PHASE 2 INITIAL BOREHOLE DRILLING AND TESTING, SOUTH BRUCE

WP04C Data Report: Porewater Extraction and Analyses, and Petrographic Analysis for SB_BH02

APM-REP-01332-0332 January 2024

Geofirma Engineering

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Phase 2 Initial Borehole Drilling and Testing, South Bruce

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Revision Tracking Table

Revision	Revision Release Date	Description of Modifications/Edits
R0A	November 7, 2023	Initial draft release to NWMO for review
R0B	December 28, 2023	Second draft release to NWMO with initial NWMO comments dispositioned
R0	January 11, 2024	Final Release

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APPENDICES

1 INTRODUCTION

Geofirma Engineering Ltd. (Geofirma) completed a drilling and testing program at borehole SB_BH02 northwest of Teeswater, Ontario (Figure 1). This report provides a detailed summary of one component of the Geofirma geoscientific investigation as part of the NWMO Phase 2 Initial Borehole Drilling and Testing Program at the South Bruce site. Specifically, this report describes the activities associated with Geofirma's Work Package 4C (WP04C), which included porewater extraction and analyses, and petrographic analyses for core obtained from borehole SB_BH02.

1.1 Background

Geofirma was retained by the Nuclear Waste Management Organization (NWMO) to complete a drilling and testing program for two deep bedrock boreholes (SB_BH01 and SB_BH02) as part of the NWMO's Phase 2 Geoscientific Preliminary Field Investigations. The full scope of the drilling and testing program for SB_BH02 is described in the Initial Borehole Characterization Plan.

NWMO's process is called the Adaptive Phased Management (APM) plan and comprises multiple phases.

Phase 1 of NWMO's APM plan included preliminary desktop studies using available geoscientific information and a set of key geoscientific characteristics and factors that can be realistically assessed at the desktop phase of the Preliminary Assessment. The Phase 1 Preliminary Assessment of the South Bruce site identified the Cobourg Formation as the preferred host formation for a deep geological repository for used nuclear fuel. The Initial Borehole Drilling and Testing study is a key component of the Phase 2 Geoscientific Preliminary Field Investigations for the NWMO's APM plan.

Borehole SB_BH02 was the second borehole drilled in the South Bruce study site as part of the Phase 2 Initial Borehole Drilling and Testing program. SB_BH02 is located approximately 5.5 km northwest of the community of Teeswater, Ontario, and was drilled to 900.57 m below ground surface (m BGS). SB_BH02 was drilled through the entire sedimentary bedrock sequence to approximately 14 m into the Precambrian basement.

1.2 Geologic Setting

The sequence of rocks encountered in the SB_BH02 borehole consist of Paleozoic-aged strata that were deposited within the Michigan Basin northwest of the Algonquin Arch in Southwestern Ontario. The Michigan Basin is a circular-shaped cratonic basin that is composed primarily of shallow marine carbonates, evaporites, and shales that were deposited while eastern North America was in tropical latitudes during the Paleozoic Era (Armstrong and Carter 2010). West of the Algonquin Arch, strata from the Michigan Basin gradually dip westward into the Michigan Basin. Borehole SB_BH02 was drilled through the entire Paleozoic sequence to approximately 14 m into the Precambrian basement, which is composed of high-grade metamorphic rocks of the Grenville Province.

LEGEND

- SB_BH02 Drill Site
- Municipality of South Bruce
- Municipality of Brockton
- Township of Huron-Kinloss
- Provincially Significant Wetland
- Wetland
- Waterbody
- Watercourse
- Major Road
- Local / Street
- OGSRL Well Locations

INSET MAP

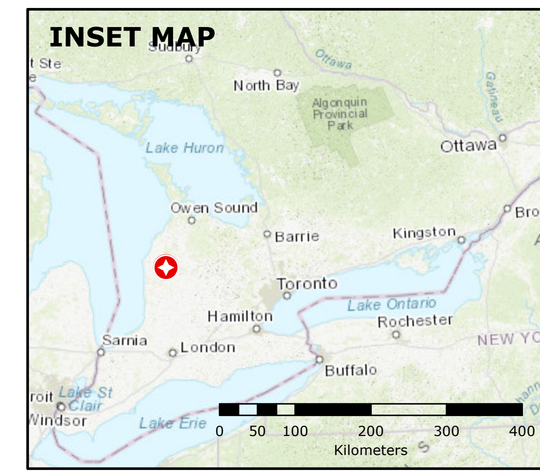

Figure 1
Location of SB_BH02 Drill Site

Scale 1:60,000

0 500 1,000 2,000 3,000 4,000
Meters

N

Projection: NAD 1983 UTM Zone 17N

Source: NWMO, Ontario GeoBase

Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

PROJECT No. 20-211-1

NWMO South Bruce
Drilling and Testing

DESIGN: ADG
CAD/GIS: ADG
CHECK: SNS
REV: 1

DATE: 2023-10-30

GEOFIRMA ENGINEERING

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1.3 Technical Objectives

The primary technical objective of the WP04C porewater program was to characterize the fluid chemistry of the sedimentary bedrock at the South Bruce site based on core obtained from boreholes SB_BH01 and SB_BH02. This report has been prepared to provide a detailed summary of the sampling methods, laboratory procedures, and results from the WP04C porewater characterization program that was completed for core obtained from borehole SB_BH02.

Results of the porewater and dissolved gas extraction and analysis work will be used as part of data integration activities (Work Package 10) to assess the age of porewater in the Upper Ordovician shale and limestone formations, as well as obtain evidence of whether the porewater has been in contact with modern surface waters.

2 DESCRIPTION OF ACTIVITIES

2.1 Sample Collection and Preservation

2.1.1 Sample Selection and Collection

Selection and collection of porewater, noble gas, and dissolved gas (CO_2 & CH_4) samples were completed by Geofirma staff during drilling of borehole SB_BH02. Intact sections of core were collected as samples according to NMWO-specified geologic/depth interval targets. Samples were collected such that they were representative of the unit being sampled and did not cross a lithological contact. In addition, samples were generally not taken from the immediate top or bottom of a core run to preserve the ability to re-align adjacent core runs by re-fitting the reference line. All samples were extracted using a hammer and chisel, or at pre-existing mechanical/natural breaks.

As much as possible, the porewater, noble gas, and dissolved gas core samples were preserved within 15 minutes of core retrieval, immediately after core run photography, but prior to core logging. All core samples were weighed and photographed prior to preservation.

Core sample locations and procedures for sample collection are described in detail in the Work Package 3 (WP03) Data Report (Geofirma 2022).

2.1.2 Sample Preservation for Paper Absorption, Vacuum Distillation, and Petrography

Samples for paper absorption, vacuum distillation and petrography were collected as porewater samples and were assigned “PW” sample designation using NWMO’s acQuire data management system (e.g., SB_BH02_PW002). A set of two PW samples was collected at each sample location: a 20-30 cm sample for paper absorption and petrography/mineralogy testing, and a second 15 cm sample for vacuum distillation, vacuum distillation leaching, and crush and leach testing. Each set of PW samples was paired with samples for noble gases and dissolved gases (CO_2, CH_4).

The porewater samples were preserved following the standard procedure outline below:

1. Wrap in plastic film.
2. Wrap in Polyethylene (PE) bag.
3. Flush with nitrogen, evacuate, and heat seal using vacuum sealer.
4. Wrap in second PE bag.
5. Flush with nitrogen, evacuate, and heat seal using vacuum sealer.
6. Wrap in aluminum foil pouch.
7. Flush with nitrogen, evacuate, and heat seal using vacuum sealer.
8. Refrigerate sample.

2.1.3 In-Field Encapsulation for Noble Gases

Core samples collected for noble gas analysis were assigned a “NG” sample designation in acQuire. Noble gas samples were preserved using purpose-built stainless-steel containers following a specialized procedure that was provided to Geofirma by the Noble Gas Laboratory at the University of

Ottawa. Each noble gas core sample was encapsulated in a stainless-steel chamber with a flange fitted to a copper-seated high-vacuum valve. The encapsulation and preservation process for noble gas samples is summarized below:

1. Insert core into stainless steel chamber and assemble the chamber.
2. Interface chamber with flushing/evacuating manifold.
3. Flushing-evacuating follows the **1-2 1-2** method.
    - Fill the chamber with high purity nitrogen until 5 PSI on the gauge, **1 minute**.
    - Evacuate the chamber for **2 minutes**.
    - Fill the chamber with high purity nitrogen until 10 PSI above background/atmospheric pressure, **1 minute**.
    - Evacuate the chamber for **2 minutes**.
4. Close the valve on the stainless-steel chamber. Ensure the vacuum pump is isolated and remove the chamber from the line.
5. Place a plug and gasket into the valve at the top of the chamber and tighten.
6. Label and store the chambers as required.

Figure 2 provides a schematic of the system that was used to complete encapsulation and preservation of core samples for noble gases at SB_BH02.

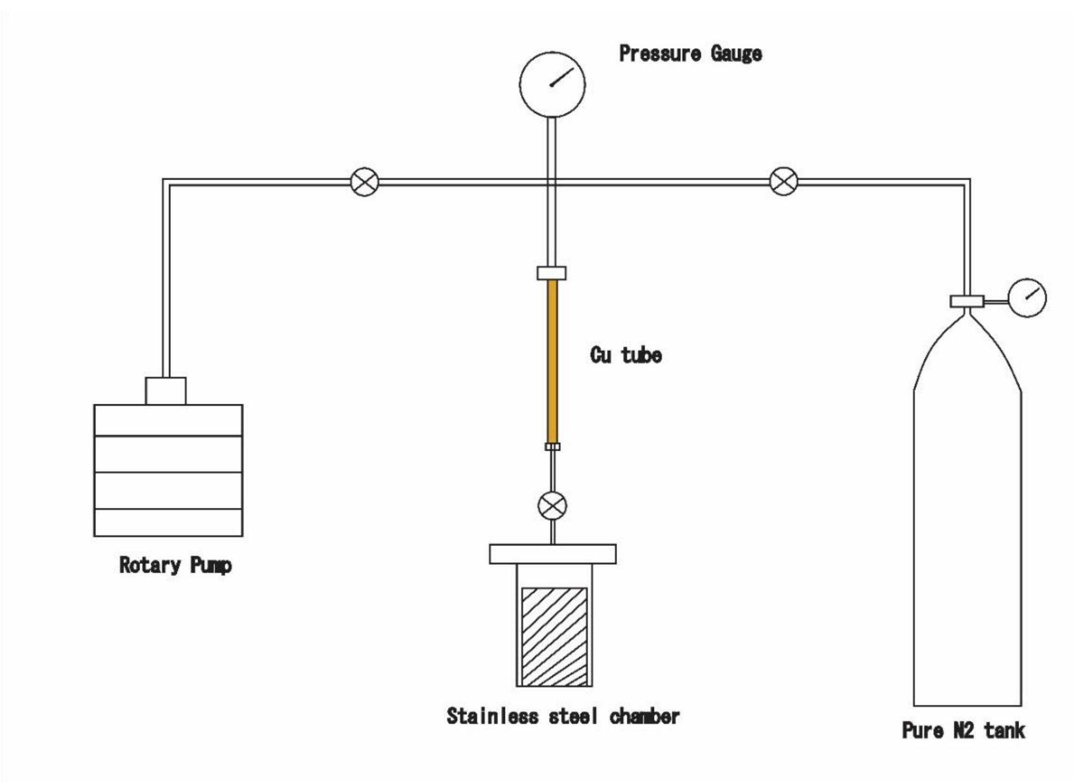

Figure 2 Schematic for noble gas core sample encapsulation (Source: University of Ottawa, Noble Gas Isotope Laboratory)

2.1.4 In-Field Encapsulation for CO_2 and CH_4

Samples for CH_4 and CO_2 analyses were collected as dissolved gas samples and were assigned a “DG” sample designation using acQuire. Full diameter core samples for CH_4 and CO_2 analysis were broken into large chunks (< 5 cm) and placed into two IsoJar (Isotech, USA) containers, capped with a septum-fitted cap. While filling the IsoJar containers, high-purity nitrogen gas was flushed into the containers by a needle through the septum to displace air in the containers. The nitrogen gas was added as the lid was tightened, allowing for air to be flushed out from the rim. The IsoJars were refrigerated after preservation.

2.2 Sample Processing and Analyses

2.2.1 Vacuum Distillation

Porewater isotopes were sampled from core by vacuum distillation. Vacuum distillation was undertaken on core samples, with the outer perimeter removed and a subsample mechanically crushed and sieved to retrieve a 2 to 4 mm size fraction. Of this fraction, approximately 30 g per sample was encapsulated in pre-weighed vessels and attached to an extraction line. Evacuation was carried out with a –180°C cold trap in place to collect evaporated porewater during evacuation of the line.

The samples were then heated with temperature-controlled ovens to 150°C. This temperature has proven to yield reliable results for the Ordovician shales and carbonates at the Bruce Site (Clark et al., 2013) and for the Tournemire argillite (Altinier et al., 2006). Samples were monitored during a 6-hour distillation period after which the recovered porewater was transferred to 12 mL Exetainers® and weighed for gravimetric water content. The measured water content was compared with the weight loss in the core material to assess water recovery. Isotopes ($\delta^{18}O$ and $\delta^{2}H$) were measured by off-axis integrated cavity output laser spectroscopy using a Los Gatos Research Inc. (LGR) instrument in the Ján Veizer Stable Isotope Laboratory at the University of Ottawa. Porewater extractions and isotope analysis are run in quadruplicate, using 30 g splits from a single core sample.

2.2.1.1 *Vacuum Distillation Leaching*

The primary method for determination of major/minor ion chemistry of the porewaters was the vacuum distillation leaching (VDL) method. The extraction vessel and dry core material following vacuum distillation were rinsed with distilled water into a pre-weighed falcon tube for out-diffusion of porewater salts. The mass of leach water was recorded and then monitored over time until a stable electrical conductivity was attained. The leach water was then filtered and analyzed for major and trace solutes.

Solute masses, determined from concentration and leach water mass, were normalized to the water mass recovered from distillation to determine total porewater concentrations. Leach water was analyzed (ICP-MS, ICP-OES, IC) for major, minor and trace metals (Na, K, Mg, Ca, Sr, plus Al, Fe, Mn Li, Rb, and Si) as well as major and minor anionic species (B, Cl, Br, I, S) in the Geochemistry Laboratory at the University of Ottawa.

2.2.2 Paper Absorption

A second method, paper absorption (PA), was used to complement and allow comparison with the VDL results for porewater samples. The PA method (Celejewski et al., 2014, 2018) was developed for extraction of mobile porewater for analysis of major anions and cations. The mobile porewater is that which is free to flow among the largest pores, and it is a fraction of the total porewater which also includes water in clay interlayers and in the electric double layer adjacent to mineral surfaces.

For the PA method, preserved, saturated core sections of minimum 20 cm length were broken in two, and then reassembled with a cellulosic paper placed between the two pieces, and tightly bound. Reassembled cores were left for a period of approximately two months to allow capillary uptake of porewater into the filter paper. When reopened, the recovered filter paper was leached to remove solutes and the leached solution was analyzed (ICP-MS, ICP-OES, IC) to determine the extracted masses of major, and some minor elements (Na, K, Mg, Ca, Li, Sr, and Ba) as well as major and minor anionic species (Cl, Br, S) at the University of Ottawa. The mass of absorbed water was determined by near-infrared spectrometry, before and after insertion in the core. The mass of extracted water, after 2 months, represents porewater uptake and was used to convert the solute masses to concentrations.

2.2.3 Analysis for CO_2 and CH_4

Headspace gas in the IsoJars was periodically analyzed for concentrations of CH_4 and CO_2 by gas chromatography. When stable concentrations were attained (three successive measurements within analytical uncertainty), the headspace was sampled and analyzed for $\delta^{13}C$ and $\delta^{2}H$ of CH_4, and for $\delta^{13}C$ of CO_2 by routine isotope ratio mass spectrometry at Jan Veizer Stable Isotope Laboratory, University of Ottawa.

2.2.4 Analysis for Noble Gases

All noble gas concentrations were measured on a Thermo-Finnigan Helix SFT noble gas mass spectrometer at the University of Ottawa Lalonde noble gas laboratory using aliquots from the stainless-steel encapsulation chamber, following an outgassing period of at least six months. The out-diffused gases were treated with a Ti getter pump maintained at 450°C to remove non-inert gases (principally CH_4 and CO_2). The noble gases were then cryogenically separated by freezing Ar, Kr, and Xe on charcoal traps before sorbing Ne and He on a 5 K cold-head. He and Ne were successively released to the mass spectrometer by ramping the cold-head temperature accordingly. The isotopes of Ar, Kr and Xe were then analyzed.

2.2.5 Analysis for Radiohalides, $\delta^{37}Cl$ and Strontium Isotopes

Pieces of the core samples were crushed in an aerobic glove box, followed by leaching with an equal mass of deionized and distilled water. These crushed and leached samples were used to extract porewater for radiohalide analyses (^{129}I, ^{36}Cl, and $\delta^{37}Cl$). Sampled water for ^{129}I was treated to precipitate AgI target material and analyzed by the Dresden AMS laboratory in Germany. Sampled water for ^{36}Cl was treated to precipitate AgCl target material which was subsequently analyzed on a high energy AMS system at the Lawrence Livermore National Laboratories facility in California. Water for $\delta^{37}Cl$ analysis and $^{87}Sr/^{86}Sr$ isotope ratios for porewater samples were analyzed at Isotope Tracer Technologies Inc., Waterloo. Part of the leached solution extracted using the PA technique was also used for Sr isotope analyses at the Carleton University Isotope Geochemistry and Geochronology Research Centre.

2.3 Mineralogy and Petrography

Mineralogical and petrological analyses were completed on a subset of porewater samples by the University of Ottawa to obtain mineralogical data required for interpretation and geochemical modelling of the porewater results. Rock core samples that were used for PA analyses were also used for the mineralogical and petrophysical analyses. Thin sections were cut for petrographic analyses and a subsample of core was crushed and milled into a powder for x-ray diffraction (XRD). Following the review of the petrological results from the SB_BH01 samples, it was decided to forgo the petrological analyses on SB_BH02 samples as the petrography was deemed not essential for data interpretation and could be completed later, as required.

3 RESULTS

3.1 Porewater Geochemistry

Results from the SB_BH02 porewater characterization program are summarized in the following section, with select mineralogical, geochemical, and isotopic results presented as profiles with depth. A summary of the porewater sample information, including sample type, depth, and logged primary lithology is included as a table in Appendix A. Complete results from the porewater characterization program are provided in Appendix B.

The results presented in this data report have not been corrected for potential mineral dissolution during analysis, apparent halite undersaturation, or anion exclusion. These processes were shown to impact geochemical results for porewater samples that were collected as part of the Ontario Power Generation (OPG) Deep Geological Repository site characterization program (Intera 2011) from similar strata to what was encountered in SB_BH01 and SB_BH02. The Intera (2011) report showed that the relative magnitude of impact from these processes, and the corrections that were required to obtain representative porewater concentrations, depended on the porewater chemistry and the sampled lithology/mineralogy.

Detailed interpretation of the porewater results, including geochemical modelling and correction for mineral dissolution, halite under-saturation, and anion exclusion will be completed separately as part of Work Package 10 (Data Integration) activities.

3.1.1 Major/Minor Ions and Total Dissolved Solids

Figure 3 presents depth profiles of chloride (Cl), sodium (Na), and calculated total dissolved solids (TDS) measured using both the VDL and PA methods. The TDS values shown in Figure 3 were calculated assuming a fresh-water density and overestimate the true TDS for brackish water, saline water, and brines that were encountered in many of the samples.

Concentrations of Cl and Na are generally low through the top of the Salina Group. Na and Cl concentrations in the Guelph Formation were slightly higher in comparison to other samples from the overlying/underlying units. Below the Guelph Formation, porewater concentrations of Na and Cl generally increase with depth through the lower Silurian units and the Ordovician-aged shales (Queenston, Georgian Bay, and Blue Mountain formations) to the top of the Cobourg Formation. VDL-derived Na and Cl concentrations remain high and relatively consistent from the Cobourg Formation to the Shadow Lake Formation. The PA-derived concentrations of Na and Cl are high and relatively stable from the Cobourg to the Kirkfield, but then decrease with depth to the Shadow Lake Formation.

Since Na and Cl generally dominate the ionic composition of porewaters, particularly below the Salina Group, the TDS depth profiles show similar trends to the Na and Cl depth profiles. VDL-derived TDS values increased with depth from 25 to 240 g/L across the Salina Group to the Guelph Formation. Below the Guelph Formation, the VDL TDS values remained high with most sample concentrations between 200 and 300 g/L.

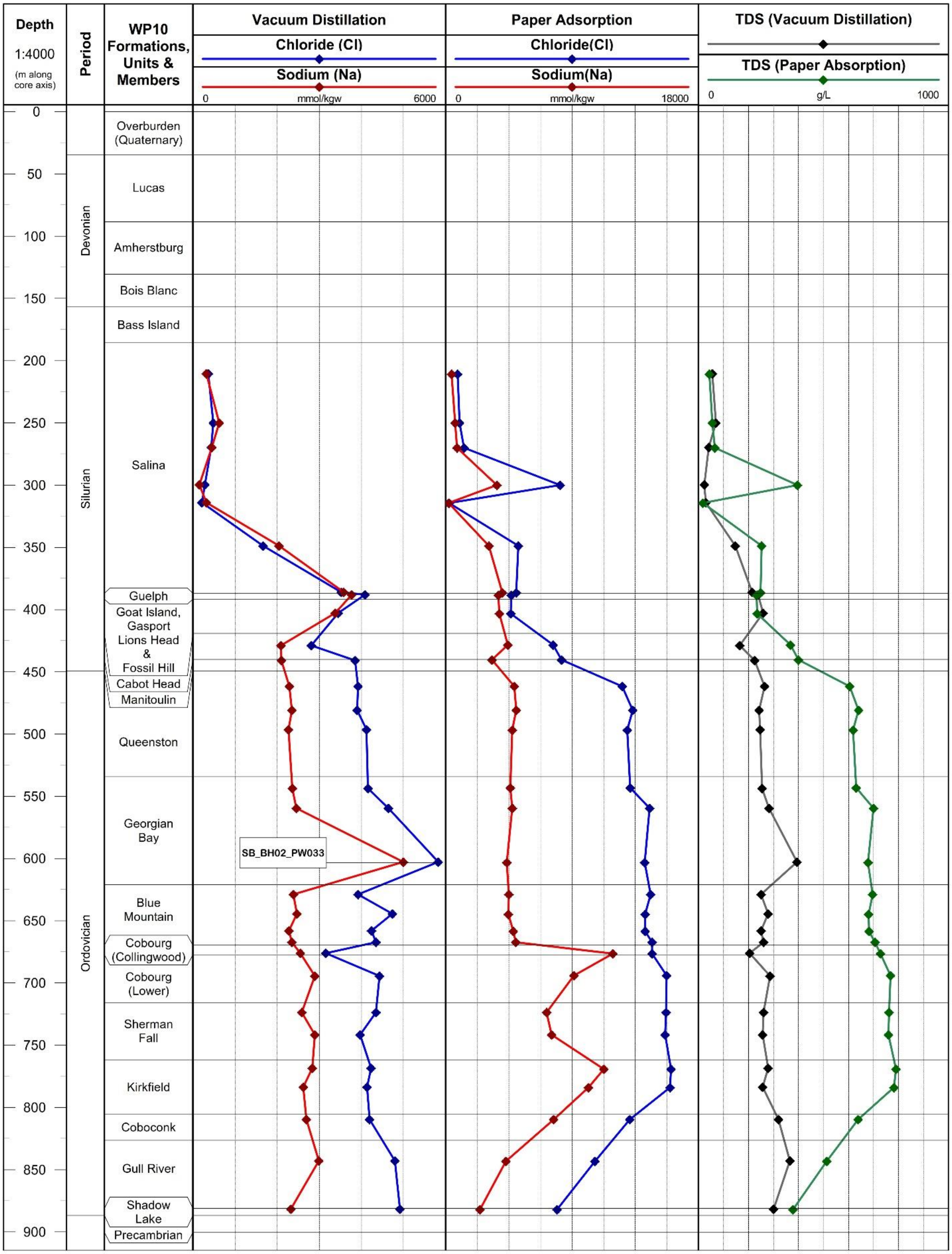

Figure 3 **Profile of Chloride, Sodium, and TDS Concentrations of Porewater from Vacuum Distillation and Paper Absorption, SB_BH02 Core Samples. TDS calculated assuming freshwater density (1000 kg/m^3).**

Comparison of Cl and Na concentrations measured using the VDL and PA methods show considerable variation, with PA-derived concentrations that were 1-3 orders of magnitude higher than corresponding concentrations obtained using the VDL method. Many of the PA-derived concentrations were supersaturated relative to halite solubility. The significant variation in porewater concentrations that is observed between these two methods may reflect differences in the proportional uptake of clay-bound, capillary-bound, and mobile porewaters.

VDL-measured concentrations of Na, Cl, and other major ions were high and outside of the anticipated range for a porewater sample that was collected at the bottom of the Georgian Bay Formation (SB_BH02_PW033). This positive anomaly is likely due to halite dissolution.

Figure 4 shows depth profiles for porewater concentrations of calcium (Ca), magnesium (Mg), and strontium (Sr) measured by VDL. These three elements show similar depth profiles, with low concentrations in the Salina Group through to the bottom of the Silurian strata, except for one porewater sample (SB_BH02_PW011) that has an anomalously high concentration of Sr. Concentrations of Ca, Mg, and Sr are stable, or increase gradually, from the top of the Queenston Formation to the base of the Kirkfield Formation. Concentrations of Ca, Mg, and Sr are higher in the Coboconk and Gull River relative to porewater in the overlying strata, and then decrease in the basal Shadow Lake Formation.

Figure 5 shows depth profiles for porewater concentrations of potassium (K), bromine (Br) and boron (B) measured by VDL. K and Br show similar trends at shallow to intermediate depths, with relatively low concentrations through the Silurian-aged strata. Similar trends of increasing concentrations of K and Br are observed across the Ordovician shales. Concentrations of Br remain high, from the Cobourg through to the Gull River formation, with a slight increase in the Shadow Lake. Concentrations of K are more scattered, but remain high, from the Cobourg through the Kirkfield formations, and then decrease in the Coboconk and Shadow Lake formations relative to the overlaying strata.

Except for one anomalously high sample from the bottom of the Salina Group (SB_BH02_PW011), boron (B) concentrations in porewater are low through the shallow bedrock to the Guelph Formation. From the Goat Island/Gasport Formation through to the base of the Blue Mountain, B concentrations remain relatively low and stable. Boron concentrations are slightly more elevated in in the Ordovician-aged limestones, with a sharp increase in the Coboconk and Gull River formations, and then decreasing in the Shadow Lake Formation.

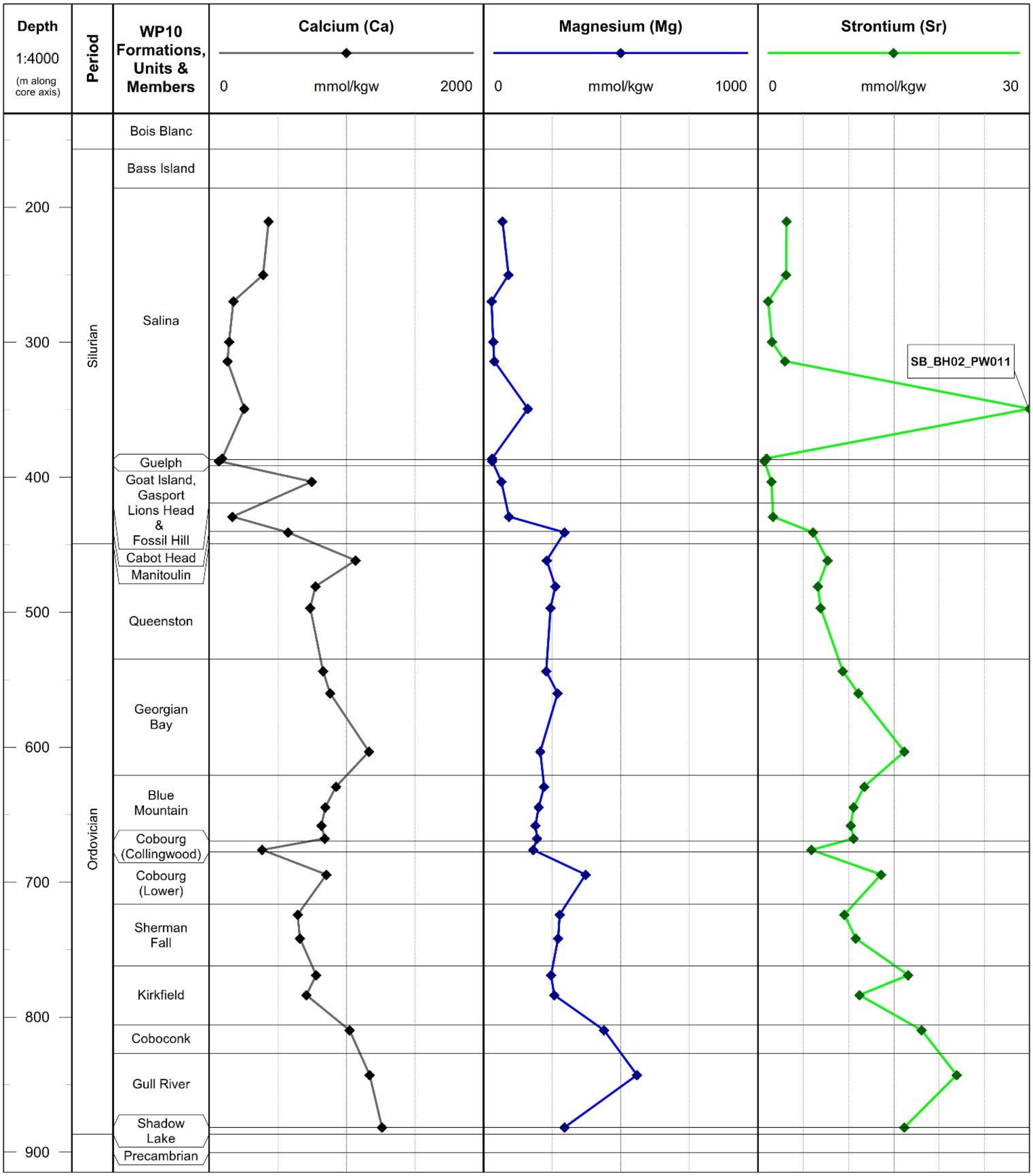

Figure 4 **Profile of Calcium, Magnesium, and Strontium Concentrations in Porewater from Vacuum Distillation, SB_BH02 Core Samples**

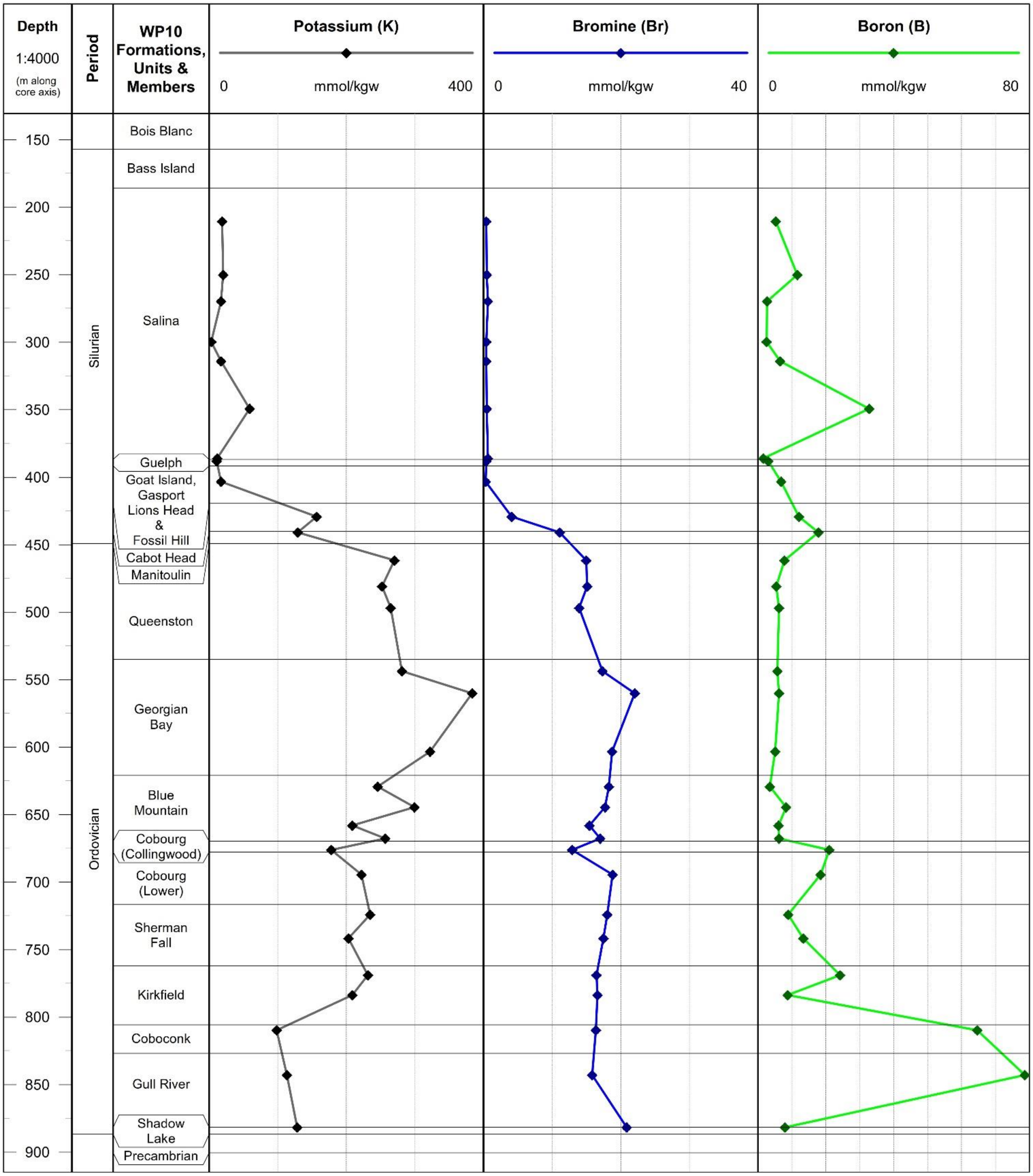

Figure 5 **Profile of Potassium, Bromine, and Boron Concentrations in Porewater from Vacuum Distillation, SB_BH02 Core Samples.**

3.1.2 Environmental Isotopes

Figure 6 shows a cross plot of isotopic ratios for deuterium (^{2}H) and ^{18}O for porewater extracted by vacuum distillation. The accompanying laboratory report for the environmental isotopes had some results that were flagged due to interpreted trace hydrocarbon contamination, but comparison of the results to trends in a depth profile for $\delta^{2}H$ and $\delta^{18}O$ (Figure 7) suggests that the magnitude of contamination for the impacted samples is not significant.

Shown as green squares in Figure 7, Salina group porewaters tended to plot above the global meteoric water line (GWML). All other samples tended to plot adjacent to, or below, the GWML, except for SB_BH02_PW055 and SB_BH02_PW057. Both SB_BH02_PW055 and SB_BH02_PW057 were more depleted in $\delta ^{18}O$ and $\delta ^{2}H$ than other samples from below 650 m and had very low lab-reported water content (~0.1%).

Figure 7 shows depth profiles for $\delta^{18}O$ and $\delta^{2}H$. Samples from the Salina group are slightly depleted in both $\delta^{18}O$ and $\delta^{2}H$. Samples from the Guelph and Goat Island formations were the most depleted in $\delta^{18}O$ and $\delta^{2}H$. After a sharp increase at the top of the Queenston Formation, $\delta^{18}O$ and $\delta^{2}H$ values remain relatively stable, and become slightly less depleted, with depth to the Cobourg Formation. Below the Cobourg Formation $\delta^{18}O$ values show a generally decreasing trend while $\delta^{2}H$ values are generally consistent. Samples SB_BH02_PW055 and SB_BH02_PW057, with the slightly depleted ratios discussed above, are observed in the Coboconk and Gull River Formations, respectively.

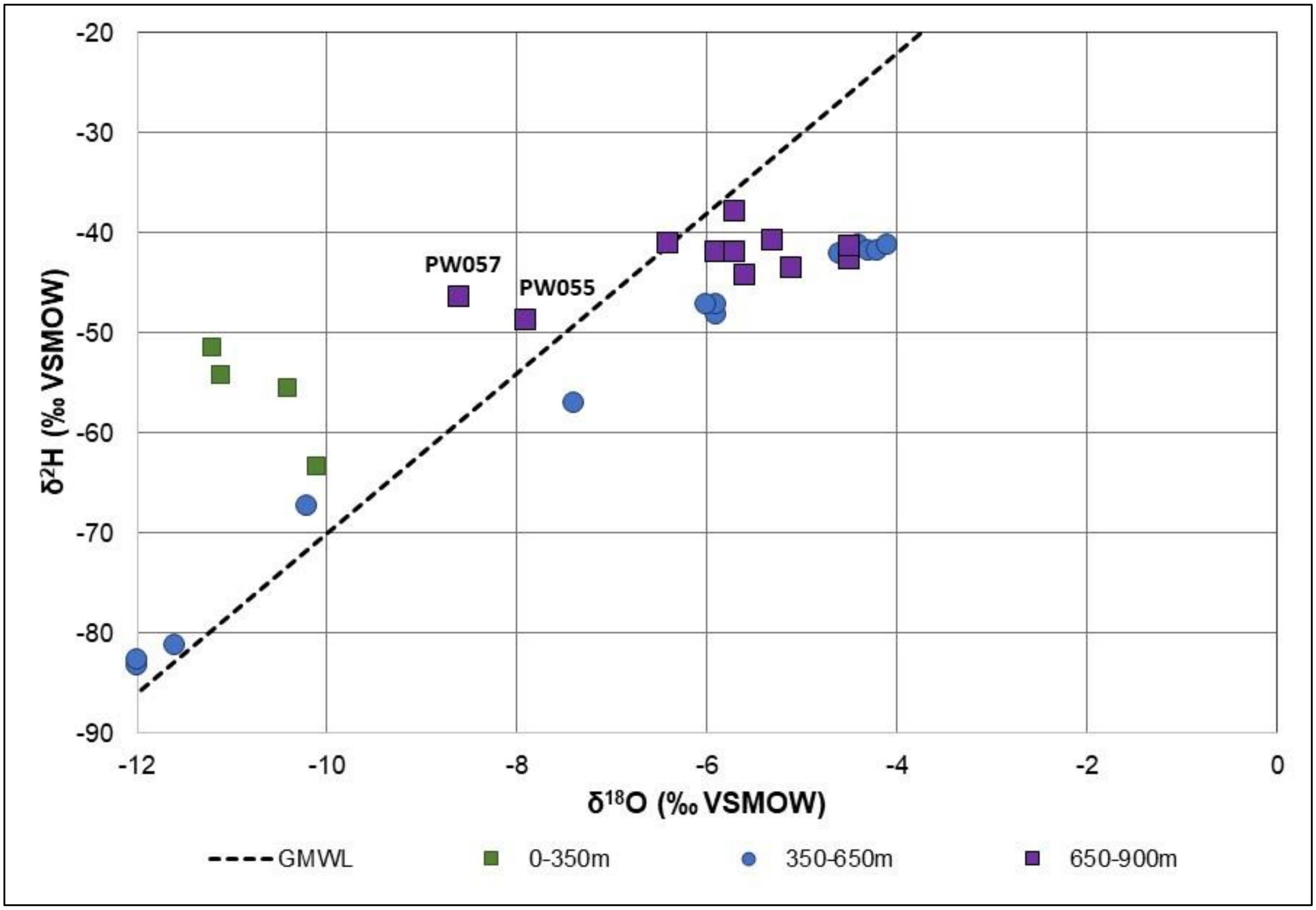

Figure 6 **^{18}O-^{2}H Cross Plot, SB_BH02 Porewater Samples.** Samples SB_BH02_PW055 and SB_BH02_PW057 were noted to have low water content (~0.1%).

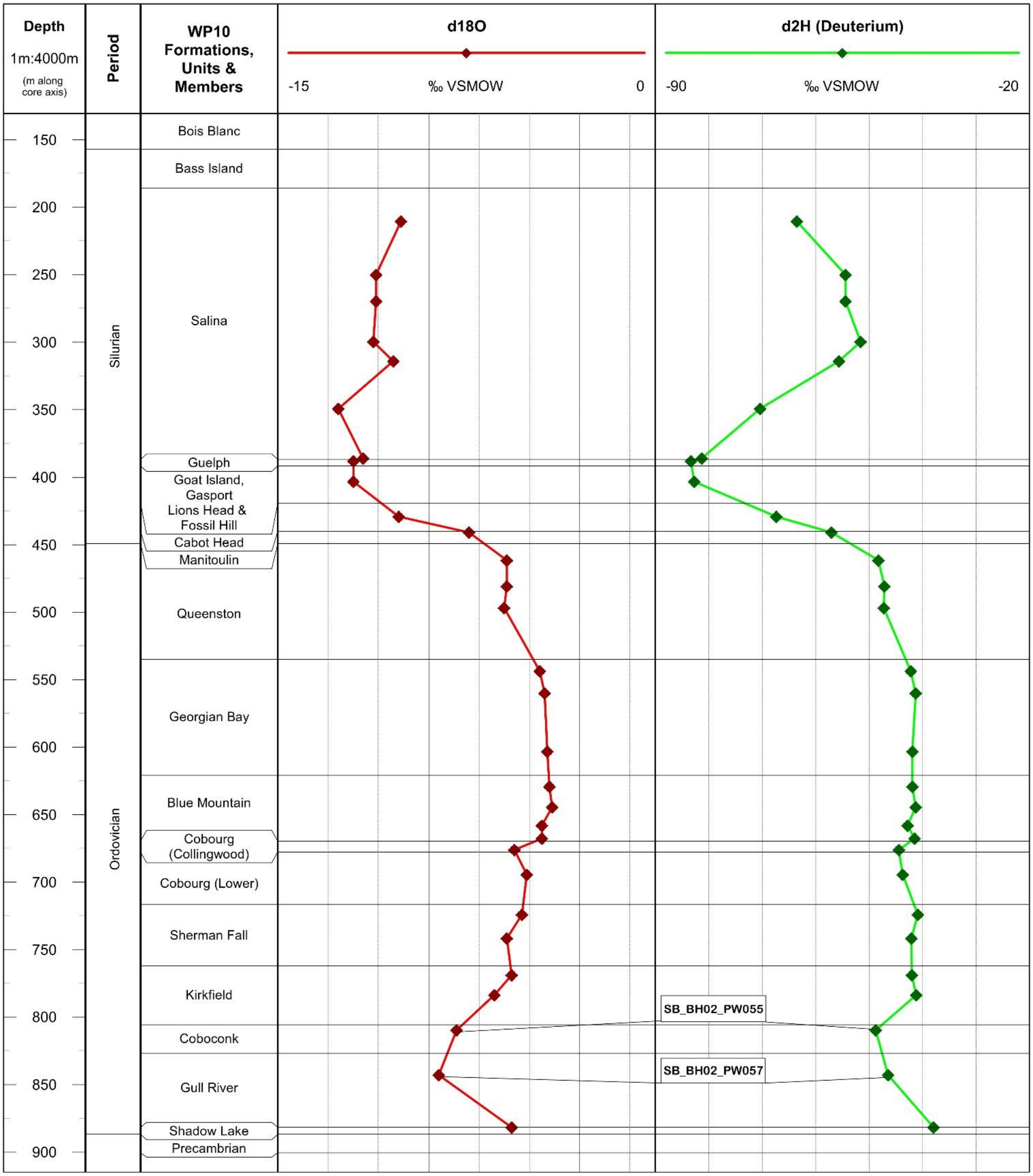

Figure 7 **Profile of δ[18]O and δ[2]H (Deuterium) of Porewater, SB_BH02 Core Samples.** Samples SB_BH02_PW055 and SB_BH02_PW057 were noted to have low water content (~0.1%).

3.1.3 Radiohalides, δ^{37}Cl and Strontium Isotopes

Figure 8 shows depth profiles for radiohalides (^{129}I, ^{36}Cl), ^{37}Cl and strontium isotopes (^{87}Sr/^{86}Sr) measured from porewater samples at SB_BH02. The porewater that was analyzed was extracted by crushing and leaching fresh core; for Sr, both crush and leach and PA were used.

The depth profile of the ^{36}Cl/Cl (Figure 8) shows decreasing proportions of ^{36}Cl from the top of the Salina Group and into the Guelph Formation, where the lowest ratio is observed (~$9.0x10^{-16}$). From the top of the Guelph Formation, proportions of ^{36}Cl increase rapidly to $3.9x10^{-15}$ near the top of the Cabot Head Formation, and then continue to increase gradually with depth to approximately $8x10^{-15}$ in the Blue Mountain Formation. Below the Ordovician shales, proportions of ^{36}Cl remain stable at ~$3x10^{-15}$ to the bottom of the Gull River Formation, and then increase in the Shadow Lake Formation to $4.4x10^{-15}$.

The depth profile for ^{129}I (Figure 8) shows significant scatter in ^{129}I concentrations for porewaters from the shallow bedrock units to the top of the Queenston Formation. In these shallow to intermediate samples, ^{129}I concentrations vary from $5.9x10^{4}$ atoms/kgw in the bottom of the Salina Group to $6.5x10^{6}$ atoms/kgw at the top of the Queenston Formation. Through the remaining Ordovician shales, ^{129}I concentrations are relatively stable between $9.7x10^{4}$ to $7.5x10^{5}$ atoms/kgw. ^{129}I concentrations are an order of magnitude lower than in the overlying shale units and vary from below detection limit (at ~724 m and ~810 m depth) to $2.2x10^{5}$ atoms/kgw.

Strontium isotope ratios of ^{87}Sr/^{86}Sr were recorded for porewater extracted by both the VDL and PA methods. In general, both ^{87}Sr/^{86}Sr results show similar profiles (Figure 8), with changes in the proportion of Sr isotopes noted at the Guelph Formation, near the top of the Cabot Head Formation, and at the base of the Ordovician shales. In the Silurian units, the PA-derived values are more stable near 0.7085, whereas the VD-derived values show more scatter and are slightly higher near 0.7090; for both techniques, the ratios gradual increasing through the Guelph and the Cabot Head Formation. The PA and VDL-derived ratios are similar in the Ordovician shales. In the Ordovician limestones, the PA-derived values remain stable near 0.7100, while the VDL-derived values show more scatter and are generally lower (~0.7090).

Figure 8 also provides a depth profile of isotopic ratios of δ^{37}Cl for porewater extracted from core samples. Except for sample SB_BH02_PW007, in the middle of the Salina, the δ^{37}Cl ratios for all samples are within the range of -0.38 to +0.37. The Ordovician strata had positive δ^{37}Cl ratios between 0-0.27 throughout the shales up to the top of the Blue Mountain Formation. From the Blue Mountain to the top of the Kirkfield formation, porewater samples are slightly more depleted, with δ^{37}Cl ratios between -0.23 and -0.05. The four deepest samples from the Kirkfield, Coboconk, Gull River and Shadow Lake units show slightly enriched ^{37}Cl compared to samples from the Cobourg and Sherman Fall formations. δ^{37}Cl for sample SB_BH02_PW007 was flagged as anomalous; the sample was re-extracted and run again, confirming the original result. Further investigation would be required to determine the cause of this anomaly.

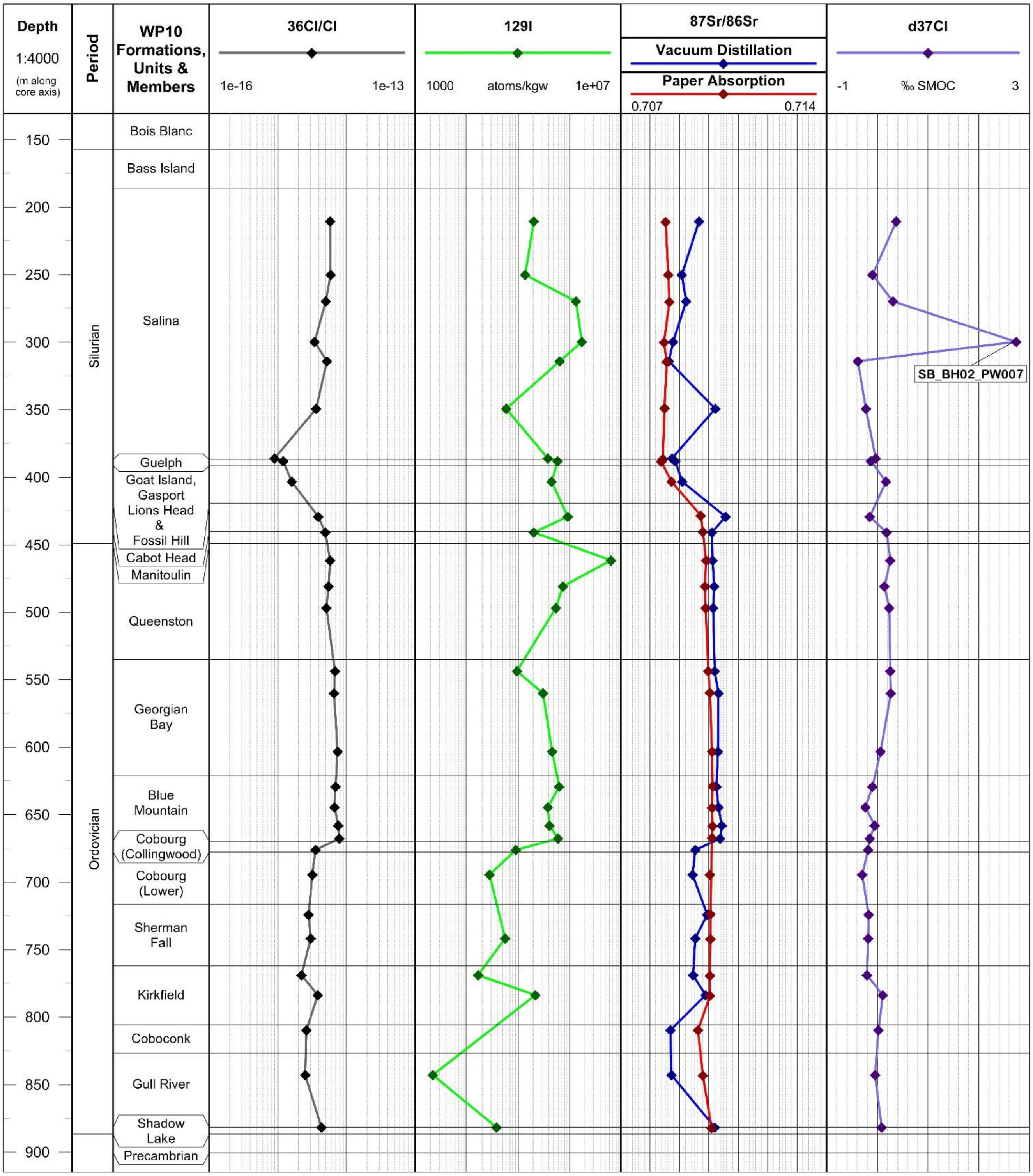

Figure 8 **Profile of ^{36}Cl, ^{129}I, ^{87}Sr/^{86}Sr, and ^{37}Cl Isotopic Results for Porewater from SB_BH02 Core Samples.** Sample SB_BH02_PW007 is flagged as anomalous.

3.1.4 Noble Gas Concentrations and Isotopes

Figure 9 provides depth profiles of concentrations and isotopic ratios for select noble gases in porewater samples from SB_BH02. Concentrations of He, Ar, and Ne are reported in cubic centimeters of gas per cubic centimeter of water (cc/ccw). Concentrations of Kr were also measured but are not shown in Figure 9. With a few exceptions, concentrations of He, Ar, and Ne in porewaters generally increase with depth, with the highest concentrations observed in the Ordovician strata spanning from the Georgian Bay Formation to the Shadow Lake Formation.

Results from sample SB_BH02_NG022, collected from the top of the Cobourg Formation, show some evidence of atmospheric contamination, with an air-normalized $^{3}He/^{4}He$ ratio of 0.23. Small amounts of air/drill water contamination are expected due to the sampling method, so further assessment of contamination for each NG sample should be completed as part of subsequent data integration activities (WP10).

A depth profile of air-normalized $^{3}He/^{4}He$ ratios (xRa) shows two distinct intervals with similar isotopic ratios of He. The Ordovician shales have xRa ratios averaging 0.026 (0.019-0.032), below which the profile shifts to a higher xRa range averaging 0.042, with a slight increasing trend to 0.055 at the base of the profile.

Most of the porewater samples from SB_BH02 had $^{22}Ne/^{20}Ne$ ratios of approximately 0.10. Two samples had $^{22}Ne/^{20}Ne$ ratios of 0.11, including one sample from the Georgian Bay formation and one from the Blue Mountain formation.

$^{40}Ar/^{36}Ar$ ratios were relatively low (300-390) through the Silurian-aged strata to the Georgian Bay Formation, except for four samples from the Queenston and Georgian Bay, that were somewhat enriched in ^{40}Ar with $^{40}Ar/^{36}Ar$ ratios from 425 to 600. Samples from the Blue Mountain through to the top of the top of the Sherman Fall Formation had more scattered $^{40}Ar/^{36}Ar$ ratios between 310 and 695. The highest $^{40}Ar/^{36}Ar$ ratios were from the five deepest samples, with ratios between 635 and 1400.

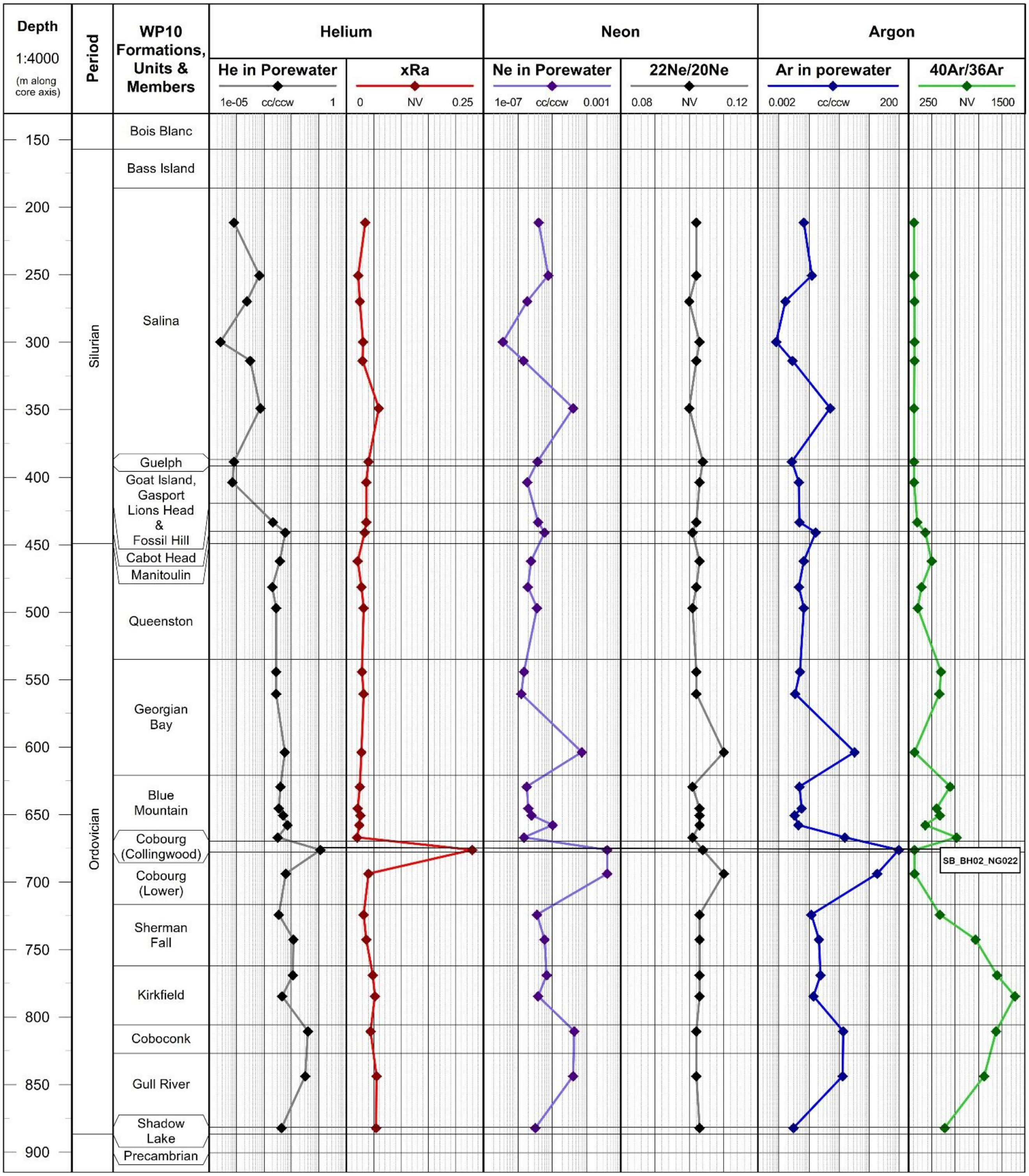

Figure 9 **Profile of Noble Gas (He, Ne, Ar) Concentrations and Isotopes for Porewater from SB_BH02 Core Samples, xRa = Air-normalized $^{3}He/^{4}He$ ratio.**

3.1.5 Methane (CH_4) and Carbon Dioxide (CO_2) Concentrations and Isotopes

Figure 10 shows depths profiles of methane (CH_4) and carbon dioxide (CO_2) concentrations (in mmol/kgw) measured from degassing of core samples into the headspace of IsoJars. Concentrations of CH_4 increased with depth from less-than-detection in the top of the Salina Group to approximately 47 mmol/kgw in the Coboconk Formation. Below the Coboconk, concentrations decrease with depth to 26 mmol/kgw in the Gull River Formation and 1.21 mmol/kgw in the Shadow Lake Formation.

The profile of $\delta^{13}C$ in CH_4 shows a relative enrichment in ^{13}C with depth from approximately -52‰ VPDB in samples from the Salina Group to -41.5‰ VPDB in samples from below the Sherman Fall Formation. The profile of $\delta^{2}H$ for CH_4 also shows an enrichment in ^{2}H from approximately -307‰ VSMOW in samples from the Blue Mountain to -186‰ VSMOW in samples from the Gull River and Shadow Lake formations. Several samples were below the detection limit for the $\delta^{13}C$ and $\delta^{2}H$ in CH_4, including five samples from the Salina Group, plus samples from each of the Guelph, Goat Island, Queenston, Georgian Bay, and Shadow Lake formations.

CO_2 concentrations are variable in the Silurian down to the top of the Georgian Bay Formation. Through the Ordovician shales, CO_2 concentrations are constrained within the range of 0.7 to 1.5 mmol/kgw. A sharp inflection occurs, with lower concentrations of CO_2, in the underlying Cobourg Formation. CO_2 concentrations through the Ordovician limestones range from 0.8 to 3.2 mmol/kgw and then decrease to 0.08 mmol/kgw in the Shadow Lake formation.

The profile of $\delta^{13}C$ in CO_2 shows a constrained range of approximately -16‰ VPDB from the lower Salina to upper Georgian Bay Formation, followed by a sharp positive excursion to +0.5‰ VPDB through the lower Georgian Bay and Blue Mountain shales. This positive anomaly is reversed at the top of the Cobourg formation through to the Shadow Lake Formation, where the ^{13}C is more depleted and ranges from approximately -7.7 to -11.9‰ VPDB.

3.1 Mineralogy and Petrography

Mineralogical analyses were completed to obtain sample-specific mineralogical data required for interpretation of the porewater results and reconstructive geochemical modelling. This advanced analyses of porewater results will be completed as part of data integration (WP10) activities, so results from the mineralogical and petrographic testing are not discussed in detail in this data report. The mineralogical testing completed as part of this work package (WP04C) complements a more substantial mineralogical testing program that was completed by SGS Laboratories and the British Geologic Survey as part of WP04D.

Figure 11 shows the major mineralogical components (by XRD) for core porewater (PW) samples that were also used for the PA method. Shale samples from the Queenston, Georgian Bay, Blue Mountain and top of Cobourg formations show a variable mineralogy, including significant proportions of clay minerals and quartz. Calcite is the most abundant mineral in samples from the Ordovician limestones.

Complete results from the mineralogical analyses are provided in Appendix C.

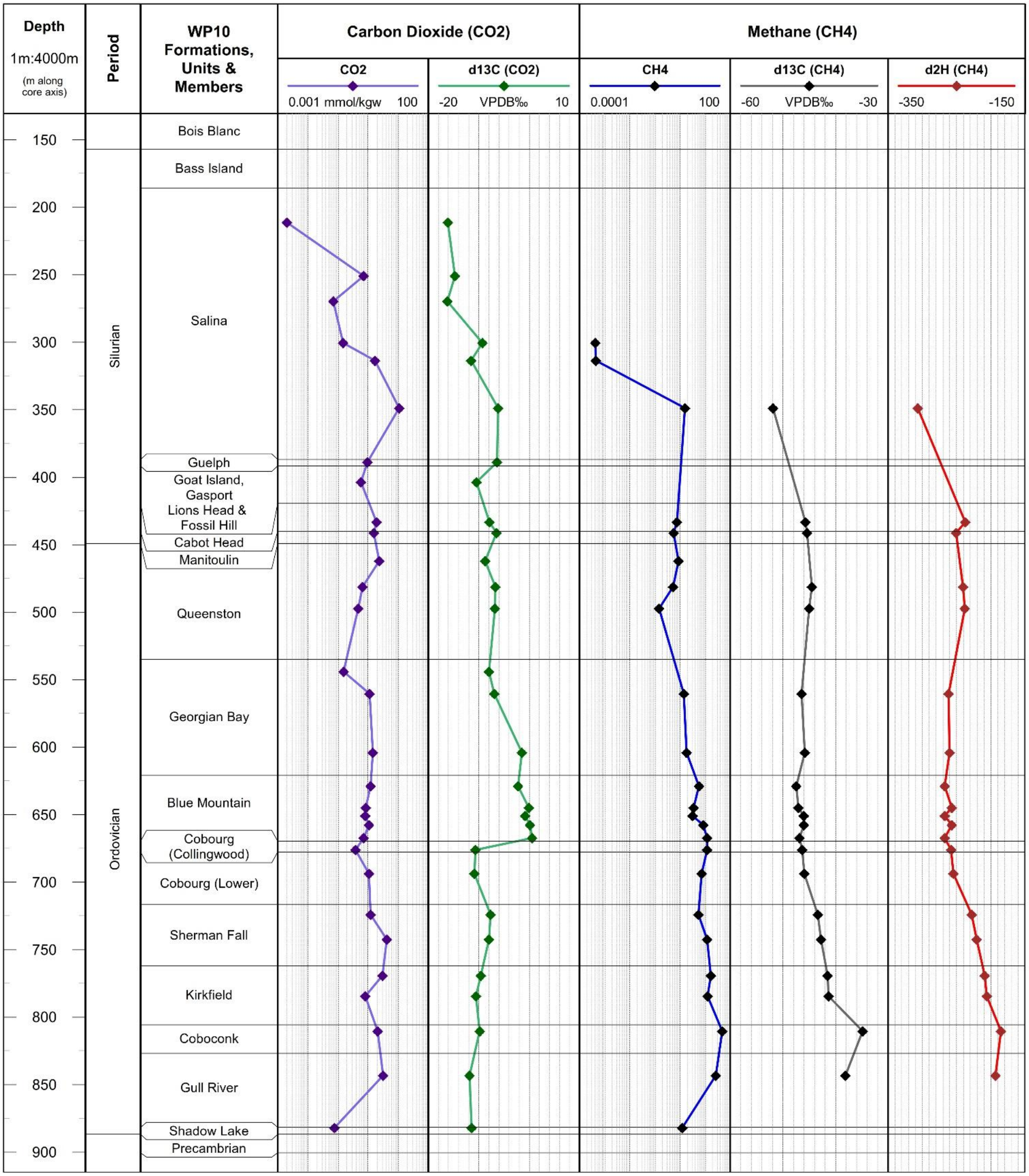

Figure 10 **Profile of Methane and Carbon Dioxide Concentrations and Isotopes from SB_BH02 Core Samples**

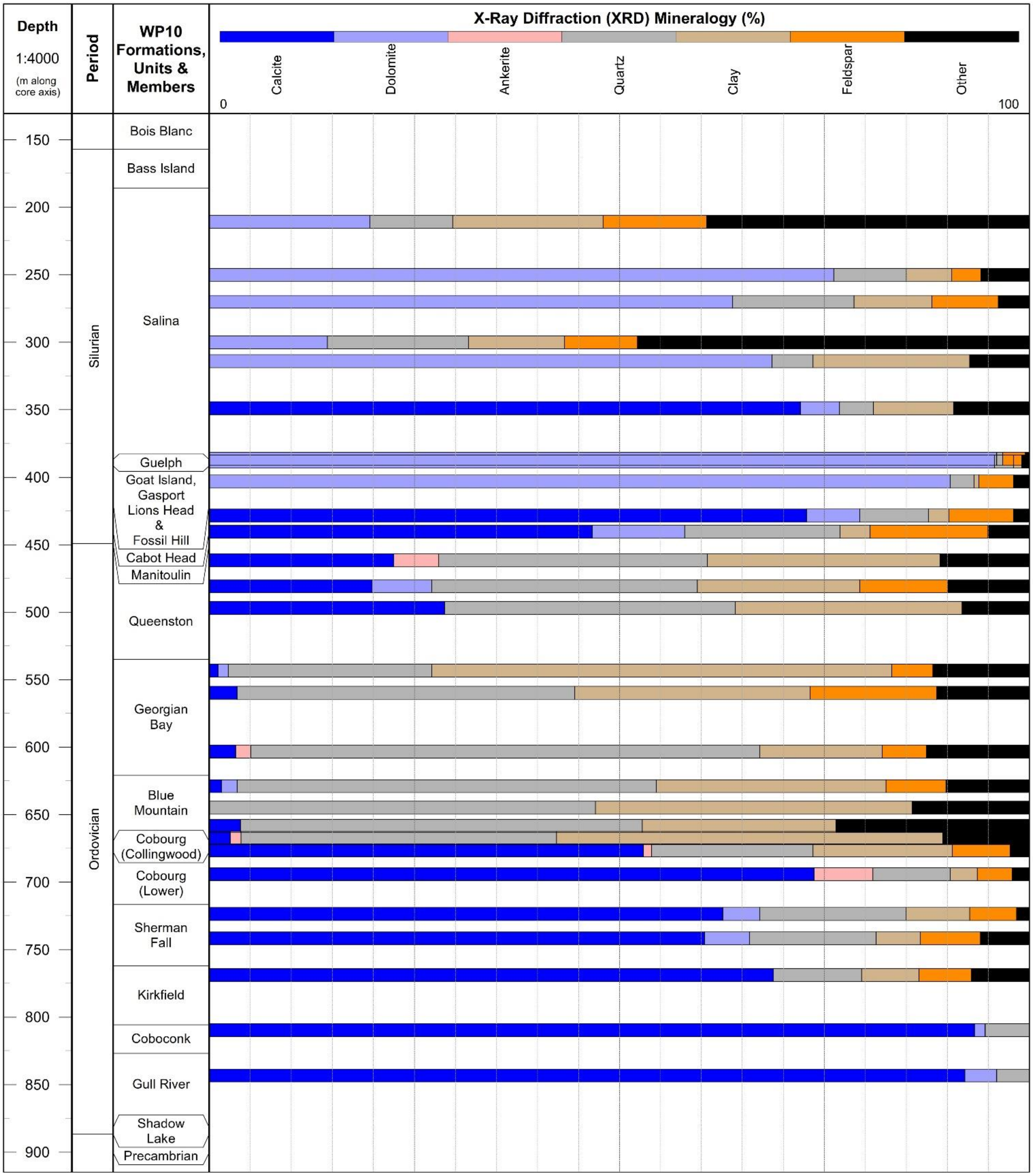

Figure 11 Mineralogical Components, by X-Ray Diffraction, SB_BH02 Core Samples

4 CONCLUSIONS

Geofirma Engineering Ltd. completed sampling and preservation of core samples as part of porewater characterization activities (Work Package 04C) at SB_BH02, the second of two boreholes at the South Bruce site that were drilled as part of the NWMO's Phase 2 Geoscientific Preliminary Field Investigations. The porewater samples were collected and preserved between December 31, 2021 to March 21, 2022.

A total of 120 preserved samples were sent to the University of Ottawa for analysis, including:

- 30 pairs of porewater (PW) samples for porewater analysis. Each pair included one PW sample that was used for vacuum distillation leaching (VDL), and a second PW sample that was used for paper absorption (PA) and mineralogical analyses.
- 30 dissolved gas (DG) samples collected in IsoJars for measurement of carbon dioxide and methane concentrations and their associated isotopic ratios (δ^2H, δ^{13}C).
- 30 noble gas (NG) samples that were encapsulated in air-tight stainless-steel vessels for measurement of noble gas concentrations and isotopic compositions.

Porewater extraction and laboratory testing completed as part of porewater characterization activities for SB_BH02, including the accompanying mineralogical testing, was coordinated by the University of Ottawa, with a subset of analyses completed by subcontracted research and commercial laboratories.

Results from the porewater characterization program provide high resolution depth profiles of key porewater parameters, including major/minor ionic composition, environmental isotopes, radiohalides, dissolved gases, and noble gases. Results presented in this report show laboratory-reported values, but were not corrected for mineral dissolution, halite under-saturation, and anion exclusion processes. Detailed interpretation of the porewater results, including geochemical modelling, will be completed separately as part of data integration activities (Work Package 10).

Notable results from the porewater characterization program at SB_BH02 include:

- Comparison of Cl and Na concentrations measured using the VDL and PA methods show substantial variation, with PA-derived concentrations that were 1-3 orders of magnitude higher than corresponding concentrations obtained using the VDL method. The variation may reflect differences in the proportional uptake of clay-bound, capillary-bound, and mobile porewaters.
- Na and Cl dominate the ionic composition of porewaters.
- TDS concentrations calculated assuming a water density of 1000 kg/m^3 were generally between 25-240 g/L in the Salina Group and increased to approximately 250-400 g/L in the lower Silurian units and through the Ordovician strata.
- Profiles for environmental isotopes (δ^{18}O, δ^2H), radiohalides (^{36}Cl, ^{129}I), ^{87}Sr/^{86}Sr and δ^{37}Cl in porewater show similar trends with depth across the Paleozoic bedrock sequence. Inflections were generally observed in the depth profiles for these analytes in the Guelph Formation, near

the top of the Ordovician shales (Queenston Formation), and near the top of the Ordovician carbonates (Cobourg Fm).

- A profile of air-normalized $^3He/^4He$ ratios (xRa) shows two distinct depth intervals with similar He isotopic ratios. Samples from the Ordovician shales have xRa ratios close to 0.026, with a shift to an average of 0.042 in the underlying Ordovician limestones.

- Methane concentrations generally increased with depth, with the highest concentrations observed from samples near the top of the Coboconk Formation. Profiles of $\delta^{13}C$ and δ^2H in methane show distinctions between methane in the Ordovician shales and the limestones.

- The profile for $\delta^{13}C$ of CO_2 shows a strong positive anomaly in the lower Ordovician shales relative to a well-constrained baseline through the upper shales and through the underlying limestones.

5 REFERENCES

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Appendix A

SB_BH02 Porewater (PW), Dissolved Gas (DG), and Noble Gas (NG) Sample Summary

Sample ID	Sample Type	From (m)	To (m)	Date Sampled	Lithology	Comments
SB_BH02_DG001	DG	211.16	211.28	2021-12-31 1:20	Shale	Sampling note: Sample crushed to fit into jars. Didn't all fit into jar hence after weight is less than before. Broken fragments returned to core box.
SB_BH02_DG002	DG	250.7	250.83	2022-01-01 14:50	Dolostone	
SB_BH02_DG003	DG	269.53	269.63	2022-01-02 0:20	Shale	
SB_BH02_DG004	DG	300.63	300.75	2022-01-02 15:45	Dolostone	
SB_BH02_DG005	DG	313.65	313.75	2022-01-03 0:59	Shale	
SB_BH02_DG006	DG	349.01	349.11	2022-01-04 3:35	Limestone	
SB_BH02_DG007	DG	388.65	388.75	2022-01-05 0:30	Dolostone	Sampling note: Extremely hard core to break. Only 90% of sample could fit in isojar hence after weight is less than before. Remaining piece returned to box.
SB_BH02_DG008	DG	403.51	403.6	2022-01-05 10:10	Dolostone	
SB_BH02_DG009	DG	433.23	433.34	2022-01-05 0:50	Shale	
SB_BH02_DG010	DG	441.13	441.25	2022-01-06 4:50	Limestone	
SB_BH02_DG011	DG	462.02	462.14	2022-01-06 23:25	Shale	
SB_BH02_DG012	DG	481.26	481.37	2022-01-07 14:25	Shale	
SB_BH02_DG013	DG	497.13	497.21	2022-03-01 0:20	Shale	
SB_BH02_DG014	DG	544.23	544.36	2022-03-04 23:21	Shale	
SB_BH02_DG015	DG	560.4	560.55	2022-03-07 22:55	Shale	
SB_BH02_DG016	DG	603.88	604.03	2022-03-09 10:50	Shale	
SB_BH02_DG017	DG	628.64	628.76	2022-03-10 1:32	Shale	
SB_BH02_DG018	DG	644.92	645.08	2022-03-11 12:05	Shale	
SB_BH02_DG019	DG	650.75	650.86	2022-03-11 15:21	Shale	
SB_BH02_DG020	DG	657.67	657.8	2022-03-11 20:55	Shale	
SB_BH02_DG021	DG	667.34	667.44	2022-03-12 11:54	Shale	
SB_BH02_DG022	DG	675.91	676.03	2022-03-13 10:39	Limestone	
SB_BH02_DG023	DG	693.8	693.91	2022-03-13 18:51	Limestone	
SB_BH02_DG024	DG	724.16	724.26	2022-03-14 15:49	Limestone	
SB_BH02_DG025	DG	742.42	742.55	2022-03-15 1:20	Limestone	
SB_BH02_DG026	DG	769.42	769.54	2022-03-17 17:35	Limestone	
SB_BH02_DG027	DG	784.42	784.54	2022-03-18 2:40	Limestone	Sampling note: Shaly limestone.
SB_BH02_DG028	DG	810.38	810.49	2022-03-19 2:40	Limestone	
SB_BH02_DG029	DG	843.13	843.24	2022-03-20 16:24	Limestone	
SB_BH02_DG030	DG	882.06	882.16	2022-03-21 15:33	Sandstone	
SB_BH02_NG001	NG	211.05	211.16	2021-12-31 1:25	Shale	
SB_BH02_NG002	NG	250.36	250.49	2022-01-01 14:48	Dolostone	
SB_BH02_NG003	NG	269.63	269.75	2022-01-02 0:20	Shale	
SB_BH02_NG004	NG	299.81	299.93	2022-01-02 14:02	Dolostone	
SB_BH02_NG005	NG	313.75	313.87	2022-01-03 0:59	Shale	
SB_BH02_NG006	NG	348.91	349.01	2022-01-04 3:40	Limestone	
SB_BH02_NG007	NG	388.54	388.65	2022-01-05 0:30	Dolostone	
SB_BH02_NG008	NG	403.6	403.75	2022-01-05 10:10	Dolostone	
SB_BH02_NG009	NG	433.34	433.47	2022-01-06 0:45	Shale	
SB_BH02_NG010	NG	441.01	441.13	2022-01-06 4:50	Limestone	
SB_BH02_NG011	NG	461.92	462.02	2022-01-06 23:25	Shale	
SB_BH02_NG012	NG	481.16	481.26	2022-01-07 14:25	Shale	
SB_BH02_NG013	NG	497.04	497.13	2022-03-01 0:20	Shale	
SB_BH02_NG014	NG	544.06	544.16	2022-03-04 23:20	Shale	
SB_BH02_NG015	NG	560.26	560.4	2022-03-07 22:52	Shale	
SB_BH02_NG016	NG	603.72	603.82	2022-03-09 10:48	Shale	
SB_BH02_NG017	NG	629.3	629.41	2022-03-10 1:41	Shale	
SB_BH02_NG018	NG	645.08	645.18	2022-03-11 12:05	Shale	
SB_BH02_NG019	NG	650.63	650.74	2022-03-11 15:22	Shale	
SB_BH02_NG020	NG	657.57	657.67	2022-03-11 20:59	Shale	
SB_BH02_NG021	NG	667.00	667.14	2022-03-12 11:53	Shale	
SB_BH02_NG022	NG	676.03	676.15	2022-03-13 10:38	Limestone	
SB_BH02_NG023	NG	693.70	693.80	2022-03-13 18:50	Limestone	
SB_BH02_NG024	NG	724.04	724.16	2022-03-14 15:47	Limestone	
SB_BH02_NG025	NG	742.30	742.42	2022-03-15 1:16	Limestone	
SB_BH02_NG026	NG	768.92	769.07	2022-03-17 17:48	Limestone	
SB_BH02_NG027	NG	784.30	784.42	2022-03-18 2:45	Limestone	
SB_BH02_NG028	NG	810.27	810.38	2022-03-19 2:45	Limestone	
SB_BH02_NG029	NG	843.67	843.80	2022-03-20 18:02	Limestone	
SB_BH02_NG030	NG	881.91	882.06	2022-03-21 16:41	Sandstone	
SB_BH02_PW001	PW-VD	210.54	210.74	2021-12-31 1:10	Shale	
SB_BH02_PW002	PW-PA	210.74	210.96	2021-12-31 1:20	Shale	
SB_BH02_PW003	PW-VD	249.91	250.11	2022-01-01 14:50	Dolostone	
SB_BH02_PW004	PW-PA	250.11	250.36	2022-01-01 14:50	Dolostone	
SB_BH02_PW005	PW-VD	269.75	269.9	2022-01-02 0:19	Shale	
SB_BH02_PW006	PW-PA	269.9	270.1	2022-01-02 0:22	Shale	
SB_BH02_PW007	PW-VD	299.58	299.81	2022-01-02 13:52	Dolostone	
SB_BH02_PW008	PW-PA	299.93	300.17	2022-01-02 13:58	Dolostone	
SB_BH02_PW009	PW-VD	314.15	314.3	2022-01-03 0:52	Shale	
SB_BH02_PW010	PW-PA	314.3	314.54	2022-01-03 0:54	Shale	

Sample ID	Sample Type	From (m)	To (m)	Date Sampled	Lithology	Comments
SB_BH02_PW011	PW-VD	349.11	349.26	2022-01-04 3:32	Limestone	
SB_BH02_PW012	PW-PA	348.71	348.91	2022-01-04 3:35	Limestone	
SB_BH02_PW013	PW-VD	386.17	386.32	2022-01-04 22:20	Dolostone	Sampling note: Precautionary sample from bottom of A0 Unit. Guelph was the targeted fm
SB_BH02_PW014	PW-PA	386.32	386.54	2022-01-04 22:24	Dolostone	Sampling note: Precautionary sample from bottom of A0 Unit. Guelph was the targeted fm
SB_BH02_PW015	PW-VD	387.92	388.09	2022-01-05 0:41	Dolostone	
SB_BH02_PW016	PW-PA	388.34	388.54	2022-01-05 0:43	Dolostone	
SB_BH02_PW017	PW-VD	403.05	403.2	2022-01-05 10:00	Dolostone	
SB_BH02_PW018	PW-PA	403.26	403.51	2022-01-05 10:00	Dolostone	
SB_BH02_PW019	PW-VD	429.06	429.22	2022-01-05 21:40	Shale	Sampling note: Shale with carbonate interbeds.
SB_BH02_PW020	PW-PA	428.58	428.78	2022-01-05 21:43	Shale	Sampling note: Shale with carbonate interbeds.
SB_BH02_PW021	PW-VD	440.75	440.93	2022-01-06 4:53	Limestone	
SB_BH02_PW022	PW-PA	440.52	440.75	2022-01-06 4:55	Limestone	
SB_BH02_PW023	PW-VD	461.52	461.71	2022-01-06 23:15	Shale	
SB_BH02_PW024	PW-PA	461.71	461.92	2022-01-06 23:18	Shale	
SB_BH02_PW025	PW-VD	480.8	480.95	2022-01-07 14:30	Shale	
SB_BH02_PW026	PW-PA	480.95	481.16	2022-01-07 14:30	Shale	
SB_BH02_PW027	PW-VD	496.66	496.85	2022-03-01 0:20	Shale	
SB_BH02_PW028	PW-PA	496.85	497.04	2022-03-01 0:23	Shale	
SB_BH02_PW029	PW-VD	543.69	543.87	2022-03-04 23:16	Shale	
SB_BH02_PW030	PW-PA	543.48	543.69	2022-03-04 23:13	Shale	
SB_BH02_PW031	PW-VD	559.83	560.01	2022-03-07 22:45	Shale	
SB_BH02_PW032	PW-PA	559.64	559.83	2022-03-07 22:46	Shale	
SB_BH02_PW033	PW-VD	603.04	603.19	2022-03-09 8:52	Shale	
SB_BH02_PW034	PW-PA	603.19	603.42	2022-03-09 8:53	Shale	
SB_BH02_PW035	PW-PA	628.83	629.06	2022-03-10 1:26	Shale	
SB_BH02_PW036	PW-VD	629.09	629.3	2022-03-10 4:36	Shale	
SB_BH02_PW037	PW-VD	644.56	644.72	2022-03-11 12:06	Shale	
SB_BH02_PW038	PW-PA	644.72	644.92	2022-03-11 12:08	Shale	
SB_BH02_PW039	PW-VD	658.17	658.33	2022-03-11 20:44	Shale	
SB_BH02_PW040	PW-PA	658.33	658.53	2022-03-11 20:46	Shale	
SB_BH02_PW041	PW-PA	667.14	667.34	2022-03-12 11:51	Shale	
SB_BH02_PW042	PW-VD	667.44	667.61	2022-03-12 11:52	Shale	
SB_BH02_PW043	PW-VD	676.15	676.31	2022-03-13 10:36	Limestone	
SB_BH02_PW044	PW-PA	676.31	676.6	2022-03-13 10:37	Limestone	
SB_BH02_PW045	PW-PA	694.19	694.41	2022-03-13 18:49	Limestone	
SB_BH02_PW046	PW-VD	694.41	694.62	2022-03-13 18:49	Limestone	
SB_BH02_PW047	PW-VD	723.88	724.04	2022-03-14 15:45	Limestone	
SB_BH02_PW048	PW-PA	723.66	723.88	2022-03-14 15:46	Limestone	
SB_BH02_PW049	PW-VD	741.57	741.8	2022-03-15 1:11	Limestone	
SB_BH02_PW050	PW-PA	741.8	742.04	2022-03-15 1:12	Limestone	
SB_BH02_PW051	PW-VD	768.67	768.92	2022-03-17 17:31	Limestone	
SB_BH02_PW052	PW-PA	769.07	769.34	2022-03-17 17:38	Limestone	
SB_BH02_PW053	PW-VD	783.72	783.89	2022-03-18 2:40	Limestone	
SB_BH02_PW054	PW-PA	783.89	784.13	2022-03-18 2:38	Limestone	
SB_BH02_PW055	PW-VD	809.75	809.9	2022-03-19 2:47	Limestone	Lab noted that sample had low water content (~0.1%)
SB_BH02_PW056	PW-PA	809.53	809.75	2022-03-19 2:45	Limestone	
SB_BH02_PW057	PW-VD	842.97	843.13	2022-03-20 16:22	Limestone	Lab noted that sample had low water content (~0.1%)
SB_BH02_PW058	PW-PA	843.3	843.54	2022-03-20 16:20	Limestone	
SB_BH02_PW059	PW-VD	881.74	881.91	2022-03-21 15:24	Sandstone	
SB_BH02_PW060	PW-PA	882.16	882.33	2022-03-21 15:28	Sandstone	Sampling note: Unable to collect full 20cm length within the glauconitic sands, Shipped on COC GFSB_UofO_0046.

DG = Dissolved Gas
NG = Noble Gas
PW-VD = Porewater Vacuum Distillation
PW-PA = Porewater Paper Absorption

Appendix B

Results Tables for Porewater Characterization Activities at SB_BH02

B.1. – Porewater Sample Results – VDL
B.2 – Porewater Sample Results – PA
B.3 – Noble Gas Sample Results
B.4. Dissolved Gas Sample Results

	Sample ID	SB_BH02_PW001	SB_BH02_PW003	SB_BH02_PW005	SB_BH02_PW007	SB_BH02_PW009	SB_BH02_PW011	SB_BH02_PW013
Major/Minor Ions								
Aluminum (Al)	mmol/kgw	0.43	1.39	0.17	0.13	0.32	2.63	0.27
Boron (B)	mmol/kgw	5.17	11.67	2.70	2.49	6.45	32.74	1.64
Bromine (Br)	mmol/kgw	0.38	0.49	0.61	0.42	0.37	0.45	0.60
Calcium (Ca)	mmol/kgw	433.48	393.27	178.35	147.21	133.74	255.51	94.88
Chlorine (Cl)	mmol/kgw	365.07	480.96	442.53	286.71	214.58	1661.92	3518.38
Iodine (I)	mmol/kgw	0.00	0.00	0.00	0.00	0.00	0.01	0.00
Iron (Fe)	mmol/kgw	0.01	0.04	0.00	0.00	0.03	0.02	0.02
Lithium (Li)	mmol/kgw	0.23	0.36	0.27	0.12	0.11	0.78	0.20
Magnesium (Mg)	mmol/kgw	68.90	90.16	28.59	35.28	39.69	161.60	31.28
Manganese (Mn)	mmol/kgw	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Potassium (K)	mmol/kgw	18.54	20.49	17.44	2.86	17.71	59.11	11.82
Rubidium (Rb)	mmol/kgw	0.00	0.00	0.00	0.00	0.00	0.01	0.00
Silicon (Si)	mmol/kgw	17.85	40.46	6.31	4.19	10.86	95.32	9.32
Sodium (Na)	mmol/kgw	320.31	625.68	444.47	158.08	322.83	2041.84	3582.09
Strontium (Sr)	mmol/kgw	3.16	3.12	1.12	1.56	2.99	51.60	0.95
Sulfur (S)	mmol/kgw	486.68	535.58	216.45	112.13	220.44	518.93	53.35
Environmental Isotopes		**SB_BH02_PW001**	**SB_BH02_PW003**	**SB_BH02_PW005**	**SB_BH02_PW007**	**SB_BH02_PW009**	**SB_BH02_PW011**	**SB_BH02_PW013**
$\delta^{18}O$	‰VSMOW	-10.1	-11.1	-11.1	-11.2	-10.4	-12.6	-11.6
$\delta^{2}H$	‰VSMOW	-63.5	-54.4	-54.4	-51.6	-55.7	-70.4	-81.3
Radiohalides and Strontium Isotopes		**SB_BH02_PW001**	**SB_BH02_PW003**	**SB_BH02_PW005**	**SB_BH02_PW007**	**SB_BH02_PW009**	**SB_BH02_PW011**	**SB_BH02_PW013**
Chlorine-37 ($\delta^{37}Cl$)	‰ SMOC	0.37	-0.10	0.31	**2.73**	-0.38	-0.22	-0.03
Chlorine-36 ($^{36}Cl/Cl$)	--	5.79E-15	5.90E-15	5.04E-15	3.46E-15	5.23E-15	3.62E-15	9.04E-16
Iodine-129 (^{129}I)	atoms/kgw	2.03E+05	1.37E+05	1.34E+06	1.76E+06	6.52E+05	5.91E+04	3.83E+05
Strontium isotope ratio ($^{87}Sr/^{86}Sr$)	--	0.70966	0.70908	0.70922	0.70879	0.70864	0.71022	0.70875

BDL = Below Detection Limit

Flagged as anomalous result

	Sample ID	SB_BH02_PW015	SB_BH02_PW017	SB_BH02_PW019	SB_BH02_PW021	SB_BH02_PW023	SB_BH02_PW025	SB_BH02_PW027
Major/Minor Ions								
Aluminum (Al)	mmol/kgw	0.43	0.62	0.49	1.25	0.38	0.26	0.38
Boron (B)	mmol/kgw	3.01	6.79	12.14	17.75	7.72	5.48	6.14
Bromine (Br)	mmol/kgw	0.36	0.31	4.13	11.13	14.96	15.15	13.95
Calcium (Ca)	mmol/kgw	68.95	746.66	168.92	575.88	1066.20	775.56	736.48
Chlorine (Cl)	mmol/kgw	4082.95	3452.05	2816.48	3846.59	3925.19	3895.94	4122.75
Iodine (I)	mmol/kgw	0.00	0.00	0.02	0.06	0.06	0.06	0.07
Iron (Fe)	mmol/kgw	0.08	0.01	0.00	0.02	0.01	0.00	0.01
Lithium (Li)	mmol/kgw	0.11	0.10	1.05	1.40	1.46	1.09	1.22
Magnesium (Mg)	mmol/kgw	31.31	64.23	91.91	295.40	230.02	262.54	243.99
Manganese (Mn)	mmol/kgw	0.00	0.01	0.01	0.04	0.08	0.08	0.06
Potassium (K)	mmol/kgw	11.38	17.67	156.93	128.96	269.79	252.32	264.73
Rubidium (Rb)	mmol/kgw	0.00	0.00	0.04	0.03	0.07	0.06	0.07
Silicon (Si)	mmol/kgw	17.17	24.02	16.25	44.87	14.21	10.34	15.06
Sodium (Na)	mmol/kgw	3766.03	3373.88	2085.28	2099.74	2286.93	2353.97	2273.43
Strontium (Sr)	mmol/kgw	0.74	1.47	1.68	6.10	7.72	6.61	6.92
Sulfur (S)	mmol/kgw	63.27	814.74	23.72	51.35	343.89	12.44	22.57
Environmental Isotopes		**SB_BH02_PW015**	**SB_BH02_PW017**	**SB_BH02_PW019**	**SB_BH02_PW021**	**SB_BH02_PW023**	**SB_BH02_PW025**	**SB_BH02_PW027**
$\delta^{18}O$	‰VSMOW	-12	-12	-10.2	-7.4	-5.9	-5.9	-6
$\delta^{2}H$	‰VSMOW	-83.3	-82.7	-67.4	-57.1	-48.3	-47.2	-47.3
Radiohalides and Strontium Isotopes		**SB_BH02_PW015**	**SB_BH02_PW017**	**SB_BH02_PW019**	**SB_BH02_PW021**	**SB_BH02_PW023**	**SB_BH02_PW025**	**SB_BH02_PW027**
Chlorine-37 ($\delta^{37}Cl$)	‰ SMOC	-0.13	0.17	-0.15	0.18	0.25	0.14	0.23
Chlorine-36 ($^{36}Cl/Cl$)	--	1.19E-15	1.60E-15	3.91E-15	4.94E-15	5.82E-15	5.51E-15	5.08E-15
Iodine-129 (^{129}I)	atoms/kgw	5.93E+05	4.50E+05	9.31E+05	2.05E+05	6.47E+06	7.49E+05	5.49E+05
Strontium isotope ratio ($^{87}Sr/^{86}Sr$)	--	0.70886	0.70910	0.71056	0.71011	0.71013	0.71018	0.71014

BDL = Below Detection Limit

Flagged as anomalous result

	Sample ID	SB_BH02_PW029	SB_BH02_PW031	SB_BH02_PW033	SB_BH02_PW036	SB_BH02_PW037	SB_BH02_PW039	SB_BH02_PW042
Major/Minor Ions								
Aluminum (Al)	mmol/kgw	0.33	0.50	0.35	0.22	0.69	0.44	0.38
Boron (B)	mmol/kgw	5.76	6.20	5.12	3.53	8.21	6.07	6.18
Bromine (Br)	mmol/kgw	17.34	22.01	18.77	18.26	17.74	15.41	17.03
Calcium (Ca)	mmol/kgw	829.32	880.77	1167.00	926.19	846.83	819.90	843.76
Chlorine (Cl)	mmol/kgw	4159.00	4642.68	5820.42	3925.23	4739.49	4239.17	4344.50
Iodine (I)	mmol/kgw	0.08	0.09	0.07	0.07	0.07	0.06	0.06
Iron (Fe)	mmol/kgw	0.02	0.04	0.02	0.02	0.03	0.03	0.04
Lithium (Li)	mmol/kgw	1.47	2.03	1.34	1.20	1.68	1.04	1.38
Magnesium (Mg)	mmol/kgw	228.39	270.54	207.59	220.24	200.57	188.49	194.79
Manganese (Mn)	mmol/kgw	0.24	0.36	0.32	0.35	0.29	0.30	0.28
Potassium (K)	mmol/kgw	281.47	383.57	321.99	245.31	299.28	208.99	256.59
Rubidium (Rb)	mmol/kgw	0.08	0.10	0.08	0.06	0.09	0.05	0.07
Silicon (Si)	mmol/kgw	15.41	18.37	15.25	11.08	27.71	15.53	32.56
Sodium (Na)	mmol/kgw	2360.45	2452.36	5000.80	2383.01	2467.88	2284.24	2346.91
Strontium (Sr)	mmol/kgw	9.37	11.10	16.18	11.72	10.53	10.23	10.53
Sulfur (S)	mmol/kgw	6.01	11.00	116.09	25.87	17.06	11.28	9.32
Environmental Isotopes		**SB_BH02_PW029**	**SB_BH02_PW031**	**SB_BH02_PW033**	**SB_BH02_PW036**	**SB_BH02_PW037**	**SB_BH02_PW039**	**SB_BH02_PW042**
$\delta^{18}O$	‰VSMOW	-4.6	-4.4	-4.3	-4.2	-4.1	-4.5	-4.5
$\delta^{2}H$	‰VSMOW	-42.2	-41.3	-41.9	-41.9	-41.3	-42.8	-41.5
Radiohalides and Strontium Isotopes		**SB_BH02_PW029**	**SB_BH02_PW031**	**SB_BH02_PW033**	**SB_BH02_PW036**	**SB_BH02_PW037**	**SB_BH02_PW039**	**SB_BH02_PW042**
Chlorine-37 ($\delta^{37}Cl$)	‰ SMOC	0.25	0.27	0.06	-0.10	-0.23	-0.05	-0.15
Chlorine-36 ($^{36}Cl/Cl$)	--	6.89E-15	6.56E-15	7.49E-15	6.98E-15	6.68E-15	7.59E-15	7.96E-15
Iodine-129 (^{129}I)	atoms/kgw	9.67E+04	3.05E+05	4.67E+05	6.28E+05	3.84E+05	4.12E+05	6.00E+05
Strontium isotope ratio ($^{87}Sr/^{86}Sr$)	--	0.71019	0.71033	0.71030	0.71025	0.71033	0.71043	0.71038

BDL = Below Detection Limit

Flagged as anomalous result

	Sample ID	SB_BH02_PW043	SB_BH02_PW046	SB_BH02_PW047	SB_BH02_PW049	SB_BH02_PW051	SB_BH02_PW053	SB_BH02_PW055
Major/Minor Ions								
Aluminum (Al)	mmol/kgw	1.48	1.89	0.87	1.58	2.41	0.70	7.89
Boron (B)	mmol/kgw	20.94	18.51	8.84	13.30	24.16	8.82	64.25
Bromine (Br)	mmol/kgw	12.94	18.81	18.03	17.45	16.48	16.63	16.36
Calcium (Ca)	mmol/kgw	387.65	852.88	645.48	660.19	778.91	710.09	1025.24
Chlorine (Cl)	mmol/kgw	3152.97	4433.25	4341.32	3972.87	4233.33	4136.58	4194.73
Iodine (I)	mmol/kgw	0.25	0.10	0.08	0.07	0.12	0.07	0.07
Iron (Fe)	mmol/kgw	0.05	0.12	0.14	0.10	0.46	0.02	0.37
Lithium (Li)	mmol/kgw	1.98	2.14	1.62	1.45	2.66	1.56	3.06
Magnesium (Mg)	mmol/kgw	181.67	372.56	277.73	271.41	246.36	256.90	439.49
Manganese (Mn)	mmol/kgw	0.01	0.04	0.02	0.02	0.01	0.02	0.02
Potassium (K)	mmol/kgw	178.24	221.75	234.45	202.77	231.60	208.39	98.79
Rubidium (Rb)	mmol/kgw	0.05	0.07	0.06	0.05	0.05	0.04	0.02
Silicon (Si)	mmol/kgw	67.31	89.95	37.58	68.16	337.57	126.59	1274.94
Sodium (Na)	mmol/kgw	2555.60	2890.16	2590.22	2899.01	2832.65	2617.84	2693.65
Strontium (Sr)	mmol/kgw	5.92	13.62	9.57	10.79	16.61	11.23	18.05
Sulfur (S)	mmol/kgw	98.13	180.36	44.18	105.49	144.73	51.26	447.72
Environmental Isotopes		SB_BH02_PW043	SB_BH02_PW046	SB_BH02_PW047	SB_BH02_PW049	SB_BH02_PW051	SB_BH02_PW053	SB_BH02_PW055
$\delta^{18}O$	‰VSMOW	-5.6	-5.1	-5.3	-5.9	-5.7	-6.4	**-7.9**
$\delta^{2}H$	‰VSMOW	-44.4	-43.7	-40.9	-42.1	-42	-41.2	**-48.8**
Radiohalides and Strontium Isotopes		SB_BH02_PW043	SB_BH02_PW046	SB_BH02_PW047	SB_BH02_PW049	SB_BH02_PW051	SB_BH02_PW053	SB_BH02_PW055
Chlorine-37 ($\delta^{37}Cl$)	‰ SMOC	-0.18	-0.30	-0.17	-0.18	-0.20	0.11	0.02
Chlorine-36 ($^{36}Cl/Cl$)	--	3.54E-15	3.18E-15	2.81E-15	3.04E-15	2.24E-15	3.85E-15	2.60E-15
Iodine-129 (^{129}I)	atoms/kgw	9.17E+04	2.79E+04	BDL	5.64E+04	1.69E+04	2.21E+05	BDL
Strontium isotope ratio ($^{87}Sr/^{86}Sr$)	--	0.70954	0.70944	0.70994	0.70954	0.70946	0.70988	0.70869

BDL = Below Detection Limit

Flagged as anomalous result

Sample ID		SB_BH02_PW057	SB_BH02_PW059
Major/Minor Ions			
Aluminum (Al)	mmol/kgw	10.47	0.60
Boron (B)	mmol/kgw	78.54	8.02
Bromine (Br)	mmol/kgw	15.86	20.86
Calcium (Ca)	mmol/kgw	1171.18	1261.55
Chlorine (Cl)	mmol/kgw	4800.96	4908.67
Iodine (I)	mmol/kgw	0.09	0.09
Iron (Fe)	mmol/kgw	1.78	0.04
Lithium (Li)	mmol/kgw	2.52	0.38
Magnesium (Mg)	mmol/kgw	558.84	294.53
Manganese (Mn)	mmol/kgw	0.04	0.43
Potassium (K)	mmol/kgw	113.60	128.26
Rubidium (Rb)	mmol/kgw	0.02	0.05
Silicon (Si)	mmol/kgw	1388.76	87.25
Sodium (Na)	mmol/kgw	2989.17	2324.45
Strontium (Sr)	mmol/kgw	21.97	16.14
Sulfur (S)	mmol/kgw	576.43	149.11
Environmental Isotopes		**SB_BH02_PW057**	**SB_BH02_PW059**
$\delta^{18}O$	‰VSMOW	**-8.6**	-5.7
$\delta^{2}H$	‰VSMOW	**-46.5**	-38
Radiohalides and Strontium Isotopes		**SB_BH02_PW057**	**SB_BH02_PW059**
Chlorine-37 ($\delta^{37}Cl$)	‰ SMOC	-0.04	0.09
Chlorine-36 ($^{36}Cl/Cl$)	--	2.53E-15	4.38E-15
Iodine-129 (^{129}I)	atoms/kgw	2.22E+03	3.84E+04
Strontium isotope ratio ($^{87}Sr/^{86}Sr$)	--	0.70873	0.71019

BDL = Below Detection Limit

Flagged as anomalous result

Sample ID		SB_BH02_PW002	SB_BH02_PW004	SB_BH02_PW006	SB_BH02_PW008	SB_BH02_PW010	SB_BH02_PW012	SB_BH02_PW014
Major/Minor Ions								
Barium (Ba)	mmol/kgw	0.00	0.01	0.00	0.07	0.00	0.01	0.00
Bromine (Br)	mmol/kgw	1.08	1.51	2.39	17.80	0.00	2.13	0.00
Calcium (Ca)	mmol/kgw	110.82	84.26	101.61	1149.55	22.21	313.91	62.40
Chlorine (Cl)	mmol/kgw	712.83	818.73	1083.21	6800.67	209.13	4301.51	4178.30
Lithium (Li)	mmol/kgw	0.51	0.68	1.18	11.75	0.56	1.86	0.22
Magnesium (Mg)	mmol/kgw	54.22	40.88	51.54	649.88	20.27	309.99	13.00
Potassium (K)	mmol/kgw	3.58	5.64	5.02	29.25	3.62	44.49	6.80
Sodium (Na)	mmol/kgw	427.54	660.53	830.94	3666.26	221.24	3087.79	4031.28
Strontium (Sr)	mmol/kgw	0.98	0.66	0.91	7.87	0.20	2.46	0.66
Sulfate (SO_4)	mmol/kgw	21.89	61.68	24.84	44.26	30.81	74.10	42.79
Radiohalides and Strontium Isotopes		SB_BH02_PW002	SB_BH02_PW004	SB_BH02_PW006	SB_BH02_PW008	SB_BH02_PW010	SB_BH02_PW012	SB_BH02_PW014
Strontium isotope ratio ($^{87}Sr/^{86}Sr$)	--	0.708530	0.708610	0.708650	0.708470	0.708570	0.708490	0.708440

BDL = Below Detection Limit

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Appendix B.2 Porewater Sample Results - Paper Absorption (PA) Method

Sample ID		SB_BH02_PW016	SB_BH02_PW018	SB_BH02_PW020	SB_BH02_PW022	SB_BH02_PW024	SB_BH02_PW026	SB_BH02_PW028
Major/Minor Ions								
Barium (Ba)	mmol/kgw	0.00	0.00	0.03	0.05	0.02	0.01	0.01
Bromine (Br)	mmol/kgw	0.97	0.00	14.85	34.60	60.14	66.17	63.16
Calcium (Ca)	mmol/kgw	81.29	54.81	714.23	1512.69	2442.55	2641.68	2586.39
Chlorine (Cl)	mmol/kgw	3899.81	3872.01	6367.89	6872.05	10471.93	11112.90	10765.36
Lithium (Li)	mmol/kgw	0.35	0.14	3.59	6.55	9.67	9.82	9.61
Magnesium (Mg)	mmol/kgw	12.77	17.63	222.85	383.52	449.42	489.35	481.86
Potassium (K)	mmol/kgw	7.81	4.71	72.63	82.46	127.42	133.08	126.56
Sodium (Na)	mmol/kgw	3765.51	3826.98	4418.80	3311.95	4903.87	5041.85	4739.18
Strontium (Sr)	mmol/kgw	0.85	0.47	6.79	12.87	18.82	20.62	22.50
Sulfate (SO_4)	mmol/kgw	33.26	61.60	20.12	23.58	0.00	0.00	0.00
Radiohalides and Strontium Isotopes		SB_BH02_PW016	SB_BH02_PW018	SB_BH02_PW020	SB_BH02_PW022	SB_BH02_PW024	SB_BH02_PW026	SB_BH02_PW028
Strontium isotope ratio ($^{87}Sr/^{86}Sr$)	--	0.708380	0.708730	0.709710	0.709790	0.709910	0.709860	0.709880

BDL = Below Detection Limit

Appendix B.2 Porewater Sample Results - Paper Absorption (PA) Method

Sample ID		SB_BH02_PW030	SB_BH02_PW032	SB_BH02_PW034	SB_BH02_PW035	SB_BH02_PW038	SB_BH02_PW040	SB_BH02_PW041
Major/Minor Ions								
Barium (Ba)	mmol/kgw	0.03	0.04	0.03	0.04	0.04	0.04	0.05
Bromine (Br)	mmol/kgw	67.63	88.89	86.89	88.71	89.94	89.67	93.04
Calcium (Ca)	mmol/kgw	2780.12	3315.79	3272.17	3323.91	3238.93	3113.63	3223.20
Chlorine (Cl)	mmol/kgw	10941.55	12092.32	11802.06	12172.70	11850.57	11847.42	12251.78
Lithium (Li)	mmol/kgw	9.15	10.48	10.45	10.64	10.77	11.43	12.29
Magnesium (Mg)	mmol/kgw	471.35	501.87	490.15	495.89	460.27	437.95	443.59
Potassium (K)	mmol/kgw	120.06	121.86	111.47	110.26	108.09	115.42	123.67
Sodium (Na)	mmol/kgw	4622.33	4765.73	4348.75	4488.49	4473.33	4834.73	5011.88
Strontium (Sr)	mmol/kgw	30.09	37.62	39.47	41.75	40.62	39.12	39.30
Sulfate (SO_4)	mmol/kgw	14.48	14.28	15.03	0.00	0.00	0.00	0.00
Radiohalides and Strontium Isotopes		SB_BH02_PW030	SB_BH02_PW032	SB_BH02_PW034	SB_BH02_PW035	SB_BH02_PW038	SB_BH02_PW040	SB_BH02_PW041
Strontium isotope ratio ($^{87}Sr/^{86}Sr$)	--	0.709980	0.710030	0.710110	0.710120	0.710110	0.710130	0.710110

BDL = Below Detection Limit

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Appendix B.2 Porewater Sample Results - Paper Absorption (PA) Method

Sample ID		SB_BH02_PW044	SB_BH02_PW045	SB_BH02_PW048	SB_BH02_PW050	SB_BH02_PW052	SB_BH02_PW054	SB_BH02_PW056
Major/Minor Ions								
Barium (Ba)	mmol/kgw	0.02	0.07	0.09	0.08	0.07	0.06	0.08
Bromine (Br)	mmol/kgw	93.12	106.53	101.55	98.84	105.30	98.57	71.88
Calcium (Ca)	mmol/kgw	56.61	1701.39	2635.62	2510.42	933.96	1383.62	1354.51
Chlorine (Cl)	mmol/kgw	12262.60	13112.88	13091.02	13012.71	13390.74	13315.47	10935.33
Lithium (Li)	mmol/kgw	28.85	24.94	18.68	15.78	22.03	18.50	13.00
Magnesium (Mg)	mmol/kgw	20.13	269.26	429.27	347.78	89.04	135.99	272.27
Potassium (K)	mmol/kgw	219.60	187.43	139.03	147.82	186.16	188.78	128.20
Sodium (Na)	mmol/kgw	11915.04	9158.86	7204.00	7551.99	11279.82	10175.68	7697.82
Strontium (Sr)	mmol/kgw	0.14	16.53	30.66	30.19	9.60	14.13	12.83
Sulfate (SO_4)	mmol/kgw	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Radiohalides and Strontium Isotopes		SB_BH02_PW044	SB_BH02_PW045	SB_BH02_PW048	SB_BH02_PW050	SB_BH02_PW052	SB_BH02_PW054	SB_BH02_PW056
Strontium isotope ratio ($^{87}Sr/^{86}Sr$)	--		0.710040	0.710050	0.710050	0.710030	0.710030	0.709630

BDL = Below Detection Limit

Appendix B.2 Porewater Sample Results - Paper Absorption (PA) Method

Sample ID		SB_BH02_PW058	SB_BH02_PW060
Major/Minor Ions			
Barium (Ba)	mmol/kgw	0.24	0.02
Bromine (Br)	mmol/kgw	50.19	35.57
Calcium (Ca)	mmol/kgw	1855.98	1811.13
Chlorine (Cl)	mmol/kgw	8871.92	6603.06
Lithium (Li)	mmol/kgw	4.57	1.64
Magnesium (Mg)	mmol/kgw	609.28	319.93
Potassium (K)	mmol/kgw	71.56	39.27
Sodium (Na)	mmol/kgw	4285.64	2455.82
Strontium (Sr)	mmol/kgw	23.22	23.13
Sulfate (SO_4)	mmol/kgw	16.98	6.64
Radiohalides and Strontium Isotopes		**SB_BH02_PW058**	**SB_BH02_PW060**
Strontium isotope ratio ($^{87}Sr/^{86}Sr$)	--	0.709800	0.710080

BDL = Below Detection Limit

Sample ID		SB_BH02_NG001	SB_BH02_NG002	SB_BH02_NG003	SB_BH02_NG004	SB_BH02_NG005	SB_BH02_NG006	SB_BH02_NG007
Noble Gas Concentrations								
Helium (He) - total	cc/ccw	8.21E-05	6.75E-04	2.38E-04	2.58E-05	3.12E-04	7.50E-04	7.88E-05
^{4}He	cc/ccw	8.21E-05	6.75E-04	2.38E-04	2.58E-05	3.12E-04	7.50E-04	7.88E-05
^{3}He	cc/ccw	3.91E-12	2.00E-11	7.96E-12	1.07E-12	1.27E-11	6.09E-11	4.34E-12
Neon (Ne) - total	cc/ccw	4.01E-06	7.71E-06	1.90E-06	3.67E-07	1.46E-06	4.12E-05	3.79E-06
^{20}Ne	cc/ccw	3.64E-06	7.00E-06	1.73E-06	3.32E-07	1.33E-06	3.74E-05	3.44E-06
^{22}Ne	cc/ccw	3.71E-07	7.13E-07	1.74E-07	3.43E-08	1.35E-07	3.76E-06	3.57E-07
Argon (Ar) - total	cc/ccw	6.78E-02	1.26E-01	1.63E-02	8.30E-03	2.78E-02	4.94E-01	2.72E-02
^{40}Ar	cc/ccw	6.76E-02	1.26E-01	1.63E-02	8.27E-03	2.77E-02	4.93E-01	2.71E-02
^{36}Ar	cc/ccw	2.19E-04	4.08E-04	5.23E-05	2.63E-05	8.80E-05	1.59E-03	8.90E-05
Krypton (Kr) - total	cc/ccw	8.10E-04	1.94E-03	4.45E-04	8.90E-05	4.22E-04	5.47E-03	1.33E-03
Xenon (Xe) - total	cc/ccw	5.55E-08	1.49E-07	2.10E-08	4.10E-09	3.10E-08	3.04E-07	1.19E-07
Noble Gas Isotopic Ratios								
^{3}He/^{4}He (air-normalized, xRa)	--	3.45E-02	2.15E-02	2.42E-02	3.01E-02	2.96E-02	5.88E-02	3.99E-02
^{22}Ne/^{20}Ne	--	1.02E-01	1.02E-01	1.00E-01	1.03E-01	1.02E-01	1.00E-01	1.04E-01
^{40}Ar/^{36}Ar	--	3.1E+02	3.1E+02	3.1E+02	3.1E+02	3.1E+02	3.1E+02	3.0E+02

NV = Not reported or no value measured

Flagged as anomalous result

Sample ID		SB_BH02_NG008	SB_BH02_NG009	SB_BH02_NG010	SB_BH02_NG011	SB_BH02_NG012	SB_BH02_NG013	SB_BH02_NG014
Noble Gas Concentrations								
Helium (He) - total	cc/ccw	7.16E-05	2.14E-03	5.84E-03	3.73E-03	1.97E-03	2.74E-03	2.70E-03
^{4}He	cc/ccw	7.16E-05	2.14E-03	5.84E-03	3.73E-03	1.97E-03	2.74E-03	2.70E-03
^{3}He	cc/ccw	3.59E-12	1.08E-10	2.70E-10	1.09E-10	7.45E-11	1.21E-10	1.05E-10
Neon (Ne) - total	cc/ccw	1.92E-06	3.86E-06	6.03E-06	2.46E-06	1.94E-06	3.59E-06	1.53E-06
^{20}Ne	cc/ccw	1.74E-06	3.50E-06	5.48E-06	2.23E-06	1.76E-06	3.26E-06	1.39E-06
^{22}Ne	cc/ccw	1.78E-07	3.58E-07	5.55E-07	2.29E-07	1.79E-07	3.30E-07	1.42E-07
Argon (Ar) - total	cc/ccw	4.51E-02	4.86E-02	1.63E-01	6.67E-02	4.53E-02	6.79E-02	5.02E-02
^{40}Ar	cc/ccw	4.49E-02	4.84E-02	1.63E-01	6.65E-02	4.52E-02	6.77E-02	5.02E-02
^{36}Ar	cc/ccw	1.45E-04	1.42E-04	3.81E-04	1.33E-04	1.17E-04	1.93E-04	8.39E-05
Krypton (Kr) - total	cc/ccw	5.09E-04	6.58E-04	6.93E-04	1.79E-04	1.59E-04	3.61E-04	1.28E-04
Xenon (Xe) - total	cc/ccw	4.89E-08	2.94E-08	5.65E-08	1.73E-08	1.25E-08	2.31E-08	1.77E-08
Noble Gas Isotopic Ratios								
^{3}He/^{4}He (air-normalized, xRa)	--	3.63E-02	3.65E-02	3.35E-02	2.11E-02	2.74E-02	3.19E-02	2.81E-02
^{22}Ne/^{20}Ne	--	1.03E-01	1.02E-01	1.01E-01	1.03E-01	1.02E-01	1.01E-01	1.02E-01
^{40}Ar/^{36}Ar	--	3.1E+02	3.4E+02	4.3E+02	5.0E+02	3.9E+02	3.5E+02	6.0E+02

NV = Not reported or no value measured

Flagged as anomalous result

	Sample ID	SB_BH02_NG015	SB_BH02_NG016	SB_BH02_NG017	SB_BH02_NG018	SB_BH02_NG019	SB_BH02_NG020	SB_BH02_NG021
Noble Gas Concentrations								
Helium (He) - total	cc/ccw	2.81E-03	5.63E-03	4.02E-03	3.52E-03	4.99E-03	7.12E-03	3.18E-03
^{4}He	cc/ccw	2.81E-03	5.63E-03	4.02E-03	3.52E-03	4.99E-03	7.12E-03	3.18E-03
^{3}He	cc/ccw	1.22E-10	2.12E-10	1.38E-10	1.01E-10	1.74E-10	2.33E-10	8.41E-11
Neon (Ne) - total	cc/ccw	1.27E-06	7.47E-05	1.80E-06	2.02E-06	2.52E-06	1.03E-05	1.51E-06
^{20}Ne	cc/ccw	1.15E-06	6.73E-05	1.64E-06	1.84E-06	2.28E-06	9.32E-06	1.37E-06
^{22}Ne	cc/ccw	1.18E-07	7.39E-06	1.65E-07	1.89E-07	2.35E-07	9.61E-07	1.39E-07
Argon (Ar) - total	cc/ccw	3.45E-02	3.21E+00	4.76E-02	5.67E-02	3.32E-02	4.37E-02	1.51E+00
^{40}Ar	cc/ccw	3.45E-02	3.20E+00	4.75E-02	5.66E-02	3.31E-02	4.36E-02	1.50E+00
^{36}Ar	cc/ccw	5.92E-05	1.01E-02	6.85E-05	1.03E-04	5.63E-05	1.01E-04	1.97E-03
Krypton (Kr) - total	cc/ccw	1.56E-04	1.05E-02	2.84E-04	2.78E-04	5.92E-04	2.00E-03	5.86E-04
Xenon (Xe) - total	cc/ccw	1.62E-08	3.82E-07	3.04E-08	2.56E-08	5.12E-08	1.04E-07	4.66E-08
Noble Gas Isotopic Ratios								
^{3}He/^{4}He (air-normalized, xRa)	--	3.15E-02	2.74E-02	2.49E-02	2.08E-02	2.52E-02	2.37E-02	1.92E-02
^{22}Ne/^{20}Ne	--	1.02E-01	1.10E-01	1.01E-01	1.03E-01	1.03E-01	1.03E-01	1.01E-01
^{40}Ar/^{36}Ar	--	5.8E+02	3.2E+02	6.9E+02	5.5E+02	5.9E+02	4.3E+02	7.6E+02

NV = Not reported or no value measured

Flagged as anomalous result

GEOFIRMA ENGINEERING

	Sample ID	SB_BH02_NG022	SB_BH02_NG023	SB_BH02_NG024	SB_BH02_NG025	SB_BH02_NG026	SB_BH02_NG027	SB_BH02_NG028
Noble Gas Concentrations								
Helium (He) - total	cc/ccw	**1.11E-01**	6.31E-03	3.45E-03	1.16E-02	1.15E-02	4.56E-03	3.96E-02
^{4}He	cc/ccw	**1.11E-01**	6.31E-03	3.45E-03	1.16E-02	1.15E-02	4.56E-03	3.96E-02
^{3}He	cc/ccw	**3.51E-08**	3.50E-10	1.52E-10	5.89E-10	7.66E-10	3.27E-10	2.40E-09
Neon (Ne) - total	cc/ccw	**4.06E-04**	4.04E-04	3.59E-06	6.02E-06	6.97E-06	3.96E-06	4.37E-05
^{20}Ne	cc/ccw	**3.68E-04**	3.64E-04	3.26E-06	5.46E-06	6.32E-06	3.59E-06	3.97E-05
^{22}Ne	cc/ccw	**3.84E-05**	4.01E-05	3.35E-07	5.63E-07	6.48E-07	3.68E-07	4.04E-06
Argon (Ar) - total	cc/ccw	**9.48E+01**	1.79E+01	1.18E-01	2.10E-01	2.35E-01	1.40E-01	1.36E+00
^{40}Ar	cc/ccw	**9.45E+01**	1.79E+01	1.18E-01	2.10E-01	2.34E-01	1.40E-01	1.35E+00
^{36}Ar	cc/ccw	**3.04E-01**	5.74E-02	2.01E-04	2.17E-04	1.95E-04	1.01E-04	1.14E-03
Krypton (Kr) - total	cc/ccw	**6.33E-02**	3.95E-02	1.95E-04	5.88E-04	5.94E-04	2.91E-04	3.92E-03
Xenon (Xe) - total	cc/ccw	**2.94E-06**	1.94E-06	2.99E-08	8.46E-08	8.85E-08	4.80E-08	5.99E-07
Noble Gas Isotopic Ratios								
^{3}He/^{4}He (air-normalized, xRa)	--	2.29E-01	4.01E-02	3.19E-02	3.69E-02	4.82E-02	5.19E-02	4.40E-02
^{22}Ne/^{20}Ne	--	1.04E-01	1.10E-01	1.03E-01	1.03E-01	1.03E-01	1.03E-01	1.02E-01
^{40}Ar/^{36}Ar	--	3.1E+02	3.1E+02	5.9E+02	9.7E+02	1.2E+03	1.4E+03	1.2E+03

NV = Not reported or no value measured

Flagged as anomalous result

Appendix B.3 Noble Gas Sample Results

	Sample ID	SB_BH02_NG029	SB_BH02_NG030
Noble Gas Concentrations			
Helium (He) - total	cc/ccw	3.15E-02	4.43E-03
^{4}He	cc/ccw	3.15E-02	4.43E-03
^{3}He	cc/ccw	2.40E-09	3.34E-10
Neon (Ne) - total	cc/ccw	4.18E-05	3.23E-06
^{20}Ne	cc/ccw	3.79E-05	2.93E-06
^{22}Ne	cc/ccw	3.88E-06	3.01E-07
Argon (Ar) - total	cc/ccw	1.31E+00	3.02E-02
^{40}Ar	cc/ccw	1.31E+00	3.01E-02
^{36}Ar	cc/ccw	1.23E-03	4.73E-05
Krypton (Kr) - total	cc/ccw	2.43E-03	3.40E-04
Xenon (Xe) - total	cc/ccw	3.40E-07	1.79E-08
Noble Gas Isotopic Ratios			
$^{3}He/^{4}He$ (air-normalized, xRa)	--	5.52E-02	5.46E-02
$^{22}Ne/^{20}Ne$	--	1.02E-01	1.03E-01
$^{40}Ar/^{36}Ar$	--	1.1E+03	6.4E+02

NV = Not reported or no value measured

Flagged as anomalous result

Sample ID		SB_BH02_DG001	SB_BH02_DG002	SB_BH02_DG003	SB_BH02_DG004	SB_BH02_DG005	SB_BH02_DG006	SB_BH02_DG007	SB_BH02_DG008
Carbon Dioxide and Methane Concentrations									
CO_2	mmol/kgw	2.04E-03	6.94E-01	6.98E-02	1.49E-01	1.65E+00	1.08E+01	9.34E-01	5.76E-01
CH_4	mmol/kgw	BDL	BDL	BDL	4.25E-04	4.45E-04	1.58E+00	BDL	BDL
Carbon Dioxide and Methane Isotopic Ratios									
δ^{13} CO_2	VPDB (‰)	-16.2	-14.8	-16.3	-9.3	-11.5	-6.1	-6.4	-10.5
$\delta^{13}C$ CH_4	VPDB (‰)	BDL	BDL	BDL	BDL	BDL	-51.9	BDL	BDL
$\delta^{2}H$ CH_4	VSMOW (‰)	BDL	BDL	BDL	BDL	BDL	-306.9	BDL	BDL

BDL = below detection limit

Sample ID		SB_BH02_DG009	SB_BH02_DG010	SB_BH02_DG011	SB_BH02_DG012	SB_BH02_DG013	SB_BH02_DG014	SB_BH02_DG015	SB_BH02_DG016
Carbon Dioxide and Methane Concentrations									
CO_2	mmol/kgw	1.91E+00	1.55E+00	2.35E+00	6.64E-01	4.68E-01	1.54E-01	1.12E+00	1.44E+00
CH_4	mmol/kgw	7.40E-01	5.47E-01	8.77E-01	5.16E-01	1.45E-01	BDL	1.40E+00	1.85E+00
Carbon Dioxide and Methane Isotopic Ratios									
δ^{13} CO_2	VPDB (‰)	-7.9	-6.5	-8.7	-6.7	-6.9	-8.0	-6.9	-1.5
$\delta^{13}C$ CH_4	VPDB (‰)	-45.7	-45.5	BDL	-44.5	-45.0	BDL	-46.4	-45.9
$\delta^{2}H$ CH_4	VSMOW (‰)	-237.2	-250.8	BDL	-240	-238	BDL	-262	-260

BDL = below detection limit

Sample ID		SB_BH02_DG017	SB_BH02_DG018	SB_BH02_DG019	SB_BH02_DG020	SB_BH02_DG021	SB_BH02_DG022	SB_BH02_DG023	SB_BH02_DG024
Carbon Dioxide and Methane Concentrations									
CO_2	mmol/kgw	1.19E+00	8.47E-01	8.04E-01	1.06E+00	7.11E-01	3.76E-01	1.08E+00	1.23E+00
CH_4	mmol/kgw	5.65E+00	3.49E+00	3.09E+00	8.42E+00	1.19E+01	1.17E+01	7.18E+00	5.32E+00
Carbon Dioxide and Methane Isotopic Ratios									
δ^{13} CO_2	VPDB (‰)	-2.2	0.0	-0.9	0.2	0.6	-10.7	-10.9	-7.7
$\delta^{13}C$ CH_4	VPDB (‰)	-47.4	-47.1	-46.1	-46.1	-46.9	-46.4	-45.9	-43.3
$\delta^{2}H$ CH_4	VSMOW (‰)	-267	-257	-267	-257	-267	-258	-255	-228

BDL = below detection limit

Sample ID		SB_BH02_DG025	SB_BH02_DG026	SB_BH02_DG027	SB_BH02_DG028	SB_BH02_DG029	SB_BH02_DG030
Carbon Dioxide and Methane Concentrations							
CO_2	mmol/kgw	4.22E+00	3.06E+00	7.99E-01	2.03E+00	3.15E+00	7.66E-02
CH_4	mmol/kgw	1.20E+01	1.69E+01	1.26E+01	4.73E+01	2.59E+01	1.21E+00
Carbon Dioxide and Methane Isotopic Ratios							
δ^{13} CO_2	VPDB (‰)	-8.0	-9.6	-10.6	-9.8	-11.9	-11.5
$\delta^{13}C$ CH_4	VPDB (‰)	-42.7	-41.5	-41.3	-34.8	-38.1	BDL
$\delta^{2}H$ CH_4	VSMOW (‰)	-220.7	-208.7	-206	-186	-193.2	BDL

BDL = below detection limit

Appendix C

Mineralogical Results for Porewater Samples at SB_BH02

C.1. – X-Ray Diffraction Results (XRD)

Appendix C.1. X-Ray Diffraction (XRD) Results for Select Core Porewater Samples

Sample ID	Phase Proportion (%) by Relative Intensity Ratio																
	Calcite	Dolomite	Ankerite	Quartz	Muscovite and/or illite and/or glauconite and/or celadonite	Other micas and/or clays	Clinochlore	Gypsum	Anhydrite	Celestite	Feldspars	Pyrite	Halite	Hematite	Goethite	Anatatse	Sum
SB_BH02_PW002	--	19.60	--	10.10	18.30	--	4.00	35.40	--	--	12.60	--	--	--	--	--	100.0
SB_BH02_PW004	--	76.10	--	8.90	3.60	1.90	5.90	--	--	--	3.60	--	--	--	--	--	100.0
SB_BH02_PW006	--	63.80	--	14.80	9.50	--	1.80	1.10	--	0.80	8.10	--	--	--	--	--	99.9
SB_BH02_PW008	--	14.40	--	17.20	11.70	--	1.60	46.30	--	--	8.90	--	--	--	--	--	100.1
SB_BH02_PW010	--	68.60	--	5.00	19.10	--	--	4.70	--	--	--	2.70	--	--	--	--	100.1
SB_BH02_PW012	72.10	4.70	--	4.20	9.70	--	--	3.60	--	3.50	--	2.20	--	--	--	--	100.0
SB_BH02_PW014	--	96.00	--	0.70	--	--	--	--	--	--	2.80	--	0.40	0.10	--	--	100.0
SB_BH02_PW016	--	95.70	--	2.30	1.00	--	--	--	--	--	--	0.20	0.80	--	--	--	100.0
SB_BH02_PW018	--	90.30	--	2.90	--	0.60	--	2.00	--	--	4.20	--	--	--	--	--	100.0
SB_BH02_PW020	72.80	6.50	--	8.40	2.50	--	--	--	--	--	7.80	2.00	--	--	--	--	100.0
SB_BH02_PW022	46.70	11.20	--	19.00	3.70	--	3.70	--	--	--	14.30	1.40	--	--	--	--	100.0
SB_BH02_PW024	22.50	--	5.50	32.70	28.40	--	4.20	--	5.20	--	--	--	--	1.50	--	--	100.0
SB_BH02_PW026	19.90	7.20	--	32.40	19.80	--	8.50	--	--	--	10.70	--	--	1.50	--	--	100.0
SB_BH02_PW028	28.70	--	--	35.40	27.70	--	6.00	--	--	--	--	--	--	2.30	--	--	100.1
SB_BH02_PW030	1.10	1.20	--	24.80	56.10	--	10.20	--	--	--	5.00	--	0.80	--	--	0.90	100.1
SB_BH02_PW032	3.4	--	--	41.2	28.6	--	11.4	--	--	--	15.5	--	--	--	--	--	100.1
SB_BH02_PW034	3.2	--	1.9	62	14.9	--	11.7	--	--	--	5.4	0.9	--	--	--	--	100.0
SB_BH02_PW035	1.5	1.9	--	51.1	28	--	7.2	--	--	--	7.3	3	--	--	--	--	100.0
SB_BH02_PW038	--	--	--	47.1	38.6	--	10.3	--	1.6	--	--	2.4	--	--	--	--	100.0
SB_BH02_PW040	3.8	--	--	49	23.6	--	15.1	--	5.8	--	--	2.7	--	--	--	--	100.0
SB_BH02_PW041	2.6	--	1.3	38.4	47.1	--	9.3	--	--	--	--	1.3	--	--	--	--	100.0
SB_BH02_PW044	52.9	--	1	19.7	17	--	2.5	--	--	--	7	--	--	--	--	--	100.1
SB_BH02_PW045	73.7	--	7.2	9.4	3.3	--	0.9	--	--	--	4.3	1.2	--	--	--	--	100.0
SB_BH02_PW048	62.6	4.5	--	17.8	7.8	--	--	--	--	--	5.7	1.6	--	--	--	--	100.0
SB_BH02_PW050	60.4	5.5	--	15.4	5.4	--	4.4	--	--	--	7.3	1.6	--	--	--	--	100.0
SB_BH02_PW052	68.8	--	--	10.7	7	--	2.5	--	--	--	6.4	4.7	--	--	--	--	100.1
SB_BH02_PW054	Not analysed																
SB_BH02_PW056	93.3	1.3	--	5.4	--	--	--	--	--	--	--	--	--	--	--	--	100.0
SB_BH02_PW058	92.1	3.9	--	4	--	--	--	--	--	--	--	--	--	--	--	--	100.0

-- = not detected or not reported