501	151.836	210.004
2	No	RC	35	n64	quenched	3	5	RC-35	18.5	18.4	75.1	104	30.834	30.667	125.169	173.337
2	No	RC	29	n45	quenched	3	6	RC-29	14.5	15	63.1	85	24.167	25.001	105.169	141.670
2	No	RC	29	n62	ccc	3	7	RC-29ccc	14.9	16.5	64.1	91.1	24.834	27.501	106.836	151.836
2	No	RC	25	n60	ccc	3	8	RC-25ccc	15.9	17	71.2	88.1	26.501	28.334	118.669	146.836
2	No	std	0	std-b3-2		3	9	soln std	20.1	9.72	83.8	50.6	20.100	9.720	83.800	50.600
2	No	RC	27	n40	quenched	3	10	RC-27	26.7	25.6	102	135	44.501	42.668	170.003	225.005
2	No	RC	33	n83	ccc	3	11	RC-33ccc	16.3	16.7	77	91.1	27.167	27.834	128.336	151.836
2	No	RC	33	n07	quenched	3	12	RC-33	16.5	16	79.6	90.1	27.501	26.667	132.669	150.170
2	No	RC	37	n17	ccc	3	13	RC-37ccc	21.1	21.9	79.1	118	35.167	36.501	131.836	196.671
2	Yes	RC	35	n04	ccc	3	14	RC-35ccc	19.1	20.5	77.2	111	31.834	34.167	128.669	185.004

[a] As indicated, this sample solution was spilled during handling and the data from its analysis are not considered to be representative.

Table G.1: SRTC-ML Measurements of the PCT Solutions for the RC Glasses

Study	Water-Loss Problem	Glass ID	Glass #	SRTC-ML ID	Heat Treatment	Block	Seq. #	Planning ID	As-Reported (ppm) B	Li	Na	Si	Adjusted for Dilutions (ppm) B	Li	Na	Si
2	No	RC	31	n09	quenched	3	15	RC-31	5.48	11.9	44.8	69.1	9.134	19.834	74.668	115.169
2	No	RC	31	n02	ccc	3	16	RC-31ccc	5.22	12	41.1	71.1	8.700	20.000	68.501	118.502
2	No	std	0	std-b3-3		3	17	soln std	20.5	9.83	83.5	50.6	20.500	9.830	83.500	50.600
2	No	std	0	std-b4-1		4	1	soln std	21	9.81	82	51.3	21.000	9.810	82.000	51.300
2	No	RC	26	n35	quenched	4	2	RC-26	19.5	17.7	79	95.1	32.501	29.501	131.669	158.503
2	No	RC	34	n78	quenched	4	3	RC-34	17.5	16.9	70.2	98.7	29.167	28.167	117.002	164.503
2	No	RC	28	n27	quenched	4	4	RC-28	19.7	18.2	75.5	102	32.834	30.334	125.836	170.003
2	No	ARM	101	n23		4	5	ARM	10.8	7.99	20.1	36	18.000	13.317	33.501	60.001
2	No	RC	36	n59	ccc	4	6	RC-36ccc	70.4	67.8	172	276	117.336	113.002	286.672	460.009
2	No	RC	30	n24	quenched	4	7	RC-30	67.9	54.8	225	234	113.169	91.335	375.008	390.008
2	No	RC	34	n56	ccc	4	8	RC-34ccc	18.6	18.9	70	102	31.001	31.501	116.669	170.003
2	No	std	0	std-b4-2		4	9	soln std	21.4	10	80.4	51.3	21.400	10.000	80.400	51.300
2	No	RC	32	n82	ccc	4	10	RC-32ccc	17.8	17.2	72.8	96.1	29.667	28.667	121.336	160.170
2	No	RC	36	n58	quenched	4	11	RC-36	97.3	93.4	232	366	162.170	155.670	386.674	610.012
2	No	RC	26	n06	ccc	4	12	RC-26ccc	19	18.6	72.7	91.9	31.667	31.001	121.169	153.170
2	Yes	RC	32	n18	quenched	4	13	RC-32	17.7	16.7	73.4	93	29.501	27.834	122.336	155.003
2	No	RC	30	n22	ccc	4	14	RC-30ccc	32.3	32.3	119.7	164	53.834	53.834	199.504	273.339
2	No	EA	100	n44		4	15	EA	21.6	7.01	54.7	35.6	360.007	116.836	911.685	593.345
2	No	RC	28	n49	ccc	4	16	RC-28ccc	20.1	19.6	73.2	106	33.501	32.667	122.002	176.670
2	No	std	0	std-b4-3		4	17	soln std	21.5	10.1	80.4	51.4	21.500	10.100	80.400	51.400
2	No	std	0	std-b5-1		5	1	soln std	20.1	9.56	81.4	49.9	20.100	9.560	81.400	49.900
2	No	ARM	101	n86		5	2	ARM	11.1	8.43	22.2	37.4	18.500	14.050	37.001	62.335
2	No	RC	36	n72	ccc	5	3	RC-36ccc	69.7	67.2	179	277	116.169	112.002	298.339	461.676
2	No	RC	30	n51	quenched	5	4	RC-30	64.9	52.5	230	226	108.169	87.502	383.341	376.674
2	No	RC	26	n47	quenched	5	5	RC-26	18.4	17.2	76.9	89.8	30.667	28.667	128.169	149.670
2	No	RC	34	n71	quenched	5	6	RC-34	17.1	16.9	72.1	97.1	28.501	28.167	120.169	161.837
2	No	RC	28	n25	quenched	5	7	RC-28	18.5	17.8	74.8	100	30.834	29.667	124.669	166.670
2	No	RC	30	n79	ccc	5	8	RC-30ccc	28.1	28.7	115	152	46.834	47.834	191.671	253.338
2	No	std	0	std-b5-2		5	9	soln std	20.5	9.73	82.6	50.4	20.500	9.730	82.600	50.400
2	No	RC	34	n21	ccc	5	10	RC-34ccc	15.7	16.6	65.3	92.1	26.167	27.667	108.836	153.503
2	No	RC	32	n08	ccc	5	11	RC-32ccc	15	14.9	66.8	86.1	25.001	24.834	111.336	143.503
2	No	EA	100	n30		5	12	EA	19	6.62	53.4	34	316.673	110.336	890.018	566.678
2	No	RC	26	n05	ccc	5	13	RC-26ccc	16.8	17.2	72.7	90.7	28.001	28.667	121.169	151.170
2	No	RC	36	n03	quenched	5	14	RC-36	88.6	83.9	226	342	147.670	139.836	376.674	570.011
2	No	RC	28	n12	ccc	5	15	RC-28ccc	17.1	17.3	68.7	94.8	28.501	28.834	114.502	158.003
2	No	RC	32	n33	quenched	5	16	RC-32	16.6	16.4	77.9	95.5	27.667	27.334	129.836	159.170
2	No	std	0	std-b5-3		5	17	soln std	20	9.76	81.8	49.8	20.000	9.760	81.800	49.800

Table G.1: SRTC-ML Measurements of the PCT Solutions for the RC Glasses

Study	Water-Loss Problem	Glass ID	Glass #	SRTC-ML ID	Heat Treatment	Block	Seq. #	Planning ID	As-Reported (ppm)				Adjusted for Dilutions (ppm)			
									B	Li	Na	Si	B	Li	Na	Si
2	No	std	0	std-b6-1		6	1	soln std	20.4	9.59	82.8	50	20.400	9.590	82.800	50.000
2	No	RC	26	n10	quenched	6	2	RC-26	17.9	16.8	77.7	92.2	29.834	28.001	129.503	153.670
2	No	RC	28	n52	ccc	6	3	RC-28ccc	17.6	17.6	73.1	99.2	29.334	29.334	121.836	165.337
2	No	RC	32	n29	ccc	6	4	RC-32ccc	15.4	15.2	70.9	91	25.667	25.334	118.169	151.670
2	No	EA	100	n48		6	5	EA	24.5	8.16	69.9	41.6	408.342	136.003	1165.023	693.347
2	No	RC	36	n54	quenched	6	6	RC-36	93.9	91.8	249	370	156.503	153.003	415.008	616.679
2	No	ARM	101	n34		6	7	ARM	11.1	8.4	22.3	36.8	18.500	14.000	37.167	61.335
2	No	RC	30	n42	quenched	6	8	RC-30	61.5	50.4	227	213	102.502	84.002	378.341	355.007
2	No	std	0	std-b6-2		6	9	soln std	20.2	9.69	84.7	50.1	20.200	9.690	84.700	50.100
2	No	RC	28	n20	quenched	6	10	RC-28	18.5	18.1	78.8	100	30.834	30.167	131.336	166.670
2	Yes	RC	34	n66	ccc	6	11	RC-34ccc	17.1	18.6	75.6	101	28.501	31.001	126.003	168.337
2	No	RC	34	n84	quenched	6	12	RC-34	17.8	18.2	79.4	103	29.667	30.334	132.336	171.670
2	No	RC	30	n67	ccc	6	13	RC-30ccc	29.8	31.2	130	161	49.668	52.001	216.671	268.339
2	No	RC	32	n39	quenched	6	14	RC-32	16.3	16.1	79.6	93.6	27.167	26.834	132.669	156.003
2	No	RC	36	n13	ccc	6	15	RC-36ccc	74.9	75	209	310	124.836	125.003	348.340	516.677
2	No	RC	26	n57	ccc	6	16	RC-26ccc	18	18.3	81.6	96.3	30.001	30.501	136.003	160.503
2	No	std	0	std-b6-3		6	17	soln std	20.1	9.72	87.7	51	20.100	9.720	87.700	51.000
3	No	std	0	STD-B1-1		1	1	soln std	19.6	9.52	81.6	49.6	19.600	9.520	81.600	49.600
3	No	RC	45	J04	ccc	1	2	RC-45ccc	15.3	21.5	72.9	116	25.501	35.834	121.502	193.337
3	No	RC	51	J76	quenched	1	3	RC-51	15.9	22.4	75.1	131	26.501	37.334	125.169	218.338
3	No	RC	49	J24	quenched	1	4	RC-49	13.7	20.2	70.7	118	22.834	33.667	117.836	196.671
3	No	RC	57	J39	quenched	1	5	RC-57	13.4	20	70	117	22.334	33.334	116.669	195.004
3	No	RC	53	J23	ccc	1	6	RC-53ccc	12.4	19.2	73.1	107	20.667	32.001	121.836	178.337
3	No	RC	55	J44	quenched	1	7	RC-55	14.4	20	77.1	115	24.000	33.334	128.503	191.671
3	No	RC	49	J31	ccc	1	8	RC-49ccc	13.5	20.3	68.3	118	22.500	33.834	113.836	196.671
3	No	std	0	STD-B1-2		1	9	soln std	19.4	9.46	79.8	49.2	19.400	9.460	79.800	49.200
3	No	RC	57	J57	ccc	1	10	RC-57ccc	18.3	24.1	83	134	30.501	40.167	138.336	223.338
3	No	RC	53	J30	quenched	1	11	RC-53	13.7	18.7	78.4	105	22.834	31.167	130.669	175.004
3	No	RC	45	J65	quenched	1	12	RC-45	13	18.7	71	107	21.667	31.167	118.336	178.337
3	No	RC	47	J67	quenched	1	13	RC-47	11.9	17.5	65.1	100	19.834	29.167	108.502	166.670
3	No	RC	55	J25	ccc	1	14	RC-55ccc	15	21.5	78.3	123	25.001	35.834	130.503	205.004
3	No	RC	47	J86	ccc	1	15	RC-47ccc	12.2	19.3	65	105	20.334	32.167	108.336	175.004
3	No	RC	51	J37	ccc	1	16	RC-51ccc	14.1	21.4	69.2	124	23.500	35.667	115.336	206.671
3	No	blank	102	J88		1	17	blank	0.433	0.421	0.05	< 0.079	0.722	0.702	0.083	0.066
3	No	std	0	STD-B1-3		1	18	soln std	19.5	9.6	82.7	49.5	19.500	9.600	82.700	49.500
3	No	std	0	STD-B2-1		2	1	soln std	20.3	9.67	81.6	50.1	20.300	9.670	81.600	50.100
3	No	RC	49	J63	quenched	2	2	RC-49	14.2	20.8	72.2	122	23.667	34.667	120.336	203.337

Table G.1: SRTC-ML Measurements of the PCT Solutions for the RC Glasses

Study	Water-Loss Problem	Glass ID	Glass #	SRTC-ML ID	Heat Treatment	Block	Seq. #	Planning ID	As-Reported (ppm) B	Li	Na	Si	Adjusted for Dilutions (ppm) B	Li	Na	Si
3	No	RC	47	J32	quenched	2	3	RC-47	12.6	18.1	66.6	102	21.000	30.167	111.002	170.003
3	No	RC	55	J33	ccc	2	4	RC-55ccc	15	21.1	76.1	118	25.001	35.167	126.836	196.671
3	No	RC	51	J52	quenched	2	5	RC-51	15.4	21.9	73.7	131	25.667	36.501	122.836	218.338
3	No	RC	49	J64	ccc	2	6	RC-49ccc	13.2	19.9	65.9	115	22.000	33.167	109.836	191.671
3	No	RC	47	J74	ccc	2	7	RC-47ccc	12.4	19.1	64.1	104	20.667	31.834	106.836	173.337
3	No	RC	55	J53	quenched	2	8	RC-55	14.8	20.2	76.7	116	24.667	33.667	127.836	193.337
3	No	std	0	STD-B2-2		2	9	soln std	19.9	9.58	80	49.4	19.900	9.580	80.000	49.400
3	No	RC	57	J36	quenched	2	10	RC-57	13.4	20	69.9	117	22.334	33.334	116.502	195.004
3	No	RC	53	J56	quenched	2	11	RC-53	14.2	19	79.1	105	23.667	31.667	131.836	175.004
3	No	RC	45	J58	ccc	2	12	RC-45ccc	14	21.3	71.7	115	23.334	35.501	119.502	191.671
3	No	RC	53	J42	ccc	2	13	RC-53ccc	11.7	18.2	72	103	19.500	30.334	120.002	171.670
3	No	RC	57	J73	ccc	2	14	RC-57ccc	18.8	24.3	83.7	136	31.334	40.501	139.503	226.671
3	No	RC	51	J83	ccc	2	15	RC-51ccc	14.4	21.3	69.4	126	24.000	35.501	115.669	210.004
3	No	RC	45	J18	quenched	2	16	RC-45	13.2	18.5	69.1	106	22.000	30.834	115.169	176.670
3	No	blank	102	J14		2	17	blank	0.244	0.45	< 0.01	< 0.079	0.407	0.750	0.008	0.066
3	No	std	0	STD-B2-3		2	18	soln std	19.8	9.58	80.7	49.5	19.800	9.580	80.700	49.500
3	No	std	0	STD-B3-1		3	1	soln std	20	9.52	81.3	49.4	20.000	9.520	81.300	49.400
3	No	RC	47	J08	ccc	3	2	RC-47ccc	12.8	19.4	66.3	106	21.334	32.334	110.502	176.670
3	No	RC	57	J80	quenched	3	3	RC-57	13.5	20	71.1	117	22.500	33.334	118.502	195.004
3	No	RC	49	J12	quenched	3	4	RC-49	13.7	20	72	116	22.834	33.334	120.002	193.337
3	No	RC	51	J35	quenched	3	5	RC-51	15.1	21.5	73.4	127	25.167	35.834	122.336	211.671
3	No	RC	57	J54	ccc	3	6	RC-57ccc	18.1	23.9	83.5	134	30.167	39.834	139.170	223.338
3	No	RC	47	J19	quenched	3	7	RC-47	12.6	18.2	67.5	102	21.000	30.334	112.502	170.003
3	No	RC	55	J46	quenched	3	8	RC-55	14.8	20.7	79.7	117	24.667	34.501	132.836	195.004
3	No	std	0	STD-B3-2		3	9	soln std	19.6	9.71	81.6	50	19.600	9.710	81.600	50.000
3	No	RC	53	J05	ccc	3	10	RC-53ccc	11.6	18.7	71	99.5	19.334	31.167	118.336	165.837
3	No	RC	49	J17	ccc	3	11	RC-49ccc	12.8	19.7	65.7	113	21.334	32.834	109.502	188.337
3	No	RC	45	J20	quenched	3	12	RC-45	12.6	18.4	69.2	102	21.000	30.667	115.336	170.003
3	No	RC	51	J28	ccc	3	13	RC-51ccc	14	21.4	68.7	123	23.334	35.667	114.502	205.004
3	No	RC	45	J41	ccc	3	14	RC-45ccc	13.5	21.2	71.4	111	22.500	35.334	119.002	185.004
3	No	RC	55	J45	ccc	3	15	RC-55ccc	14.5	21	75.6	117	24.167	35.001	126.003	195.004
3	No	RC	53	J02	quenched	3	16	RC-53	14	19.2	79.5	104	23.334	32.001	132.503	173.337
3	No	RC	38	J87	ccc	3	17	RC-38ccc	15.6	9.17	43.8	72.9	26.001	15.284	73.001	121.502
3	No	std	0	STD-B3-3		3	18	soln std	19.5	9.55	79.8	48.8	19.500	9.550	79.800	48.800
3	No	std	0	STD-B4-1		4	1	soln std	20	9.57	82.5	50.4	20.000	9.570	82.500	50.400
3	No	RC	52	J51	ccc	4	2	RC-52ccc	13.5	22	64.1	127	22.500	36.667	106.836	211.671
3	No	EA	100	J85		4	3	EA	36.3	10.8	98.3	53	605.012	180.004	1638.366	883.351

Table G.1: SRTC-ML Measurements of the PCT Solutions for the RC Glasses

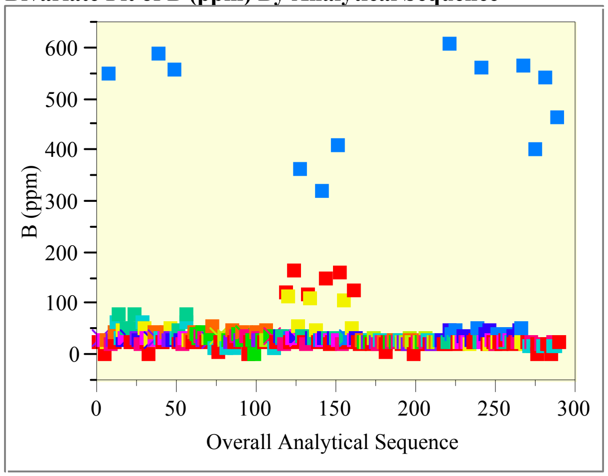
Study	Water-Loss Problem	Glass ID	Glass #	SRTC-ML ID	Heat Treatment	Block	Seq. #	Planning ID	As-Reported (ppm) B	Li	Na	Si	Adjusted for Dilutions (ppm) B	Li	Na	Si
3	No	RC	50	J81	quenched	4	4	RC-50	27.8	33.3	131	188	46.334	55.501	218.338	313.340
3	No	RC	46	J21	ccc	4	5	RC-46ccc	22.2	30.9	115	169	37.001	51.501	191.671	281.672
3	No	RC	52	J59	quenched	4	6	RC-52	13.8	20.7	67.8	123	23.000	34.501	113.002	205.004
3	No	RC	46	J66	quenched	4	7	RC-46	28.3	35.3	143	186	47.168	58.835	238.338	310.006
3	No	RC	48	J79	quenched	4	8	RC-48	14	19.1	77	107	23.334	31.834	128.336	178.337
3	No	std	0	STD-B4-2		4	9	soln std	19.6	9.51	82.2	50.2	19.600	9.510	82.200	50.200
3	No	RC	54	J47	ccc	4	10	RC-54ccc	12.2	20.2	63	114	20.334	33.667	105.002	190.004
3	No	RC	56	J43	ccc	4	11	RC-56ccc	13.9	22.8	68.8	125	23.167	38.001	114.669	208.338
3	No	RC	50	J68	ccc	4	12	RC-50ccc	21.1	32.4	109	186	35.167	54.001	181.670	310.006
3	No	RC	48	J61	ccc	4	13	RC-48ccc	13.7	20.8	75.3	116	22.834	34.667	125.503	193.337
3	No	ARM	101	J55		4	14	ARM	12.1	9.12	24.8	40.1	20.167	15.200	41.334	66.835
3	No	RC	56	J15	quenched	4	15	RC-56	13.9	21.5	71.4	123	23.167	35.834	119.002	205.004
3	No	RC	54	J50	quenched	4	16	RC-54	11.7	18.4	63.3	107	19.500	30.667	105.502	178.337
3	No	RC	38	J13	ccc	4	17	RC-38ccc	16	9.27	45.4	75.3	26.667	15.450	75.668	125.503
3	No	std	0	STD-B4-3		4	18	soln std	20.1	9.64	83.9	49.6	20.100	9.640	83.900	49.600
3	No	std	0	STD-B5-1		5	1	soln std	20.3	9.78	82.7	50.6	20.300	9.780	82.700	50.600
3	No	RC	48	J75	quenched	5	2	RC-48	14.7	20.1	78.9	110	24.500	33.501	131.503	183.337
3	No	RC	46	J70	quenched	5	3	RC-46	30.5	37.6	149	199	50.834	62.668	248.338	331.673
3	No	RC	52	J38	ccc	5	4	RC-52ccc	14	22.9	64.7	123	23.334	38.167	107.836	205.004
3	No	EA	100	J06		5	5	EA	33.5	10.4	90.8	50.3	558.345	173.337	1513.364	838.350
3	No	RC	52	J62	quenched	5	6	RC-52	14.1	21.1	66.9	121	23.500	35.167	111.502	201.671
3	No	RC	56	J60	quenched	5	7	RC-56	13.7	20.9	70	118	22.834	34.834	116.669	196.671
3	No	RC	50	J01	ccc	5	8	RC-50ccc	21.6	32.2	108	190	36.001	53.668	180.004	316.673
3	No	std	0	STD-B5-2		5	9	soln std	20	9.68	80.8	50.2	20.000	9.680	80.800	50.200
3	No	RC	50	J78	quenched	5	10	RC-50	27.3	32.9	128	182	45.501	54.834	213.338	303.339
3	No	RC	54	J34	quenched	5	11	RC-54	11.7	17.8	60.8	103	19.500	29.667	101.335	171.670
3	No	RC	56	J71	ccc	5	12	RC-56ccc	14.6	23	69.4	123	24.334	38.334	115.669	205.004
3	No	RC	48	J26	ccc	5	13	RC-48ccc	14.2	21	75.5	106	23.667	35.001	125.836	176.670
3	No	ARM	101	J03		5	14	ARM	11.6	8.84	23.9	39.6	19.334	14.734	39.834	66.001
3	No	RC	46	J48	ccc	5	15	RC-46ccc	21.8	30.8	113	154	36.334	51.334	188.337	256.672
3	No	RC	54	J40	ccc	5	16	RC-54ccc	12.5	19.8	62.1	109	20.834	33.001	103.502	181.670
3	No	std	0	STD-B5-3		5	17	soln std	20.3	9.75	82.1	50.6	20.300	9.750	82.100	50.600
3	No	std	0	STD-B6-1		6	1	soln std	20	9.54	81.1	49.6	20.000	9.540	81.100	49.600
3	No	RC	56	J49	quenched	6	2	RC-56	14.3	21.2	71.4	120.6	23.834	35.334	119.002	201.004
3	No	RC	52	J11	quenched	6	3	RC-52	14.2	21.3	67.9	120.8	23.667	35.501	113.169	201.337
3	No	RC	48	J72	quenched	6	4	RC-48	14.5	19.7	77.9	106.9	24.167	32.834	129.836	178.170
3	No	RC	46	J69	ccc	6	5	RC-46ccc	22.4	31.3	116	168.5	37.334	52.168	193.337	280.839

Table G.1: SRTC-ML Measurements of the PCT Solutions for the RC Glasses

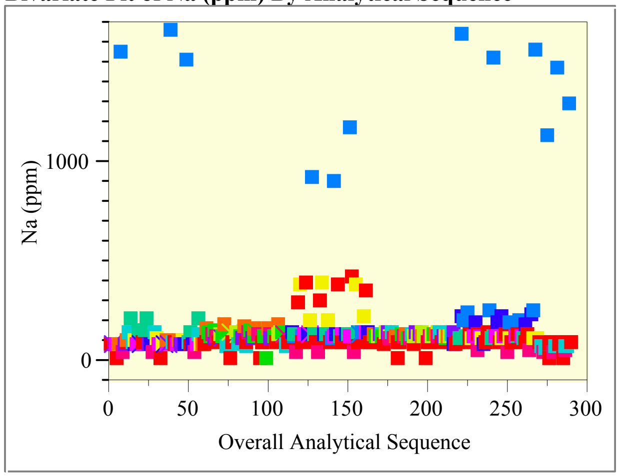
Study	Water-Loss Problem	Glass ID	Glass #	SRTC-ML ID	Heat Treatment	Block	Seq. #	Planning ID	As-Reported (ppm) B	Li	Na	Si	Adjusted for Dilutions (ppm) B	Li	Na	Si
3	No	RC	56	J27	ccc	6	6	RC-56ccc	14.6	23	70.7	125.4	24.334	38.334	117.836	209.004
3	No	RC	52	J82	ccc	6	7	RC-52ccc	13.5	22.2	63.9	124.2	22.500	37.001	106.502	207.004
3	No	RC	50	J10	ccc	6	8	RC-50ccc	20.8	30.6	102.7	169.3	34.667	51.001	171.170	282.172
3	No	std	0	STD-B6-2		6	9	soln std	20	9.66	82.2	50	20.000	9.660	82.200	50.000
3	No	RC	48	J77	ccc	6	10	RC-48ccc	13.9	20.9	76.1	109.1	23.167	34.834	126.836	181.837
3	No	ARM	101	J16		6	11	ARM	12	8.98	24.8	39.7	20.000	14.967	41.334	66.168
3	No	RC	50	J22	quenched	6	12	RC-50	27.8	33.8	133.3	187.5	46.334	56.334	222.171	312.506
3	No	RC	54	J84	ccc	6	13	RC-54ccc	12.7	20.4	64	112.6	21.167	34.001	106.669	187.670
3	No	RC	46	J07	quenched	6	14	RC-46	30.4	37.1	149.3	194	50.668	61.835	248.838	323.340
3	No	EA	100	J09		6	15	EA	33.7	10.4	93.1	50.8	561.678	173.337	1551.698	846.684
3	No	RC	54	J29	quenched	6	16	RC-54	11.9	17.9	62.4	104.1	19.834	29.834	104.002	173.504
3	No	std	0	STD-B6-3		6	17	soln std	20.1	9.66	82.4	49.8	20.100	9.660	82.400	49.800
4	No	std	0	soln std-11		1	1	soln std	19.6	9.55	80.3	49.1	19.600	9.550	80.300	49.100
4	No	RC	31	n089	quenched	1	2	RC-31q-3	8.7	10.4	37	62.1	14.500	17.334	61.668	103.502
4	No	ARM	101	n091		1	3	ARM-3	12	8.85	23.6	38.5	20.000	14.750	39.334	64.168
4	No	RC	31	n087	ccc	1	4	RC-31ccc-3	8.27	10.2	34.7	61.7	13.784	17.000	57.834	102.835
4	No	EA	100	n088		1	5	EA-1	23.9	7.91	67.3	39.7	398.341	131.836	1121.689	661.680
4	No	blank	102	n093		1	6	blank-2	0.333	0.554	0.148	0.21	0.555	0.923	0.247	0.350
4	No	std	0	soln std-12		1	7	soln std	19.4	9.59	79.4	49.1	19.400	9.590	79.400	49.100
4	No	std	0	soln std-21		2	1	soln std	19.9	9.69	80.7	50.2	19.900	9.690	80.700	50.200
4	No	ARM	101	n094		2	2	ARM-2	11.4	8.59	23.1	38.2	19.000	14.317	38.501	63.668
4	No	RC	31	n090	ccc	2	3	RC-31ccc-1	8.54	10.5	36.1	64.3	14.234	17.500	60.168	107.169
4	No	EA	100	n095		2	4	EA-3	32.4	10.1	87.8	49.3	540.011	168.337	1463.363	821.683
4	No	RC	31	n096	quenched	2	5	RC-31q-1	8.62	10.6	36.8	63	14.367	17.667	61.335	105.002
4	No	std	0	soln std-22		2	6	soln std	19.8	9.72	79.1	50.1	19.800	9.720	79.100	50.100
4	No	std	0	soln std-31		3	1	soln std	20	9.57	80.7	49.7	20.000	9.570	80.700	49.700
4	No	blank	102	n099		3	2	blank-1	0.245	0.538	< 0.01	< 0.079	0.408	0.897	0.008	0.066
4	No	ARM	101	n100		3	3	ARM-1	12.1	8.89	24	39.1	20.167	14.817	40.001	65.168
4	No	RC	31	n097	quenched	3	4	RC-31q-2	8.59	10.3	37.2	62.8	14.317	17.167	62.001	104.669
4	No	RC	31	n098	ccc	3	5	RC-31ccc-2	8.54	10.4	36.3	64.9	14.234	17.334	60.501	108.169
4	No	EA	100	n092		3	6	EA-2	27.6	8.63	77.2	44.4	460.009	143.836	1286.692	740.015
4	No	std	0	soln std-32		3	7	soln std	20.1	9.49	81.6	50	20.100	9.490	81.600	50.000

Exhibit G.1: SRTC-ML PCT Measurements in Overall Analytical Sequence Including All RC Glasses, EA, ARM, Blanks, and Samples of the Solution Standard

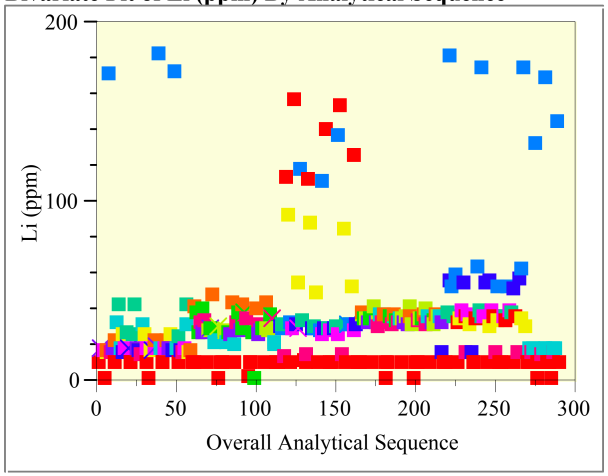
Bivariate Fit of B (ppm) By Analytical Sequence



Bivariate Fit of Na (ppm) By Analytical Sequence



Bivariate Fit of Li (ppm) By Analytical Sequence



Bivariate Fit of Si (ppm) By Analytical Sequence

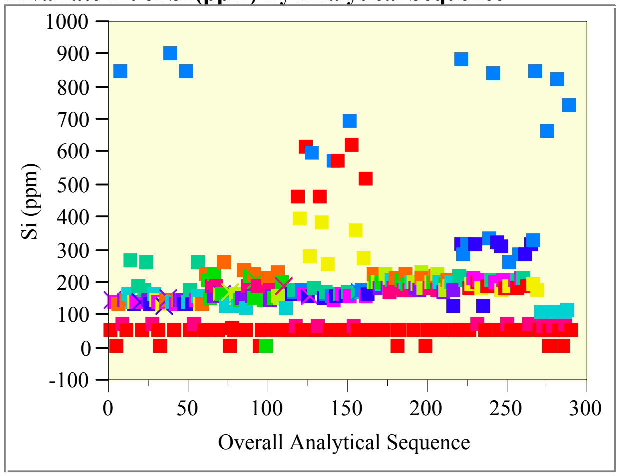
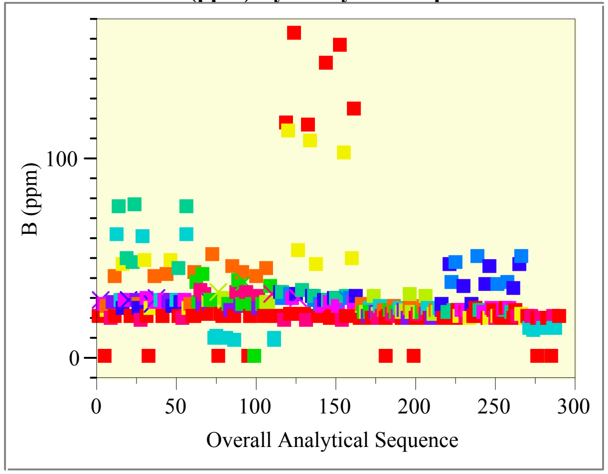
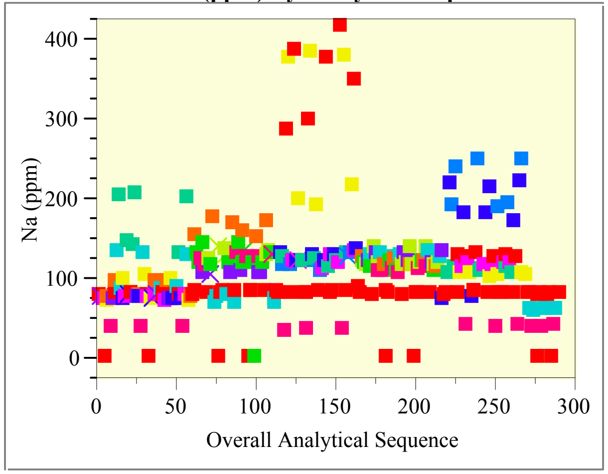


Exhibit G.2: SRTC-ML PCT Measurements in Overall Analytical Sequence Including All RC Glasses, ARM, Blanks, and Samples of the Solution Standard but Excluding EA

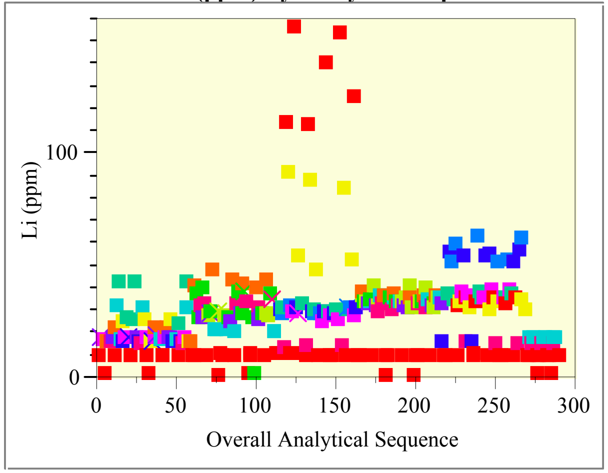
Bivariate Fit of B (ppm) By Analytical Sequence



Bivariate Fit of Na (ppm) By Analytical Sequence



Bivariate Fit of Li (ppm) By Analytical Sequence



Bivariate Fit of Si (ppm) By Analytical Sequence

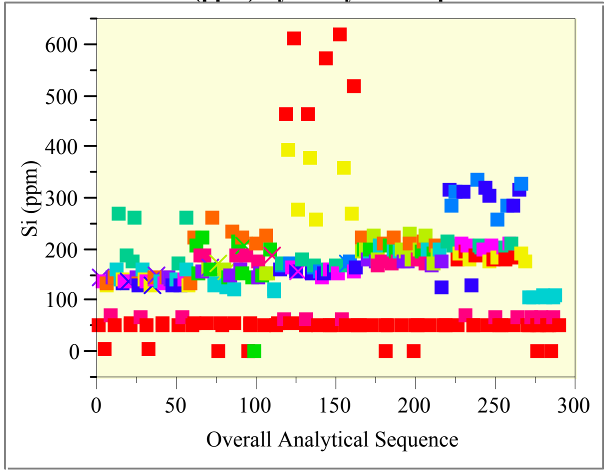
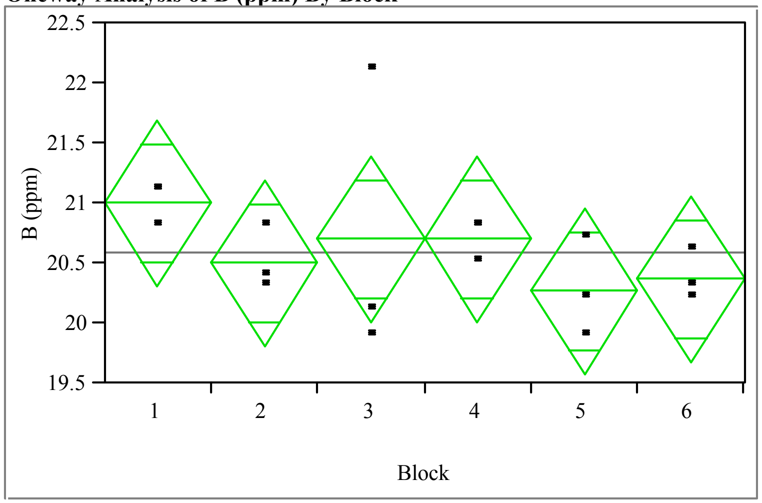


Exhibit G.3: Measurements of the Multi-Element Solution Standard by ICP Block

Oneway Analysis of B (ppm) By Block



Oneway Anova

Summary of Fit

Rsquare	0.226585
Adj Rsquare	-0.09567
Root Mean Square Error	0.550252
Mean of Response	20.58889
Observations (or Sum Wgts)	18

Analysis of Variance

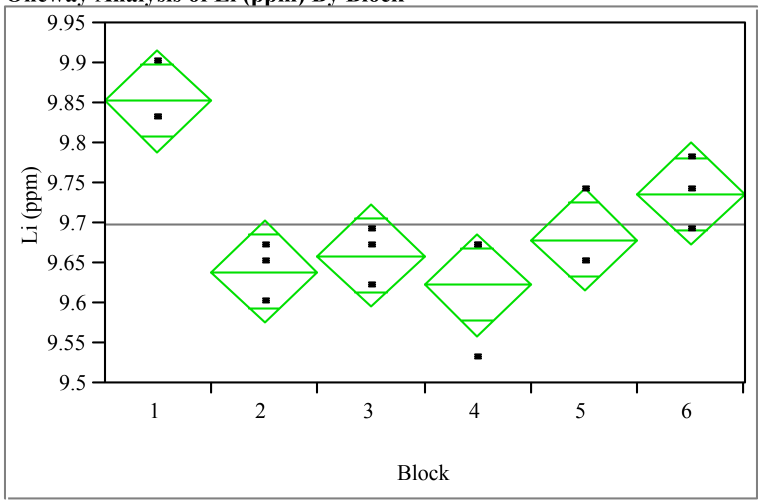
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block	5	1.0644444	0.212889	0.7031	0.6319
Error	12	3.6333333	0.302778		
C. Total	17	4.6977778			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1	3	21.0000	0.31769	20.308	21.692
2	3	20.5000	0.31769	19.808	21.192
3	3	20.7000	0.31769	20.008	21.392
4	3	20.7000	0.31769	20.008	21.392
5	3	20.2667	0.31769	19.574	20.959
6	3	20.3667	0.31769	19.674	21.059

Std Error uses a pooled estimate of error variance

Oneway Analysis of Li (ppm) By Block



Oneway Anova

Summary of Fit

Rsquare	0.778536
Adj Rsquare	0.68626
Root Mean Square Error	0.050827
Mean of Response	9.698889
Observations (or Sum Wgts)	18

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block	5	0.10897778	0.021796	8.4370	0.0013
Error	12	0.03100000	0.002583		
C. Total	17	0.13997778			

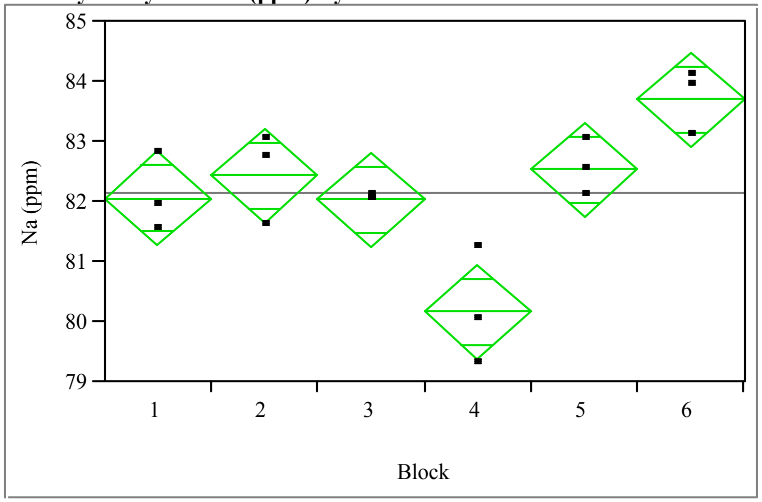
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1	3	9.85333	0.02934	9.7894	9.9173
2	3	9.64000	0.02934	9.5761	9.7039
3	3	9.66000	0.02934	9.5961	9.7239
4	3	9.62333	0.02934	9.5594	9.6873
5	3	9.68000	0.02934	9.6161	9.7439
6	3	9.73667	0.02934	9.6727	9.8006

Std Error uses a pooled estimate of error variance

Exhibit G.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	0.804708
Adj Rsquare	0.723336
Root Mean Square Error	0.632016
Mean of Response	82.15556
Observations (or Sum Wgts)	18

Analysis of Variance

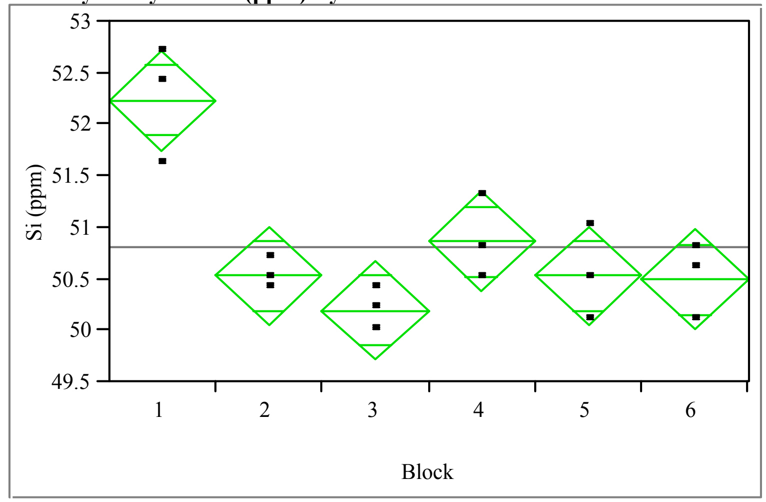
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block	5	19.751111	3.95022	9.8893	0.0006
Error	12	4.793333	0.39944		
C. Total	17	24.544444			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1	3	82.0667	0.36489	81.272	82.862
2	3	82.4333	0.36489	81.638	83.228
3	3	82.0333	0.36489	81.238	82.828
4	3	80.1667	0.36489	79.372	80.962
5	3	82.5333	0.36489	81.738	83.328
6	3	83.7000	0.36489	82.905	84.495

Std Error uses a pooled estimate of error variance

Oneway Analysis of Si (ppm) By Block



Oneway Anova

Summary of Fit

Rsquare	0.818203
Adj Rsquare	0.742454
Root Mean Square Error	0.383695
Mean of Response	50.81111
Observations (or Sum Wgts)	18

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block	5	7.9511111	1.59022	10.8015	0.0004
Error	12	1.7666667	0.14722		
C. Total	17	9.7177778			

Means for Oneway Anova

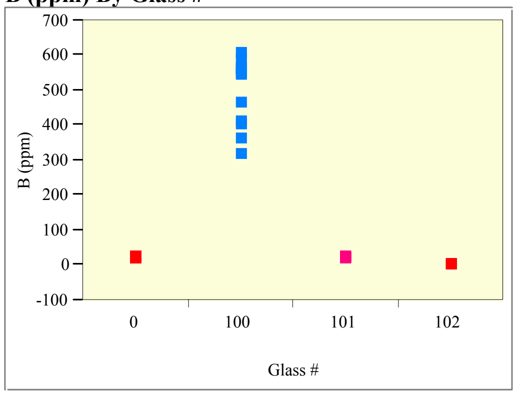
Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1	3	52.2333	0.22153	51.751	52.716
2	3	50.5333	0.22153	50.051	51.016
3	3	50.2000	0.22153	49.717	50.683
4	3	50.8667	0.22153	50.384	51.349
5	3	50.5333	0.22153	50.051	51.016
6	3	50.5000	0.22153	50.017	50.983

Std Error uses a pooled estimate of error variance

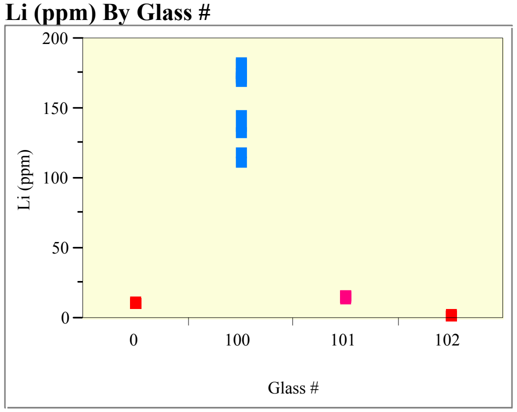
Exhibit G.4: SRTC-ML PCT Measurements by Glass Number Grouped by Standards, (0 –Solution Standard, 100 – EA, 101 – ARM, and 102 – Blanks), Centerline-Cooled (ccc), and Quenched Results

Standards

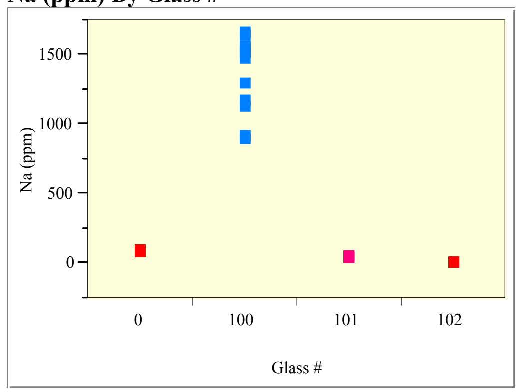
B (ppm) By Glass #



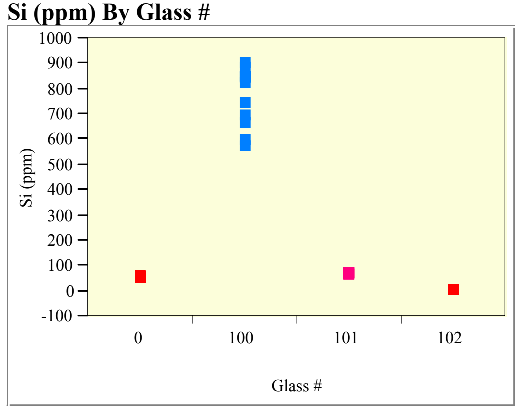
Li (ppm) By Glass #



Na (ppm) By Glass #

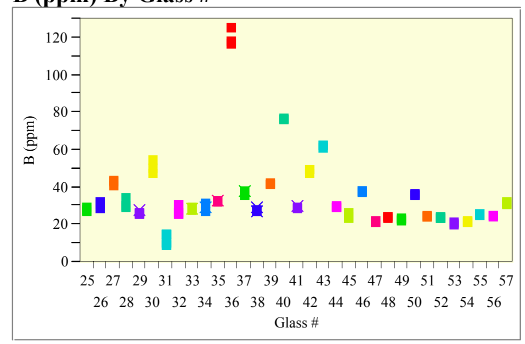


Si (ppm) By Glass #



ccc

B (ppm) By Glass #



Li (ppm) By Glass #

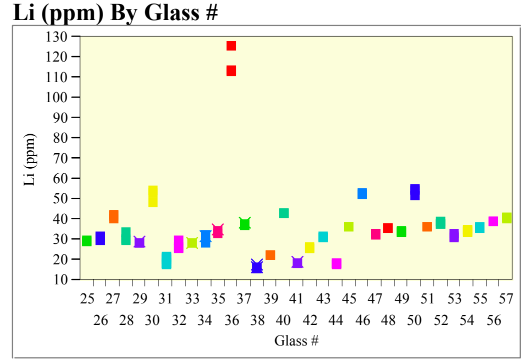
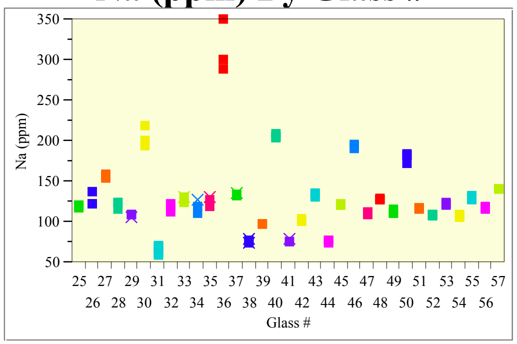


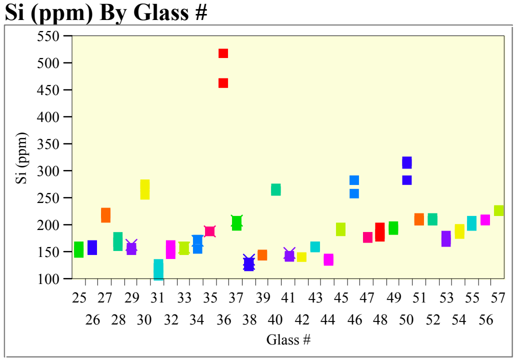
Exhibit G.4: SRTC-ML PCT Measurements by Glass Number Grouped by Standards, (0 –Solution Standard, 100 – EA, 101 – ARM, and 102 – Blanks), Centerline-Cooled (ccc), and Quenched Results

ccc *(continued)*

Na (ppm) By Glass

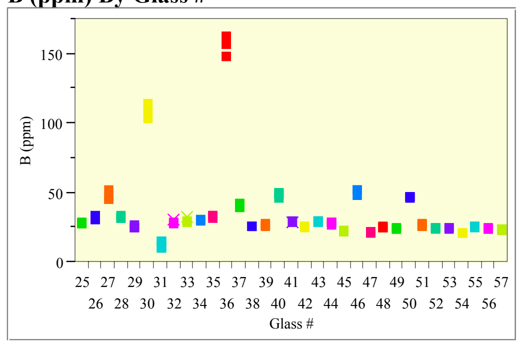


Si (ppm) By Glass #

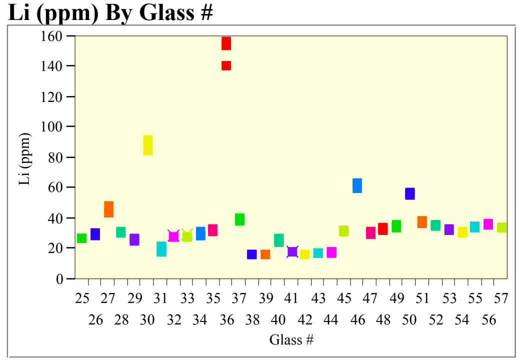


quenched

B (ppm) By Glass #

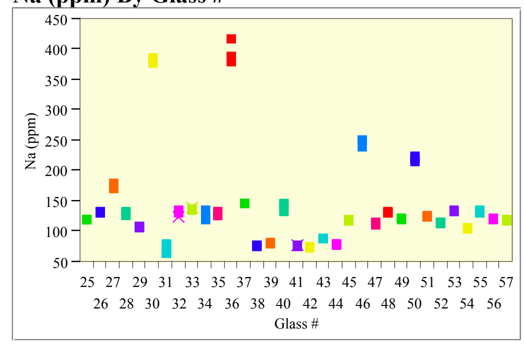


Li (ppm) By Glass #



quenched *(continued)*

Na (ppm) By Glass #



Si (ppm) By Glass #

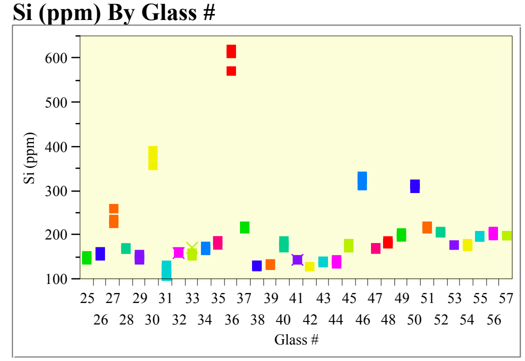
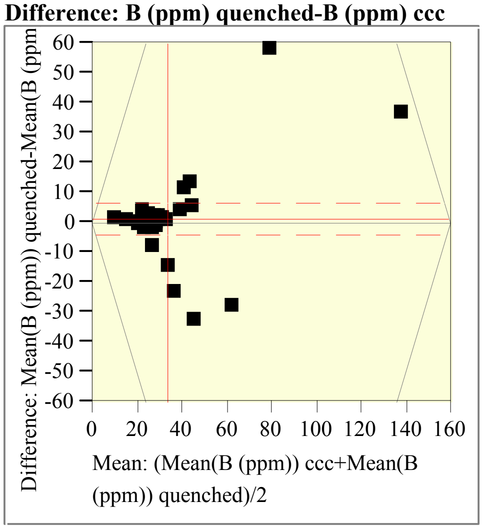


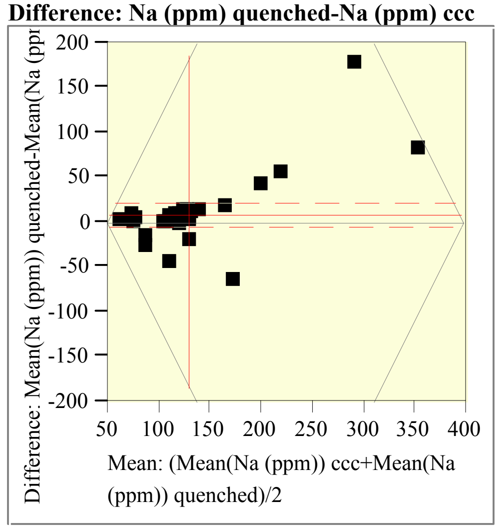
Exhibit G.5: Pairwise Comparisons between the PCTs (in ppm) for the Two Heat Treatments (Quenched and Centerline-Cooled)

Difference: B (ppm) quenched-B (ppm) ccc



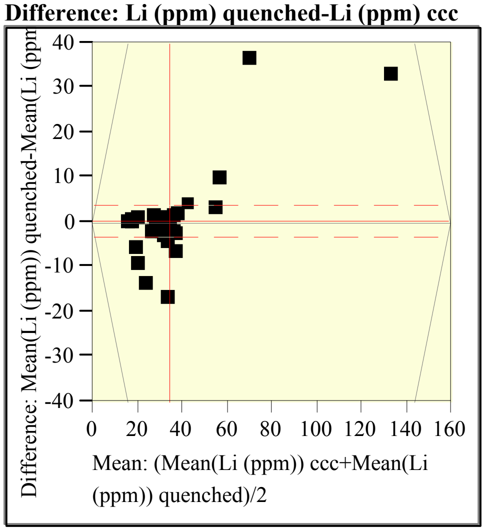
Mean(B (ppm)) quenched	34.1314	t-Ratio	0.261868
Mean(B (ppm)) ccc	33.4445	DF	33
Mean Difference	0.68694	Prob > |t|	0.7951
Std Error	2.62323	Prob > t	0.3975
Upper95%	6.02395	Prob < t	0.6025
Lower95%	-4.6501		
N	34		
Correlation	0.82794		

Difference: Na (ppm) quenched-Na (ppm) ccc



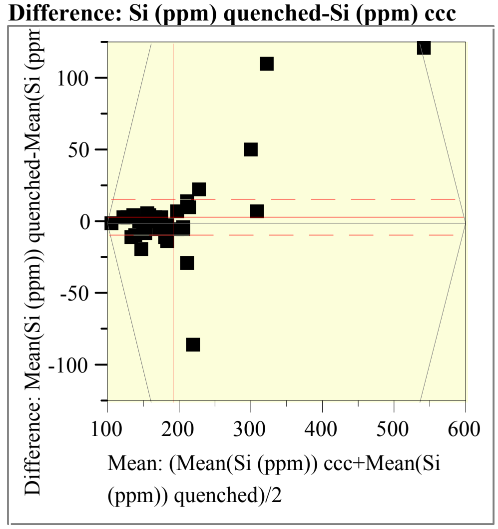
Mean(Na (ppm)) quenched	135.225	t-Ratio	1.315055
Mean(Na (ppm)) ccc	126.551	DF	33
Mean Difference	8.6737	Prob > |t|	0.1976
Std Error	6.5957	Prob > t	0.0988
Upper95%	22.0928	Prob < t	0.9012
Lower95%	-4.7453		
N	34		
Correlation	0.89009		

Difference: Li (ppm) quenched-Li (ppm) ccc



Mean(Li (ppm)) quenched	34.887	t-Ratio	0.133861
Mean(Li (ppm)) ccc	34.6591	DF	33
Mean Difference	0.22785	Prob > |t|	0.8943
Std Error	1.70212	Prob > t	0.4472
Upper95%	3.69084	Prob < t	0.5528
Lower95%	-3.2351		
N	34		
Correlation	0.95167		

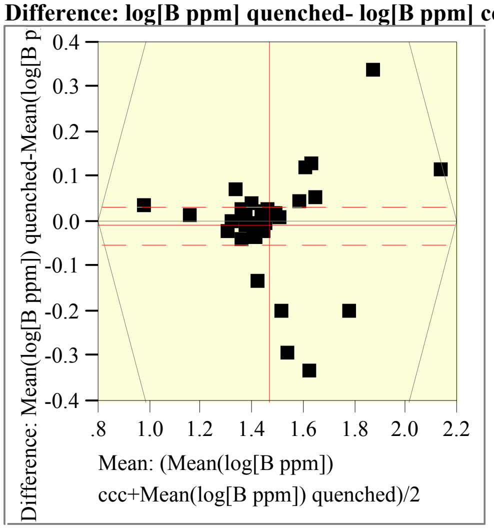
Difference: Si (ppm) quenched-Si (ppm) ccc



Mean(Si (ppm)) quenched	194.607	t-Ratio	0.587742
Mean(Si (ppm)) ccc	191.162	DF	33
Mean Difference	3.44484	Prob > |t|	0.5607
Std Error	5.86114	Prob > t	0.2804
Upper95%	15.3694	Prob < t	0.7196
Lower95%	-8.4797		
N	34		
Correlation	0.95078		

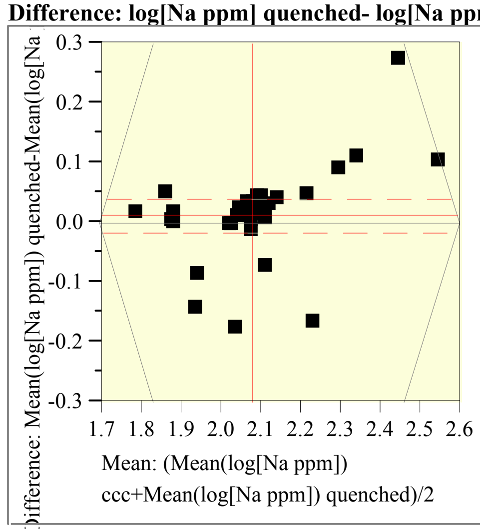
Exhibit G.6: Pairwise Comparisons between the PCTs (in log ppm) for the Two Heat Treatments (Quenched and Centerline-Cooled)

Difference: log[B ppm] quenched- log[B ppm] ccc



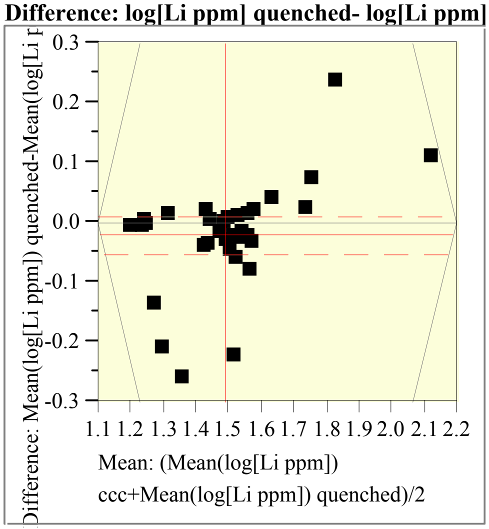
Mean(log[B ppm]) quenched	1.46592	t-Ratio	-0.39143
Mean(log[B ppm]) ccc	1.47394	DF	33
Mean Difference	-0.008	Prob > |t|	0.6980
Std Error	0.02049	Prob > t	0.6510
Upper95%	0.03367	Prob < t	0.3490
Lower95%	-0.0497		
N	34		
Correlation	0.83704		

Difference: log[Na ppm] quenched- log[Na ppm] ccc



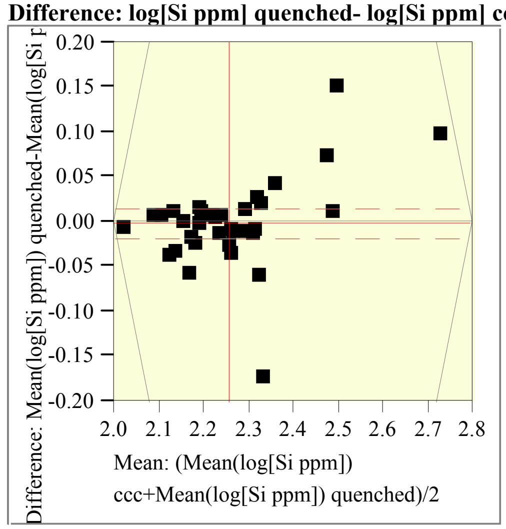
Mean(log[Na ppm]) quenched	2.08844	t-Ratio	0.768749
Mean(log[Na ppm]) ccc	2.0779	DF	33
Mean Difference	0.01054	Prob > |t|	0.4475
Std Error	0.01371	Prob > t	0.2238
Upper95%	0.03843	Prob < t	0.7762
Lower95%	-0.0174		
N	34		
Correlation	0.90374		

Difference: log[Li ppm] quenched- log[Li ppm] ccc



Mean(log[Li ppm]) quenched	1.4821	t-Ratio	-1.50118
Mean(log[Li ppm]) ccc	1.50499	DF	33
Mean Difference	-0.0229	Prob > |t|	0.1428
Std Error	0.01524	Prob > t	0.9286
Upper95%	0.00813	Prob < t	0.0714
Lower95%	-0.0539		
N	34		
Correlation	0.91502		

Difference: log[Si ppm] quenched- log[Si ppm] ccc



Mean(log[Si ppm]) quenched	2.25881	t-Ratio	-0.25215
Mean(log[Si ppm]) ccc	2.261	DF	33
Mean Difference	-0.0022	Prob > |t|	0.8025
Std Error	0.00867	Prob > t	0.5988
Upper95%	0.01544	Prob < t	0.4012
Lower95%	-0.0198		
N	34		
Correlation	0.94678		

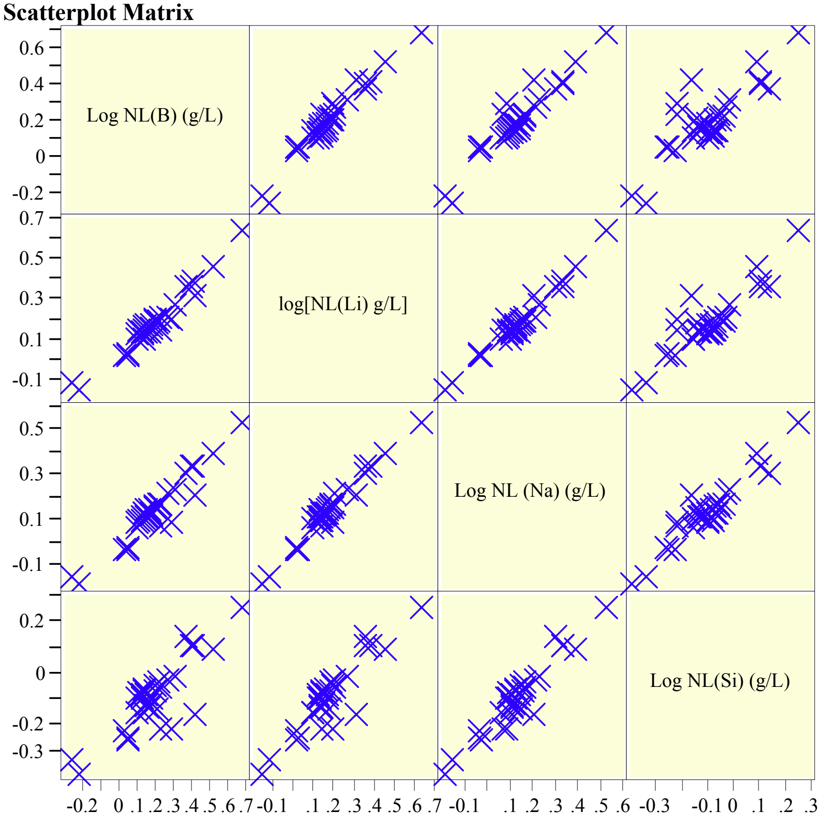
Exhibit G.7: Scatter Plots of Normalized PCTs by Screened vs Not Screened/Compositional View/Heat Treatment

Not Screened/Measured bc/ccc

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	0.9780	0.9545	0.8402
log NL[Li(g/L)]	0.9780	1.0000	0.9827	0.9100
log NL[Na (g/L)]	0.9545	0.9827	1.0000	0.9483
log NL[Si (g/L)]	0.8402	0.9100	0.9483	1.0000

Scatterplot Matrix



Not Screened/Measured bc/quenched

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	0.9902	0.9869	0.9668
log NL[Li(g/L)]	0.9902	1.0000	0.9884	0.9769
log NL[Na (g/L)]	0.9869	0.9884	1.0000	0.9823
log NL[Si (g/L)]	0.9668	0.9769	0.9823	1.0000

Scatterplot Matrix

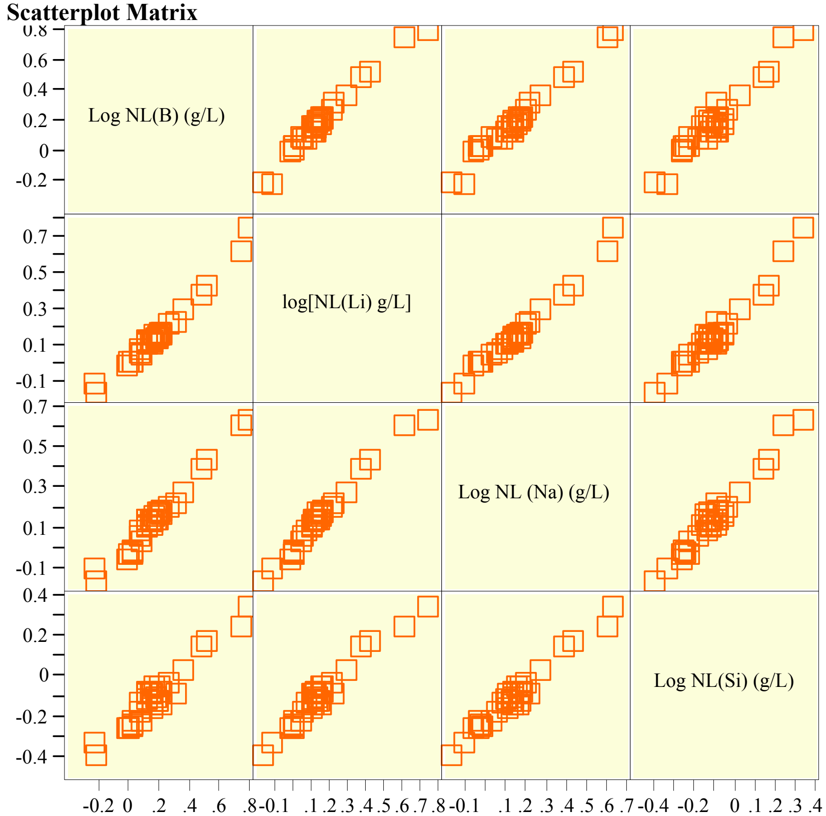


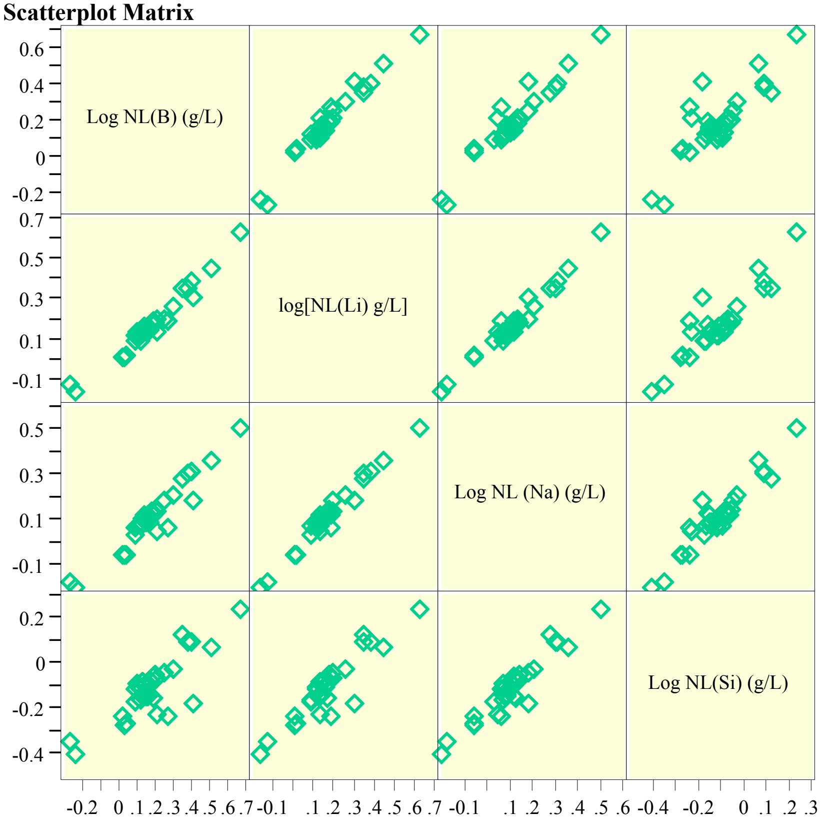
Exhibit G.7: Scatter Plots of Normalized PCTs by Screened vs Not Screened/Compositional View/Heat Treatment *(continued)*

Not Screened/Measured/ccc

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	0.9776	0.9546	0.8387
log NL[Li(g/L)]	0.9776	1.0000	0.9827	0.9086
log NL[Na (g/L)]	0.9546	0.9827	1.0000	0.9473
log NL[Si (g/L)]	0.8387	0.9086	0.9473	1.0000

Scatterplot Matrix



Not Screened/Measured/quenched

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	0.9898	0.9871	0.9666
log NL[Li(g/L)]	0.9898	1.0000	0.9885	0.9766
log NL[Na (g/L)]	0.9871	0.9885	1.0000	0.9823
log NL[Si (g/L)]	0.9666	0.9766	0.9823	1.0000

Scatterplot Matrix

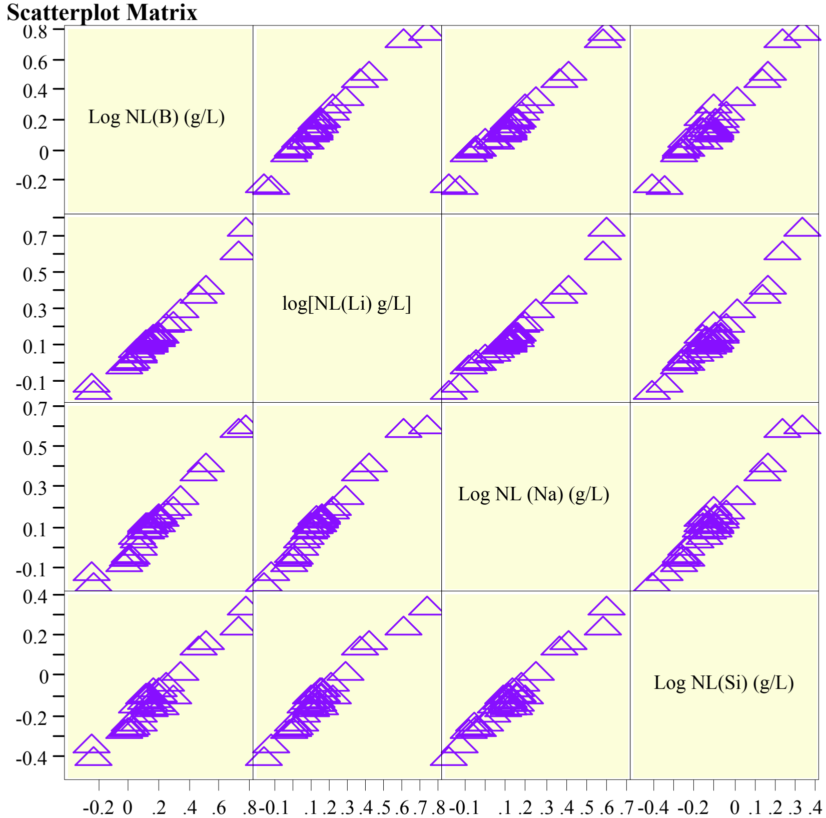


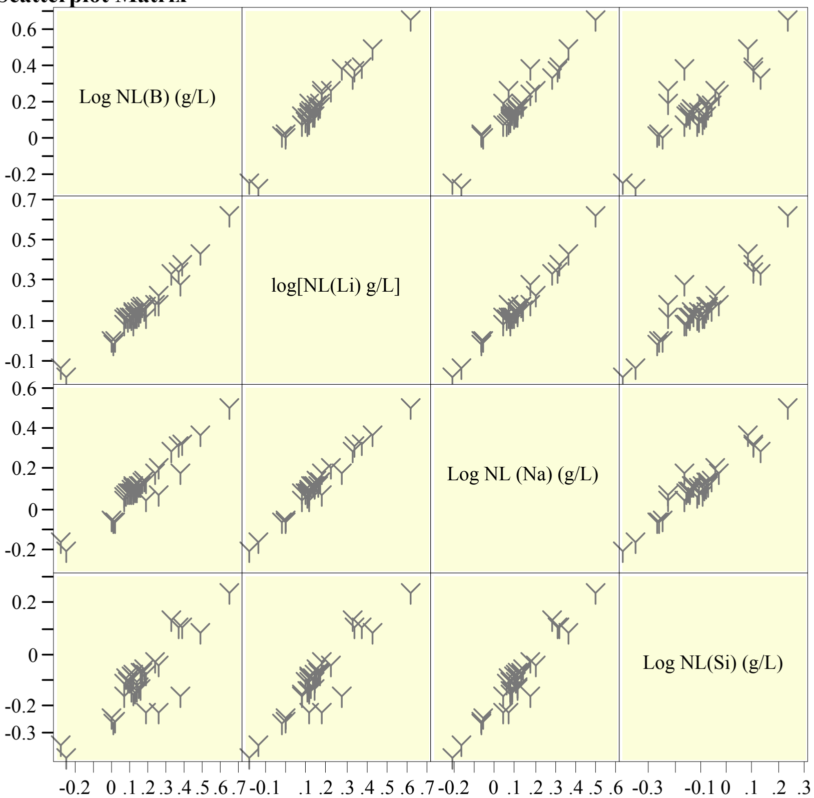
Exhibit G.7: Scatter Plots of Normalized PCTs by Screened vs Not Screened/Compositional View/Heat Treatment *(continued)*

Not Screened/Targeted/ccc

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	0.9772	0.9558	0.8533
log NL[Li(g/L)]	0.9772	1.0000	0.9846	0.9175
log NL[Na (g/L)]	0.9558	0.9846	1.0000	0.9568
log NL[Si (g/L)]	0.8533	0.9175	0.9568	1.0000

Scatterplot Matrix



Not Screened/Targeted/quenched

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	0.9897	0.9882	0.9743
log NL[Li(g/L)]	0.9897	1.0000	0.9887	0.9790
log NL[Na (g/L)]	0.9882	0.9887	1.0000	0.9869
log NL[Si (g/L)]	0.9743	0.9790	0.9869	1.0000

Scatterplot Matrix

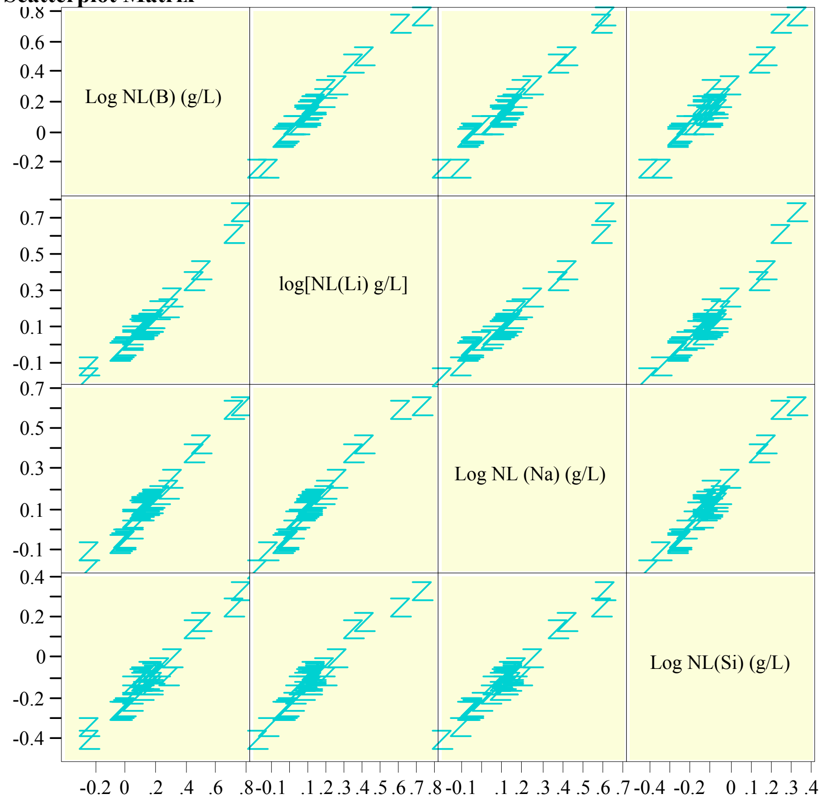


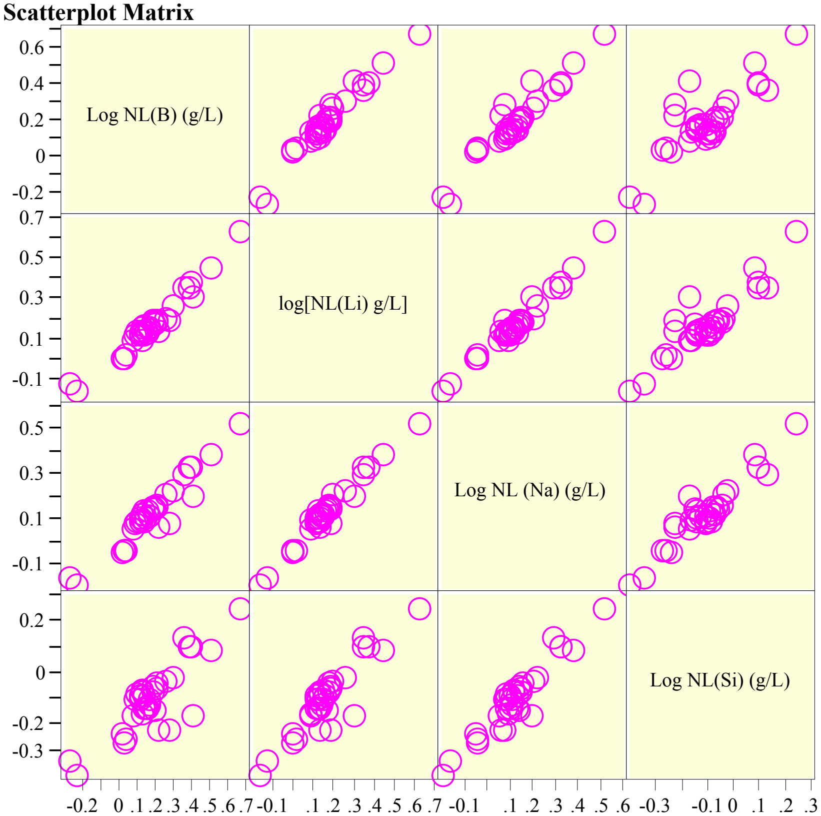
Exhibit G.7: Scatter Plots of Normalized PCTs by Screened vs Not Screened/Compositional View/Heat Treatment *(continued)*

Screened/Measured bc/ccc

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	0.9778	0.9551	0.8410
log NL[Li(g/L)]	0.9778	1.0000	0.9834	0.9107
log NL[Na (g/L)]	0.9551	0.9834	1.0000	0.9489
log NL[Si (g/L)]	0.8410	0.9107	0.9489	1.0000

Scatterplot Matrix



Screened/Measured bc/quenched

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	0.9903	0.9861	0.9670
log NL[Li(g/L)]	0.9903	1.0000	0.9876	0.9769
log NL[Na (g/L)]	0.9861	0.9876	1.0000	0.9812
log NL[Si (g/L)]	0.9670	0.9769	0.9812	1.0000

Scatterplot Matrix

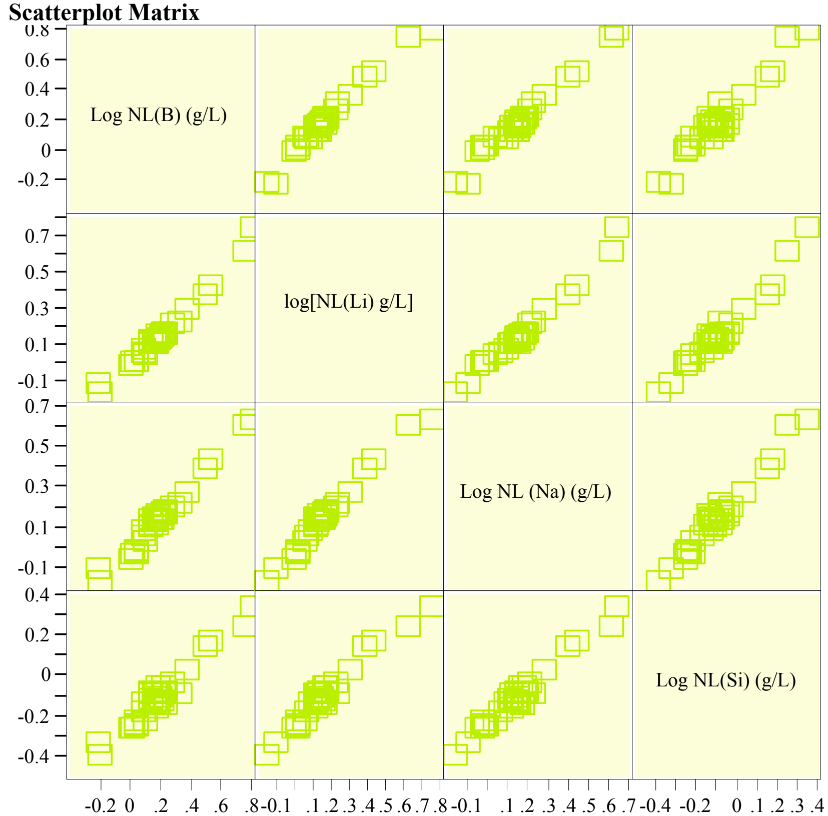


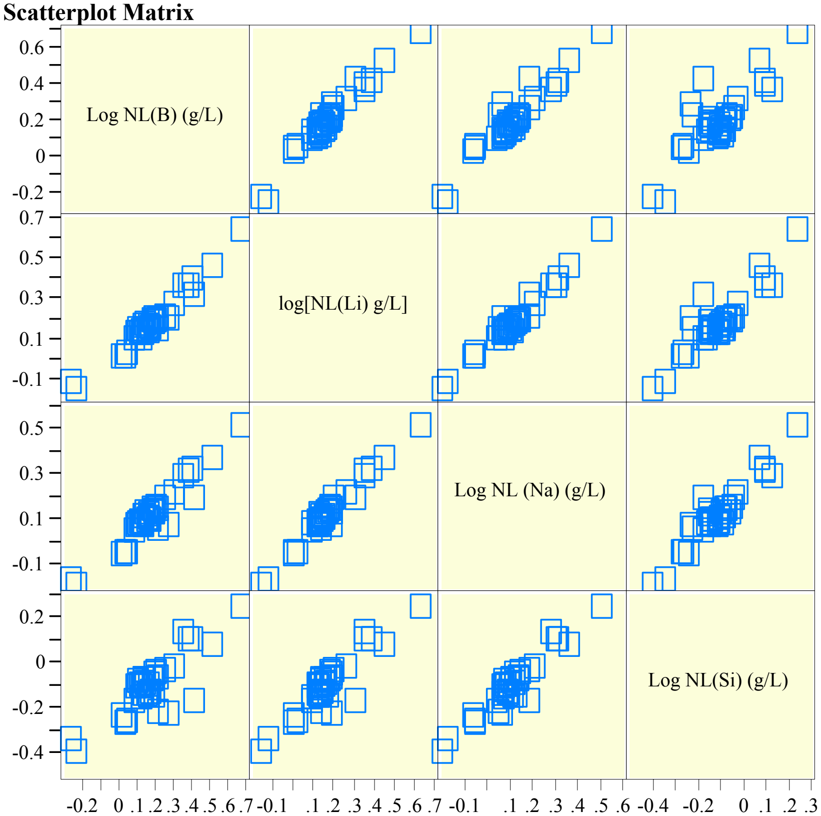
Exhibit G.7: Scatter Plots of Normalized PCTs by Screened vs Not Screened/Compositional View/Heat Treatment *(continued)*

Screened/Measured/ccc

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	0.9775	0.9551	0.8396
log NL[Li(g/L)]	0.9775	1.0000	0.9834	0.9094
log NL[Na (g/L)]	0.9551	0.9834	1.0000	0.9479
log NL[Si (g/L)]	0.8396	0.9094	0.9479	1.0000

Scatterplot Matrix



Screened/Measured/quenched

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	0.9900	0.9863	0.9668
log NL[Li(g/L)]	0.9900	1.0000	0.9877	0.9766
log NL[Na (g/L)]	0.9863	0.9877	1.0000	0.9812
log NL[Si (g/L)]	0.9668	0.9766	0.9812	1.0000

Scatterplot Matrix

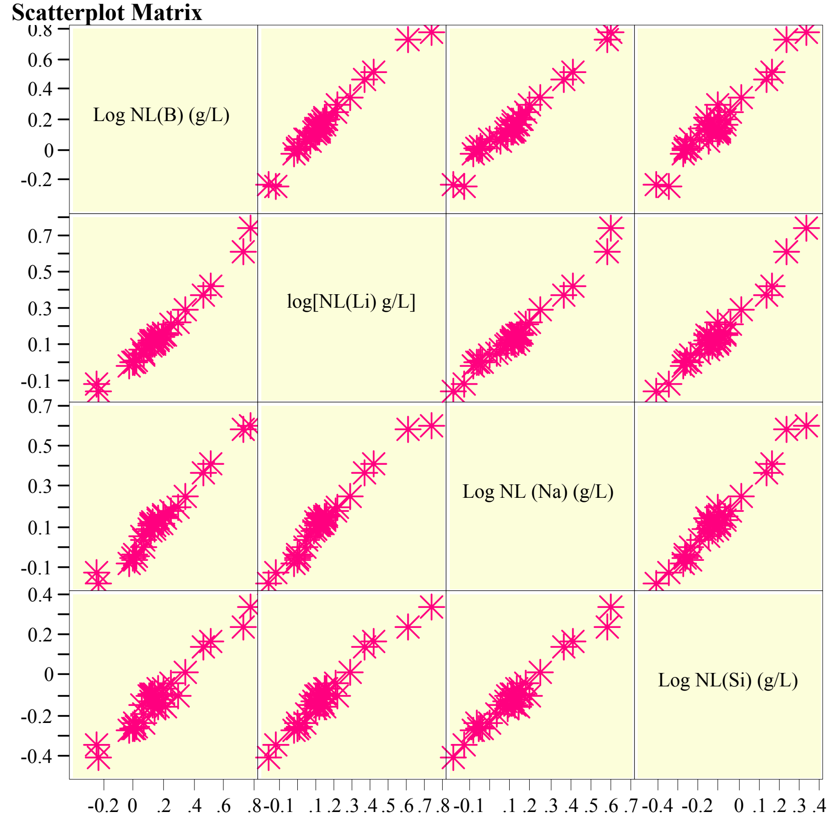


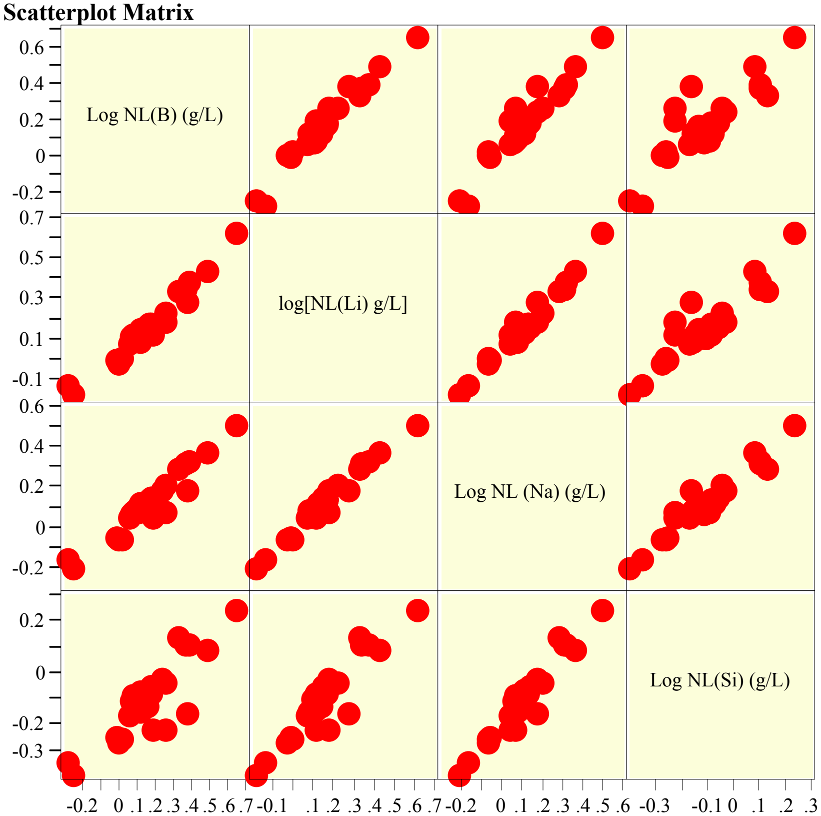
Exhibit G.7: Scatter Plots of Normalized PCTs by Screened vs Not Screened/Compositional View/Heat Treatment *(continued)*

Screened/Targeted/ccc

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	0.9770	0.9562	0.8541
log NL[Li(g/L)]	0.9770	1.0000	0.9850	0.9182
log NL[Na (g/L)]	0.9562	0.9850	1.0000	0.9572
log NL[Si (g/L)]	0.8541	0.9182	0.9572	1.0000

Scatterplot Matrix



Screened/Targeted/quenched

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	0.9899	0.9876	0.9745
log NL[Li(g/L)]	0.9899	1.0000	0.9881	0.9790
log NL[Na (g/L)]	0.9876	0.9881	1.0000	0.9861
log NL[Si (g/L)]	0.9745	0.9790	0.9861	1.0000

Scatterplot Matrix

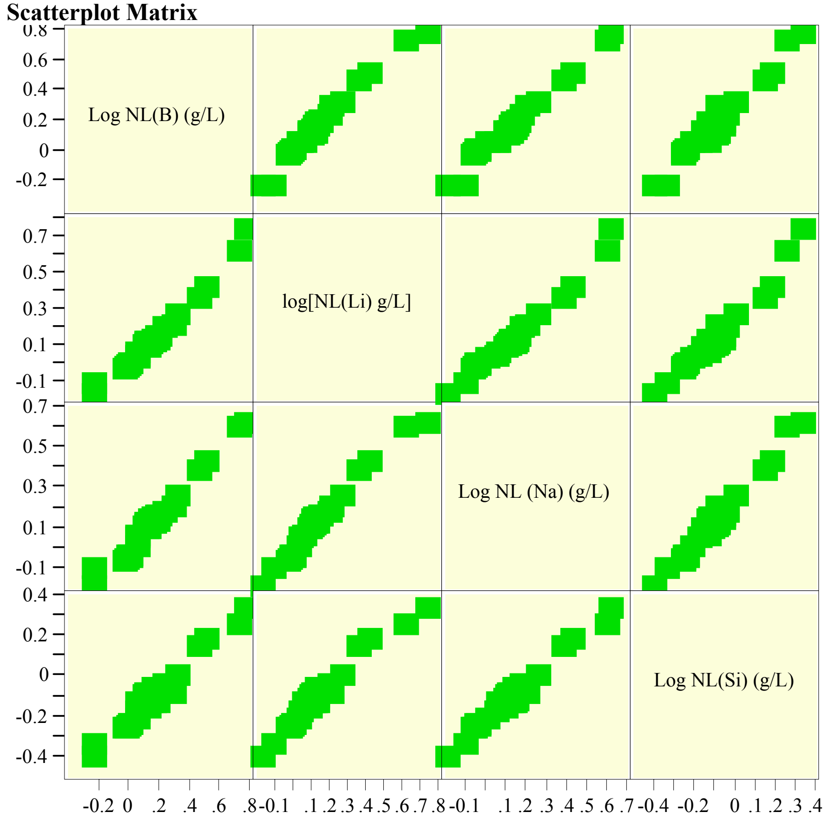
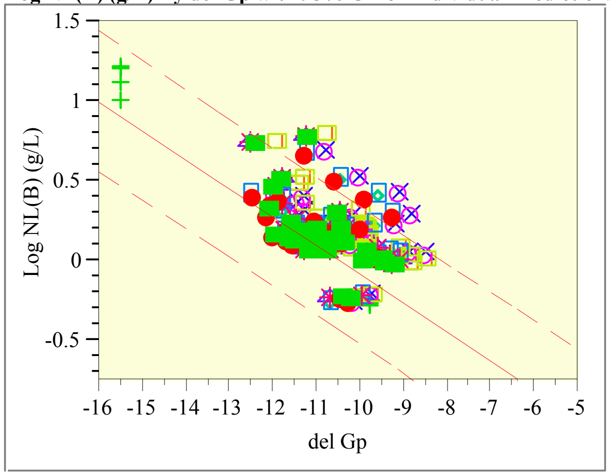


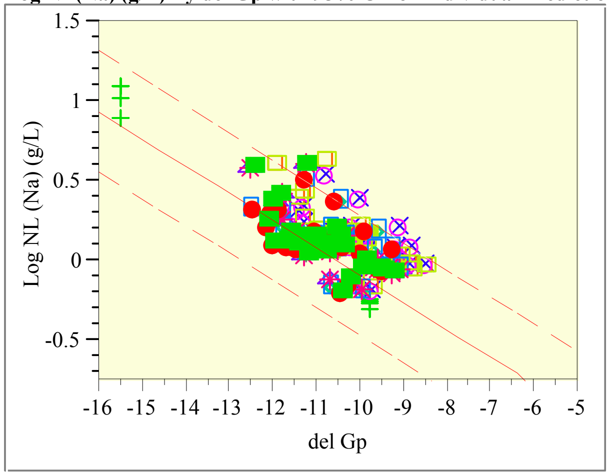
Exhibit G.8: del Gp (ΔG_p) Predictions versus Common Logarithm Normalized Leachate (log NL[.]) for B, Li, Na, and Si by Screened vs Not Screened Data/Compositional View/Heat Treatment

All Data

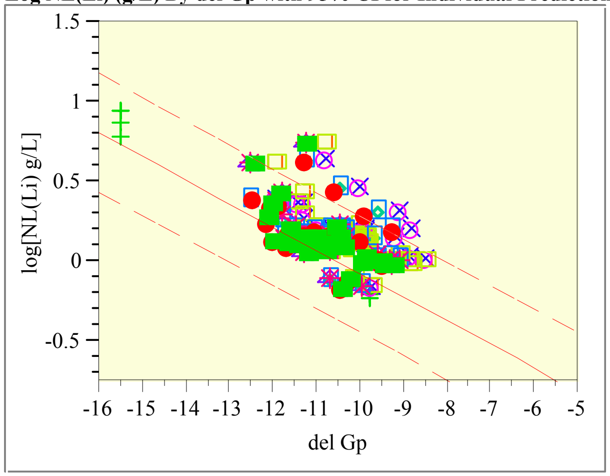
Log NL(B) (g/L) By del Gp with 95% CI for Individual Predictions



Log NL(Na) (g/L) By del Gp with 95% CI for Individual Predictions



Log NL(Li) (g/L) By del Gp with 95% CI for Individual Predictions



Log NL(Si) (g/L) By del Gp with 95% CI for Individual Predictions

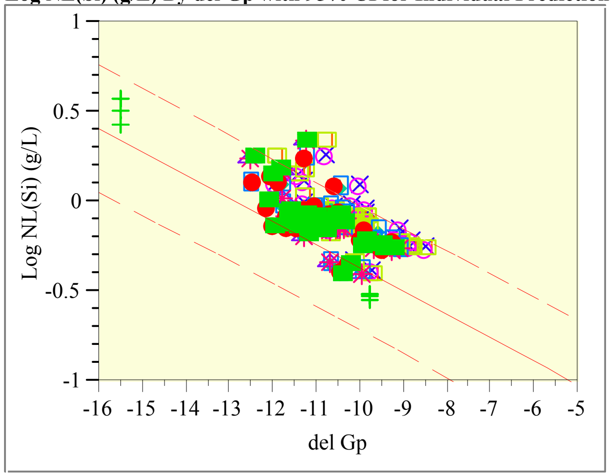
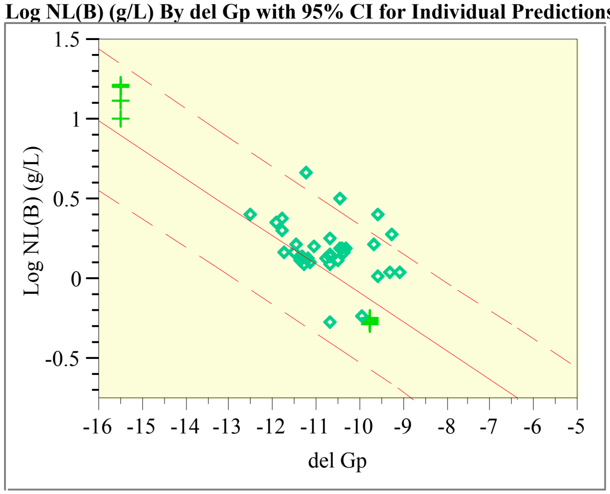


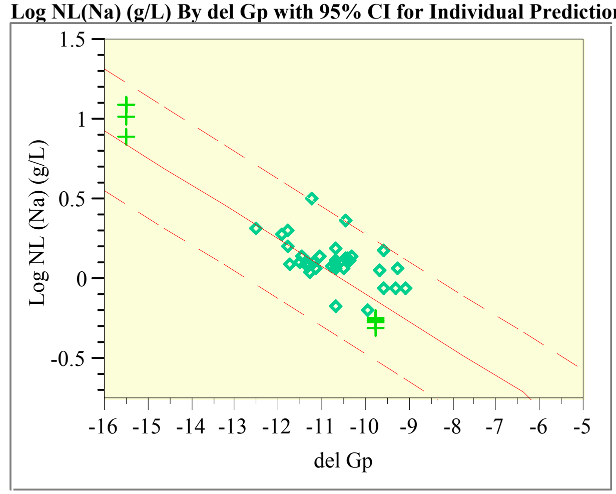
Exhibit G.8: del Gp (ΔG_p) Predictions versus Common Logarithm Normalized Leachate (log NL[.]) for B, Li, Na, and Si by Screened vs Not Screened Data/Compositional View/Heat Treatment *(continued)*

Not Screened/Measured/ccc

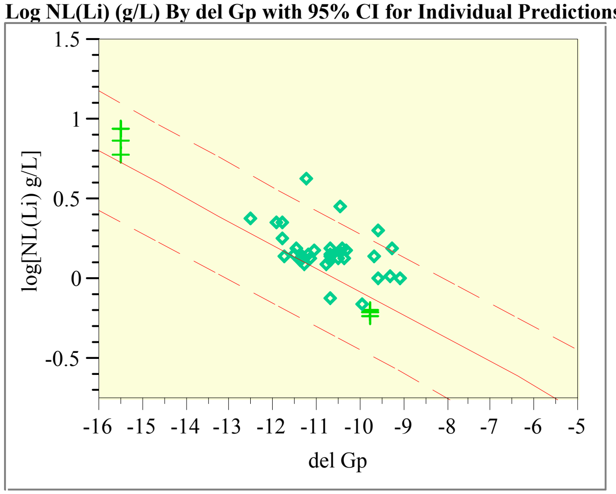
Log NL(B) (g/L) By del Gp with 95% CI for Individual Predictions



Log NL(Na) (g/L) By del Gp with 95% CI for Individual Predictions



Log NL(Li) (g/L) By del Gp with 95% CI for Individual Predictions



Log NL(Si) (g/L) By del Gp with 95% CI for Individual Predictions

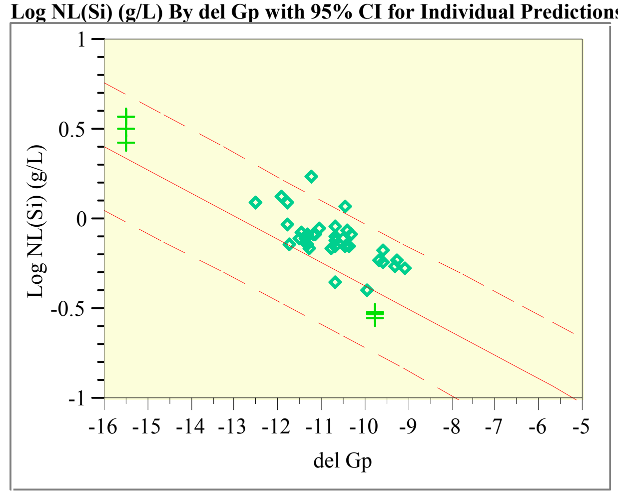
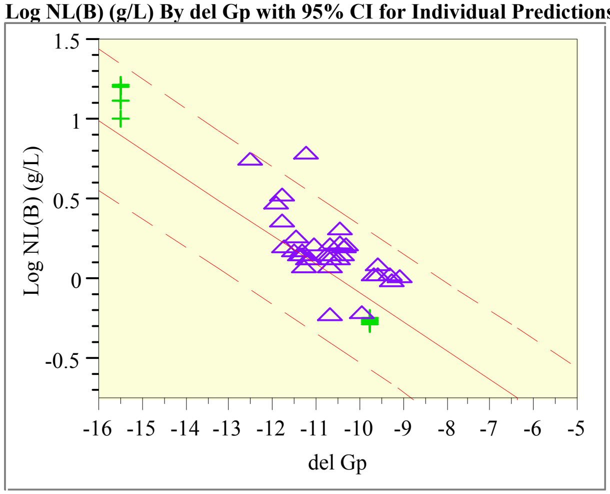


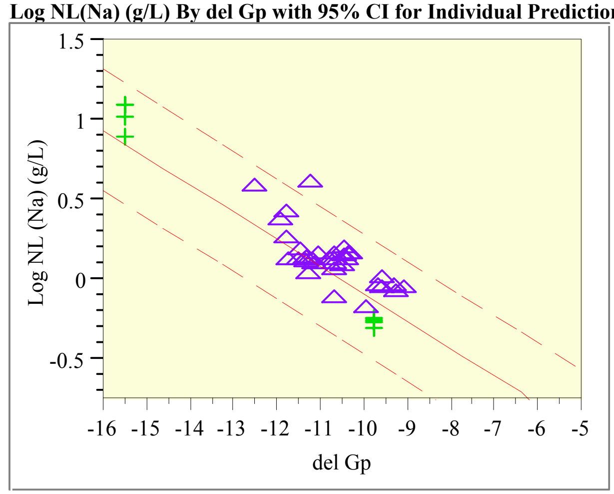
Exhibit G.8: del Gp (ΔG_p) Predictions versus Common Logarithm Normalized Leachate (log NL[.]) for B, Li, Na, and Si by Screened vs Not Screened Data/Compositional View/Heat Treatment *(continued)*

Not Screened/Measured/quenched

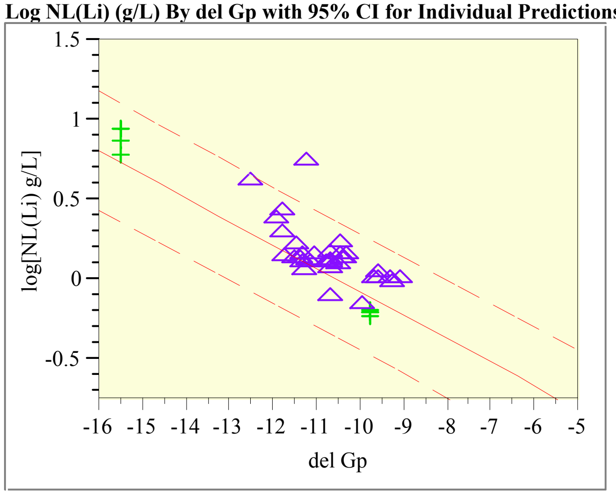
Log NL(B) (g/L) By del Gp with 95% CI for Individual Predictions



Log NL(Na) (g/L) By del Gp with 95% CI for Individual Predictions



Log NL(Li) (g/L) By del Gp with 95% CI for Individual Predictions



Log NL(Si) (g/L) By del Gp with 95% CI for Individual Predictions

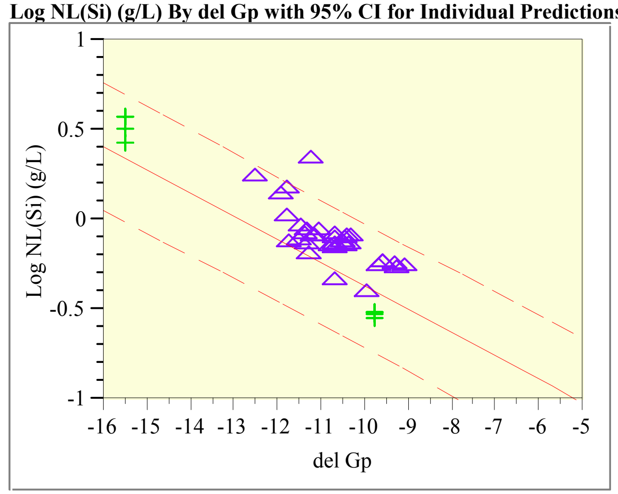
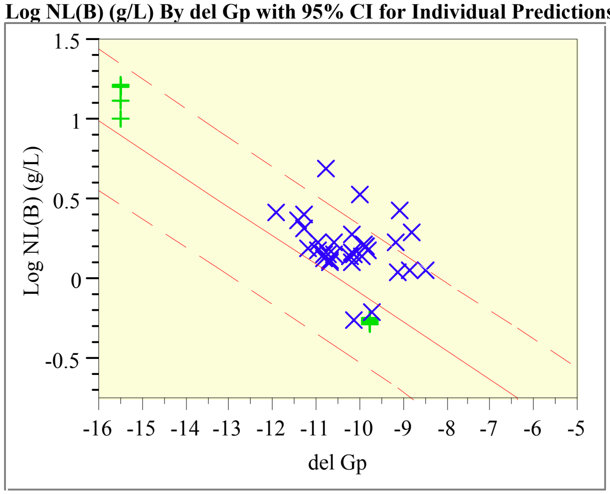


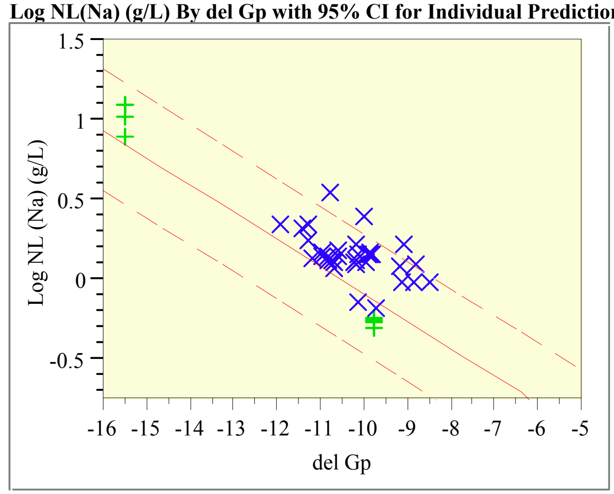
Exhibit G.8: del Gp (ΔG_p) Predictions versus Common Logarithm Normalized Leachate (log NL[.]) for B, Li, Na, and Si by Screened vs Not Screened Data/Compositional View/Heat Treatment *(continued)*

Not Screened/Measured bc/ccc

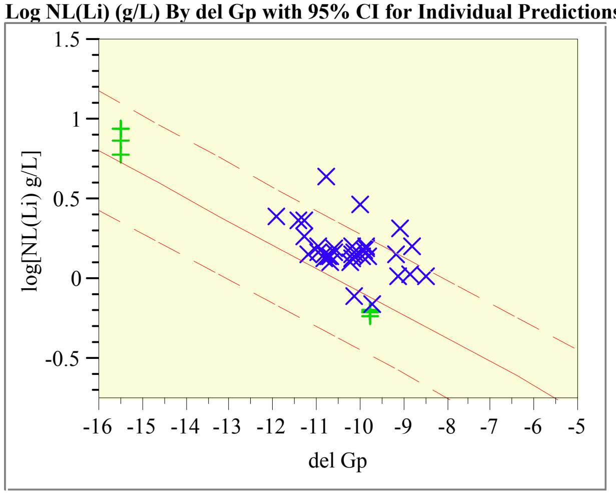
Log NL(B) (g/L) By del Gp with 95% CI for Individual Predictions



Log NL(Na) (g/L) By del Gp with 95% CI for Individual Predictions



Log NL(Li) (g/L) By del Gp with 95% CI for Individual Predictions



Log NL(Si) (g/L) By del Gp with 95% CI for Individual Predictions

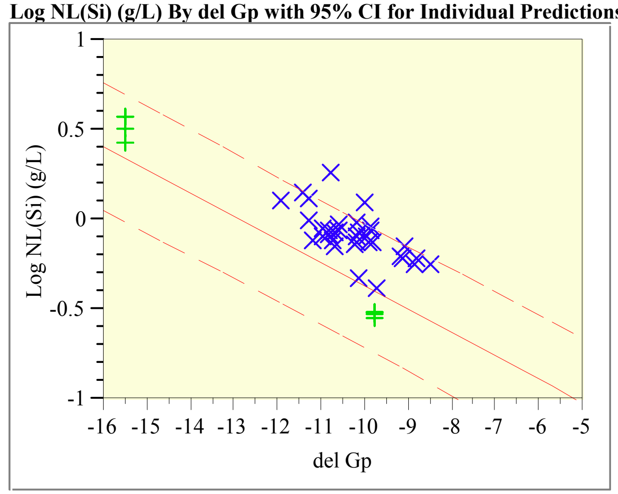
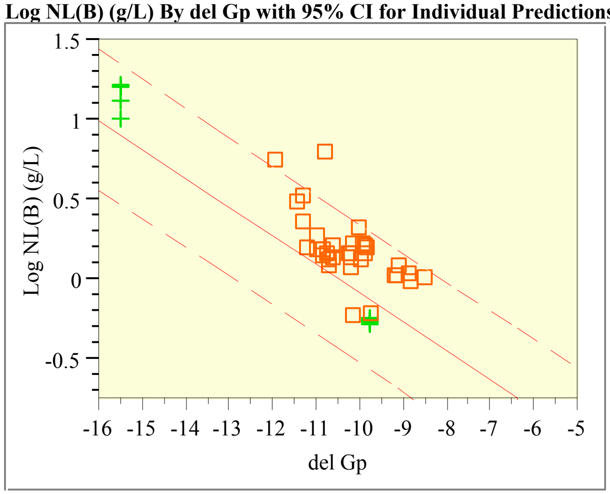


Exhibit G.8: del Gp (ΔG_p) Predictions versus Common Logarithm Normalized Leachate (log NL[.]) for B, Li, Na, and Si by Screened vs Not Screened Data/Compositional View/Heat Treatment *(continued)*

Not Screened/Measured bc/quenched

Log NL(B) (g/L) By del Gp with 95% CI for Individual Predictions



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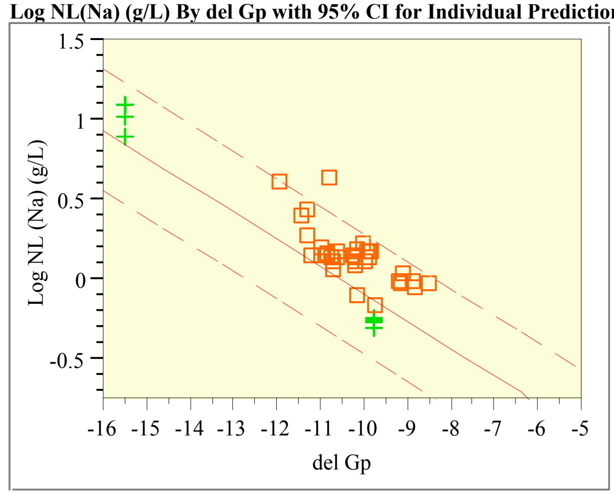
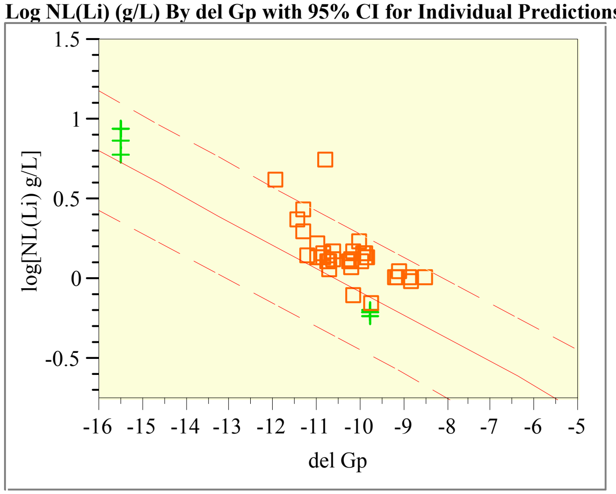


Log NL(Li) (g/L) By del Gp with 95% CI for Individual Predictions



Log NL(Si) (g/L) By del Gp with 95% CI for Individual Predictions

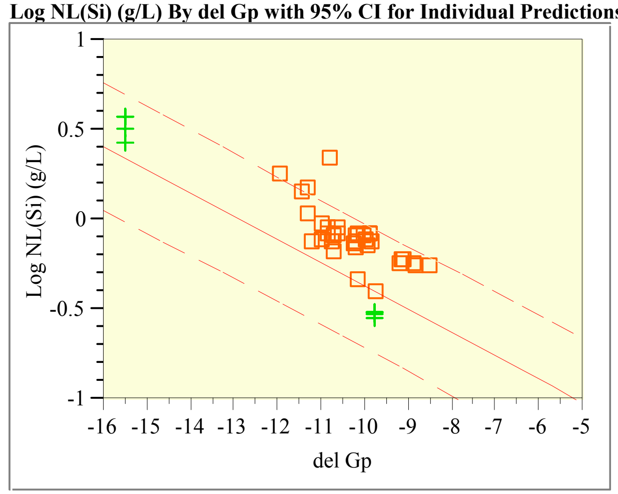
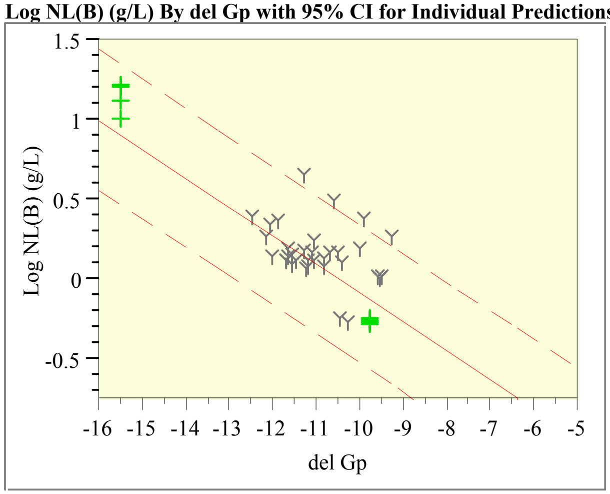


Exhibit G.8: del Gp (ΔG_p) Predictions versus Common Logarithm Normalized Leachate (log NL[.]) for B, Li, Na, and Si by Screened vs Not Screened Data/Compositional View/Heat Treatment *(continued)*

Not Screened/Targeted/ccc

Log NL(B) (g/L) By del Gp with 95% CI for Individual Predictions



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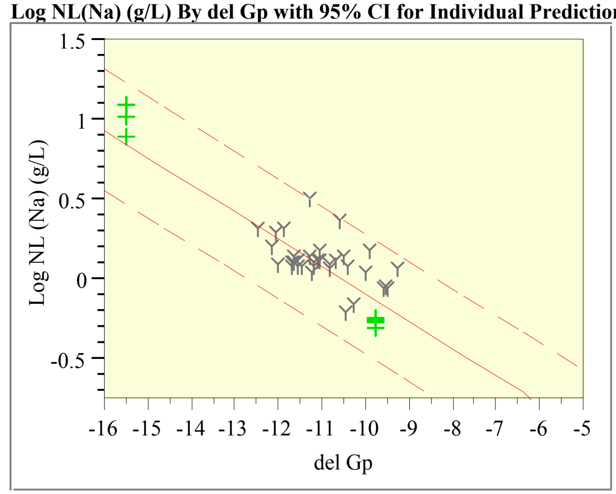
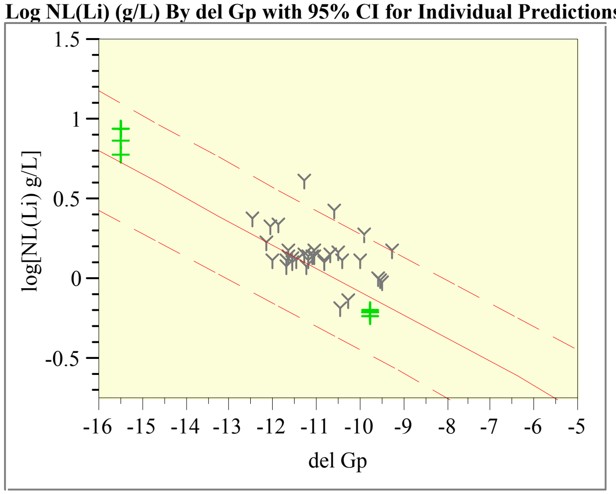


Log NL(Li) (g/L) By del Gp with 95% CI for Individual Predictions



Log NL(Si) (g/L) By del Gp with 95% CI for Individual Predictions

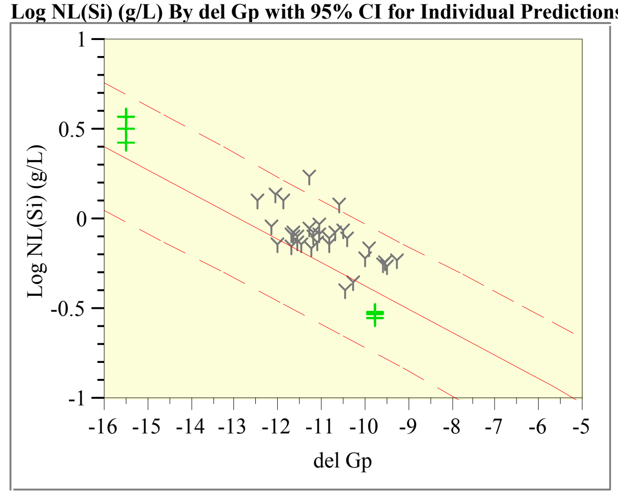
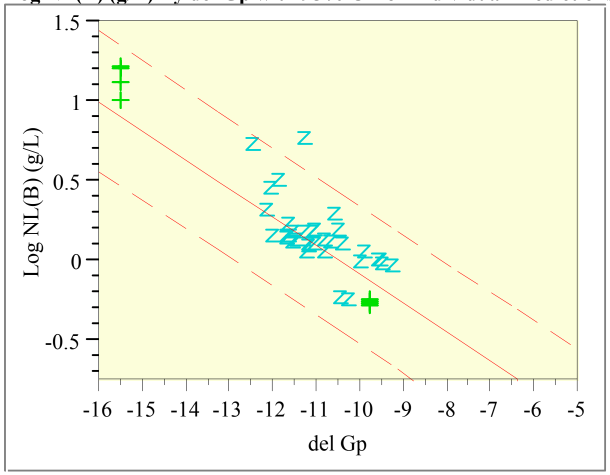


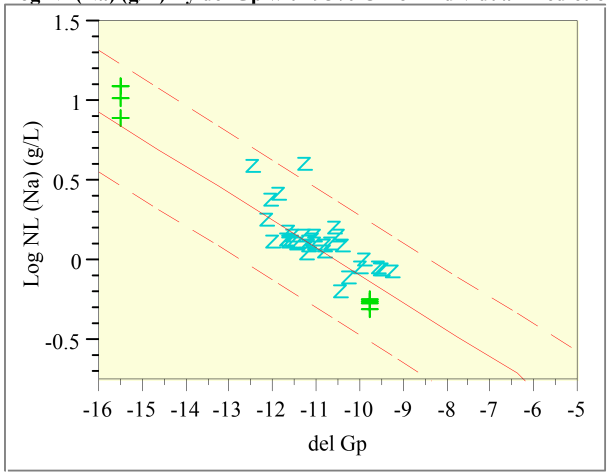
Exhibit G.8: del Gp (ΔG_p) Predictions versus Common Logarithm Normalized Leachate (log NL[.]) for B, Li, Na, and Si by Screened vs Not Screened Data/Compositional View/Heat Treatment *(continued)*

Not Screened/Targeted/quenched

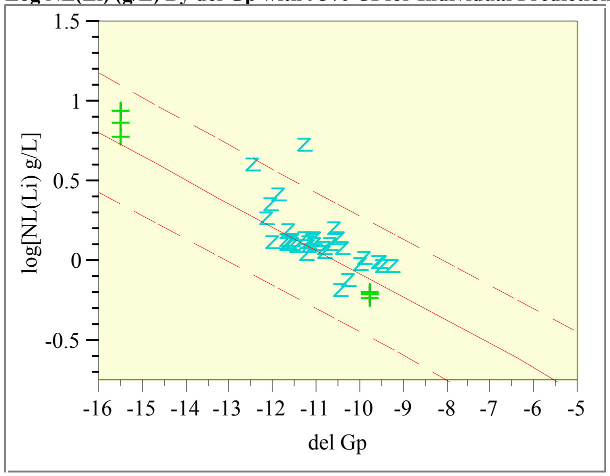
Log NL(B) (g/L) By del Gp with 95% CI for Individual Predictions



Log NL(Na) (g/L) By del Gp with 95% CI for Individual Predictions



Log NL(Li) (g/L) By del Gp with 95% CI for Individual Predictions



Log NL(Si) (g/L) By del Gp with 95% CI for Individual Predictions

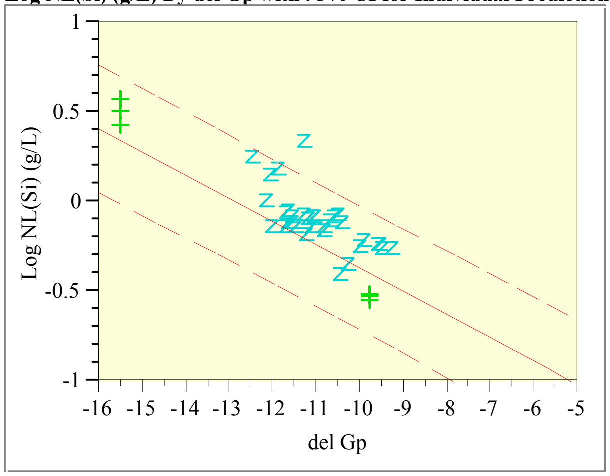
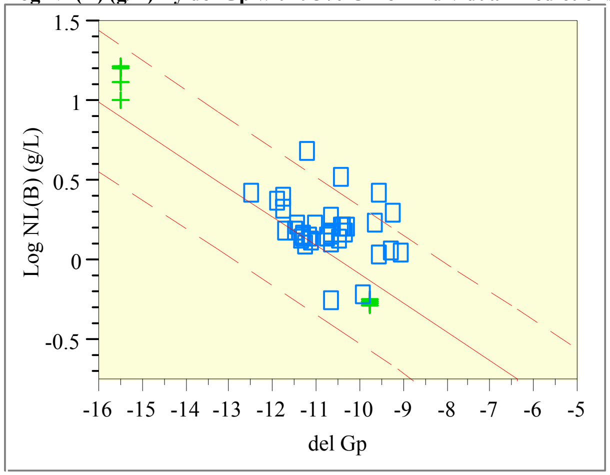


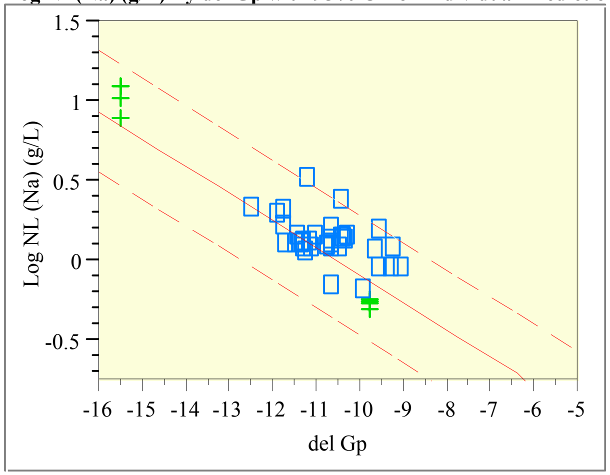
Exhibit G.8: del Gp (ΔG_p) Predictions versus Common Logarithm Normalized Leachate (log NL[.]) for B, Li, Na, and Si by Screened vs Not Screened Data/Compositional View/Heat Treatment *(continued)*

Screened/Measured/ccc

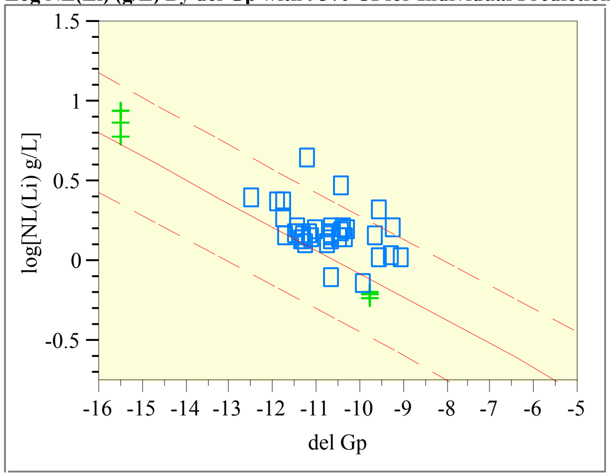
Log NL(B) (g/L) By del Gp with 95% CI for Individual Predictions



Log NL(Na) (g/L) By del Gp with 95% CI for Individual Predictions



Log NL(Li) (g/L) By del Gp with 95% CI for Individual Predictions



Log NL(Si) (g/L) By del Gp with 95% CI for Individual Predictions

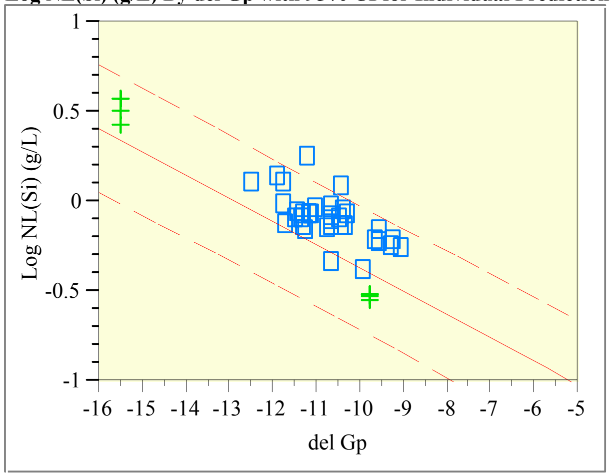
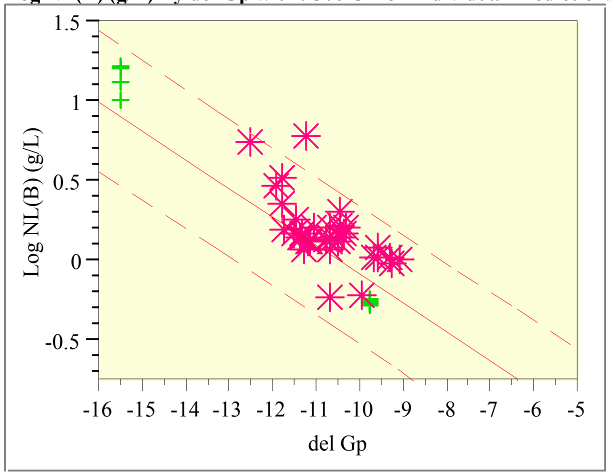


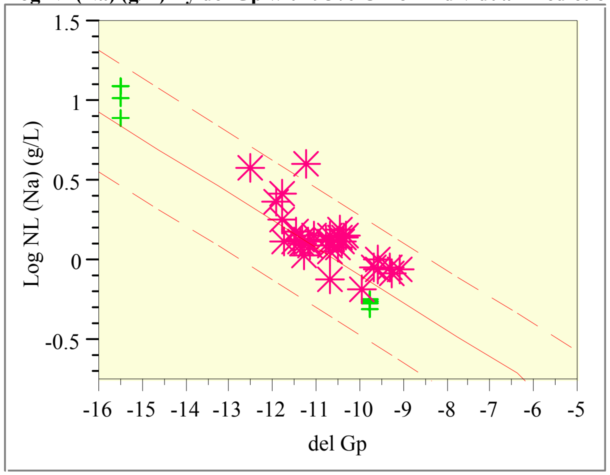
Exhibit G.8: del Gp (ΔG_p) Predictions versus Common Logarithm Normalized Leachate (log NL[.]) for B, Li, Na, and Si by Screened vs Not Screened Data/Compositional View/Heat Treatment *(continued)*

Screened/Measured/quenched

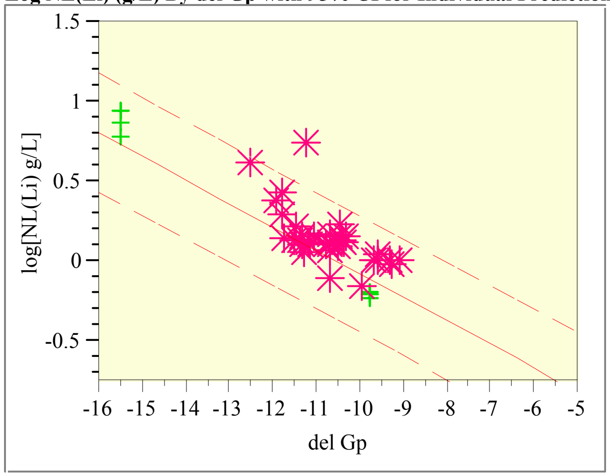
Log NL(B) (g/L) By del Gp with 95% CI for Individual Predictions



Log NL(Na) (g/L) By del Gp with 95% CI for Individual Predictions



Log NL(Li) (g/L) By del Gp with 95% CI for Individual Predictions



Log NL(Si) (g/L) By del Gp with 95% CI for Individual Predictions

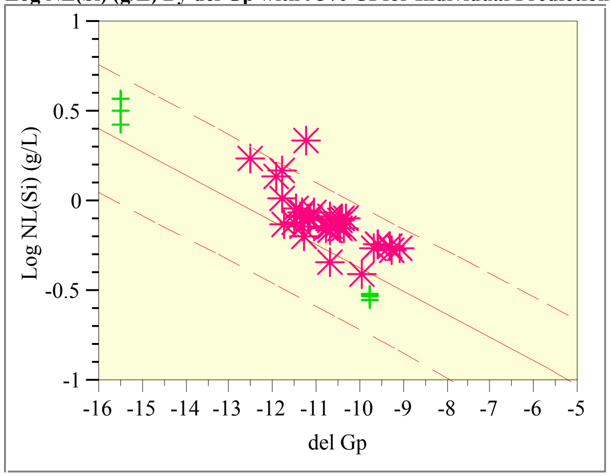
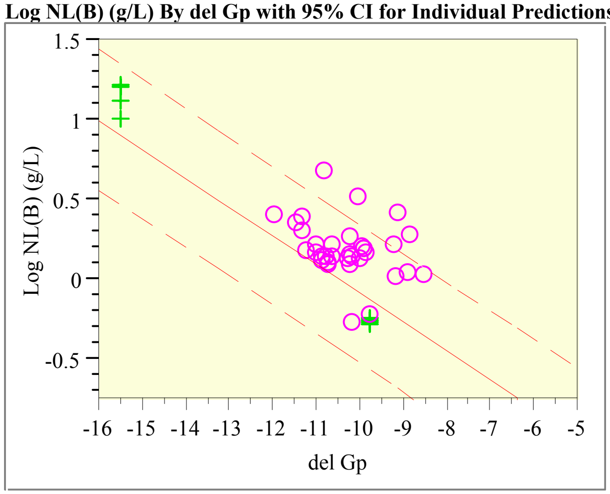


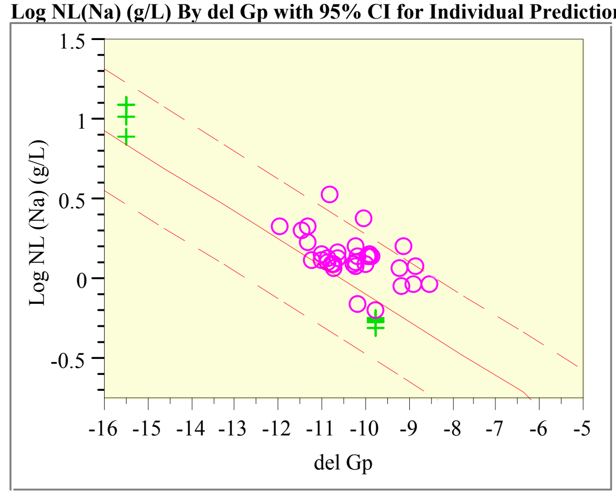
Exhibit G.8: del Gp (ΔG_p) Predictions versus Common Logarithm Normalized Leachate (log NL[.]) for B, Li, Na, and Si by Screened vs Not Screened Data/Compositional View/Heat Treatment *(continued)*

Screened/Measured bc/ccc

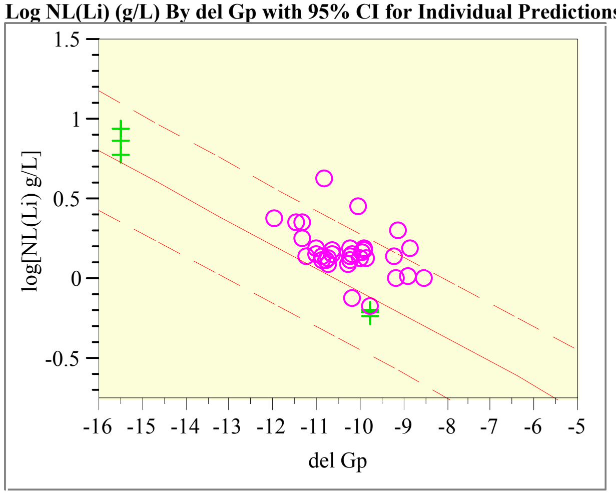
Log NL(B) (g/L) By del Gp with 95% CI for Individual Predictions



Log NL(Na) (g/L) By del Gp with 95% CI for Individual Predictions



Log NL(Li) (g/L) By del Gp with 95% CI for Individual Predictions



Log NL(Si) (g/L) By del Gp with 95% CI for Individual Predictions

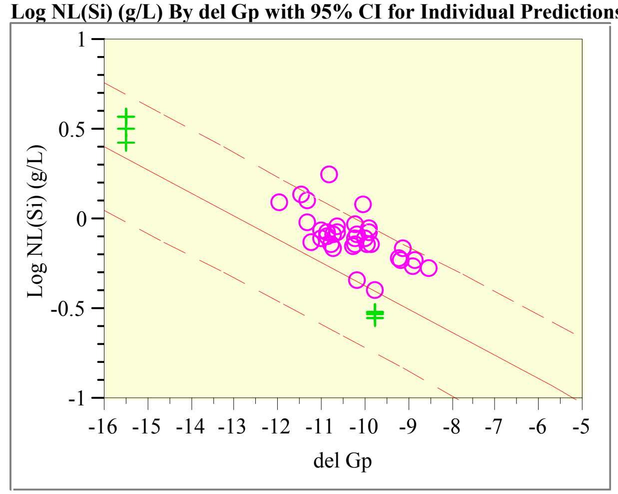
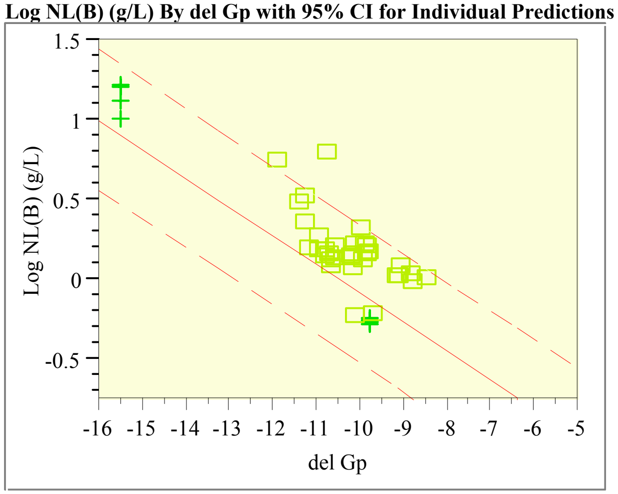
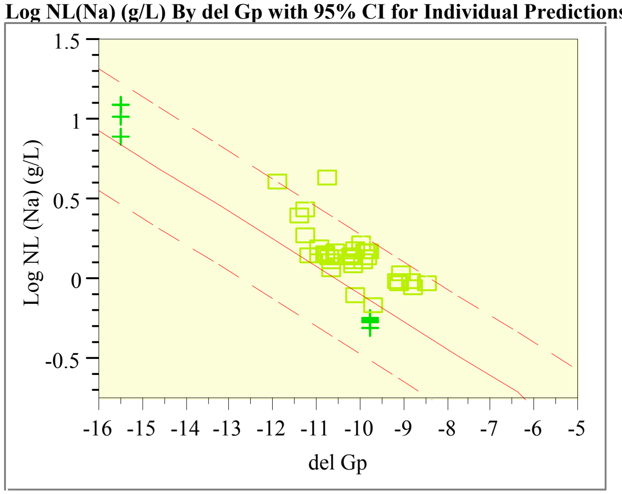
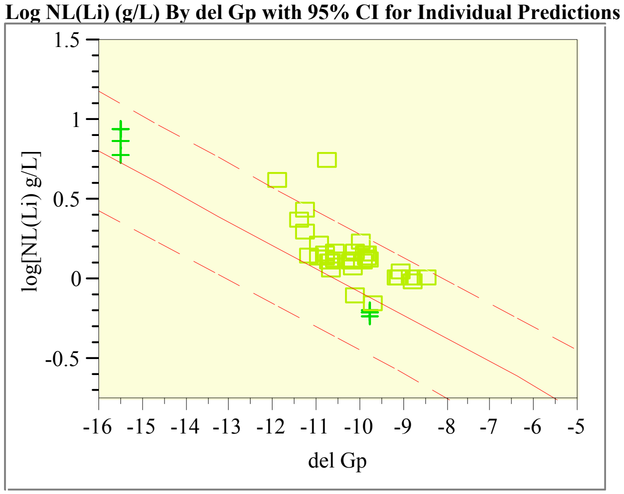


Exhibit G.8: del Gp (ΔG_p) Predictions versus Common Logarithm Normalized Leachate (log NL[.]) for B, Li, Na, and Si by Screened vs Not Screened Data/Compositional View/Heat Treatment *(continued)*

Screened/Measured bc/quenched







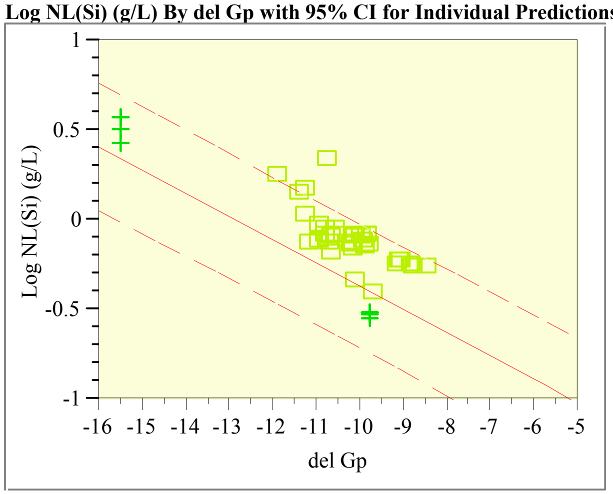
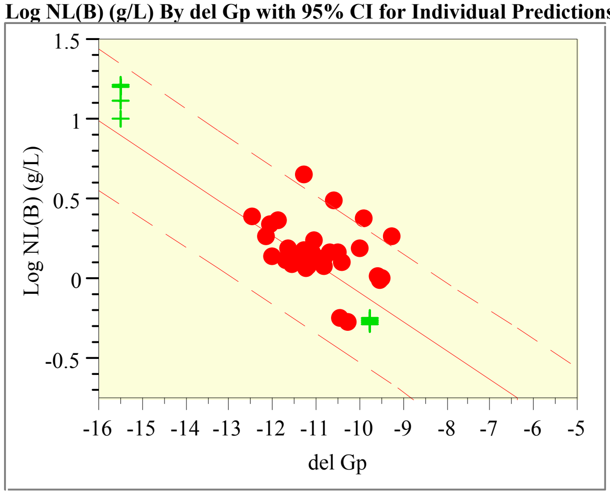


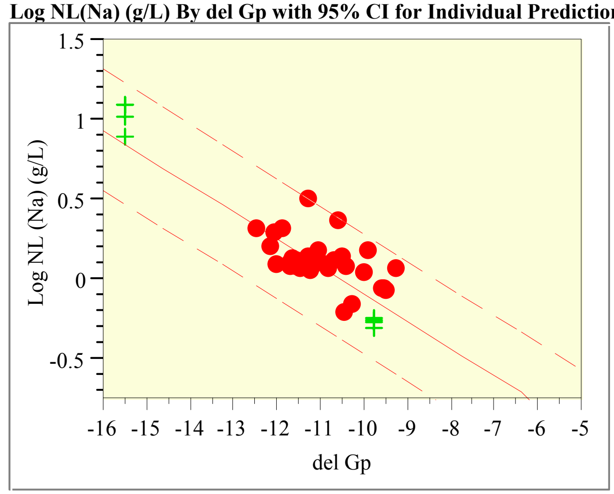
Exhibit G.8: del Gp (ΔG_p) Predictions versus Common Logarithm Normalized Leachate (log NL[.]) for B, Li, Na, and Si by Screened vs Not Screened Data/Compositional View/Heat Treatment *(continued)*

Screened/Targeted/ccc

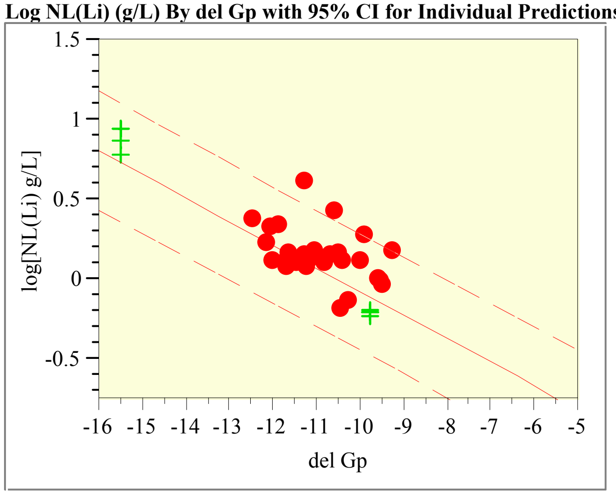
Log NL(B) (g/L) By del Gp with 95% CI for Individual Predictions



Log NL(Na) (g/L) By del Gp with 95% CI for Individual Predictions



Log NL(Li) (g/L) By del Gp with 95% CI for Individual Predictions



Log NL(Si) (g/L) By del Gp with 95% CI for Individual Predictions

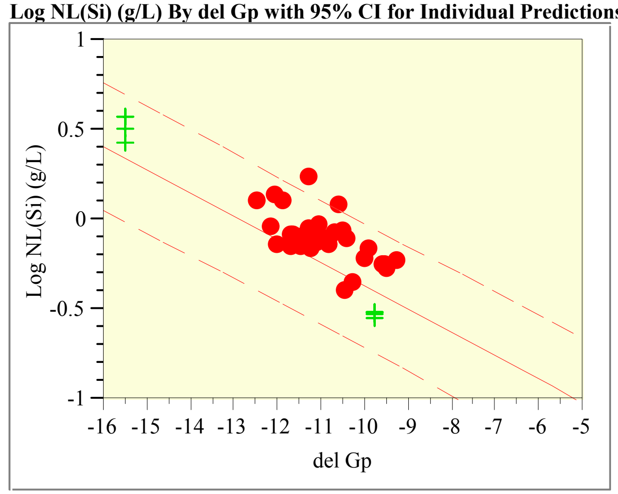
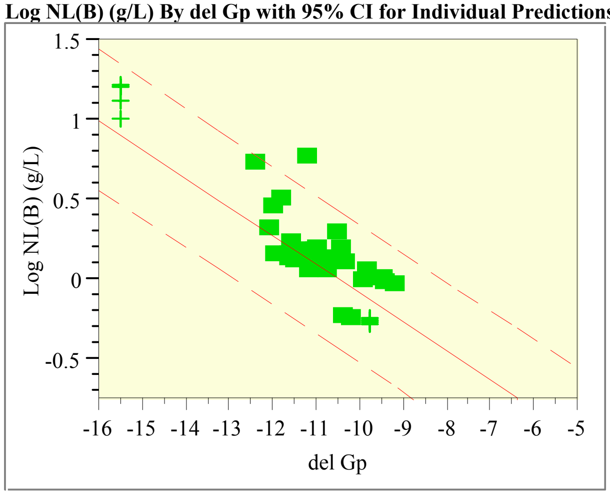


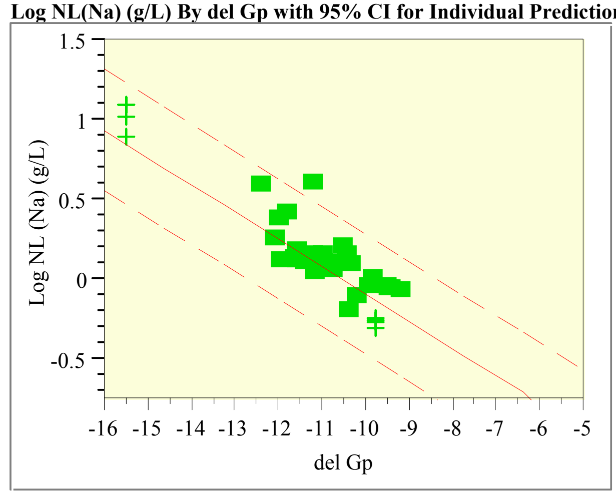
Exhibit G.8: del Gp (ΔG_p) Predictions versus Common Logarithm Normalized Leachate (log NL[.]) for B, Li, Na, and Si by Screened vs Not Screened Data/Compositional View/Heat Treatment *(continued)*

Screened/Targeted/quenched

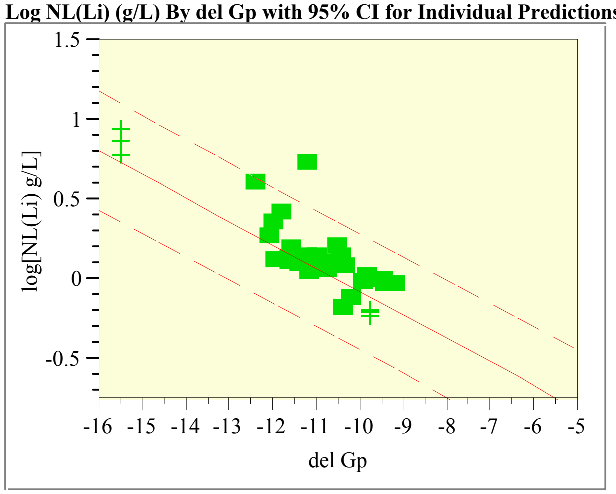
Log NL(B) (g/L) By del Gp with 95% CI for Individual Predictions



Log NL(Na) (g/L) By del Gp with 95% CI for Individual Predictions



Log NL(Li) (g/L) By del Gp with 95% CI for Individual Predictions



Log NL(Si) (g/L) By del Gp with 95% CI for Individual Predictions

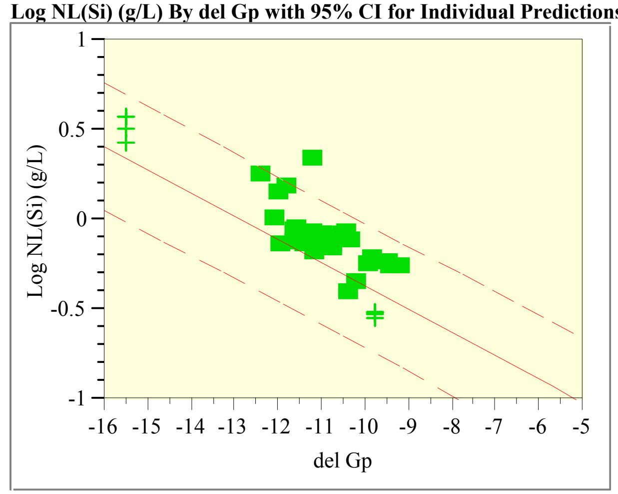
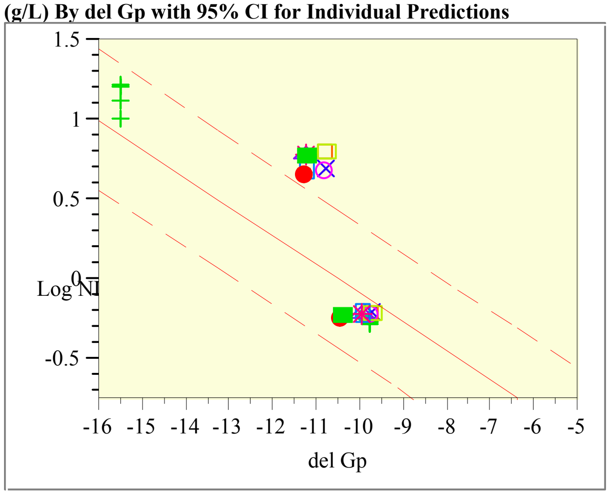


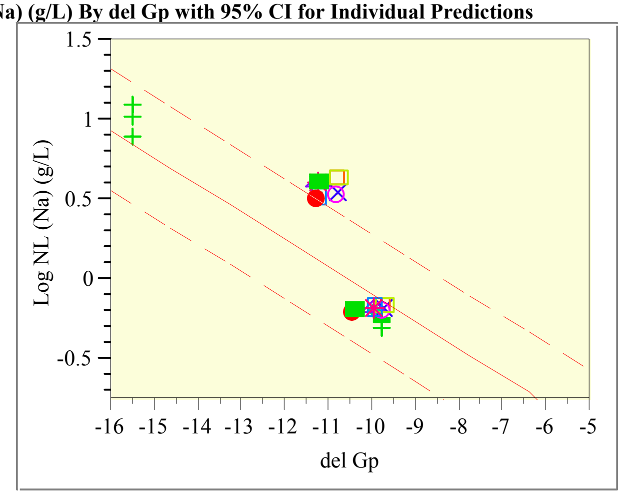
Exhibit G.9: del Gp (ΔG_p) Predictions versus Common Logarithm Normalized Leachate (log NL[.]) for B, Li, Na, and Si by Sludge Type

For HHF Sludge Type

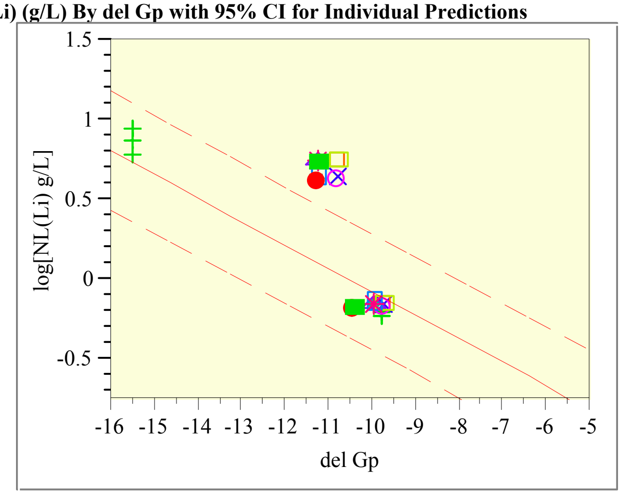
Log NL(B) (g/L) By del Gp with 95% CI for Individual Predictions



Log NL(Na) (g/L) By del Gp with 95% CI for Individual Predictions



Log NL(Li) (g/L) By del Gp with 95% CI for Individual Predictions



Log NL(Si) (g/L) By del Gp with 95% CI for Individual Predictions

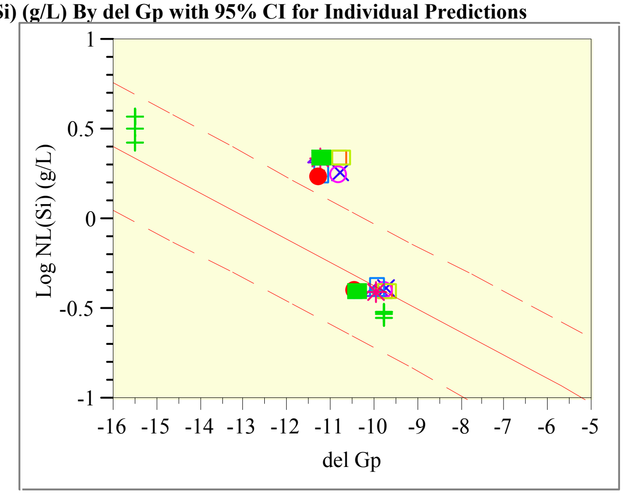
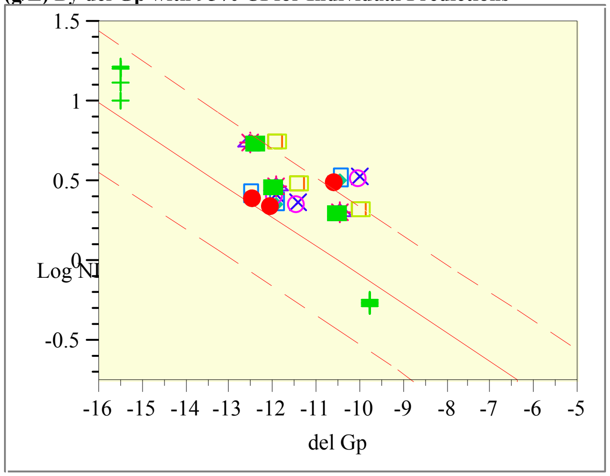


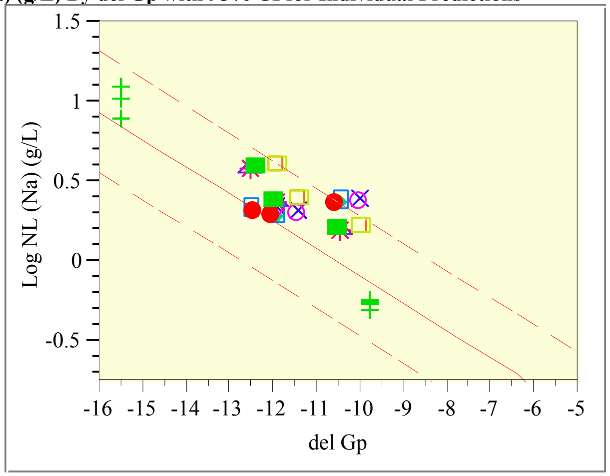
Exhibit G.9: del Gp (ΔG_p) Predictions versus Common Logarithm Normalized Leachate (log NL[.]) for B, Li, Na, and Si by Sludge Type *(continued)*

For PHF Sludge Type

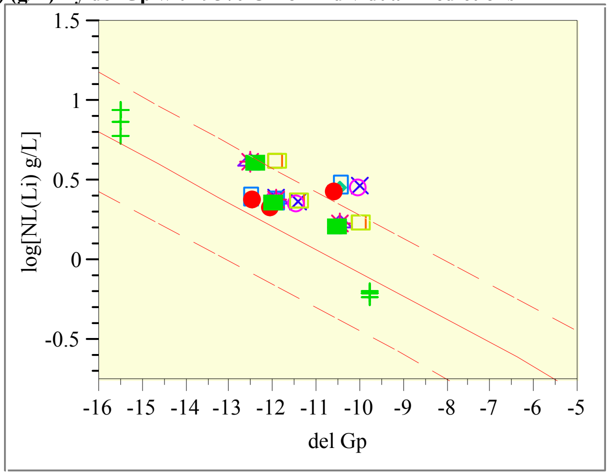
Log NL(B) (g/L) By del Gp with 95% CI for Individual Predictions



Log NL(Na) (g/L) By del Gp with 95% CI for Individual Predictions



Log NL(Li) (g/L) By del Gp with 95% CI for Individual Predictions



Log NL(Si) (g/L) By del Gp with 95% CI for Individual Predictions

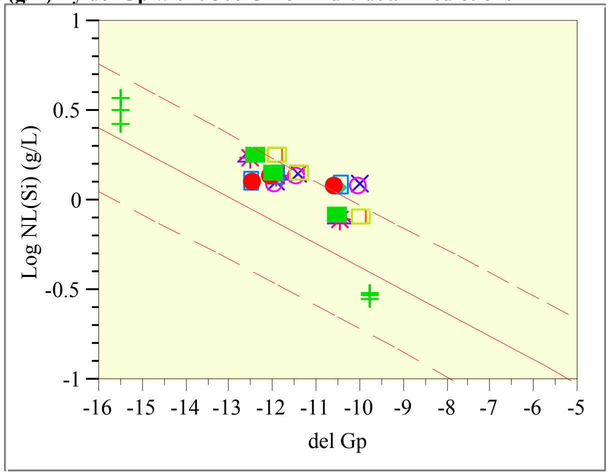
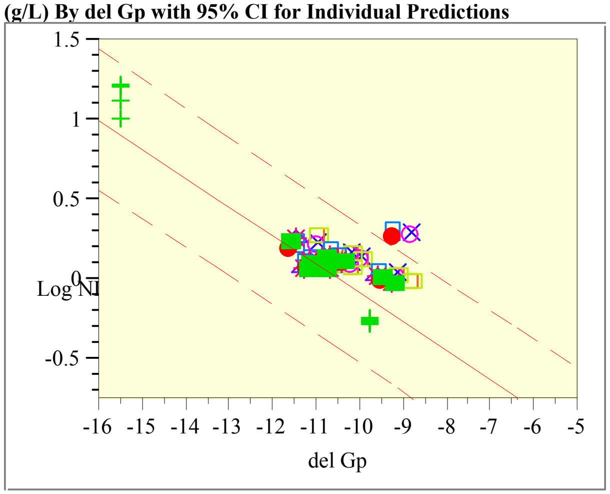


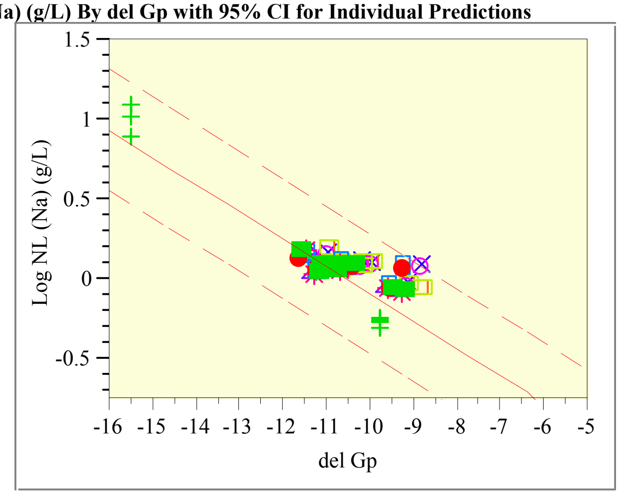
Exhibit G.9: del Gp (ΔG_p) Predictions versus Common Logarithm Normalized Leachate (log NL[.]) for B, Li, Na, and Si by Sludge Type *(continued)*

For xxx Sludge Type

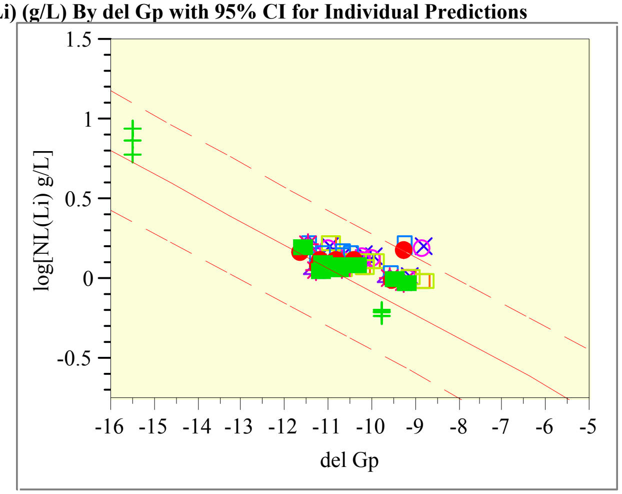
Log NL(B) (g/L) By del Gp with 95% CI for Individual Predictions



Log NL(Na) (g/L) By del Gp with 95% CI for Individual Predictions



Log NL(Li) (g/L) By del Gp with 95% CI for Individual Predictions



Log NL(Si) (g/L) By del Gp with 95% CI for Individual Predictions

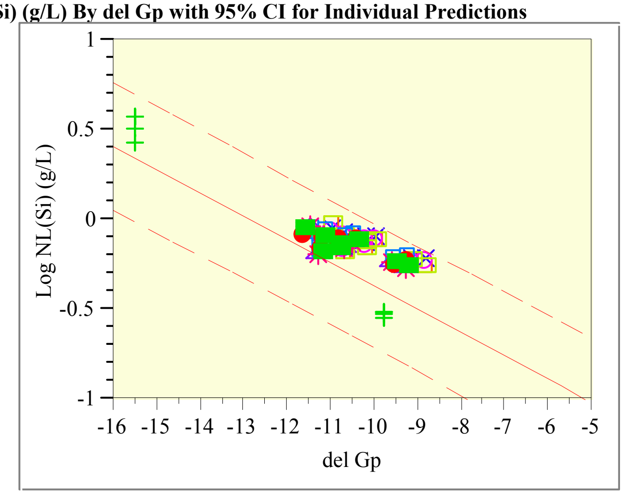
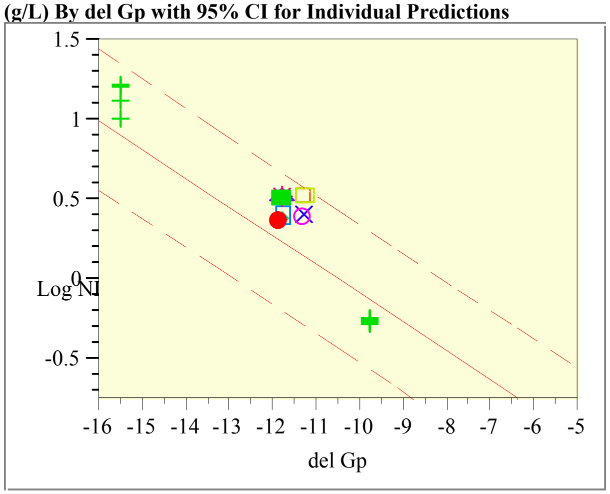


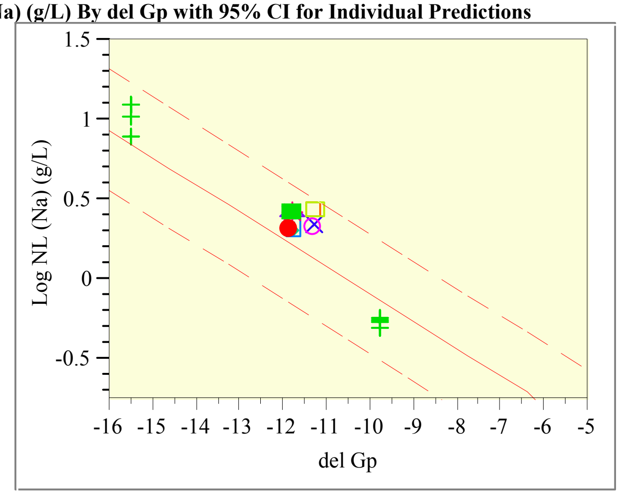
Exhibit G.9: del Gp (ΔG_p) Predictions versus Common Logarithm Normalized Leachate (log NL[.]) for B, Li, Na, and Si by Sludge Type *(continued)*

For PMF Sludge Type

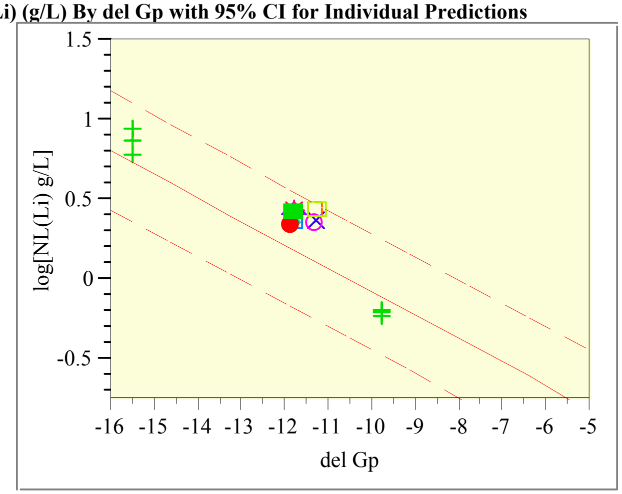
Log NL(B) (g/L) By del Gp with 95% CI for Individual Predictions



Log NL(Na) (g/L) By del Gp with 95% CI for Individual Predictions



Log NL(Li) (g/L) By del Gp with 95% CI for Individual Predictions



Log NL(Si) (g/L) By del Gp with 95% CI for Individual Predictions

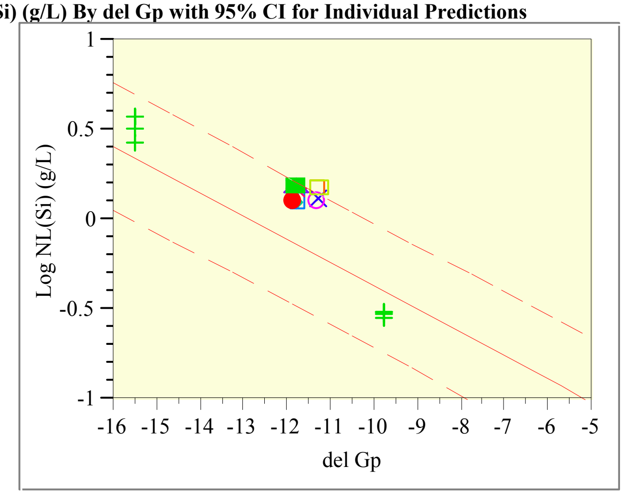
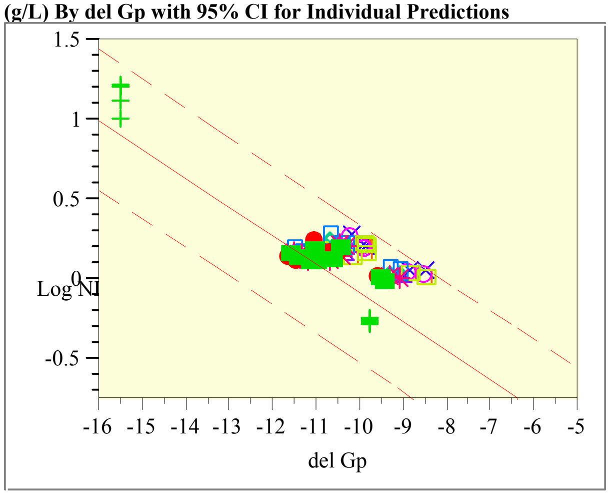


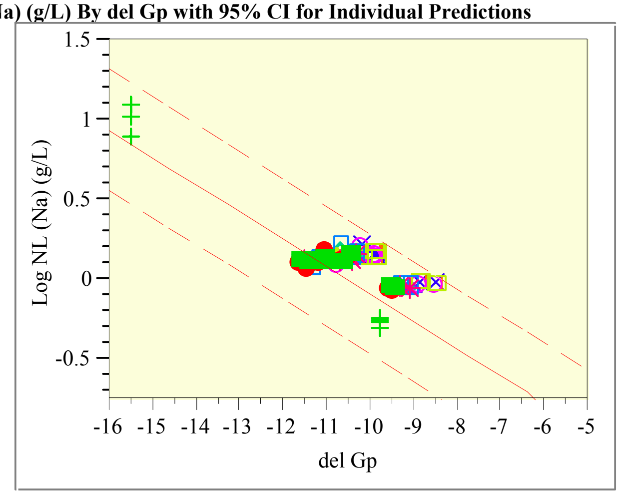
Exhibit G.9: del Gp (ΔG_p) Predictions versus Common Logarithm Normalized Leachate (log NL[.]) for B, Li, Na, and Si by Sludge Type *(continued)*

For SB3 Sludge Type

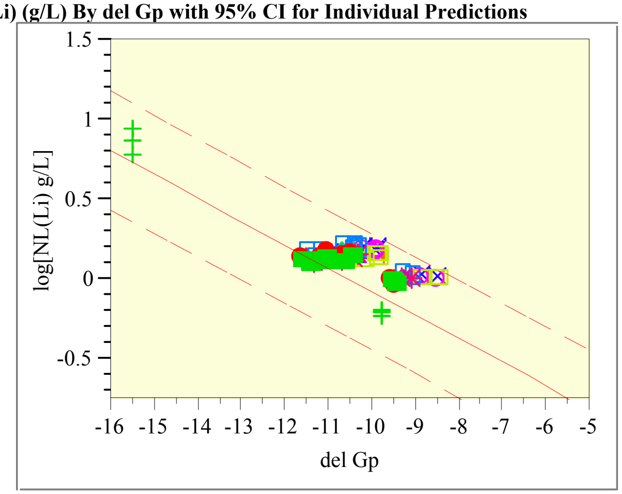
Log NL(B) (g/L) By del Gp with 95% CI for Individual Predictions



Log NL(Na) (g/L) By del Gp with 95% CI for Individual Predictions



Log NL(Li) (g/L) By del Gp with 95% CI for Individual Predictions



Log NL(Si) (g/L) By del Gp with 95% CI for Individual Predictions

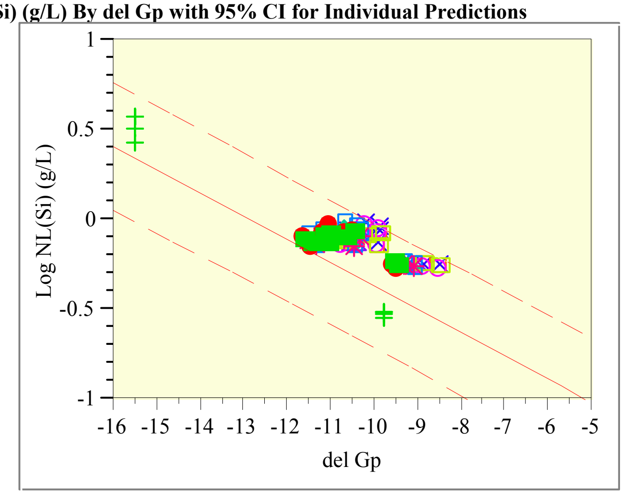
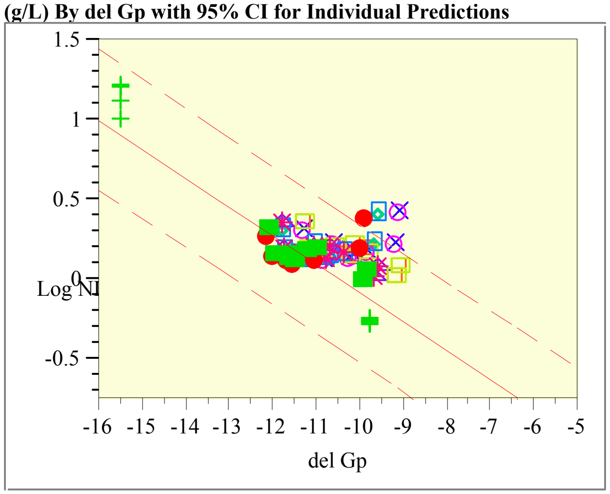


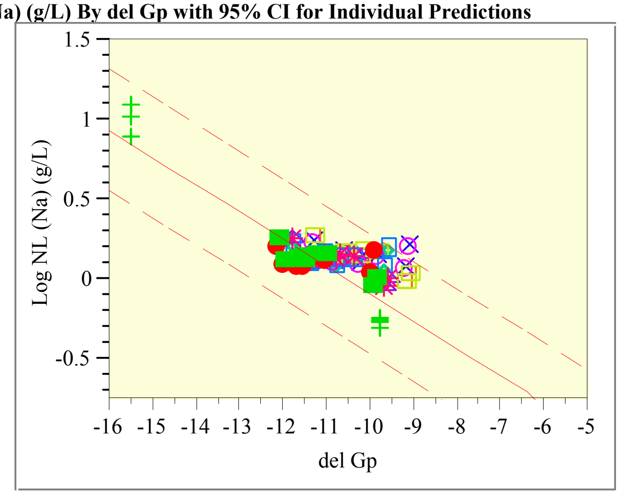
Exhibit G.9: del Gp (ΔG_p) Predictions versus Common Logarithm Normalized Leachate (log NL[.]) for B, Li, Na, and Si by Sludge Type *(continued)*

For SB4 Sludge Type

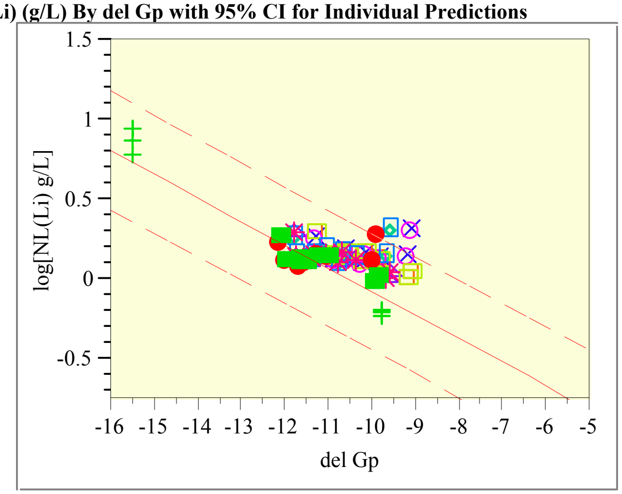
Log NL(B) (g/L) By del Gp with 95% CI for Individual Predictions



Log NL(Na) (g/L) By del Gp with 95% CI for Individual Predictions



Log NL(Li) (g/L) By del Gp with 95% CI for Individual Predictions



Log NL(Si) (g/L) By del Gp with 95% CI for Individual Predictions

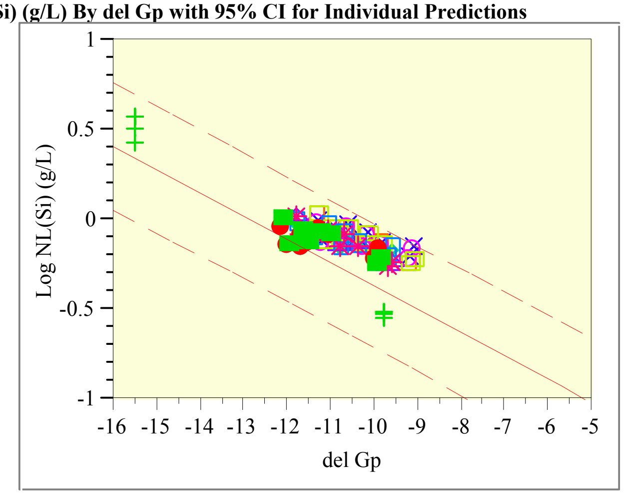
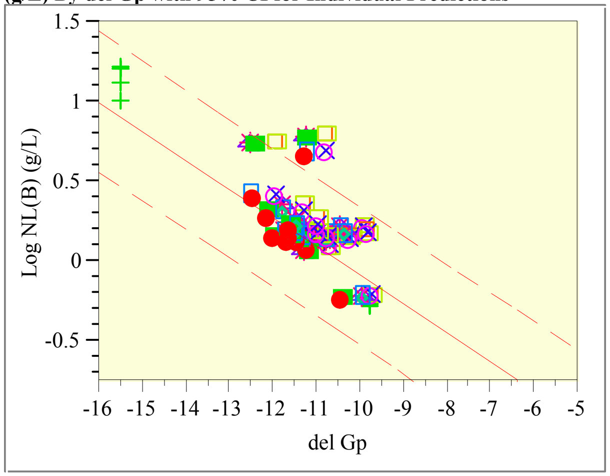


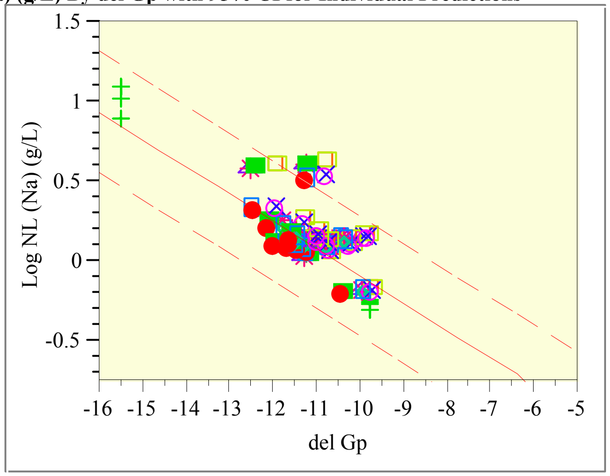
Exhibit G.10: del Gp (ΔG_p) Predictions versus Common Logarithm Normalized Leachate (log NL[.]) for B, Li, Na, and Si by Frit Type

For Frit 165

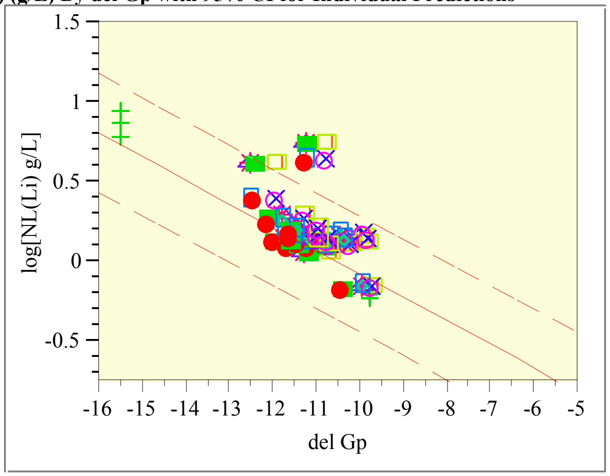
Log NL(B) (g/L) By del Gp with 95% CI for Individual Predictions



Log NL(Na) (g/L) By del Gp with 95% CI for Individual Predictions



Log NL(Li) (g/L) By del Gp with 95% CI for Individual Predictions



Log NL(Si) (g/L) By del Gp with 95% CI for Individual Predictions

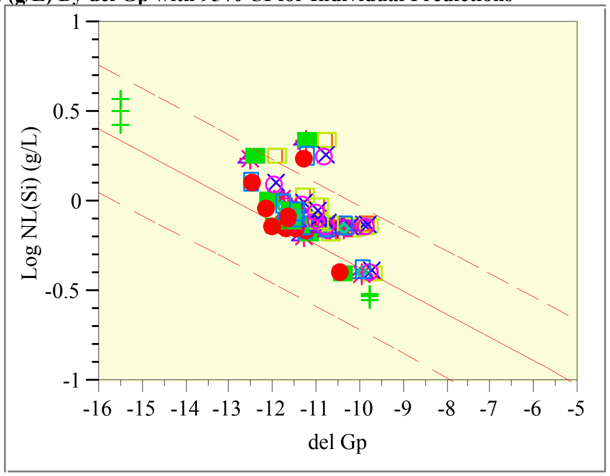
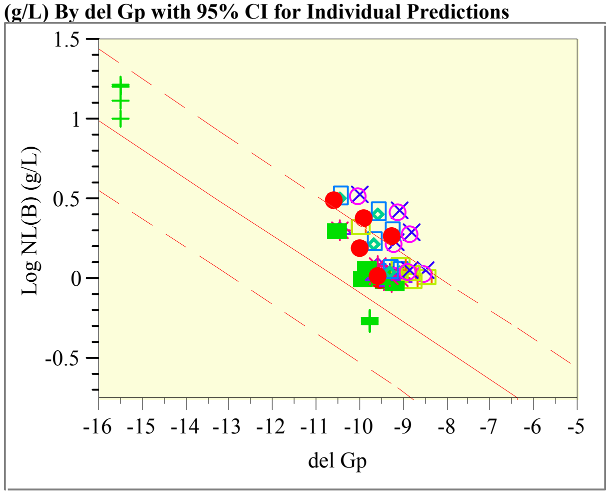


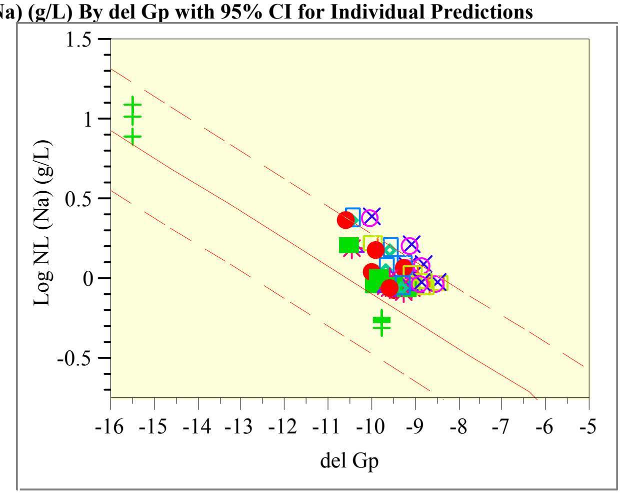
Exhibit G.10: del Gp (ΔG_p) Predictions versus Common Logarithm Normalized Leachate (log NL[.]) for B, Li, Na, and Si by Frit Type *(continued)*

For Frit 200

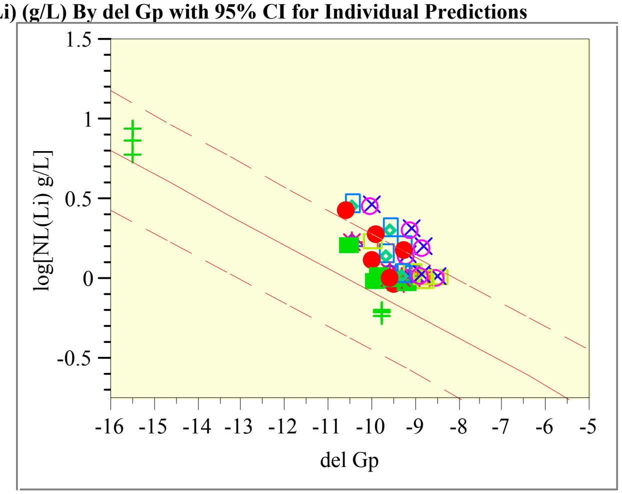
Log NL(B) (g/L) By del Gp with 95% CI for Individual Predictions



Log NL(Na) (g/L) By del Gp with 95% CI for Individual Predictions



Log NL(Li) (g/L) By del Gp with 95% CI for Individual Predictions



Log NL(Si) (g/L) By del Gp with 95% CI for Individual Predictions

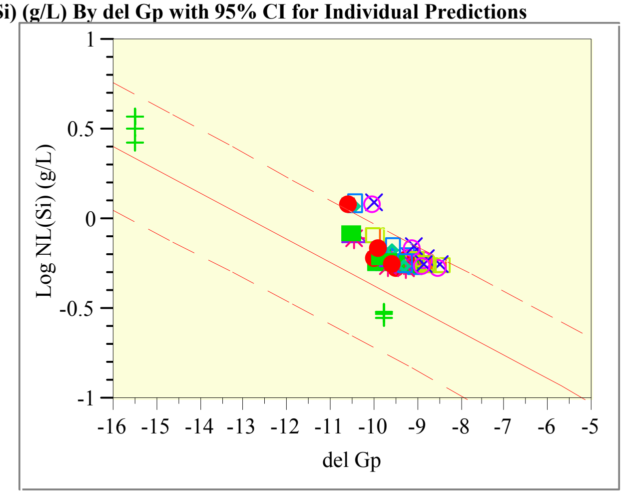
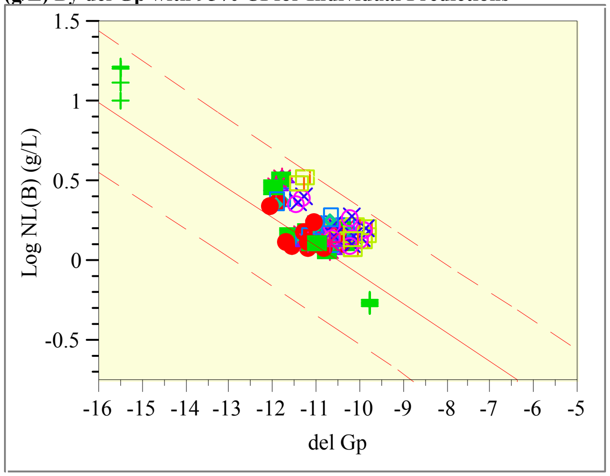
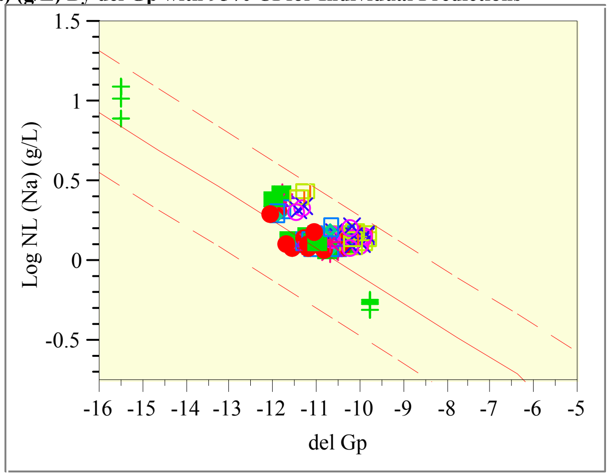


Exhibit G.10: del Gp (ΔG_p) Predictions versus Common Logarithm Normalized Leachate (log NL[.]) for B, Li, Na, and Si by Frit Type *(continued)*
For Frit 320

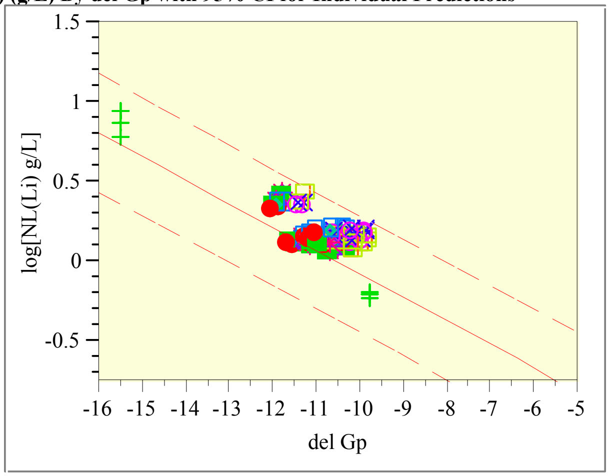
Log NL(B) (g/L) By del Gp with 95% CI for Individual Predictions



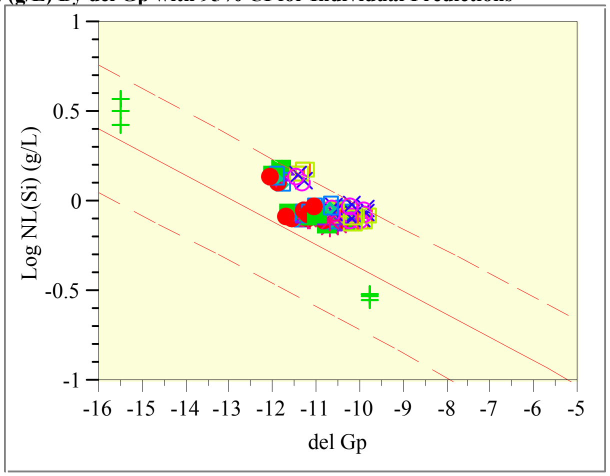
Log NL(Na) (g/L) By del Gp with 95% CI for Individual Predictions



Log NL(Li) (g/L) By del Gp with 95% CI for Individual Predictions



Log NL(Si) (g/L) By del Gp with 95% CI for Individual Predictions



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