The sedimentological and Arsenic contamination history of Frame Lake, Yellowknife, Northwest Territories, Canada

by

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A thesis submitted to the Faculty of Graduate and Postdoctoral Affairs in partial fulfillment of the requirements for the degree of

Master in Science

in

Earth Sciences

Carleton University
Ottawa, Ontario

Abstract

Frame Lake, a small (88.4 ha), shallow (max < 6.5m), high-latitude lake found within the city limits of Yellowknife, Northwest Territories, Canada was selected due to the known legacy contamination of the lake's sediments to test the feasibility of using seismic sub-bottom profiling to estimate total volumes of heavy metal contaminated sediments in lacustrine environments. To ground-truth the sub-bottom profiling results, physical and ICP-MS analyses were carried out on freeze cores collected from Frame Lake's southern basin, and sedimentological marker beds and 14C dating was used to chronologically constrain the lake depositional history. ICP-MS results showed high levels of arsenic contamination (up to 1538 µg g-1) in late 20th-century lake sediments, which contrasts sharply with measured Holocene values that averaged only 16 µg g-1 (n=41, ± 5.4 SD). The high arsenic content in lakebed sediments, which tends to be concentrated within specific horizons, results in distinct seismic reflectors within the acquired Sonar data. Stratigraphic horizons where arsenic was concentrated do not necessarily correlate with actual depositional events as changes in lake hydrology and redox conditions have resulted in remobilization and migration of arsenic in lake sediments. Direct GIS software comparison of core data against the sub-bottom profiler transect results permitted an interpolated lateral and vertical reconstruction of the distribution of variously contaminated sediments throughout the entire lake basin. Based on our analysis, a minimum of ~230,000 m3 of contaminated sediments would need to be dredged from Frame Lake to achieve a minimum residual sediment arsenic concentration of < 150 µg g-1.

Acknowledgements

I would like to thank my supervisor Dr. R. Timothy Patterson for his support and guidance throughout this project. I would also like to thank Dr. Jennifer Galloway, Dr. Peter A. Cott, Dr. Bruce W. Hanna and Hendrick Falck for their constructive comments, warm encouragements, and knowledgeable inputs on Frame Lake, Yellowknife, and the Northern-Territories. I thank the members of my defense committee for taking the time out of their busy schedules to attend the thesis defense.

I would like to thank Nawaf A. Nasser and Braden R.B. Gregory, Ph. D. candidates in our lab group who have been incredible pillars of moral support and guidance throughout these past few years.

Although the following individuals had no direct input on my research and the writing of this manuscript, I would like to thank my friends and family whom have supported me through all this time, and special thanks to my wife Shannon M. Sullivan for all her loving support and encouragement throughout my university career at Carleton, and her initial encouragements to pursue a university degree in Earth Sciences.

I would also like to take this opportunity to thank my father, Gilles Menard. You are gone, but you continue to inspire me every day to be a better person. Thanks Dad.

Preface

This thesis is based on a peer-reviewed publication that has been submitted for review to Environmental Earth Sciences (submission ID: ENGE-D-18-02051). It has been formatted to fit within the Carleton University Thesis Template. My contribution include the processing of Sonar data, map interpolation and contaminated volume assessment, and writing the manuscript for submission to the journal. Dr. R. Timothy Patterson is responsible for the original concept and design. All co-authors (Nawaf A. Nasser, Dr. R. Timothy Patterson, Dr. Jennifer M. Galloway, Dr. Peter A. Cott, Bruce W. Hanna & Hendrick Falck) added feedback and helped with revision of the manuscript.

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1.1 Introduction

The City of Yellowknife, Northwest Territories, Canada, was founded in 1934 and thrived on the strength of major local gold mining operations, such as Giant Mine (1948-2004) and Con Mine (1938-1999). The Giant Mine was one of the longest-running and most productive gold mining operations in Canadian mining history, producing ~7 million ounces of gold through the mine's 56-year lifespan (Silke 2009; Sandlos and Keeling 2012). Although profitable to mine, gold mineralization at the Giant Mine was closely associated with sulfides containing elevated concentrations of elements of environmental concern such as zinc, copper, lead and nickel, and especially arsenic (As; Mudroch 1989; Jamieson 2014; Fawcett et al. 2015). The refractory nature of the gold-bearing ore in the Yellowknife area required the use of roasting to liberate gold from the hosting massive sulfides, primarily arsenopyrite. A by-product of this type of ore processing was the aerial release of ~7,400 kg/day of the highly toxic arsenic trioxide (As_2O_3) during the early years of production (1948-1951), which was drastically reduced following the implementation of progressively more stringent emission controls in subsequent years (~16 kg/day; MacDonald 1997; SRK Consulting 2002). As part of the mine remediation process following the Giant Mine closure, an estimated ~237,000 tonnes of As_2O_3 will be placed in cryostorage on site (Galloway et al. 2012).

While gold mining and ore processing at Giant Mine and Con Mine officially ceased in 2004, the long-term environmental impact of these operations on the Yellowknife area persists to this day. The aerial release of As_2O_3 from stack emissions at the Con Mine and, especially, Giant Mine left behind a legacy of As contamination on the landscape (e.g., lakes, rivers, peatlands, and soil) and covered an area that extends to a radius of ~30 km around the mine sites (Palmer et al. 2015; Galloway et al. 2015). Lacustrine systems around mine sites, especially those located on Canadian Shield substrates such as in the Yellowknife area, are very susceptible to contaminant runoff from the catchment and direct air fall due to their low buffering capacity (Palmer et al. 2015). While efforts to remediate the Giant Mine site are currently underway (e.g., Giant Mine Remediation Project; GNWT 2018), areas off-site have received little or no attention.

Frame Lake, a highly As-contaminated lake within the Yellowknife city limits, was once an important community recreational area, with the popular McNiven bathing beach established by the 1950s (Healey and Woodall 1973). By the early 1970's, however, Frame Lake had experienced a notable decline in lake health due to the impact of 1) historic gold-mining-induced As contamination; 2) the physical dumping of tailings and/or waste into the lake; 3) runoff of nutrient-rich water from municipal development around the lake; and 4) changes in circulation and water throughput to the lake due to urban development—notably the construction of a causeway equipped with sluiceways at the lake outlet in 1975, though these sluiceways remain closed most of the year, as well as stormwater sewers that diverted a significant amount of inflow from entering the lake , the cumulative impact of these changes led to the collapse and disappearance of fish populations in Frame Lake (Gavel et al. 2018). Additionally, in the years following the building of the causeway, there was a concomitant increase in the production of aquatic macrophytes, and the rapid sediment accretion of a dark brown to black organic-rich sedimentary horizon, as the lake became progressively more eutrophic. Deposition of this variable thickness black sedimentary horizon has been associated with high levels of legacy contaminants, primarily As, from the mining operation of Giant Mine and Con

Mine (Dirszowsky and Wilson 2013, 2016; Gavel et al. 2018). By the late 1970s, the steadily deteriorating environmental conditions within the lake resulted in a significant decline in the number of swimmers and beachgoers using McNiven Beach, which in turn led the city to eventually remove recreational facilities there. The beach itself has since disappeared, having been overgrown with grass (Mallon and Rendell 2015).

There is a desire to rehabilitate Frame Lake so that it may once again become an important recreational area for residents and tourists alike. With the closure of the last operating gold mine in the area, the city of Yellowknife has refocused its economic development plan, with eco-tourism being an important component (CCG 2014). Increased access to natural attractions such as local lakes, rivers, and wildlife is highly desired by visitors to the area. Frame Lake is in the middle of the City of Yellowknife, with City Hall, the Legislative Assembly of the NWT, and the Prince of Wales Northern Heritage Centre on its shore making rehabilitation of the lake also advantageous from a tourism and aesthetic perspective. Several remediation strategies for Frame Lake have been considered, including 1) dredging of contaminated sediments; 2) installation of aerators to permit fish to survive winter anoxia; 3) construction of storm-water management facilities at the inflows; and 4) opening of the sluiceways to increase the amount of outflow to increase lake water throughput (Gavel et al. 2018). If the lake is to be dredged, a significant amount of contaminated sediments would have to be removed. Removal of these sediments, which have accumulated since the early 1960s, has the potential of accelerating the overall remediation process, regardless of which other steps are pursued after dredging. In an effort to constrain the cost and feasibility of dredging the lake, a necessary first step is to map out the spatial extent and the thickness of the contaminated sediments within Frame Lake.

Dredging costs are largely associated with the amount of material required to be dredged (i.e., total volume) along with any subsequent treatment and/or disposal, which requires information on the concentration of contained contaminants. Although the analysis of sedimentary cores can provide fairly reliable baseline data to assist dredging efforts, collection of a number of cores sufficient to generate reliable baseline data may be cost-prohibitive. To provide cost-effective baseline data useful for determining the future dredging costs associated with remediation efforts in Frame Lake, an innovative, cost-effective, multidisciplinary approach was designed, where data derived from sub-bottom profiling, freeze and Glew cores, as well as geospatial interpolation, were together utilized to 1) assess the geochemical condition and spatiotemporal distribution of As-contaminated sediments within Frame Lake; and 2) estimate the thickness and volume of As-contaminated sediments throughout the lake.

Improving the geoscience tools available to assess the nature and environmental impact of contaminated sediments in lakes is of considerable use to resaerchers and resource managers so that they can better and more cost effectively direct resources toward remediation efforts, and to better inform regulatory agencies and the concerned public.

1.2 Regional Setting

Frame Lake (62.454°N, -114.390°E) is a subarctic lake within the Yellowknife Supergroup of the southern Slave structural province of the Canadian Shield (see Cousens 2000; Sandlos and Keeling 2012) in the central Northwest Territories, Canada

(Figure 1). Bedrock geology is mainly comprised of Archean meta-volcanic and meta-sedimentary rocks that are intruded by younger granitoids (see detailed discussion in Henderson 1985; Stubley 1997; Siddorn et al. 2007).

Surficial sediments in the study area are primarily comprised of a thin (< 2 m thick) discontinuous veneer of till and Glacial Lake McConnell sediments (Kerr and Wilson 2000). The till is comprised of a stony and loosely compacted matrix-supported diamicton (Kerr and Wilson 2000). Sediments derived from glacial Lake McConnell (11,800 to 8,300 y BP), the remnants of which forms modern Great Slave Lake, Great Bear Lake, and Athabasca Lake basins, were laid down during deglaciation and are comprised of poorly to moderately sorted coarse to fine sand, silt, and clay that can be up to 20 m thick in some topographic lows (Dyke and Prest 1987; Smith 1994; Kerr and Wilson 2000). Holocene peatlands are also common in the study region and can be ≥ 1m thick in bogs and other low-lying wetlands (Kerr and Wilson 2000).

The Yellowknife area has a continental subarctic climate with relatively cool, dry summers and even dryer, cold winters, a mean annual temperature of -4.3°C and mean annual precipitation of only 288.6 mm (Environment Canada 2010). July is characterized by mean daily temperature and precipitation of 17.0°C and 40.8 mm respectively, while mean January values are -25.6°C and 14.3 mm (Environment Canada 2010). The record summer maximum and winter minimum temperatures are separated by more than 80°C (32.5°C, July 1989; -51.2°C February 1947; Environment Canada 2010). Both mean daily temperatures and mean total precipitation have increased in recent years when comparing average mean daily temperatures and annual mean precipitation for the intervals 1961-1990 and 1981-2010 (-5.2°C vs. -4.3°C, 267.3 mm vs. 288.6 mm;

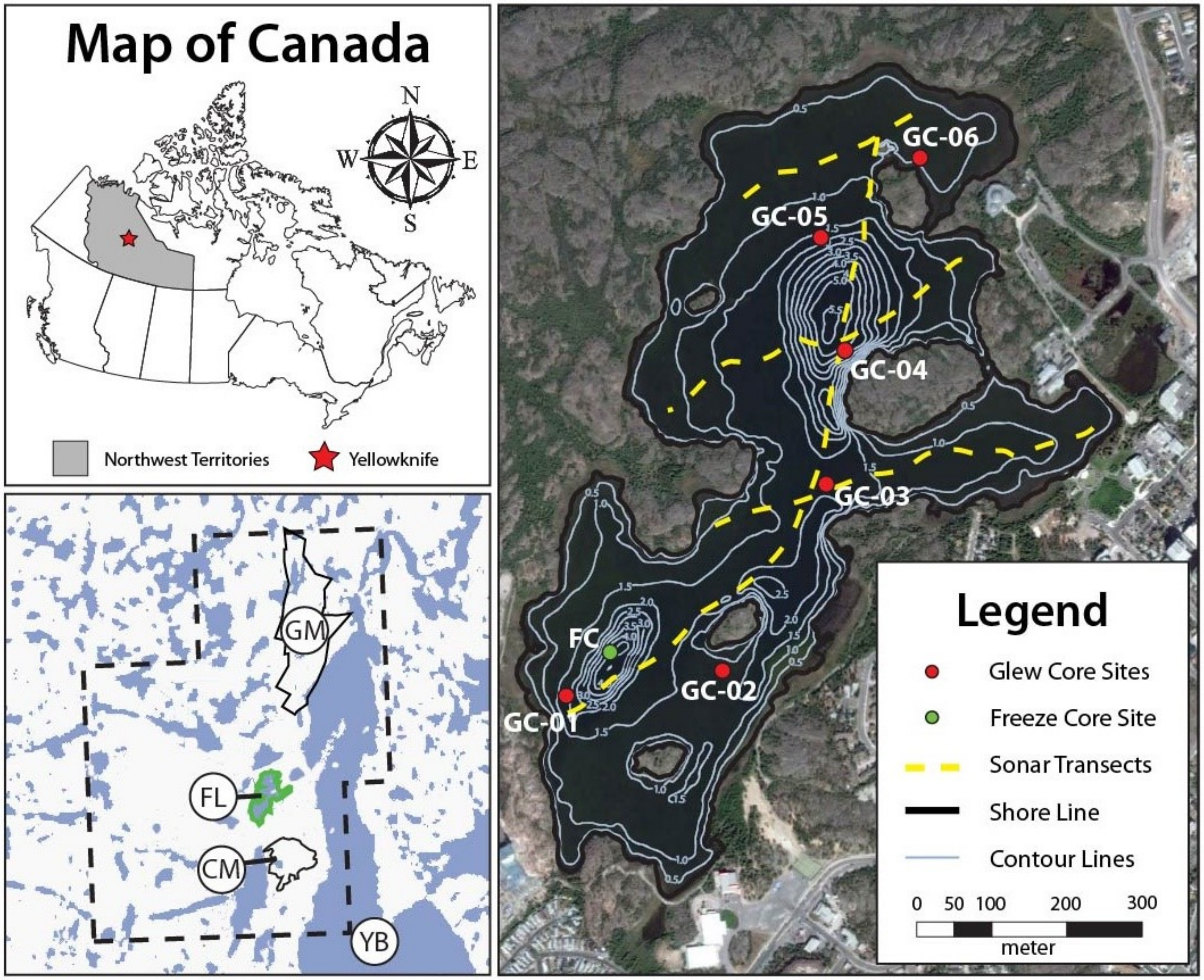

Figure 1 : Map showing the location of the study area marked by the red star (top left); regional view of the study area with the locations of Giant Mine (GM) and Con mine (CM), Frame Lake (FL) and Yellowknife Bay (YB), City of Yellowknife (Municipal boundary line as dashed line; bottom left); Frame Lake, NWT, Canada (right). Modified after Gavel et al. (2018).

Environment Canada 1990, 2010). Prevailing winds are from the east most of the year, with the exception of the summer months, June, July, and August, when they tend to be out of the south (Environment Canada 2010).

1.2.1 Frame Lake

The overall morphology of lakes and rivers in the Yellowknife region are heavily influenced by the local topography and resistance to erosion of local bedrock, which was sculpted primarily by glacial scouring rather than by fluvial erosion (Kerr and Wilson 2000). Frame Lake has a surface area of 88.4 ha, with a maximum depth of 6.5 m, with ~54% of the surrounding 3.48 km^2 catchment area having some sort of man-made infrastructure (Healey and Woodall 1973; Dirszowsky and Wilson 2016), with a morphology similar to many other lakes in the area. The area immediately around the lake is characterized by low relief terrain that is comprised mostly of bare rock outcrops with topographic lows infilled with glacial and glaciolacustrine sediments (Kerr and Wilson 2000). The lake's catchment in places supports vegetation, including conifers, paper birch and shrubs, as well as peat bogs, fens and marshes (Kerr and Wilson 2000). The oldest lake sediments are Lake McConnell deposits laid down immediately following post-glacial retreat of the Laurentide Ice Sheet, which transitioned to Ancestral Great Slave Lake sediments as the larger lake fractured into smaller water bodies. Frame Lake existed as an embayment of Ancestral Great Slave Lake until ~7,000 years BP when it slowly became isolated (Lemmen et al. 1994; Wolfe et al. 2017). Due to the low topographic relief, rocky terrain, and small amounts of precipitation in the area, sedimentation essentially ceased in the Frame Lake basin following early Holocene isolation, until ~1962 when anthropogenic influences within the lake catchment resulted in a renewed, rapid sedimentary infill of the lake basin (Gavel et al. 2018). The present-day inflow of water to Frame Lake is mostly derived from sheet wash or from small ephemeral channels during rainfall events and snowmelt (Dirszowsky and Wilson 2016). The sluice gate in a causeway on the lake's eastern shore controls most of the water outflow from the lake, though it remains closed most of the year (Gavel et al. 2018).

1.2.2 Lacustrine Sedimentary As Levels in the Yellowknife Area

Mean background concentrations of As in the sediments of Canadian lakes fall within the range of 2.5-10.7 µg g^{-1} (Friske and Hornbrook 1991; CCME 1999), but natural background levels in the Yellowknife area are far higher (150 µg g^{-1}; Risklogic 2002), mainly due to local bedrock geochemistry. Arsenic contamination in the immediate area around the Giant Mine has been as high as 20400 µg L^{-1} in surface waters downstream from a tailing pond in Baker's Creek (1975; Moore et al. 1978). Palmer et al. (2015) found concentrations up to 646 µg L^{-1} in a study of 98 lakes, sampled in 2012 and 2014. Sediment samples in the region collected by Mudroch (1989) had peak As concentrations of 890 and 2800 µg g^{-1} in Yellowknife Bay and Back Bay respectively, while a study by Mace (1998) found peak As concentrations in surface sediment samples of up to 3821 µg g^{-1} in a tributary of Yellowknife Bay. Recent multi-lake studies in the Yellowknife region, which included Frame Lake, found maximum As concentrations in surface sediments from 155 µg g^{-1} to over 10000 µg g^{-1} (i.e., exceeding instrumental detection limit; Galloway et al. 2012, 2018; Nasser et al. 2016). High levels of various contaminants have previously been measured in Frame Lake (e.g., As, Copper, Antimony, Uranium, Lead) with As levels ranging up to 1840 µg g^{-1} (Dirszowsky and Wilson 2013; Gavel et al. 2018).

1.3 Materials and Methods

1.3.1 Research design and Field Work

Core samples, water property data, side-scan sonar and sub-bottom profile data were collected from Frame Lake during two summer field seasons in 2012 and 2014. Three freeze cores were obtained from Frame Lake's southern basin in August 2012 and six Glew cores (Glew et al. 2001) were collected from throughout the lake in 2014 (Figure 1). Cores were logged and photographed on site to visually assess stratigraphic changes across the lake and provide ground-truth data for subsequent interpretation of the sub-bottom profile results. The freeze cores were obtained from the southern basin and included: 1) a single-faced freeze core (2012-1FR; 86 cm long) obtained from 4.1 m water depth (Figure 1); 2) two double-faced freeze cores (2012-2FRF1 [60 cm] and 2012-2FRF2 [60.4 cm]) retrieved from a water depth of 4.6 m. Freeze cores were more labor-intensive to collect than the Glew cores, but they preserved fine sedimentary structures at the soupy sediment-water interface, and were subsampled with a freeze core microtome at high resolution (Macumber et al. 2011). The freeze cores were cleaned, logged and photographed before being shipped frozen to Carleton University, where they were stored in a walk-in freezer at a temperature of -20°C for subsequent analysis.

Details of the lake bottom and subsurface were obtained along 4 transects run across the lake during September of 2014 (Figure 1) using a Lowrance HDS-8 sonar with StructureScan™ (model LSS-1) and a SyQwest Strata Box HD. Sub-bottom profiling data was collected at a high wavelength frequency of 800 Hz, which was most suitable for discriminating details of the sediment-water interface and shallow subsurface reflectors in the relatively thin and soupy Frame Lake substrate (Dunbar et al. 2000).

Data files were saved in the SL2 file format and were imported and subsequently processed using the SonarTRX software (v. 15.1.5601.14680).

1.3.2 Laboratory Work

1.3.2.1 Geochemical Analysis and Radiocarbon Dating

The top 60 cm of freeze core 2012-1FR was sub-sampled into 1-mm segments using a custom-made sledge microtome (Macumber et al. 2011). Sub-samples were subsequently recombined, when necessary, to meet minimum sample weight requirements for the Inductively Coupled Plasma Mass Spectrometry analysis (ICP-MS; minimum of 250 mg dry weight) performed by ACME labs (Bureau Veritas Commodities Canada Ltd.) using the Aqua Regia digestion technique (AQ200 protocol; Supplementary Table 1). Core 2012-2FRF2 was sub-sampled into 0.5 cm segments from the top of the core down to 15 cm as well as a sub-sample from 19.5-20.5 cm. Cores 2012-2FRF1 and 2012-1FR were also sub-sampled at various depths to confirm radiocarbon findings. Samples from core 2012-2FRF2 were submitted to the A.E. Lalonde AMS Laboratory, University of Ottawa, while those from 2012-2FRF1 and 2012-1FR were submitted to the 14 Chrono Centre, Queen’s University, Belfast for radiocarbon analysis (Table 1).

1.3.2.2 Sub-Bottom Profile Analysis

To assess the amount and temporal distribution of contaminated sediments, a preliminary analysis of the freeze core ICP-MS and sonar data was conducted to 1) assess the down-core variability of As concentrations; 2) identify stratigraphic units (i.e., layers) corresponding to certain As levels; and 3) determine whether identified stratigraphic units could be observed from the sonar data. The identified units were then measured (to the closest 0.5 cm) along the sonar transects, using the Spectrum and/or Graytones colour scheme in the SonarTRX software, depending on the contrast of the sonar image at a given location. The layer thickness and GPS coordinates at 209 locations along four transects were recorded and were subsequently imported into ArcMap™ (v. 10.4.1; ArcGIS® software by ESRI, Inc.) as a shapefile. A lake contour shapefile along with several data points near the shoreline were created, the latter of which was to simulate the tapering off of the fine-grained, highly contaminated particulates measured by the ICP-MS data in the freeze core near the shore.

1.3.2.3 Interpolation, thickness and volume estimation of the contaminated horizon

An Inverse Distance Weighted (IDW) interpolation was performed to estimate the thickness of the identified sediment layers (Figure 5) using the GeoStatistical Analyst package in ArcMap. Given the density and distribution of the data, IDW was chosen for the task as it generated the best results compared to other tested interpolative techniques (e.g., kriging and spline). The identified layers were then combined to give the total thickness of highly contaminated sediment (As >150 $\mu g\ g^{-1}$) throughout Frame Lake, and the total volume of the contaminated sediment was calculated using the Surface Volume tool in ArcMap.

1.4 Results

1.4.1 Radiocarbon Dating and Other Chronostratigraphic Markers

Thirty samples from the top 15 cm of sediment from core 2012-2FRF2 yielded dateable material. High-resolution radiocarbon ^{14}C analysis of these samples yielded calibrated ages between 349 and 1233 yBP with multiple age reversals throughout the interval (Table 1). The sample between 2.5 and 3.0 cm did not return a date due to a lack

Table 1: Radiocardon data from top 15 cm Bulk sediment of freeze core 2012-2FRF2 (UOC-0004 to UOC-0033), as well as additional samples and samples from further down core of freeze cores 2012-2FRF1 (lab ID UBA-23807 to UBA-23810) and 2012-1FR (lab ID UBA-23811 to UBA-23815). Analysis performed by A.E. Lalonde AMS Laboratories (lab ID prefix UOC) and 14 Chrono Centre (lab ID prefix UBA). Calibration was performed using OxCal 4.3 (Bronk Ramsey 2009) and the IntCal 13 calibration curve (Reimer et al. 2013).

Lab ID	Depth range (cm)	^{14}C Age (BP) ± 1σ	F14C	±	cal yBP
UOC-0004	0.0-0.5	405 ± 20	0.9508	0.0024	452-511 (89.0%) 335-349 (6.4%)
UOC-0005	0.5-1.0	591± 19	0.929	0.0022	585-645 (71.1%) 542-566 (24.3%)
UOC-0006	1.0-1.5	513 ± 19	0.9382	0.0023	510-546 (95.4%)
UOC-0007	1.5-2.0	536 ± 20	0.9354	0.0023	606-625 (13.0%) 518-557 (82.4%)
UOC-0008	2.0-2.5	657 ± 20	0.9215	0.0022	634-668 (45.0%) 560-595 (50.4%)
UOC-0009	2.5-3.0	N/A	N/A	N/A	
UOC-0010	3.0-3.5	853 ± 20	0.8993	0.0022	724-794 (92.6%) 705-719 (2.8%)
UOC-0011	3.5-4.0	1044 ± 21	0.8781	0.0022	926-977 (95.4%)
UOC-0012	4.0-4.5	1005 ± 20	0.8824	0.0022	907-963 (92.7%) 832-844 (2.7%)
UOC-0013	4.5-5.0	661 ± 19	0.9211	0.0021	637-669 (47.3%) 561-593 (48.1%)
UOC-0014	5.0-5.5	349 ± 18	0.9574	0.0022	421-485 (42.7%) 316-398 (52.7%)
UOC-0015	5.5-6.0	614 ± 19	0.9264	0.0022	551-654 (95.4%
UOC-0016	6.0-6.5	788 ± 21	0.9065	0.0023	679-732 (95.4%)
UOC-0017	6.5-7.0	373 ± 19	0.9546	0.0022	428-500 (66.9%) 326-375 (28.5%)
UOC-0018	7.0-7.5	1070 ± 18	0.8753	0.002	1028-1049 (13.0%) 931-1000 (82.4%)
UOC-0019	7.5-8.0	865 ± 21	0.8979	0.0024	868-899 (6.4%) 726-799 (89.0%)
UOC-0020	8.0-8.5	519 ± 19	0.9375	0.0022	580-651 (74.8%) 546-570 (20.6%)
UOC-0021	8.5-9.0	635 ± 19	0.924	0.0022	626-661 (38.2%) 556-604 (57.2%)
UOC-0022	9.0-9.5	955 ± 21	0.8879	0.0023	891-928 (28.9% 795-883 (66.5%)
UOC-0023	9.5-10.0	749 ± 19	0.911	0.0021	719-721 (0.6%) 665-704 (94.8%)

Table 1 (cont.)

Lab ID	Depth range (cm)	^{14}C Age (BP) ± 1σ	F14C	±	cal yBP
UOC-0024	10.0-10.5	945 ± 19	0.8891	0.0021	796-922 (95.4%)
UOC-0025	10.5-11.0	1012 ± 23	0.8816	0.0025	910-966 (94.5%) 835-840 (0.9%)
UOC-0026	11.0-11.5	872 ± 22	0.8971	0.0025	866-901 (12.4%) 814-825 (2.0%) 729-800 (80.9%)
UOC-0027	11.5-12.0	1056 ± 19	0.8768	0.0021	1034-1045 (3.1%) 927-983 (92.3%)
UOC-0028	12.0-12.5	846 ± 20	0.9001	0.0023	700-789 (95.4%)
UOC-0029	12.5-13.0	736 ± 25	0.9125	0.0028	719-721 (0.6%) 657-704 (94.8%)
UOC-0030	13.0-13.5	866 ± 19	0.8978	0.0021	875-892 (3.2%) 729-797 (92.2%)
UOC-0031	13.5-14.0	1123 ± 64	0.8695	0.0069	1213-1222 (0.9%) 927-1182 (94.5%)
UOC-0032	14.0-14.5	1049 ± 45	0.8776	0.0049	905-1063 (92.8%) 830-854 (2.2%) 803-802 (0.3%)
UOC-0033	14.5-15.0	1233 ± 20	0.8578	0.0021	1201-1259 (39.1%) 1169-1189 (14.8%) 1073-1163 (41.5%)
UBA-23807	6.5-7.0	1618±25			1562-1475 (60.3%) 1465-1414 (35.1%)
UBA-23808	10.5-11.0	1458±26			1389-1303 (95.4%)
UBA-23809	20.0-20.5	6015±39			6951-6749 (95.4%)
UBA-23810	30.0-30.5	6308±45			7413-7396 (1.1%) 7370-7360 (0.5%) 7330-7158 (93.08%)
UBA-23811	7.5-8.0	1162±26			1047-1176 (75.8%) 987-1031 (19.6%)
UBA-23812	13.0-13.5	1001±25			903-964 (80.5%) 828-860 (12.3%) 801-811 (2.6%)
UBA-23813	19.5-20.0	6306±33			7167-7302 (95.4%)
UBA-23814	32.5-33.0	6573±33			7540-7562 (9.1%) 7428-7516 (86.3%)
UBA-23815	43.5-44.0	7492±35			8280-8386 (68.8%) 8203-8268 (26.6%)

of adequate dateable material. These jumbled sediments were most likely of an allochthonous origin (e.g., old carbon-bearing sediments washed into the lake from the lake catchment). Additional dates acquired from cores 2012-2FRF1 and 2012-1FR showed similar age reversals in the top 15 cm and mid-Holocene ages between 6749 and 8386 yBP from samples found at depths > 20 cm (Table 1).

1.4.2 Freeze- and Glew-Core Stratigraphy

Stratigraphic analysis of freeze core 2012-1FR revealed three distinct stratigraphic units. The top unit (U1) comprises the uppermost 17 cm of the core and is characterized by very fine-grained, organic-rich, dark green to black sediments (Figure 2). U1 was punctuated by three thin, conspicuous, light grey ash layers (~2-3 mm each) deposited between 13 and 15 cm and had a sharp stratigraphic unconformity at ~17 cm. The ash layers proved to be excellent chronostratigraphic markers as they were derived from New Year's Christmas tree bonfires that were held on the lake in 1968, 1969 and 1971 (Figure 2; Long-time Yellowknife resident Velma Sterenberg and former Yellowknife Mayor David Lovell, pers. comm. 2015). The presence of an unconformity at 17 cm is further supported by the radiocarbon dating results, which indicated a middle Holocene age for sediments deposited below 17 cm (6,749-8,386 yBP; Table 1, Figure 2). This hiatus is likely attributed to a cessation in sedimentation to Frame Lake following its gradual isolation from the nearby Yellowknife Bay (Wolfe and Morse 2015). Based on sedimentological analysis of this same core, coupled with an assessment of available air photo imagery for Frame Lake spanning from the present to the 1930s, it has been estimated that initiation of modern era sedimentation in the lake began in ~1962 (Gavel et al. 2018).

The second unit (U2) extends from the sharp stratigraphic boundary at 17 cm down to 44 cm and consists of dark olive green to brown coloured, mostly fine-grained sediments with some fraction of organic matter. The lower part of U2 (39-44 cm) was a depositional transition period marking the change from fine-grained sediments with an organic fraction to fine-grained glacial clays of the early Holocene (Figure 2). Unit 3 (U3) extends from 44 cm to the base of the core at 86 cm and was characterized by fine-grained light beige to nearly white glacial clay (Figure 2).

Glew cores collected throughout Frame Lake were similar in length (45-51 cm; n=6), with the exception of GC-02, which was only 17 cm long (Figures 1 and 3; Supplementary Figure 1; Table 2). The majority of the Glew cores were characterized by the same three stratigraphic units identified in the freeze core, with the exception of GC-02, which only contained U1 and U2 (Figure 3). All Glew cores contained the dark organic-rich colloidal (Gyttja) of uppermost U1 (thickest in core GC-03 (15 cm) and thinnest in GC-04 and GC-06 (6 cm; Figure 3), which transitioned to the olive green/brown coloured organic mud of U2.

1.4.3 Geochemistry

The ICP-MS analysis of sediments from freeze core 2012-1FR was characterized by As concentrations of just 8.2 $\mu g\ g^{-1}$ at 60 cm depth, which gradually increased up core, reaching levels above 150 $\mu g\ g^{-1}$ by 25 cm depth (Figure 2). Peaks of As contamination (AP-1 and AP-2) were found at 15 cm (688 $\mu g\ g^{-1}$; AP-2) and 9.5 cm (1538 $\mu g\ g^{-1}$; AP-1). There was a gradual decrease of As concentration through the uppermost sections of

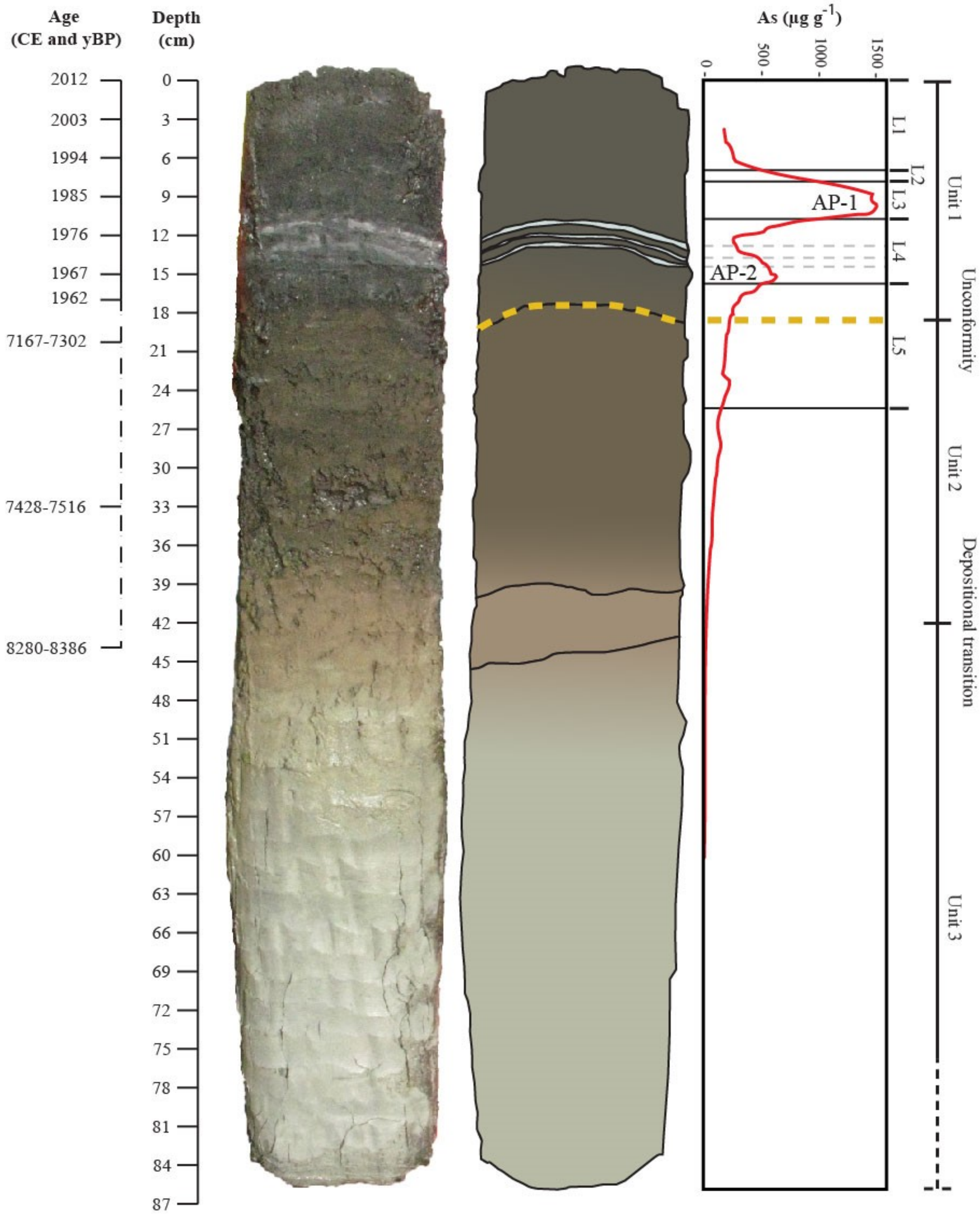

Fig. 2 : Freeze core 2012-1FR (left) and its schematic view (right) showing 3 distinct stratigraphic units. Ages are marked on the far left with top ages in CE are based on interpolated ages based on the 3 Christmas tree ash layer (13-15 cm; 1968, 1969 & 1970) and bottom ages are ranges in yBP from ^{14}C dates (table 1), with a depth scale in cm to the left of the core. ICP-MS data of As concentration (from 3.5 to 60 cm) is plotted on the right of the core schematic, with acoustic layers (L1-L5), stratigraphic units (U1-U3) unconformity (dark yellow dashed line on schematic) and transition area are on the far right. Modified after Gavel et al. (2018).

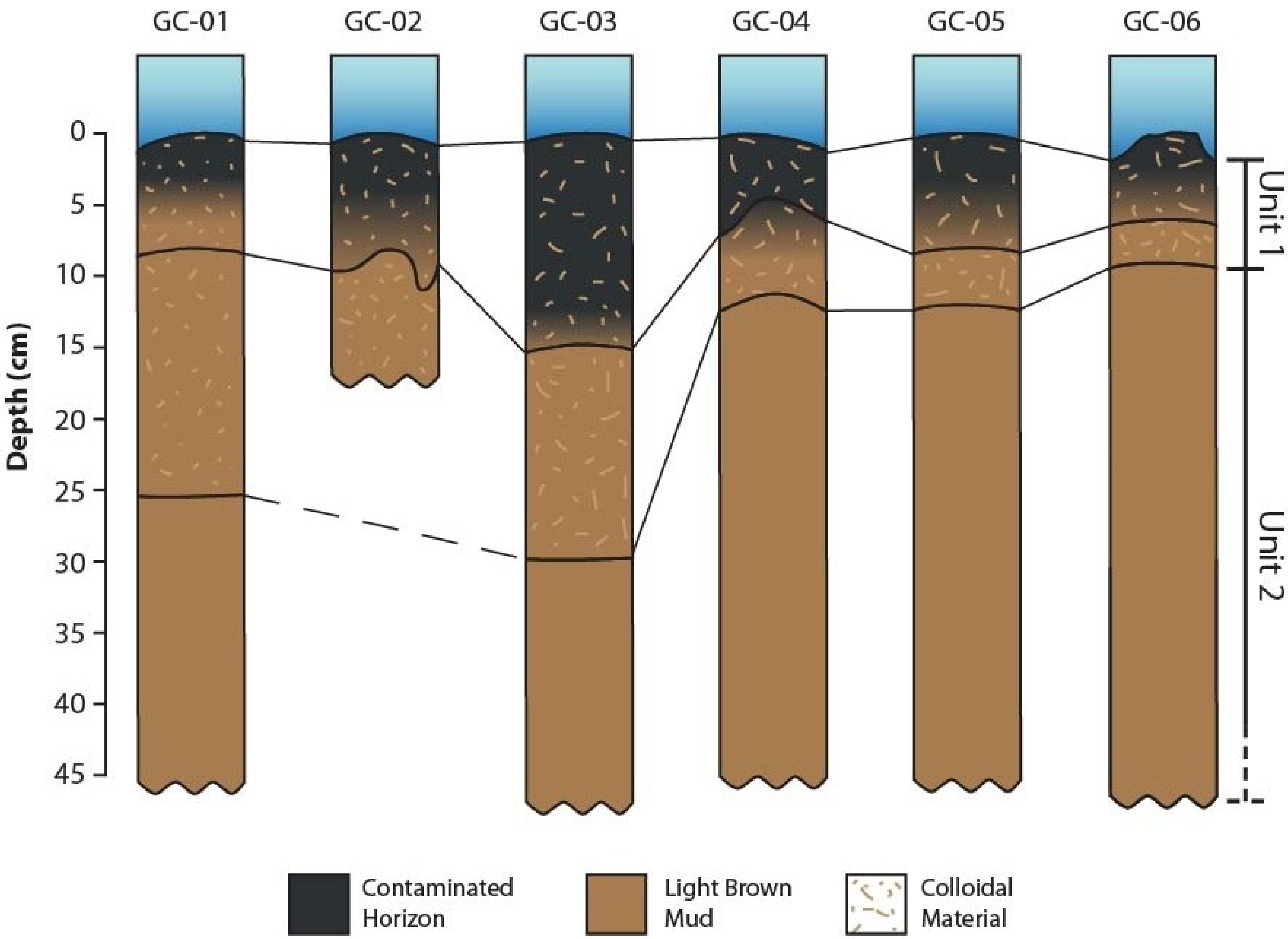

Fig. 3 : Fence diagram showing the stratigraphy within Frame Lake as captured by six examined Glew cores (GC-01 to GC-06), with stratigraphic units as seen from the Freeze core marked on the right (U1 and U2) topped by the water column (blue to white gradient). Sampling site locations of the Glew cores are marked on figure 1, while overall length and observed contaminated sediment thickness of unit 1 (U1) are detailed in table 2.

Table 2 : Detailed layer thicknesses of the collected glew cores, as well as the thickness of the heavily contaminated (>150 µg g-1) layer U-1.

Glew Core ID	Contaminated layer thickness (U-1) (cm)	Total length (cm)
GC-01	25	47
GC-02	9	17
GC-03	30	51
GC-04	11	45
GC-05	12	55
GC-06	10	48

the core with As levels declining to 179 µg g^{-1} in the near-surface sediments at 3.5 cm. There are other elements related to anthropogenic and mining activity with elevated concentrations within the lake basin, such as copper (Cu), antimony (Sb), lead (Pb), zinc (Zn), and chromium (Cr). These elements, along with As, are detailed in Table 3 and are compared to the measured maximum, recent average and background average concentrations found in the core, to the CCME (1995) Sediment Quality Guidelines for the Protection of Aquatic Life in freshwater, which set very specific targets for these elements, including Interim Sediment Quality Guidelines (ISQG) and Probable Effect Levels (PEL). However, these other elements of concern will not be discussed further in this paper, though the full geochemical analysis of the top 60 cm of this core is available in Supplementary Table 1.

1.4.4 Sub-Bottom Profile Reflector Analysis

From the results of the sub-bottom profile analysis, the upper sedimentary units (U1 and U2) could be further subdivided into five layers (L1-L5) determined by the changes in sedimentary acoustic impedance, which are controlled by variation in sediment density contrast. Acoustic layers L1-L4 were contained within U1, while L5 comprised of the lowest portion of U1 and the upper part of U2 (Table 4). These five

Table 3: Concentration of elements related to anthropogenic activity as well as other elements of concern in Frame Lake, compared with Sediment Quality guidelines for the Protection of Aquatic life, Canadian Council of Ministers of the Environment, 1995. The Modern average is based on top 10 cm of the core, while background levels are based on the average values for sediments between 40-60 cm. All values are in µg g-1.

Element	Peak Value	Modern Average	Background level	ISQG	PEL
As	1538 (AP-1) 688 (AP-2)	841.83	16.16	5.90	17.00
Cd	0.54	0.34	0.37	0.60	3.50
Cr	65.40	49.02	45.42	37.30	90.00
Cu	72.87	62.67	41.10	35.70	197.00
Pb	41.66	31.20	9.41	35.00	91.30
Sb	28.70	23.87	0.42	N/A	N/A
Zn	308.70	138.47	71.28	123.00	315.00

acoustic layers closely correlated with distinct levels of As contamination. Acoustic L1 extended from the sediment-water interface (SWI) down to the start of the first major change in acoustic impedance, with a thickness of ~5 cm (± 2.9 SD) and an estimated volume of ~44,260 m^3. Acoustic L2 was delineated by the transition zone immediately below L1 from low impedance to high impedance.

This interval was ~9.57 cm (± 4.8 SD) thick throughout the lake and comprised ~84,600 m^3 of sediment. Acoustic L3 spanned the maximum acoustic impedance recorded in Frame Lake. This unit averaged only ~1.6 cm (± 0.8 SD) thickness with a volume of ~14,330 m^3 but contained the greatest concentration of highly contaminated As-bearing sediments (AP-1). Acoustic Unit L4 extended downward from the peak of the maximum acoustic impedance recorded in L3 to the base of a lower impedance peak. The

Table 4: Acoustic layers 1 through 5 (L1-L5) mean and maximum thicknesses, and their respective calculated volumes throughout the basin. L3 includes the peak As concentration measured in the core (AP-1, 1538 µg g-1) and L4 includes the second peak As level measured (AP-2, 688 µg g-1).

Layer	Mean Thickness (cm)	SD	Maximum Thickness (cm)	Volume (m^3)
L1	5.01	2.85	10.60	44259
L2	9.57	4.76	6.20	84604
L3	1.62	0.81	5.00	14326
L4	4.64	2.35	20.00	41022
L5	5.13	2.50	25.00	45331
Total	25.96	10.90		229542
150-500 µg g^{-1} (L1+L5)				89590
500-1000 µg g^{-1} (L2+L4)				125626
<1000 µg g^{-1} (L3) (Peak 1538 µg g^{-1})				14326

L4 interval had a mean thickness of ~4.64 cm (± 2.4 SD) with a sediment volume of ~41,020 m^3 and included the second isolated As peak AP-2, which formed a strong reflector throughout the entire Frame Lake basin and was characterized by high As levels (up to 688 µg g^{-1}). Acoustic L5 is defined as the transition from the base of AP-2 downward to the stratigraphic region of low to very low impedance (Figure 4). The L5 unit had a mean thickness of ~5.1 cm (± 2.5 SD) and contained ~45,330 m^3 of sediment. Both L1 and L5 were characterized by sediments with As concentrations between 150 and 500 µg g^{-1}, which included sediments of the top 6.5 cm (L1; U1) and those between 15.5 to 25 cm (U1 and U2; L5) at the freeze core site. The As concentrations in L2 and L4 varied from 500-1000 µg g^{-1} and at the freeze core consisted of sediments found between 6.5 to 7 cm (L2; U1) and 10.5 to 15.5 cm (L4; U1). L3 was associated with As concentrations >1000 µg g^{-1} (up to 1538 µg g^{-1}) and includes sediments between 7 and 10.5 cm at the freeze core site (U1).

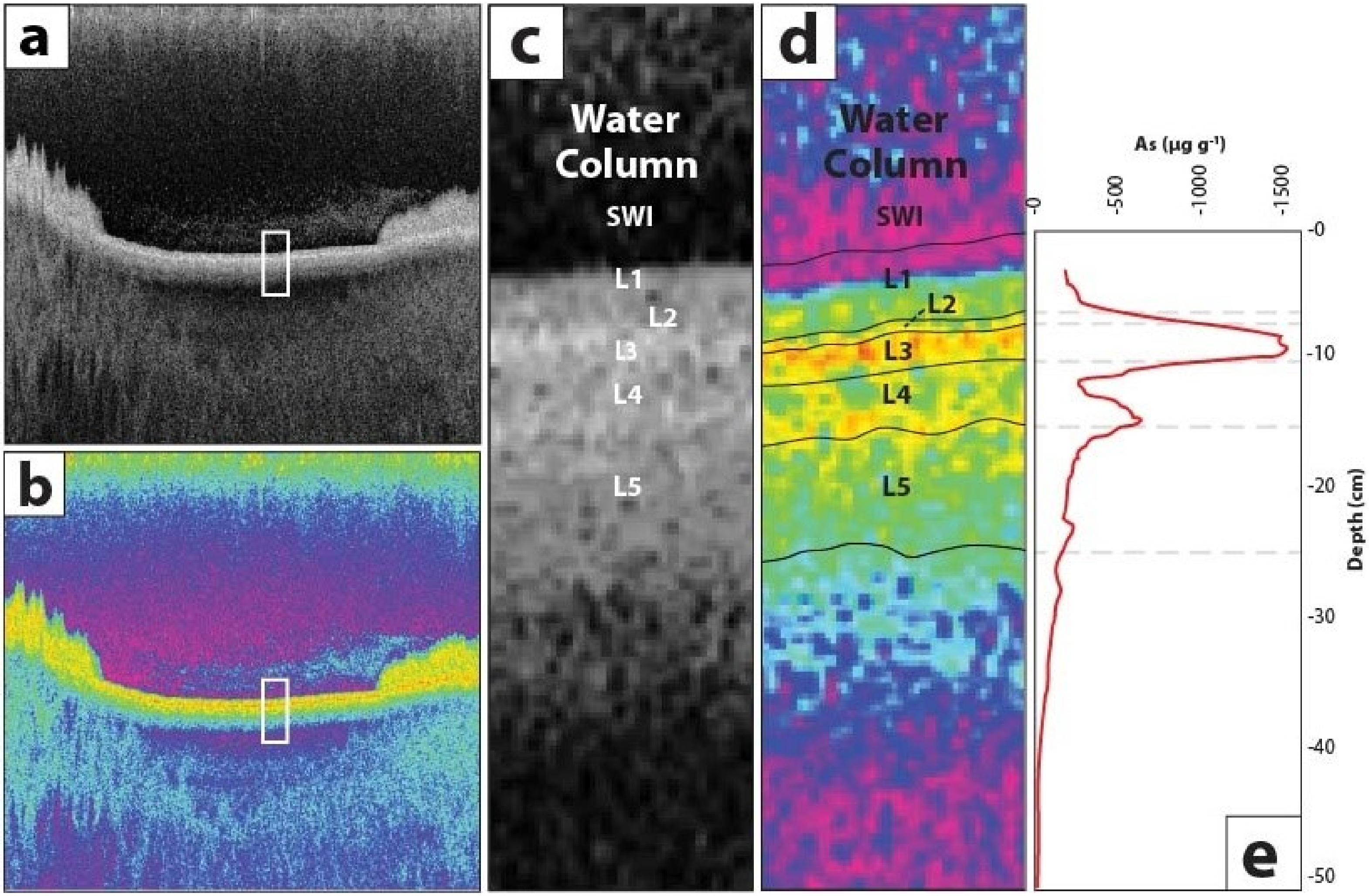

Fig. 4 (next page): Sub-bottom profile data as seen using SonarTRX software in both Graytones (A, C) and Spectrum (B, D) color schemes. A and B show a section of the Sonar transect of Frame Lake's Southern basin. C and D are close up views of the Sonar data (outlined in a box), highlights of acoustic layers 1 through 5 (L1, L2, L3, L4, L5) showing different reflectivity characteristics due to high levels of As and metalloid concentration. E) Graphed As concentration curve from data acquired by ICP-MS analysis of freeze core 2012-1FR, with acoustic layers L1-L5 marked with grey dashed lines.

1.4.5 Interpolation, Thickness and Volume Estimation of the Contaminated Horizon

Results of the IDW interpolation of L1-L5 across the Frame Lake basin revealed distinct landscape and stratigraphic spatial patterns with a total mean thickness of 26 cm (± 10.9 SD; Figure 5). Acoustic L1 tended to be thicker away from the shore with the thickest interval recorded being within Frame Lake's southern basin (Max = 10.6 cm) and, to a lesser extent, in parts of the northern basin (max = 10 cm; Figure 5-L1). Acoustic L2 had a similar distribution to that of L1, though its maximum thickness of 6.2 cm was more discretely distributed between the two basins (Figure 5-L2). Acoustic L3, characterized by the highest As concentrations in the lake, was relatively evenly distributed throughout the lake with the exception of the lake's northern and western shores where a maximum thickness of 5 cm for this unit was found (Figure 5-L3). Acoustic L4 was thickest along the western part of the northern basin of the lake, with a maximum thickness of 20 cm (Figure 5-L4). Acoustic L5 had a similar distribution to that of L4, though with a more even distribution along the northern margin of the lake (maximum thickness = 25 cm). Acoustic L3, L4, and L5 contained the bulk of the contaminated sediments and formed a package up to 50 cm thick along the northern and western shores of Frame Lake (Figure 4-A). Collectively, the combined thickness of all layers (L1-L5) in this region reached 57 cm, the thickest accumulation of contaminated sediment in the lake. Based on the results of the IDW analysis the total volume of As-contaminated sediment (>150 $\mu g\ g^{-1}$) found in L1-L5 was calculated as being 229,542 m^3 (Table 4).

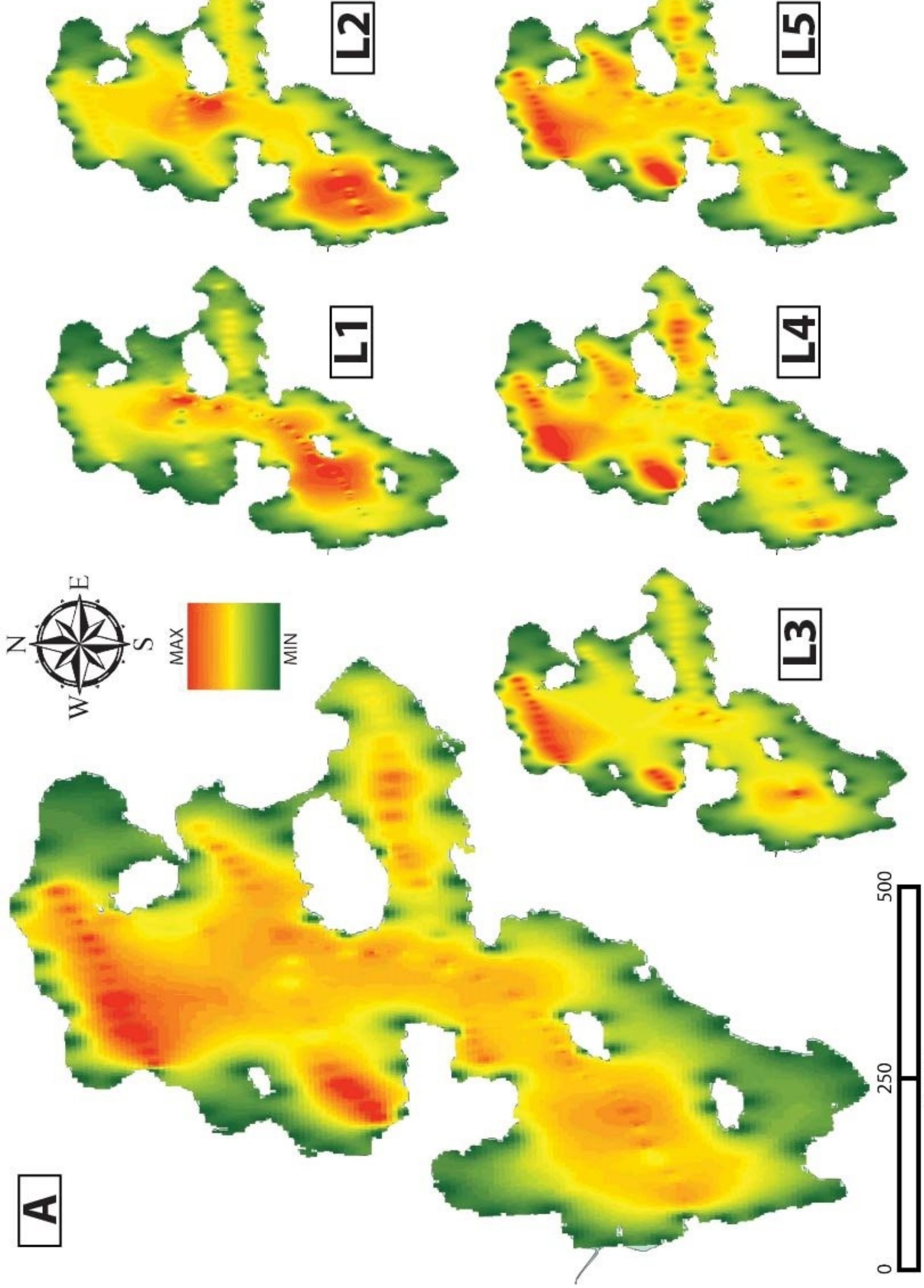
A
L1
L2
L3
L4
L5
N
E
S
W
MAX
MIN
0
250
500
Meters

Fig. 5 (previous page): IDW interpolation of the thickness of the As-contaminate sediments across Frame Lake. A) IDW Interpolated map of the total thickness of As contaminated sediments (>150µg g-1) L1 to L5 are IDW interpolated maps of As contaminated sediments as shown in figure 1 and outlined in figure 4. L1 has a maximum thickness of 10.6 cm. L2 has a maximum thickness of 6.2 cm. L3 has a maximum thickness of 5.0 cm. L4 has a maximum thickness of 20.0 cm. L5 has a maximum thickness of 25.0 cm.

1.5 Discussion

Frame Lake's health and its ability to sustain aquatic life has been in question since at least the early 1970s and provides a precautionary example of what can happen if too little is done to protect our natural resources. Conventional stratigraphic assessment of the freeze core resulted in the identification of three distinct stratigraphic units (U1-U3), with U1 sediments being deposited after ~AD1962 and separated from the early Holocene deposits of U2 and U3 by an unconformity (Gavel et al. 2018). The same general stratigraphic succession was observed in the Glew cores recovered from the lake (Figure 3). Variation in the observed unit thickness from core to core was expected as the nature and characteristics of bottom sediments within Frame Lake has been shown to vary, depending on location and basin morphology (Dirszowsky and Wilson 2016).

1.5.1 Frame Lake Contamination History

The results of ICP-MS geochemical analysis of freeze core 2012-2FRF1 revealed a gradual, yet small, increase in As concentrations between U3 and U2 overlain by drastically elevated As levels in the highly contaminated U1 horizon (~170-1540 $\mu g\ g^{-1}$). The elevated As concentrations are in part attributable to the historic operations of major gold mines in the Yellowknife area (e.g. Con Mine and Giant Mine; Dirszowsky and Wilson 2015; Gavel et al. 2018).

The elevated As concentrations within U1 (179-1538 μg g^{-1}) are represented by two peaks: a lower peak at ~ 15 cm (AP-2; 688 μg g^{-1}) and a major peak at ~10 cm (AP-1; 1538 μg g^{-1}; Figure 2). The chronologic positioning of the peaks in U1 suggests that the As contamination occurred long after Giant Mine modified its on-site ore roasting processing method in response to more stringent environmental controls on As emissions (~1980s; MacDonald 1997; SRK Consulting 2002). Based on a detailed bioindicator/geochemical analysis of this freeze core (Gavel et al. 2018), it is most likely that these chronologically anomalous peaks are the result of post-depositional remobilization of As in response to changes in several environmental factors (e.g., redox conditions, pH, and organic matter). This assessment is supported by the results of recent geochemical studies that confirm the occurrence of vertical mobilization of As through sedimentary profiles of several lakes in the Yellowknife area (e.g., Andrade et al., 2010; Van Den Berghe et al. 2016; Schuh et al. 2018).

In addition to having elevated As levels, U1 sediments are organic-rich (Gavel et al. 2018). The deterioration of lake water quality has not only been the result of input of As from air fall and contaminated sediments. Since the 1980s eutrophication has been a primary driver of Frame Lake hydroecology (Gavel et al., 2018). In an analysis of both the sediments and stratigraphic temporal distribution of shelled protist (Arcellinida [*testate lobose amoebae*]) bioindicators, Gavel et al. (2018) found that the ecology of these organisms transitioned during the 1980s from an ecological state where As was the primary control on species distribution, to a system where nutrient loading was the most important contributor to assemblage composition.

1.5.2 Total thickness and volume of Arsenic contaminated sediments

Analysis and interpretation of the ICP-MS and sub-bottom profile data permitted a determination of the lateral extent and thickness of As-contaminated sediments throughout the Frame Lake basin. Sediments with As concentrations of >150 $\mu g\ g^{-1}$ could be subdivided into five distinct layers (L1-L5), which could be acoustically recognized throughout Frame Lake (Figure 4).

The results of the IDW interpolation of the distribution of the L1-L5 reflectors throughout the lake basin provided insight into the spatial extent of As contamination of the Frame Lake sediments, as well as valuable data for determination of the volume of highly contaminated As sediment, which might possibly have to be dredged or otherwise treated as part of a future lake rehabilitation program. The results revealed a trend of increasing thickness of the contaminated substrate away from the lake shoreline, with L1 and L2 being thickest closer to the southern basin, and L3-L5 exhibiting maximum thickness closer to the northern and, to a lesser extent, western shorelines (Figure 5). The increased thickness of L3-L5 in these areas of the lake may be related to unconfirmed physical dumping of contaminated sediments in close proximity to these areas. The allochthonous source of these sediments was confirmed by the mixed radiocarbon dates from these sediments, which suggests that 'old carbon' derived from elsewhere was introduced to the lake and mixed with natural lake-bed sediments. There are multiple possible sources of this sediment such as introduction to the lake from the adjacent catchment during urban development around the lake. However, the catchment is largely composed of exposed bedrock so it is unlikely that there would have been sufficient volume of sediment from this source. Another possible origin is residue from the snow dumps that were positioned on the lake during the 1960s and 1970s, which over several years might introduce a considerable amount of sediment to the lake bed (former Yellowknife mayor, D Lovell, pers. comm. 2015). As plows removed snow from Yellowknife area streets and highways sediment would become entrained from many sources, which provides a plausible explanation for the jumbled radiocarbon dates obtained from these sediments. There are also rumors that waste material from a nearby "1000-man camp" were surreptitiously dumped in the lake, as well as the accidental dumping of a significant quantity of contaminated drilling mud that was being used to shore up a foundation of a building adjacent to the lake (V. Sterenberg; former Yellowknife mayor, G. Van Tighem, pers. comm. 2015).

Regardless of the source of the contaminated sediment, the results of IDW subsurface volume analysis indicate that at least 184,000 m^3 of sediment, much of it contaminated by high As levels, have been introduced to Frame Lake since sedimentation was reinitiated in ~1962. These sediments directly overlay sediments deposited during the early Holocene. Unfortunately, due to changing hydrological redox conditions in the lake, As in the sediments migrated throughout the lake substrate. As a result some of the underlying mid-Holocene sediments of L5 have also become contaminated, meaning that to return Frame Lake to a locally acceptable background As level of <150 µg g^{-1} a total of ~230,000 m^3 of contaminated sediments (>150 µg g^{-1} As) would be required to be dredged from Frame Lake as part of such a rehabilitation program. A dredging program would necessarily be focused on the thickest contaminated sedimentary deposits (i.e., L3-5), as removal of these sediments would contribute most significantly toward reducing the total volume of As contamination in the lake. These data will be of considerable value to researchers and resource managers as they determine the most appropriate strategies to revitalize Frame Lake as an important recreational area for the City of Yellowknife, while the techniques used in this paper and relatively low cost of these research methods may be directly applied to other remediation projects.

1.6 Conclusions

Analysis of the Frame Lake sedimentary record documents the geomorphological changes that have influenced lake history, which have been driven by deglaciation, isostatic rebound, and early Holocene warming. The considerable volume of modern deposits laid down after ~1962 (~184,000 m^3) identifies the many, primarily negative, factors that have contributed to the recent hydroecological changes experienced by Frame Lake. These direct and indirect human impacts include: 1) the introduction of a considerable volume of allochthonous sediment to the lake basin in the years after ~1962; 2) addition of high levels of As contamination (up to ~180 $\mu g\ g^{-1}$ in surface sediments and 1840 $\mu g\ g^{-1}$ down core), which was either derived from air fall from local mining operations, or associated with sediments introduced to the lake basin; and 3) nutrient loading associated with changes to both water inflow and outflow to the lake, notably influenced by urbanization over much of the lake catchment and the construction of a major causeway with sluice gate to control at the outlet.

The results of this research indicate that varying levels of As contamination can be correlated with five distinct acoustic markers (L1-L5) recognized during sub-bottom profiling, which in turn can be directly ground-truthed to three stratigraphic units (U1-U3). These acoustic units are characterized by distinct As concentrations (L1=180-500 $\mu g\ g^{-1}$, 44,259 m^3; L2=500-1000 $\mu g\ g^{-1}$, 84,604 m^3; L3=1000-1532 $\mu g\ g^{-1}$, 14,326 m^3; L4=500-1000 $\mu g\ g^{-1}$, 41,022 m^3; L5=150-500 $\mu g\ g^{-1}$, 45,331 m^3), which can be traced throughout the entire Frame Lake basin. Analysis of the stratigraphic record from Frame Lake indicates that the background sedimentary As levels are in the 18-25 $\mu g\ g^{-1}$ range (Dirszowsky and Wilson 2016; Gavel et al. 2018), although the generally accepted background level in the Yellowknife area is 150 $\mu g\ g^{-1}$ (Galloway et al. 2018). Based on IDW analysis of the distribution of L1-L5, an estimated volume of ~230,000 m^3 of sediment would have to be dredged from Frame Lake to achieve a minimum concentration of 150 $\mu g\ g^{-1}$ in lake sediments.

The road to recovery for Frame Lake will not be an easy one due to the complicated nature of the combined As contamination/eutrophication problems and Frame Lake's inherently fragile hydroecology. However, with educational outreach, the involvement and engagement of the Yellowknife community, and with increasing adoption of environmental stewardship, great strides can be made towards rehabilitating Frame Lake to the healthy ecosystem and recreational resource that it once was.

1.7 Acknowledgments

We acknowledge Andrew L. Macumber, Braden R.B. Gregory, Michel Haché and April S. Dalton of Carleton University, and Dr. Rachel Patterson, Dr. Paul Traynor, Queen's University Belfast, for their help with sample collection at Frame Lake in 2012, and Melody Gavel for laboratory assistance. We also thank Yellowknife resident Velma Sterenberg and former Yellowknife mayors Dave Lovell and Gord Van Tighem, and other Yellowknife residents for their much-valued information on the history of Frame Lake. Funding for this project was provided by a Polar Knowledge Canada grant to RTP and JMG, Tides Canada, the City of Yellowknife, the Royal Bank of Canada Blue Water Fund, NWT CIMP, NSERC and Trout Unlimited.

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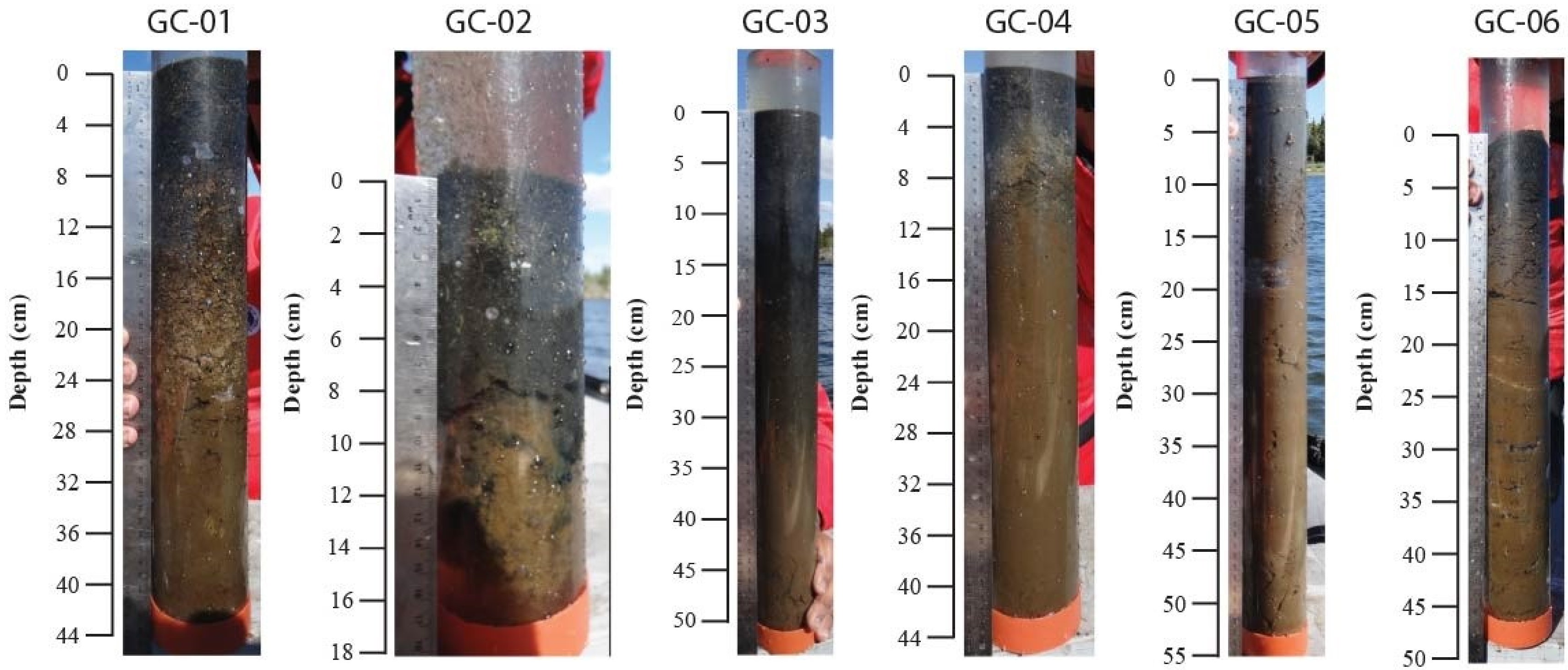
Supplementary material



Supplementary Fig. 1 : Glew cores retrieved from Frame Lake in Yellowknife during the 2014 field season. Each core was logged on-site to ground truth the IDW interpolation results. Sites of Glew core sampling are noted in figure 1, and a schematic view is presented in figure 5.

Supplementary Table 1: All samples were of the soil pulp variety and were analyzed by ACME labs (Bureau Veritas Commodities Canada Ltd.) using their AQ200 method

	Analyte	Mo	Cu	Pb	Zn	Ag	Ni	Co	Mn	Fe	As	U	Au	Th	Sr	Cd	Sb	Bi	V
	Unit	PPM	PPM	PPM	PPM	PPB	PPM	PPM	PPM	%	PPM	PPM	PPB	PPM	PPM	PPM	PPM	PPM	PPM
Lab ID (depth)	**MDL**	0.01	0.01	0.01	0.1	2	0.1	0.1	1	0.01	0.1	0.05	0.2	0.1	0.5	0.01	0.02	0.02	2
FRAME 1FR-3.5 CM		2.82	59.12	34.69	308.7	253	35.8	11.4	395	2.10	179.6	13.94	240.5	5.4	35.4	0.48	20.75	0.45	42
FRAME 1FR-4.5 CM		4.25	58.57	39.94	210.5	218	34.9	10.9	397	2.02	199.0	13.27	138.9	4.8	36.1	0.44	21.90	0.43	40
FRAME 1FR-5.0 CM		5.28	61.51	41.66	171.1	225	33.1	10.5	388	1.96	243.7	11.97	148.9	4.6	38.0	0.51	22.73	0.40	39
FRAME 1FR-6.0 CM		5.43	59.35	40.91	135.6	189	35.7	10.1	403	2.31	278.1	11.48	111.4	5.7	35.9	0.37	23.21	0.40	42
FRAME 1FR-6.5 CM		5.96	61.36	39.77	128.1	243	39.5	11.1	436	2.60	421.8	11.20	115.0	6.2	33.7	0.42	23.15	0.41	44
FRAME 1FR-7.0 CM		4.51	62.81	37.27	116.4	178	36.2	11.5	458	2.81	659.9	10.18	98.3	7.4	34.0	0.36	23.57	0.44	46
FRAME 1FR-7.5 CM		4.39	67.19	34.16	109.2	170	34.9	11.4	469	2.89	913.2	9.02	74.5	8.1	33.8	0.33	25.55	0.46	48
FRAME 1FR-8.0 CM		3.84	69.68	27.57	108.4	186	36.0	11.2	462	2.94	1237.3	8.44	91.1	8.4	34.0	0.26	26.84	0.43	48
FRAME 1FR-8.5 CM		3.80	72.87	24.75	103.1	165	33.8	10.7	472	2.98	1505.2	7.80	87.4	9.1	32.0	0.28	28.70	0.42	48
FRAME 1FR-9.0 CM		3.38	68.34	20.12	99.1	145	32.8	10.6	473	3.06	1452.6	7.00	71.7	9.2	30.2	0.24	26.84	0.42	49
FRAME 1FR-9.5 CM		3.93	60.25	18.28	86.7	142	34.1	10.9	475	3.07	1538.0	7.43	68.6	9.7	31.2	0.23	24.25	0.41	51
FRAME 1FR-10.0 CM		3.44	50.99	15.27	84.7	122	32.8	10.3	445	3.10	1473.5	6.71	41.8	10.3	30.6	0.18	18.96	0.44	49
FRAME 1FR-10.5 CM		2.18	50.60	14.29	81.7	108	39.7	12.7	498	3.42	1013.3	5.52	27.4	13.3	34.4	0.17	12.89	0.49	56
FRAME 1FR-10.6 CM		1.64	49.15	13.91	86.3	115	41.5	12.7	506	3.42	821.5	5.33	26.0	13.0	34.2	0.14	10.54	0.49	56
FRAME 1FR-11.0 CM		1.70	51.27	13.95	85.0	95	41.7	13.0	520	3.44	688.8	5.10	24.6	13.7	36.7	0.12	10.02	0.53	59
FRAME 1FR-11.2 CM		1.30	47.78	12.59	84.1	99	40.9	12.9	523	3.28	555.5	4.70	15.4	13.1	33.3	0.13	8.56	0.48	57
FRAME 1FR-11.4 CM		1.42	47.83	12.29	81.5	84	39.0	12.3	493	3.24	539.7	4.63	26.2	13.1	33.5	0.11	8.44	0.47	56
FRAME 1FR-11.6 CM		1.41	47.83	12.43	80.6	78	39.0	11.7	481	3.19	449.3	4.40	15.1	12.7	33.0	0.11	7.67	0.48	55
FRAME 1FR-11.8 CM		1.17	49.10	11.41	78.8	68	40.4	11.9	491	3.18	310.6	4.24	11.3	13.1	32.3	0.13	6.30	0.48	56
FRAME 1FR-12.0 CM		1.03	49.38	10.93	82.5	82	42.9	12.5	509	3.28	261.7	4.21	10.6	13.3	33.4	0.12	5.74	0.47	59
FRAME 1FR-12.2 CM		1.25	50.86	11.07	83.5	73	43.1	12.7	506	3.26	262.9	4.44	11.7	13.5	33.0	0.09	5.87	0.51	58
FRAME 1FR-12.4 CM		1.25	51.04	11.67	89.2	98	41.7	13.1	495	3.27	275.8	4.56	13.5	13.7	36.1	0.10	6.84	0.50	60
FRAME 1FR-12.6 CM		1.37	50.71	11.03	82.3	86	42.2	13.4	505	3.18	298.8	4.63	12.1	13.8	34.7	0.14	6.41	0.47	58
FRAME 1FR-12.8 CM		1.35	50.94	10.51	84.0	86	40.4	12.0	501	3.15	289.7	4.54	13.4	13.1	33.6	0.14	6.09	0.46	58
FRAME 1FR-13.0 CM		1.37	53.59	10.62	85.3	86	43.1	12.7	505	3.15	329.6	4.74	12.2	12.8	33.5	0.13	6.28	0.46	57
FRAME 1FR-13.2 CM		1.51	48.65	10.40	82.3	77	38.6	12.6	474	3.02	394.4	4.94	8.6	11.8	31.9	0.13	6.60	0.45	54
FRAME 1FR-13.4 CM		1.86	48.90	9.90	75.8	71	37.8	11.8	474	2.89	448.2	5.11	16.2	10.6	32.6	0.13	7.50	0.46	52
FRAME 1FR-13.6 CM		2.07	49.98	10.02	77.0	86	36.7	10.9	440	2.72	503.0	5.15	17.9	9.3	33.3	0.15	8.78	0.39	49
FRAME 1FR-13.8 CM		2.27	49.38	10.02	81.0	76	34.7	10.3	411	2.59	517.9	5.44	25.3	8.0	32.7	0.13	10.21	0.37	46
FRAME 1FR-14.0 CM		2.40	58.04	10.10	82.7	78	35.6	10.9	430	2.56	550.4	5.78	18.7	8.7	33.4	0.21	8.42	0.35	47
FRAME 1FR-14.2 CM		2.40	55.07	10.05	78.9	95	33.3	10.4	419	2.49	578.7	5.84	25.6	8.4	35.7	0.18	9.20	0.35	45
FRAME 1FR-14.4 CM		2.53	56.69	10.15	87.6	110	33.2	9.7	422	2.28	589.8	6.11	29.0	7.6	35.0	0.21	9.92	0.35	42
FRAME 1FR-14.6 CM		2.48	53.27	9.43	76.8	95	32.1	9.7	385	2.19	558.1	5.80	33.6	7.1	34.7	0.27	9.16	0.29	41
FRAME 1FR-15.0 CM		2.81	51.54	9.12	77.8	98	26.8	8.6	362	1.94	688.1	5.84	25.4	5.8	34.3	0.27	10.54	0.26	35

Supplementary Table 1-1 (cont.)

	Analyte	Mo	Cu	Pb	Zn	Ag	Ni	Co	Mn	Fe	As	U	Au	Th	Sr	Cd	Sb	Bi	V
	Unit	PPM	PPM	PPM	PPM	PPB	PPM	PPM	PPM	%	PPM	PPM	PPB	PPM	PPM	PPM	PPM	PPM	PPM
Lab ID (depth)	MDL	0.01	0.01	0.01	0.1	2	0.1	0.1	1	0.01	0.1	0.05	0.2	0.1	0.5	0.01	0.02	0.02	2
FRAME 1FR-15.2 CM		2.92	52.05	9.21	81.0	105	27.0	8.3	356	1.98	616.0	6.07	24.6	5.2	36.2	0.27	10.84	0.27	35
FRAME 1FR-15.4 CM		2.64	49.04	8.33	74.7	91	24.8	7.9	334	1.90	555.9	5.37	20.8	5.0	36.0	0.28	10.50	0.23	32
FRAME 1FR-15.6 CM		2.47	48.16	7.74	74.6	87	25.0	7.8	327	1.90	488.1	5.02	20.9	5.6	32.9	0.29	9.52	0.24	31
FRAME 1FR-15.8 CM		2.46	47.98	7.80	76.9	104	25.1	7.6	349	1.95	480.2	5.43	24.4	5.8	33.9	0.34	10.13	0.23	31
FRAME 1FR-16.0 CM		2.69	49.20	7.70	85.1	91	25.5	8.7	385	2.00	452.8	5.96	18.5	6.5	36.4	0.34	10.15	0.25	31
FRAME 1FR-16.2 CM		2.37	46.12	7.33	76.4	86	25.5	8.1	358	2.00	392.9	5.53	25.4	6.5	33.6	0.34	8.93	0.23	32
FRAME 1FR-16.4 CM		2.30	44.47	6.44	73.5	83	23.4	8.0	383	1.83	334.1	5.35	16.8	6.5	30.0	0.32	7.72	0.21	30
FRAME 1FR-16.6 CM		2.45	45.31	7.32	77.0	83	25.5	8.2	399	1.84	308.7	5.41	15.9	7.9	31.1	0.35	7.58	0.23	30
FRAME 1FR-16.8 CM		2.78	50.10	7.98	85.1	109	29.0	9.1	436	2.15	320.4	6.09	12.9	8.4	37.0	0.34	7.65	0.26	37
FRAME 1FR-17.0 CM		2.76	54.27	7.58	85.1	99	28.9	8.8	440	2.08	289.8	6.04	11.1	9.0	33.2	0.36	6.90	0.26	36
FRAME 1FR-17.2 CM		2.73	47.13	7.89	78.2	101	28.1	9.2	465	2.00	282.6	6.66	14.1	9.1	33.3	0.37	6.72	0.27	35
FRAME 1FR-17.4 CM		2.73	50.02	7.32	82.3	94	28.6	8.9	432	2.06	251.2	5.98	11.6	8.6	33.3	0.31	5.71	0.25	36
FRAME 1FR-17.6 CM		3.15	51.04	8.16	87.0	105	31.5	10.2	484	2.11	261.1	7.28	17.1	9.6	35.7	0.36	5.86	0.30	38
FRAME 1FR-17.8 CM		3.59	56.39	8.51	91.0	112	32.9	10.1	519	2.25	270.9	7.92	9.1	10.3	39.0	0.42	6.13	0.30	39
FRAME 1FR-18.0 CM		3.61	50.50	7.73	89.4	107	30.0	9.7	491	2.19	237.9	7.55	5.3	9.2	37.1	0.41	5.69	0.26	38
FRAME 1FR-18.2 CM		4.00	53.68	7.79	92.1	99	34.3	11.0	534	2.24	232.6	7.85	4.8	9.9	38.1	0.41	5.36	0.27	37
FRAME 1FR-18.4 CM		3.73	51.81	7.70	88.1	94	35.7	10.3	495	2.36	233.9	7.53	5.7	9.4	36.3	0.41	5.09	0.28	38
FRAME 1FR-18.6 CM		4.22	50.84	7.30	85.2	106	33.5	9.3	464	2.41	227.4	7.39	4.9	8.7	38.0	0.37	4.94	0.26	38
FRAME 1FR-18.8 CM		4.60	52.59	7.78	82.8	101	32.1	9.7	505	2.56	225.0	7.65	5.0	8.9	35.9	0.52	4.42	0.29	38
FRAME 1FR-19.0 CM		4.23	50.10	7.48	79.6	99	32.6	8.6	509	2.65	219.6	7.52	4.3	8.8	36.3	0.41	3.98	0.29	39
FRAME 1FR-19.2 CM		4.72	51.42	7.69	85.0	115	32.7	9.6	530	2.70	227.1	7.51	3.3	9.1	36.7	0.40	4.38	0.27	38
FRAME 1FR-19.4 CM		4.81	51.02	7.87	84.8	102	34.0	9.6	533	3.01	204.1	8.09	3.5	9.5	37.1	0.40	3.87	0.30	40
FRAME 1FR-19.6 CM		5.31	54.26	8.25	85.0	102	36.9	10.0	541	3.35	198.7	8.45	4.7	11.1	41.2	0.47	4.04	0.31	40
FRAME 1FR-19.8 CM		5.07	53.82	7.47	82.8	104	35.2	10.6	538	3.47	204.2	8.30	5.3	10.4	39.0	0.35	3.93	0.27	40
FRAME 1FR-20.0 CM		5.28	50.64	7.08	86.5	104	35.2	9.6	513	3.44	191.9	8.14	3.2	10.4	39.7	0.40	3.76	0.27	40
FRAME 1FR-20.2 CM		5.28	49.78	7.33	86.9	95	35.2	10.3	560	3.06	198.4	8.24	3.8	10.4	39.5	0.35	3.14	0.28	42
FRAME 1FR-20.5 CM		5.03	51.91	7.70	90.2	107	34.2	10.3	561	3.14	191.5	7.70	3.7	9.9	40.0	0.38	3.02	0.30	42
FRAME 1FR-21.0 CM		4.24	48.92	7.27	80.8	101	32.8	9.9	530	3.23	193.1	7.72	3.7	10.3	38.2	0.39	2.74	0.28	41
FRAME 1FR-21.5 CM		4.33	47.70	7.63	77.2	100	33.3	9.7	524	3.24	192.6	8.17	2.6	10.1	35.9	0.35	2.41	0.28	41
FRAME 1FR-22.0 CM		5.17	45.87	7.40	73.1	100	32.3	9.6	538	2.96	176.6	7.49	3.7	9.8	37.0	0.35	2.54	0.34	39
FRAME 1FR-22.5 CM		4.95	44.61	7.30	77.8	100	32.9	10.0	572	2.92	167.5	7.52	2.9	10.3	37.6	0.41	2.12	0.34	40
FRAME 1FR-23.0 CM		5.25	48.17	7.10	83.4	107	34.7	11.6	571	3.97	228.7	7.11	2.4	9.2	37.0	0.45	2.92	0.32	39
FRAME 1FR-23.5 CM		4.91	49.33	7.86	91.5	109	35.1	10.7	608	3.11	222.1	7.49	7.5	10.1	42.4	0.47	2.43	0.34	40
FRAME 1FR-24.0 CM		4.85	52.84	7.66	92.8	104	33.3	10.8	621	2.60	199.2	6.94	2.8	9.2	43.9	0.47	1.69	0.30	41
FRAME 1FR-24.5 CM		3.74	48.71	7.45	92.5	99	32.8	10.6	641	2.41	187.5	6.53	4.6	9.2	41.7	0.42	1.36	0.32	41

Supplementary Table 1-1 (cont.)

	Analyte	Mo	Cu	Pb	Zn	Ag	Ni	Co	Mn	Fe	As	U	Au	Th	Sr	Cd	Sb	Bi	V
	Unit	PPM	PPM	PPM	PPM	PPB	PPM	PPM	PPM	%	PPM	PPM	PPB	PPM	PPM	PPM	PPM	PPM	PPM
Lab ID (depth)	**MDL**	0.01	0.01	0.01	0.1	2	0.1	0.1	1	0.01	0.1	0.05	0.2	0.1	0.5	0.01	0.02	0.02	2
FRAME 1FR-25.0 CM		3.25	46.82	7.41	90.4	105	32.0	10.1	631	2.19	166.4	5.81	3.0	9.2	41.2	0.45	1.04	0.32	40
FRAME 1FR-25.5 CM		3.10	43.75	6.73	85.9	90	31.5	10.0	623	2.16	143.5	5.20	2.4	9.2	40.3	0.41	0.96	0.29	38
FRAME 1FR-26.0 CM		2.81	43.78	6.70	80.3	97	29.7	10.2	587	2.13	126.1	5.17	3.6	9.3	39.1	0.47	0.84	0.27	37
FRAME 1FR-26.5 CM		2.55	47.04	6.86	85.7	107	31.6	10.1	570	2.01	125.2	5.40	2.4	9.7	40.3	0.47	0.74	0.28	38
FRAME 1FR-27.0 CM		3.12	52.58	7.50	92.4	124	33.6	11.1	584	2.07	140.0	6.48	1.8	10.3	42.1	0.46	0.91	0.32	40
FRAME 1FR-27.5 CM		4.37	50.08	7.11	87.2	100	34.1	10.8	517	2.27	147.3	7.68	1.4	9.0	40.0	0.44	1.03	0.31	37
FRAME 1FR-28.0 CM		5.82	49.13	6.43	82.5	103	36.4	10.3	482	2.44	153.1	7.77	2.6	8.6	39.7	0.51	0.98	0.28	37
FRAME 1FR-28.5 CM		4.99	48.05	6.35	78.8	93	34.7	9.5	478	2.33	139.4	7.14	1.6	8.0	37.8	0.43	0.88	0.28	35
FRAME 1FR-29.0 CM		4.31	50.90	6.17	77.1	101	34.9	9.8	457	2.21	125.9	6.79	0.9	7.9	37.1	0.44	0.75	0.27	35
FRAME 1FR-29.5 CM		4.04	50.96	6.16	76.9	231	32.6	9.1	495	2.04	121.4	7.30	2.7	7.6	39.5	0.47	0.78	0.26	35
FRAME 1FR-30.0 CM		4.69	56.13	6.80	86.8	110	37.8	10.3	501	2.32	121.5	7.82	2.2	8.4	40.3	0.47	0.74	0.32	37
FRAME 1FR-30.5 CM		5.96	56.09	7.15	90.5	105	34.1	10.3	450	2.25	111.7	7.19	3.0	8.6	36.1	0.50	0.67	0.30	36
FRAME 1FR-31.0 CM		5.56	52.31	7.24	90.2	118	37.1	10.3	469	2.31	106.6	6.89	25.6	9.0	37.7	0.48	0.70	0.30	38
FRAME 1FR-31.5 CM		4.48	51.01	7.45	85.4	98	36.7	10.6	472	2.26	98.9	6.89	3.1	9.2	37.9	0.48	0.59	0.33	39
FRAME 1FR-32.0 CM		4.87	53.70	7.53	88.2	110	36.7	10.4	477	2.28	91.6	6.51	2.0	9.8	37.6	0.54	0.60	0.33	40
FRAME 1FR-32.5 CM		4.65	50.38	7.57	82.3	113	35.9	11.1	488	2.39	88.5	6.84	1.0	10.2	37.0	0.47	0.58	0.33	42
FRAME 1FR-33.0 CM		4.71	50.94	8.04	82.6	114	37.6	11.6	483	2.50	84.5	6.85	7.3	10.6	37.0	0.48	0.58	0.33	43
FRAME 1FR-33.5 CM		4.04	50.49	8.05	79.4	113	37.7	11.2	491	2.61	80.3	6.66	1.7	10.8	36.0	0.47	0.55	0.35	43
FRAME 1FR-34.0 CM		3.80	50.64	8.43	83.8	122	38.0	11.5	476	2.87	79.0	6.10	2.5	10.8	35.9	0.42	0.55	0.34	42
FRAME 1FR-34.5 CM		3.57	45.54	8.07	81.0	98	39.3	12.1	459	3.11	85.4	5.71	2.2	10.6	33.4	0.40	0.53	0.32	42
FRAME 1FR-35.0 CM		2.85	41.76	7.82	77.1	99	37.3	11.9	434	2.92	71.4	5.34	0.6	10.5	33.9	0.34	0.49	0.33	41
FRAME 1FR-35.5 CM		2.83	45.39	8.45	79.6	106	37.5	12.4	467	3.02	75.7	5.46	0.4	11.3	35.3	0.40	0.53	0.35	44
FRAME 1FR-36.0 CM		2.54	44.86	8.47	81.3	107	39.5	12.6	487	2.80	67.4	4.83	0.5	11.1	36.3	0.40	0.47	0.34	45
FRAME 1FR-36.5 CM		2.23	45.90	8.81	83.6	113	39.4	12.9	493	2.68	57.9	4.36	1.0	11.7	37.0	0.43	0.44	0.36	46
FRAME 1FR-37.0 CM		2.14	43.44	8.68	83.4	112	37.5	12.8	476	2.72	59.8	3.81	1.3	11.2	36.2	0.35	0.42	0.34	46
FRAME 1FR-37.5 CM		1.93	44.71	9.22	82.4	111	38.7	12.7	470	2.64	53.3	3.44	1.5	11.7	35.1	0.37	0.40	0.36	46
FRAME 1FR-38.0 CM		1.82	41.44	8.61	79.4	110	35.8	12.5	461	2.52	45.5	3.13	4.2	11.4	35.4	0.36	0.36	0.36	46
FRAME 1FR-38.5 CM		1.68	42.09	8.95	77.5	100	36.3	12.3	450	2.52	42.1	3.07	1.4	11.3	35.5	0.33	0.38	0.35	46
FRAME 1FR-39.0 CM		1.63	42.57	8.79	76.1	93	36.0	12.6	444	2.61	41.1	2.96	0.7	11.7	33.8	0.32	0.35	0.36	46
FRAME 1FR-39.5 CM		1.56	42.43	8.77	78.7	103	36.1	12.7	444	2.56	35.3	2.93	<0.2	11.3	34.3	0.29	0.34	0.36	45
FRAME 1FR-40.0 CM		1.32	39.77	8.42	73.3	80	32.6	12.2	423	2.50	30.6	2.92	4.0	11.2	30.6	0.31	0.35	0.36	44
FRAME 1FR-40.5 CM		1.38	42.43	8.86	76.4	89	36.2	12.4	419	2.62	26.6	3.10	4.4	12.0	33.3	0.36	0.30	0.36	47
FRAME 1FR-41.0 CM		1.32	43.24	9.72	81.5	102	36.9	12.8	423	2.74	26.0	3.35	2.6	12.9	33.0	0.34	0.33	0.43	48
FRAME 1FR-41.5 CM		1.33	45.44	9.42	79.6	103	39.9	13.7	397	2.72	24.5	3.48	2.6	12.6	31.9	0.34	0.34	0.38	47
FRAME 1FR-42.0 CM		1.48	45.98	9.57	75.6	141	35.4	12.6	382	2.65	21.1	3.72	2.2	12.6	33.1	0.31	0.36	0.39	46

Supplementary Table 1-1 (cont.)

	Analyte	Mo	Cu	Pb	Zn	Ag	Ni	Co	Mn	Fe	As	U	Au	Th	Sr	Cd	Sb	Bi	V
	Unit	PPM	PPM	PPM	PPM	PPB	PPM	PPM	PPM	%	PPM	PPM	PPB	PPM	PPM	PPM	PPM	PPM	PPM
Lab ID (depth)	**MDL**	0.01	0.01	0.01	0.1	2	0.1	0.1	1	0.01	0.1	0.05	0.2	0.1	0.5	0.01	0.02	0.02	2
FRAME 1FR-42.5 CM		1.62	45.89	9.20	73.6	98	34.7	12.3	369	2.54	17.7	3.71	2.3	12.2	31.7	0.40	0.41	0.37	44
FRAME 1FR-43.0 CM		1.88	47.99	9.51	75.7	103	37.0	13.4	366	2.66	20.5	4.14	2.0	12.3	30.3	0.35	0.47	0.39	45
FRAME 1FR-43.5 CM		2.07	49.97	9.46	74.0	98	38.9	13.3	362	2.76	23.3	4.32	2.9	11.6	30.1	0.52	0.44	0.40	45
FRAME 1FR-44.0 CM		2.26	47.58	9.32	73.8	94	37.3	13.6	353	2.72	20.8	4.31	3.0	11.1	28.3	0.41	0.48	0.38	43
FRAME 1FR-44.5 CM		3.29	49.66	8.84	70.0	93	39.0	13.9	359	2.90	20.2	5.18	3.2	11.0	28.3	0.44	0.53	0.36	43
FRAME 1FR-45.0 CM		3.97	52.50	9.59	71.9	102	41.9	14.6	365	2.99	23.0	5.89	3.9	11.7	30.4	0.54	0.57	0.36	45
FRAME 1FR-45.5 CM		4.22	55.15	9.59	75.0	138	42.7	14.4	378	3.12	21.0	5.85	2.0	11.8	30.6	0.51	0.58	0.39	45
FRAME 1FR-46.0 CM		4.15	53.29	10.03	77.6	109	43.6	14.3	389	3.29	18.9	5.77	1.6	12.2	31.6	0.49	0.56	0.38	46
FRAME 1FR-46.5 CM		5.04	48.50	9.69	73.4	101	43.1	14.5	381	3.28	17.9	5.74	2.8	11.9	30.9	0.54	0.57	0.36	45
FRAME 1FR-47.0 CM		4.47	46.62	9.68	74.2	101	41.9	14.7	381	3.22	16.0	5.28	1.9	12.2	31.6	0.47	0.51	0.39	46
FRAME 1FR-47.5 CM		3.90	44.02	9.60	74.4	88	40.2	13.4	358	3.05	14.6	5.37	1.5	12.4	30.9	0.37	0.54	0.38	45
FRAME 1FR-48.0 CM		3.87	43.93	8.91	69.4	96	37.3	13.4	345	2.92	12.8	5.15	1.1	11.6	29.8	0.46	0.53	0.34	45
FRAME 1FR-48.5 CM		2.84	42.97	8.84	68.8	96	36.8	13.4	324	2.95	15.5	4.67	1.7	11.4	28.9	0.43	0.60	0.34	42
FRAME 1FR-49.0 CM		2.81	43.52	9.02	66.3	103	36.2	12.8	322	3.27	18.0	4.61	4.2	11.3	27.5	0.39	0.58	0.35	42
FRAME 1FR-49.5 CM		2.76	43.93	9.08	70.2	99	39.0	12.8	328	3.44	17.3	4.55	2.4	11.9	30.1	0.43	0.54	0.36	43
FRAME 1FR-50.0 CM		2.82	43.55	9.31	70.2	103	37.7	12.4	345	3.32	15.6	4.25	1.5	12.1	29.5	0.38	0.58	0.37	44
FRAME 1FR-50.5 CM		2.70	42.22	9.36	71.9	106	38.4	12.1	329	3.19	14.2	4.19	2.0	12.2	30.2	0.35	0.54	0.35	44
FRAME 1FR-51.0 CM		2.59	41.69	9.49	72.5	95	37.7	12.6	336	3.19	13.4	4.08	2.2	12.7	31.2	0.37	0.44	0.39	45
FRAME 1FR-51.5 CM		2.25	40.60	9.82	75.0	108	38.2	11.8	338	3.15	11.9	3.86	2.0	12.7	31.9	0.37	0.43	0.37	45
FRAME 1FR-52.0 CM		2.06	40.00	9.46	73.0	98	36.6	12.1	330	3.03	11.4	3.55	2.5	12.8	30.6	0.33	0.46	0.36	45
FRAME 1FR-52.5 CM		1.94	41.26	9.58	71.0	99	37.4	12.7	332	3.07	12.9	3.42	2.7	12.8	31.8	0.40	0.47	0.34	44
FRAME 1FR-53.0 CM		1.76	37.27	9.13	67.0	83	35.2	11.3	331	3.10	11.9	3.06	0.7	12.3	30.1	0.31	0.38	0.34	43
FRAME 1FR-53.5 CM		1.65	35.55	8.82	67.1	82	34.4	11.3	305	2.97	11.4	3.07	3.2	12.0	27.6	0.28	0.38	0.32	42
FRAME 1FR-54.0 CM		1.68	34.67	8.85	67.1	93	34.6	11.5	311	2.94	11.9	3.08	7.1	12.1	28.4	0.35	0.35	0.33	42
FRAME 1FR-54.5 CM		1.79	34.88	9.02	66.7	83	35.2	11.6	301	3.05	14.1	3.06	3.3	12.7	29.3	0.28	0.34	0.32	42
FRAME 1FR-55.0 CM		1.58	31.89	8.88	66.3	78	32.4	10.8	288	2.93	13.8	2.88	0.8	13.0	27.1	0.28	0.36	0.31	40
FRAME 1FR-55.5 CM		1.76	32.80	8.89	65.1	89	35.1	10.8	296	3.07	14.1	2.75	1.5	12.5	28.0	0.33	0.36	0.32	42
FRAME 1FR-56.0 CM		1.55	32.53	8.72	64.0	79	33.9	11.6	298	2.96	15.2	2.54	1.4	12.3	28.3	0.29	0.33	0.31	40
FRAME 1FR-56.5 CM		1.37	31.95	9.23	64.9	81	35.8	12.0	296	2.91	15.6	2.57	1.4	12.7	29.6	0.24	0.38	0.33	42
FRAME 1FR-57.0 CM		1.45	31.21	9.41	65.4	86	34.0	11.7	313	2.86	12.7	2.60	1.9	12.6	29.6	0.28	0.36	0.30	42
FRAME 1FR-57.5 CM		1.37	32.04	9.80	67.8	89	33.7	11.2	308	2.74	9.8	2.69	1.1	13.1	31.1	0.32	0.32	0.33	43
FRAME 1FR-58.0 CM		1.33	32.80	9.92	66.7	90	31.9	11.3	309	2.78	9.1	2.73	1.5	14.1	29.8	0.32	0.24	0.30	44
FRAME 1FR-58.5 CM		1.35	32.68	9.73	71.8	80	33.0	11.5	336	2.71	8.4	2.71	<0.2	13.8	31.2	0.27	0.23	0.30	45
FRAME 1FR-59.0 CM		1.44	32.84	11.00	71.6	97	35.4	12.8	323	2.76	11.1	2.91	1.8	15.3	32.9	0.31	0.24	0.32	46
FRAME 1FR-59.5 CM		1.28	35.06	10.55	70.0	87	34.3	12.6	316	2.76	9.4	2.72	2.1	14.7	33.5	0.29	0.24	0.31	46
FRAME 1FR-60.0 CM		1.25	35.41	10.42	72.7	95	33.6	11.5	328	2.70	8.2	2.97	4.7	15.5	33.9	0.30	0.24	0.30	46

Supplementary Table 1-2 (cont.)

Analyte	Ca	P	La	Cr	Mg	Ba	Ti	B	Al	Na	K	W	Sc	Tl	S	Hg	Se	Te
Unit	%	%	PPM	PPM	%	PPM	%	PPM	%	%	%	PPM	PPM	PPM	%	PPB	PPM	PPM
Lab ID (depth) MDL	0.01	0.001	0.5	0.5	0.01	0.5	0.001	20	0.01	0.001	0.01	0.05	0.1	0.02	0.02	5	0.1	0.02
FRAME 1FR-3.5 CM	0.89	0.082	20.3	48.5	0.94	165.8	0.054	27	1.59	0.085	0.34	0.95	4.4	0.25	0.57	110	0.7	<0.02
FRAME 1FR-4.5 CM	0.85	0.074	19.4	43.9	0.86	147.0	0.051	<20	1.51	0.079	0.32	0.75	3.9	0.24	0.66	96	0.7	<0.02
FRAME 1FR-5.0 CM	0.89	0.075	19.0	40.7	0.83	147.9	0.048	<20	1.45	0.101	0.31	0.85	3.7	0.22	0.78	132	0.5	0.05
FRAME 1FR-6.0 CM	0.79	0.066	20.9	44.8	0.87	172.1	0.055	<20	1.58	0.075	0.35	0.85	4.1	0.24	0.79	98	0.3	0.05
FRAME 1FR-6.5 CM	0.75	0.066	21.0	52.4	0.94	189.2	0.058	<20	1.74	0.071	0.38	0.46	4.7	0.26	0.83	111	0.6	<0.02
FRAME 1FR-7.0 CM	0.73	0.064	22.7	48.0	1.00	201.0	0.063	<20	1.86	0.070	0.41	0.88	5.0	0.26	0.83	108	0.6	0.04
FRAME 1FR-7.5 CM	0.68	0.062	23.1	50.6	1.02	209.7	0.067	<20	1.89	0.068	0.42	0.44	5.4	0.28	0.84	101	0.7	0.02
FRAME 1FR-8.0 CM	0.67	0.062	23.9	52.1	1.00	215.2	0.067	<20	1.91	0.062	0.42	0.34	5.2	0.30	0.81	102	0.6	<0.02
FRAME 1FR-8.5 CM	0.63	0.059	23.4	52.5	1.02	220.4	0.067	<20	1.96	0.058	0.43	0.26	5.2	0.29	0.82	109	0.4	<0.02
FRAME 1FR-9.0 CM	0.59	0.058	24.0	51.9	1.00	213.8	0.070	<20	1.93	0.051	0.43	0.30	5.4	0.29	0.80	67	0.6	<0.02
FRAME 1FR-9.5 CM	0.58	0.058	24.9	52.5	1.01	219.7	0.073	<20	1.96	0.047	0.43	0.26	5.7	0.29	0.86	74	0.5	<0.02
FRAME 1FR-10.0 CM	0.55	0.052	24.7	50.3	1.00	220.0	0.071	<20	1.97	0.045	0.43	0.17	5.7	0.28	0.83	48	0.5	<0.02
FRAME 1FR-10.5 CM	0.58	0.054	30.7	58.3	1.15	270.5	0.093	<20	2.35	0.045	0.51	0.22	6.8	0.34	0.73	43	0.2	<0.02
FRAME 1FR-10.6 CM	0.57	0.057	30.2	60.2	1.18	271.2	0.093	<20	2.40	0.046	0.52	0.23	7.1	0.33	0.60	43	0.3	<0.02
FRAME 1FR-11.0 CM	0.58	0.056	32.2	63.1	1.21	284.4	0.100	<20	2.52	0.047	0.54	0.22	7.6	0.36	0.58	52	0.3	<0.02
FRAME 1FR-11.2 CM	0.56	0.054	30.5	63.2	1.17	266.2	0.096	<20	2.39	0.042	0.51	0.22	7.1	0.33	0.50	42	0.2	<0.02
FRAME 1FR-11.4 CM	0.56	0.054	30.2	60.2	1.14	261.2	0.092	<20	2.33	0.042	0.51	0.15	7.1	0.31	0.47	57	0.2	0.04
FRAME 1FR-11.6 CM	0.56	0.054	30.2	60.5	1.14	263.8	0.090	<20	2.32	0.042	0.51	0.19	6.9	0.31	0.47	37	0.3	0.04
FRAME 1FR-11.8 CM	0.52	0.055	29.8	61.6	1.15	260.2	0.096	<20	2.37	0.042	0.52	0.18	7.1	0.33	0.40	30	0.2	0.03
FRAME 1FR-12.0 CM	0.56	0.056	30.7	63.8	1.23	271.6	0.102	<20	2.50	0.044	0.54	0.19	7.5	0.34	0.36	28	0.2	<0.02
FRAME 1FR-12.2 CM	0.56	0.056	30.9	65.4	1.20	268.6	0.099	<20	2.47	0.043	0.53	0.18	7.2	0.33	0.38	16	0.2	<0.02
FRAME 1FR-12.4 CM	0.62	0.060	33.2	64.7	1.19	278.1	0.113	<20	2.47	0.042	0.53	0.25	7.9	0.37	0.38	26	0.1	<0.02
FRAME 1FR-12.6 CM	0.59	0.056	31.6	63.9	1.15	273.7	0.096	<20	2.36	0.043	0.51	0.17	7.3	0.33	0.43	30	<0.1	0.04
FRAME 1FR-12.8 CM	0.59	0.058	30.1	62.9	1.19	260.0	0.095	<20	2.43	0.045	0.51	0.15	7.2	0.33	0.41	32	0.2	<0.02
FRAME 1FR-13.0 CM	0.59	0.057	30.3	63.6	1.17	252.6	0.096	<20	2.41	0.045	0.51	2.86	7.2	0.32	0.41	34	0.3	<0.02
FRAME 1FR-13.2 CM	0.58	0.056	28.8	58.5	1.11	246.5	0.087	<20	2.24	0.044	0.48	0.18	6.5	0.32	0.45	53	0.3	<0.02
FRAME 1FR-13.4 CM	0.61	0.057	28.2	58.0	1.05	242.3	0.082	<20	2.14	0.045	0.45	0.25	6.2	0.30	0.51	47	0.4	0.03
FRAME 1FR-13.6 CM	0.68	0.056	26.5	52.3	0.98	219.2	0.075	<20	1.96	0.048	0.41	0.22	5.9	0.28	0.58	40	0.4	<0.02
FRAME 1FR-13.8 CM	0.69	0.059	26.3	47.7	0.91	207.6	0.076	<20	1.81	0.050	0.39	0.28	5.8	0.27	0.63	62	0.3	0.06
FRAME 1FR-14.0 CM	0.71	0.064	24.9	53.3	0.87	183.6	0.080	21	1.70	0.056	0.37	0.24	4.9	0.23	0.69	44	0.6	<0.02
FRAME 1FR-14.2 CM	0.75	0.067	24.6	48.5	0.85	179.3	0.078	<20	1.66	0.059	0.36	0.43	5.0	0.22	0.72	59	0.7	0.02
FRAME 1FR-14.4 CM	0.77	0.064	24.3	48.9	0.78	176.3	0.074	<20	1.50	0.058	0.32	0.49	4.8	0.22	0.78	74	0.6	0.02
FRAME 1FR-14.6 CM	0.76	0.065	22.3	45.3	0.75	165.4	0.069	27	1.45	0.060	0.31	0.35	4.4	0.18	0.76	56	0.8	0.06
FRAME 1FR-15.0 CM	0.79	0.070	21.0	38.3	0.65	138.8	0.057	35	1.22	0.060	0.26	0.34	3.8	0.18	0.84	90	1.0	0.03

Supplementary Table 1-2 (cont.)

	Analyte	Ca	P	La	Cr	Mg	Ba	Ti	B	Al	Na	K	W	Sc	Tl	S	Hg	Se	Te
	Unit	%	%	PPM	PPM	%	PPM	%	PPM	%	%	%	PPM	PPM	PPM	%	PPB	PPM	PPM
Lab ID (depth)	**MDL**	0.01	0.001	0.5	0.5	0.01	0.5	0.001	20	0.01	0.001	0.01	0.05	0.1	0.02	0.02	5	0.1	0.02
FRAME 1FR-15.2 CM		0.82	0.069	20.5	33.7	0.63	136.7	0.055	34	1.18	0.063	0.25	0.39	3.7	0.16	0.97	103	1.0	<0.02
FRAME 1FR-15.4 CM		0.80	0.063	19.7	31.5	0.58	125.2	0.051	22	1.09	0.059	0.23	0.35	3.4	0.15	1.05	102	1.1	0.03
FRAME 1FR-15.6 CM		0.78	0.060	18.8	34.1	0.58	125.4	0.049	20	1.08	0.058	0.22	0.34	3.1	0.15	1.05	68	1.0	<0.02
FRAME 1FR-15.8 CM		0.78	0.052	21.1	31.1	0.57	115.4	0.049	<20	1.06	0.059	0.22	0.37	3.3	0.16	1.12	109	1.3	<0.02
FRAME 1FR-16.0 CM		0.79	0.065	21.8	34.3	0.56	125.5	0.049	39	1.04	0.057	0.21	0.47	3.6	0.16	1.20	89	1.2	0.04
FRAME 1FR-16.2 CM		0.76	0.054	21.7	31.4	0.56	112.2	0.049	<20	1.04	0.052	0.21	0.36	3.3	0.15	1.15	58	1.4	0.05
FRAME 1FR-16.4 CM		0.71	0.052	20.6	29.5	0.52	107.4	0.047	22	0.96	0.046	0.19	0.37	3.4	0.14	1.01	71	1.1	<0.02
FRAME 1FR-16.6 CM		0.71	0.049	23.9	31.3	0.53	115.4	0.047	<20	1.00	0.046	0.20	0.38	3.5	0.15	0.97	68	1.2	<0.02
FRAME 1FR-16.8 CM		0.80	0.050	25.6	35.3	0.64	130.4	0.058	<20	1.20	0.051	0.23	0.35	3.8	0.16	1.04	69	1.4	0.03
FRAME 1FR-17.0 CM		0.77	0.050	25.8	35.6	0.62	124.5	0.056	<20	1.16	0.049	0.23	0.65	4.3	0.16	0.99	38	1.5	<0.02
FRAME 1FR-17.2 CM		0.75	0.047	26.2	36.2	0.60	129.0	0.056	<20	1.12	0.047	0.22	0.36	4.1	0.17	0.97	40	1.5	0.06
FRAME 1FR-17.4 CM		0.76	0.047	25.1	34.0	0.62	125.3	0.054	<20	1.17	0.050	0.23	0.34	4.1	0.18	0.96	38	1.5	<0.02
FRAME 1FR-17.6 CM		0.78	0.051	26.7	38.1	0.65	135.6	0.052	<20	1.20	0.051	0.23	0.39	3.9	0.18	1.06	44	1.6	<0.02
FRAME 1FR-17.8 CM		0.88	0.051	30.5	36.3	0.64	132.7	0.058	21	1.19	0.052	0.23	0.54	4.5	0.20	1.30	30	2.1	<0.02
FRAME 1FR-18.0 CM		0.83	0.051	27.9	34.6	0.61	123.2	0.054	24	1.11	0.051	0.21	0.54	3.9	0.17	1.30	37	2.3	0.04
FRAME 1FR-18.2 CM		0.84	0.048	30.5	37.2	0.60	132.7	0.054	27	1.10	0.051	0.21	0.51	4.2	0.20	1.42	51	2.3	<0.02
FRAME 1FR-18.4 CM		0.84	0.046	29.1	36.8	0.67	126.1	0.054	<20	1.19	0.050	0.22	0.42	4.2	0.17	1.38	30	2.0	<0.02
FRAME 1FR-18.6 CM		0.85	0.046	29.2	32.3	0.63	121.4	0.054	<20	1.16	0.051	0.22	0.50	4.0	0.19	1.51	49	2.0	<0.02
FRAME 1FR-18.8 CM		0.85	0.047	28.6	35.7	0.64	133.0	0.052	<20	1.20	0.050	0.21	0.56	4.0	0.18	1.65	30	2.4	<0.02
FRAME 1FR-19.0 CM		0.85	0.048	28.7	34.4	0.65	122.2	0.052	<20	1.22	0.049	0.22	0.53	3.9	0.18	1.71	40	2.6	<0.02
FRAME 1FR-19.2 CM		0.83	0.046	30.0	37.8	0.63	135.4	0.057	<20	1.17	0.049	0.22	0.51	3.9	0.18	1.82	28	2.7	<0.02
FRAME 1FR-19.4 CM		0.85	0.044	28.3	36.2	0.65	128.8	0.055	<20	1.23	0.048	0.22	0.49	4.0	0.19	2.12	43	2.6	<0.02
FRAME 1FR-19.6 CM		0.90	0.051	32.0	37.7	0.66	136.0	0.062	<20	1.26	0.048	0.23	0.55	4.5	0.21	2.46	18	2.7	<0.02
FRAME 1FR-19.8 CM		0.89	0.051	30.8	38.3	0.66	137.6	0.060	22	1.25	0.048	0.23	0.53	4.5	0.18	2.58	29	2.5	<0.02
FRAME 1FR-20.0 CM		0.89	0.051	31.5	36.8	0.65	134.0	0.060	<20	1.24	0.048	0.23	0.62	4.6	0.17	2.58	21	2.5	<0.02
FRAME 1FR-20.2 CM		0.90	0.045	30.8	38.5	0.68	137.9	0.056	<20	1.30	0.050	0.23	0.49	4.4	0.18	2.15	43	2.7	<0.02
FRAME 1FR-20.5 CM		0.88	0.048	30.3	36.2	0.67	126.4	0.057	<20	1.27	0.050	0.23	0.61	4.4	0.18	2.24	31	2.7	0.02
FRAME 1FR-21.0 CM		0.90	0.048	30.2	35.4	0.67	138.3	0.054	<20	1.26	0.051	0.22	0.61	4.3	0.17	2.38	40	2.9	<0.02
FRAME 1FR-21.5 CM		0.85	0.046	28.4	34.8	0.64	129.1	0.055	<20	1.21	0.048	0.21	0.62	4.2	0.18	2.38	26	2.9	<0.02
FRAME 1FR-22.0 CM		0.85	0.043	29.6	36.2	0.67	135.2	0.052	<20	1.28	0.042	0.24	0.65	4.1	0.21	2.05	17	1.6	<0.02
FRAME 1FR-22.5 CM		0.90	0.043	29.8	36.4	0.70	146.7	0.052	<20	1.33	0.044	0.24	0.68	4.2	0.19	1.93	28	1.8	<0.02
FRAME 1FR-23.0 CM		0.92	0.044	29.5	35.2	0.65	135.1	0.047	<20	1.26	0.043	0.22	0.63	4.3	0.21	3.30	44	2.4	<0.02
FRAME 1FR-23.5 CM		0.99	0.044	33.2	35.7	0.68	150.9	0.048	<20	1.30	0.047	0.23	0.65	4.4	0.21	2.24	48	2.3	<0.02
FRAME 1FR-24.0 CM		1.02	0.044	33.3	37.0	0.67	145.6	0.047	<20	1.28	0.047	0.23	0.75	4.1	0.19	1.68	39	2.1	<0.02
FRAME 1FR-24.5 CM		1.02	0.042	32.4	38.5	0.67	148.8	0.047	<20	1.31	0.046	0.23	0.77	4.2	0.19	1.35	39	1.8	0.03

Supplementary Table 1-2 (cont.)

	Analyte	Ca	P	La	Cr	Mg	Ba	Ti	B	Al	Na	K	W	Sc	Tl	S	Hg	Se	Te
	Unit	%	%	PPM	PPM	%	PPM	%	PPM	%	%	%	PPM	PPM	PPM	%	PPB	PPM	PPM
Lab ID (depth)	MDL	0.01	0.001	0.5	0.5	0.01	0.5	0.001	20	0.01	0.001	0.01	0.05	0.1	0.02	0.02	5	0.1	0.02
FRAME 1FR-25.0 CM		1.00	0.044	33.1	34.1	0.66	141.2	0.047	<20	1.30	0.045	0.23	0.64	4.2	0.17	0.97	29	1.4	0.03
FRAME 1FR-25.5 CM		0.93	0.043	33.5	34.8	0.65	138.9	0.047	<20	1.26	0.044	0.23	0.62	4.1	0.17	0.85	22	1.5	<0.02
FRAME 1FR-26.0 CM		0.90	0.043	33.5	35.5	0.66	133.1	0.048	<20	1.29	0.043	0.23	0.57	4.2	0.18	0.82	11	1.6	<0.02
FRAME 1FR-26.5 CM		0.94	0.047	34.2	36.8	0.68	149.2	0.049	<20	1.31	0.045	0.24	0.62	4.3	0.17	0.74	32	1.3	0.03
FRAME 1FR-27.0 CM		0.99	0.049	32.2	36.1	0.71	147.9	0.050	<20	1.35	0.052	0.25	0.56	4.5	0.21	0.88	31	1.4	<0.02
FRAME 1FR-27.5 CM		0.93	0.045	27.2	33.7	0.63	132.9	0.045	<20	1.22	0.047	0.22	0.69	4.0	0.19	1.47	27	1.9	<0.02
FRAME 1FR-28.0 CM		0.93	0.045	25.4	32.2	0.61	129.1	0.043	<20	1.13	0.050	0.21	0.65	3.7	0.20	1.79	39	1.7	<0.02
FRAME 1FR-28.5 CM		0.89	0.044	23.7	31.0	0.58	122.3	0.042	<20	1.08	0.048	0.20	0.65	3.4	0.18	1.74	43	2.1	<0.02
FRAME 1FR-29.0 CM		0.90	0.043	23.3	31.1	0.59	120.4	0.041	<20	1.08	0.050	0.21	0.55	3.6	0.16	1.60	39	1.9	<0.02
FRAME 1FR-29.5 CM		1.00	0.091	38.1	28.3	0.56	131.5	0.040	<20	1.05	0.049	0.20	0.62	3.6	0.18	1.46	56	1.7	<0.02
FRAME 1FR-30.0 CM		0.95	0.090	37.6	30.4	0.58	136.5	0.043	<20	1.13	0.050	0.21	0.68	3.9	0.19	1.67	52	2.2	<0.02
FRAME 1FR-30.5 CM		0.86	0.043	26.8	30.9	0.60	125.0	0.043	<20	1.13	0.049	0.22	0.72	3.9	0.20	1.57	48	1.7	<0.02
FRAME 1FR-31.0 CM		0.88	0.046	27.0	33.4	0.62	130.7	0.045	<20	1.20	0.051	0.23	0.65	4.1	0.20	1.56	60	1.6	<0.02
FRAME 1FR-31.5 CM		0.85	0.046	29.1	35.4	0.64	135.0	0.046	<20	1.26	0.050	0.23	0.58	4.0	0.19	1.37	43	1.8	<0.02
FRAME 1FR-32.0 CM		0.84	0.046	30.0	36.1	0.68	144.5	0.050	<20	1.33	0.048	0.25	0.62	4.4	0.21	1.25	44	1.7	0.03
FRAME 1FR-32.5 CM		0.81	0.047	33.1	38.0	0.72	145.4	0.053	<20	1.42	0.046	0.27	0.55	4.6	0.21	1.21	39	1.4	<0.02
FRAME 1FR-33.0 CM		0.79	0.046	33.1	38.5	0.73	145.0	0.054	<20	1.45	0.045	0.27	0.52	4.5	0.20	1.28	25	1.4	<0.02
FRAME 1FR-33.5 CM		0.76	0.045	34.1	38.9	0.74	149.1	0.056	<20	1.49	0.042	0.28	0.66	4.8	0.24	1.32	29	1.6	0.05
FRAME 1FR-34.0 CM		0.71	0.044	34.1	39.1	0.76	152.7	0.059	<20	1.49	0.040	0.28	0.71	4.8	0.24	1.50	55	1.6	0.06
FRAME 1FR-34.5 CM		0.68	0.047	33.7	40.7	0.76	152.8	0.059	<20	1.50	0.036	0.29	0.59	4.5	0.22	1.69	45	1.7	<0.02
FRAME 1FR-35.0 CM		0.63	0.041	33.6	39.0	0.75	148.1	0.058	<20	1.50	0.037	0.29	0.47	4.5	0.22	1.44	20	1.9	<0.02
FRAME 1FR-35.5 CM		0.69	0.044	34.9	41.3	0.79	163.4	0.062	<20	1.55	0.039	0.30	0.38	5.1	0.24	1.48	30	1.9	<0.02
FRAME 1FR-36.0 CM		0.70	0.042	33.3	42.2	0.79	157.2	0.063	<20	1.58	0.039	0.30	0.35	5.1	0.23	1.18	24	1.5	<0.02
FRAME 1FR-36.5 CM		0.71	0.045	35.1	43.8	0.82	162.7	0.066	<20	1.63	0.041	0.32	0.48	5.2	0.24	0.86	31	1.5	0.02
FRAME 1FR-37.0 CM		0.67	0.045	35.6	42.6	0.82	161.4	0.064	<20	1.63	0.040	0.32	0.34	5.2	0.22	0.90	19	1.5	<0.02
FRAME 1FR-37.5 CM		0.66	0.045	36.4	44.4	0.85	156.8	0.066	<20	1.72	0.040	0.33	0.41	5.2	0.22	0.73	19	1.7	<0.02
FRAME 1FR-38.0 CM		0.62	0.043	35.8	43.5	0.83	160.5	0.065	<20	1.70	0.041	0.33	0.36	5.2	0.23	0.58	29	1.5	<0.02
FRAME 1FR-38.5 CM		0.60	0.044	36.0	42.0	0.83	157.5	0.065	<20	1.69	0.040	0.33	0.27	5.2	0.22	0.57	25	1.4	<0.02
FRAME 1FR-39.0 CM		0.58	0.044	35.1	43.7	0.85	154.9	0.066	<20	1.71	0.040	0.34	0.29	5.1	0.24	0.58	17	1.6	<0.02
FRAME 1FR-39.5 CM		0.55	0.044	34.8	43.6	0.86	151.6	0.065	<20	1.74	0.039	0.34	0.32	5.0	0.23	0.51	24	1.3	<0.02
FRAME 1FR-40.0 CM		0.53	0.041	32.4	41.3	0.85	152.5	0.068	<20	1.71	0.039	0.34	0.18	5.2	0.24	0.48	23	1.2	<0.02
FRAME 1FR-40.5 CM		0.54	0.043	35.2	46.5	0.89	169.8	0.071	<20	1.83	0.041	0.36	0.20	5.5	0.25	0.45	25	1.3	<0.02
FRAME 1FR-41.0 CM		0.53	0.044	37.9	46.9	0.94	174.8	0.075	<20	1.88	0.042	0.38	0.28	5.8	0.24	0.50	28	1.2	<0.02
FRAME 1FR-41.5 CM		0.53	0.043	37.0	46.0	0.92	171.3	0.075	<20	1.86	0.040	0.37	0.23	5.9	0.25	0.54	21	1.3	0.05
FRAME 1FR-42.0 CM		0.52	0.046	37.8	47.4	0.92	180.0	0.076	<20	1.84	0.040	0.37	0.21	5.9	0.26	0.52	25	1.5	0.03

Supplementary Table 1-2 (cont.)

	Analyte	Ca	P	La	Cr	Mg	Ba	Ti	B	Al	Na	K	W	Sc	Tl	S	Hg	Se	Te
	Unit	%	%	PPM	PPM	%	PPM	%	PPM	%	%	%	PPM	PPM	PPM	%	PPB	PPM	PPM
Lab ID (depth)	**MDL**	0.01	0.001	0.5	0.5	0.01	0.5	0.001	20	0.01	0.001	0.01	0.05	0.1	0.02	0.02	5	0.1	0.02
FRAME 1FR-42.5 CM		0.46	0.046	34.8	44.7	0.89	170.6	0.074	<20	1.81	0.037	0.35	0.21	5.5	0.23	0.51	29	1.5	0.04
FRAME 1FR-43.0 CM		0.46	0.044	35.3	44.9	0.89	171.7	0.076	<20	1.78	0.036	0.35	0.26	5.7	0.26	0.69	12	2.1	<0.02
FRAME 1FR-43.5 CM		0.46	0.043	34.3	44.1	0.87	167.9	0.071	<20	1.77	0.037	0.35	0.24	5.5	0.24	0.87	20	2.2	<0.02
FRAME 1FR-44.0 CM		0.42	0.040	32.1	43.1	0.85	163.8	0.071	<20	1.67	0.036	0.33	0.21	5.1	0.25	1.02	16	2.3	0.02
FRAME 1FR-44.5 CM		0.42	0.039	30.1	41.8	0.84	159.4	0.072	<20	1.68	0.036	0.34	0.24	5.0	0.27	1.25	27	2.6	<0.02
FRAME 1FR-45.0 CM		0.44	0.040	32.7	44.7	0.87	172.3	0.073	<20	1.74	0.037	0.35	0.22	5.3	0.30	1.30	23	2.7	0.04
FRAME 1FR-45.5 CM		0.43	0.040	32.7	44.4	0.88	170.7	0.076	<20	1.78	0.038	0.36	0.24	5.7	0.30	1.42	19	3.3	0.02
FRAME 1FR-46.0 CM		0.42	0.043	34.5	47.8	0.92	186.1	0.079	<20	1.83	0.040	0.38	0.23	5.6	0.30	1.49	24	2.7	0.02
FRAME 1FR-46.5 CM		0.42	0.040	33.9	47.4	0.91	182.4	0.078	<20	1.85	0.039	0.37	0.18	5.8	0.31	1.49	15	2.9	0.04
FRAME 1FR-47.0 CM		0.44	0.042	33.9	46.5	0.94	183.1	0.081	<20	1.89	0.040	0.38	0.20	6.1	0.28	1.33	19	2.6	<0.02
FRAME 1FR-47.5 CM		0.43	0.040	34.0	47.1	0.90	180.1	0.079	<20	1.82	0.037	0.37	0.19	6.0	0.27	1.22	19	2.3	0.02
FRAME 1FR-48.0 CM		0.42	0.041	32.4	44.7	0.90	168.2	0.075	<20	1.78	0.040	0.36	0.27	5.4	0.27	1.09	17	2.1	0.03
FRAME 1FR-48.5 CM		0.40	0.038	32.5	42.5	0.83	166.4	0.075	<20	1.69	0.037	0.34	0.20	5.2	0.25	1.30	17	2.5	<0.02
FRAME 1FR-49.0 CM		0.39	0.042	31.6	42.5	0.84	160.4	0.074	<20	1.69	0.037	0.34	0.18	5.4	0.26	1.65	17	2.5	<0.02
FRAME 1FR-49.5 CM		0.41	0.041	32.4	45.4	0.90	169.3	0.080	<20	1.80	0.039	0.36	0.23	5.6	0.25	1.72	24	2.5	<0.02
FRAME 1FR-50.0 CM		0.39	0.042	32.4	47.9	0.91	175.3	0.079	<20	1.81	0.039	0.37	0.25	5.7	0.29	1.51	28	2.5	<0.02
FRAME 1FR-50.5 CM		0.42	0.044	32.0	46.9	0.92	173.7	0.079	<20	1.88	0.041	0.38	0.19	5.9	0.27	1.34	15	2.4	0.02
FRAME 1FR-51.0 CM		0.40	0.043	32.4	48.5	0.94	179.5	0.081	<20	1.91	0.041	0.39	0.20	5.9	0.27	1.25	13	2.2	<0.02
FRAME 1FR-51.5 CM		0.40	0.044	34.0	48.9	0.95	190.0	0.083	<20	1.92	0.041	0.40	0.20	5.8	0.28	1.12	23	1.6	0.02
FRAME 1FR-52.0 CM		0.40	0.044	33.5	47.3	0.95	181.2	0.082	<20	1.91	0.040	0.39	0.19	5.8	0.27	0.98	15	1.6	0.02
FRAME 1FR-52.5 CM		0.38	0.043	33.4	48.7	0.93	181.7	0.082	<20	1.89	0.040	0.39	0.21	6.0	0.26	1.06	15	2.1	<0.02
FRAME 1FR-53.0 CM		0.38	0.044	33.5	48.4	0.92	177.7	0.082	<20	1.83	0.040	0.38	0.15	5.6	0.26	1.13	21	2.0	0.02
FRAME 1FR-53.5 CM		0.38	0.043	31.8	45.0	0.89	167.0	0.079	<20	1.76	0.037	0.37	0.13	5.8	0.26	1.07	18	2.0	<0.02
FRAME 1FR-54.0 CM		0.36	0.043	32.0	46.1	0.89	165.2	0.078	<20	1.73	0.036	0.36	0.27	5.5	0.25	1.04	5	1.7	<0.02
FRAME 1FR-54.5 CM		0.37	0.047	33.0	44.7	0.89	171.0	0.082	<20	1.75	0.037	0.37	0.18	5.6	0.26	1.14	23	1.7	0.02
FRAME 1FR-55.0 CM		0.36	0.047	30.6	43.5	0.86	161.1	0.078	<20	1.71	0.035	0.36	0.32	5.4	0.25	1.07	18	1.4	0.02
FRAME 1FR-55.5 CM		0.39	0.050	31.8	43.9	0.89	163.3	0.080	<20	1.75	0.035	0.36	0.13	5.5	0.26	1.16	18	1.5	0.02
FRAME 1FR-56.0 CM		0.37	0.049	30.4	44.4	0.87	159.3	0.079	<20	1.74	0.034	0.36	0.20	5.1	0.26	1.04	14	1.6	<0.02
FRAME 1FR-56.5 CM		0.38	0.050	31.8	44.2	0.89	161.2	0.081	<20	1.75	0.034	0.36	0.15	5.4	0.26	0.94	13	1.1	0.02
FRAME 1FR-57.0 CM		0.39	0.052	32.1	45.3	0.90	167.0	0.082	<20	1.77	0.035	0.37	0.13	5.4	0.27	0.78	24	1.1	0.02
FRAME 1FR-57.5 CM		0.40	0.054	32.7	44.4	0.93	173.1	0.083	<20	1.83	0.035	0.38	0.15	5.8	0.26	0.58	23	1.1	<0.02
FRAME 1FR-58.0 CM		0.38	0.055	32.9	44.8	0.93	182.2	0.094	<20	1.79	0.042	0.38	0.11	5.5	0.25	0.50	13	1.2	<0.02
FRAME 1FR-58.5 CM		0.38	0.061	32.5	44.5	0.94	171.2	0.096	<20	1.81	0.043	0.39	0.11	5.8	0.23	0.41	20	1.1	<0.02
FRAME 1FR-59.0 CM		0.39	0.061	35.3	45.8	0.95	186.5	0.097	<20	1.86	0.043	0.39	0.12	5.7	0.27	0.48	20	1.1	<0.02
FRAME 1FR-59.5 CM		0.38	0.061	33.7	45.6	0.95	184.5	0.099	<20	1.87	0.043	0.40	0.10	5.8	0.27	0.43	16	1.2	<0.02
FRAME 1FR-60.0 CM		0.40	0.059	34.7	43.8	0.95	173.6	0.097	<20	1.85	0.044	0.40	0.10	5.8	0.27	0.34	20	1.3	0.03

Supplementary Table 1-3 (cont.)

Analyte	Ga	Cs	Ge	Hf	Nb	Rb	Sn	Ta	Zr	Y	Ce	In	Re	Be	Li	Pd	Pt
Unit	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPB	PPM	PPM	PPB	PPB
Lab ID (depth) MDL	0.1	0.02	0.1	0.02	0.02	0.1	0.1	0.05	0.1	0.01	0.1	0.02	1	0.1	0.1	10	2
FRAME 1FR-3.5 CM	5.7	2.22	0.1	0.07	1.30	31.6	1.0	<0.05	2.7	6.50	41.2	0.02	3	0.6	34.5	<10	<2
FRAME 1FR-4.5 CM	5.1	2.06	<0.1	0.08	1.33	29.8	0.9	<0.05	3.0	6.52	38.7	<0.02	6	0.4	32.2	<10	8
FRAME 1FR-5.0 CM	4.9	1.98	<0.1	0.05	1.50	27.4	0.8	<0.05	3.2	6.39	37.7	0.04	3	0.4	30.4	<10	4
FRAME 1FR-6.0 CM	5.6	2.27	0.1	0.07	1.39	33.8	0.9	<0.05	3.3	6.76	40.2	<0.02	10	0.5	33.3	<10	2
FRAME 1FR-6.5 CM	6.1	2.31	<0.1	0.12	1.55	35.2	0.9	<0.05	5.0	7.05	42.0	0.04	6	0.5	35.4	<10	3
FRAME 1FR-7.0 CM	6.8	2.45	<0.1	0.14	1.64	36.5	1.0	<0.05	6.6	7.27	44.5	0.02	5	0.6	38.9	<10	<2
FRAME 1FR-7.5 CM	6.9	2.46	<0.1	0.16	1.70	38.6	1.2	<0.05	7.5	7.66	46.5	<0.02	3	0.5	37.8	<10	<2
FRAME 1FR-8.0 CM	7.1	2.58	<0.1	0.19	1.65	42.0	1.0	<0.05	7.8	7.65	47.4	0.02	6	0.7	39.2	<10	<2
FRAME 1FR-8.5 CM	7.1	2.61	<0.1	0.22	1.70	40.1	1.0	<0.05	8.6	7.76	45.9	<0.02	7	0.7	38.9	<10	<2
FRAME 1FR-9.0 CM	7.1	2.57	<0.1	0.15	1.72	42.1	1.0	<0.05	8.9	7.80	46.9	0.03	<1	0.6	38.5	<10	<2
FRAME 1FR-9.5 CM	7.0	2.65	<0.1	0.24	1.76	41.0	1.0	<0.05	10.5	8.34	49.3	0.03	2	0.5	38.3	<10	<2
FRAME 1FR-10.0 CM	7.0	2.54	<0.1	0.28	1.60	41.9	0.8	<0.05	11.8	8.31	48.4	0.02	3	0.7	39.6	<10	<2
FRAME 1FR-10.5 CM	8.5	3.15	<0.1	0.40	1.49	48.8	1.1	<0.05	18.0	9.98	58.8	0.03	2	0.8	44.7	<10	<2
FRAME 1FR-10.6 CM	8.5	3.03	<0.1	0.40	1.48	49.7	1.1	<0.05	18.0	9.98	58.4	0.03	2	0.8	45.7	14	3
FRAME 1FR-11.0 CM	9.0	3.22	<0.1	0.43	1.75	51.0	1.0	<0.05	19.6	10.48	63.5	0.04	<1	0.7	47.4	<10	<2
FRAME 1FR-11.2 CM	8.7	3.07	<0.1	0.37	1.46	48.4	1.1	<0.05	18.1	9.93	60.4	0.03	2	0.8	45.9	11	<2
FRAME 1FR-11.4 CM	8.5	2.96	<0.1	0.39	1.64	46.6	1.1	<0.05	17.6	10.07	59.3	0.03	3	0.7	45.2	10	<2
FRAME 1FR-11.6 CM	8.3	2.92	<0.1	0.39	1.52	45.7	1.1	<0.05	17.5	9.61	58.6	0.07	<1	0.9	43.9	<10	3
FRAME 1FR-11.8 CM	8.2	2.95	<0.1	0.41	1.44	47.8	1.1	<0.05	17.6	9.51	57.7	0.04	<1	1.0	44.1	<10	2
FRAME 1FR-12.0 CM	8.8	3.07	<0.1	0.48	1.29	50.2	1.1	<0.05	18.8	9.91	61.6	0.06	2	1.1	47.4	<10	3
FRAME 1FR-12.2 CM	8.9	3.09	<0.1	0.43	1.44	48.5	1.2	<0.05	18.9	10.01	62.0	0.03	2	0.9	47.1	<10	<2
FRAME 1FR-12.4 CM	9.5	3.39	<0.1	0.49	1.91	52.5	1.2	<0.05	20.4	10.88	65.9	0.04	6	0.6	47.7	<10	2
FRAME 1FR-12.6 CM	8.5	3.09	<0.1	0.45	1.87	47.7	1.2	<0.05	19.2	10.43	61.8	0.03	3	0.7	45.6	<10	<2
FRAME 1FR-12.8 CM	8.3	3.05	<0.1	0.36	1.73	46.7	1.1	<0.05	18.4	10.09	60.4	0.07	<1	0.6	45.8	11	<2
FRAME 1FR-13.0 CM	8.2	3.00	<0.1	0.43	1.69	46.8	1.2	<0.05	17.6	10.02	60.3	0.04	5	0.9	45.3	<10	2
FRAME 1FR-13.2 CM	8.0	2.77	<0.1	0.35	1.73	43.3	1.1	<0.05	14.6	9.47	57.0	<0.02	1	0.7	43.7	<10	4
FRAME 1FR-13.4 CM	7.2	2.76	<0.1	0.22	1.87	41.4	1.0	<0.05	10.9	9.44	56.5	0.03	<1	0.5	40.2	<10	<2
FRAME 1FR-13.6 CM	6.8	2.59	<0.1	0.24	1.94	38.5	0.9	<0.05	11.1	9.28	52.1	0.02	<1	0.7	38.3	<10	3
FRAME 1FR-13.8 CM	6.3	2.59	<0.1	0.18	1.84	36.4	1.0	<0.05	8.5	9.07	50.9	0.03	<1	0.7	34.6	11	3
FRAME 1FR-14.0 CM	6.0	2.30	0.1	0.16	1.89	34.3	0.9	<0.05	8.6	8.61	46.3	0.03	8	0.5	34.7	<10	<2
FRAME 1FR-14.2 CM	6.3	2.26	0.2	0.14	1.86	34.2	0.9	<0.05	7.6	9.01	46.4	<0.02	<1	0.4	33.2	<10	<2
FRAME 1FR-14.4 CM	5.3	2.11	0.1	0.12	1.77	29.9	0.8	<0.05	6.5	8.46	45.6	0.03	8	0.6	30.5	<10	2
FRAME 1FR-14.6 CM	5.4	2.02	0.1	0.13	1.59	28.8	0.7	<0.05	5.8	8.02	44.0	0.02	6	0.7	28.5	<10	3
FRAME 1FR-15.0 CM	4.4	1.66	<0.1	0.06	1.44	23.6	0.6	<0.05	4.9	7.36	38.9	<0.02	6	0.4	25.8	<10	4

Supplementary Table 1-3 (cont.)

Lab ID (depth)	Analyte	Ga	Cs	Ge	Hf	Nb	Rb	Sn	Ta	Zr	Y	Ce	In	Re	Be	Li	Pd	Pt
	Unit	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPB	PPM	PPM	PPB	PPB
	MDL	0.1	0.02	0.1	0.02	0.02	0.1	0.1	0.05	0.1	0.01	0.1	0.02	1	0.1	0.1	10	2
FRAME 1FR-15.2 CM		4.4	1.69	<0.1	0.08	1.41	24.3	0.6	<0.05	4.6	7.46	38.2	<0.02	13	0.4	25.9	<10	4
FRAME 1FR-15.4 CM		4.3	1.54	<0.1	0.10	1.33	22.0	0.6	<0.05	4.5	7.30	39.3	<0.02	10	0.5	24.0	<10	4
FRAME 1FR-15.6 CM		4.2	1.49	<0.1	0.09	1.21	19.7	0.6	<0.05	4.5	6.95	35.4	<0.02	11	0.2	20.1	<10	3
FRAME 1FR-15.8 CM		4.3	1.49	<0.1	0.14	1.22	20.3	0.6	<0.05	4.5	7.18	41.3	0.02	9	0.4	21.2	<10	<2
FRAME 1FR-16.0 CM		3.9	1.51	0.1	0.10	1.35	21.4	0.6	<0.05	5.7	8.03	41.6	<0.02	9	0.6	23.0	<10	3
FRAME 1FR-16.2 CM		3.9	1.38	0.1	0.08	1.23	19.8	0.6	<0.05	5.5	7.56	42.9	<0.02	3	0.5	20.2	<10	3
FRAME 1FR-16.4 CM		3.7	1.30	<0.1	0.14	1.16	17.8	0.5	<0.05	5.6	7.55	39.3	0.02	6	0.3	19.0	<10	2
FRAME 1FR-16.6 CM		4.0	1.35	0.1	0.13	1.19	19.4	0.5	<0.05	6.5	7.71	44.3	<0.02	6	0.5	20.4	<10	4
FRAME 1FR-16.8 CM		4.4	1.57	<0.1	0.21	1.53	23.2	0.6	<0.05	8.4	9.25	49.8	<0.02	8	0.6	23.7	<10	2
FRAME 1FR-17.0 CM		4.7	1.50	<0.1	0.21	1.46	22.9	0.6	<0.05	8.6	8.74	46.1	<0.02	9	0.4	23.3	<10	<2
FRAME 1FR-17.2 CM		4.5	1.58	<0.1	0.20	1.50	22.5	0.6	<0.05	8.4	8.64	50.7	<0.02	5	0.6	22.7	<10	3
FRAME 1FR-17.4 CM		4.5	1.52	0.1	0.17	1.40	21.7	0.6	<0.05	8.4	8.59	48.3	<0.02	12	0.6	23.5	<10	<2
FRAME 1FR-17.6 CM		4.6	1.51	<0.1	0.24	1.61	23.5	0.6	<0.05	10.3	9.57	50.1	0.03	8	0.4	23.6	<10	<2
FRAME 1FR-17.8 CM		4.8	1.55	<0.1	0.21	1.58	23.5	0.6	<0.05	10.3	10.51	57.5	<0.02	5	0.3	22.3	<10	7
FRAME 1FR-18.0 CM		4.3	1.41	<0.1	0.23	1.42	20.2	0.6	<0.05	9.5	10.14	54.7	0.03	8	0.5	22.0	<10	<2
FRAME 1FR-18.2 CM		4.5	1.50	<0.1	0.21	1.61	22.9	0.5	<0.05	10.1	10.52	58.5	<0.02	<1	0.5	22.6	<10	5
FRAME 1FR-18.4 CM		4.7	1.51	<0.1	0.22	1.52	21.3	0.7	<0.05	10.0	10.01	56.4	<0.02	7	0.5	24.0	<10	3
FRAME 1FR-18.6 CM		4.9	1.51	<0.1	0.23	1.56	21.5	0.6	<0.05	9.8	9.99	56.5	<0.02	11	0.8	22.9	<10	<2
FRAME 1FR-18.8 CM		4.4	1.37	<0.1	0.31	1.60	21.2	0.6	<0.05	10.8	10.08	57.0	0.02	8	0.7	22.0	<10	<2
FRAME 1FR-19.0 CM		4.6	1.36	<0.1	0.27	1.66	21.6	0.6	<0.05	10.8	9.68	53.9	<0.02	7	0.4	23.8	<10	2
FRAME 1FR-19.2 CM		4.6	1.57	<0.1	0.21	1.57	21.7	0.5	<0.05	10.5	10.00	59.9	<0.02	9	0.5	22.4	<10	3
FRAME 1FR-19.4 CM		4.8	1.41	<0.1	0.30	1.79	22.6	0.6	<0.05	12.2	10.28	55.1	0.02	15	0.4	23.0	<10	3
FRAME 1FR-19.6 CM		5.4	1.64	0.1	0.28	1.80	23.9	0.7	<0.05	11.9	11.00	63.3	<0.02	8	0.5	24.2	<10	<2
FRAME 1FR-19.8 CM		5.1	1.56	0.2	0.29	1.76	22.5	0.6	<0.05	11.7	10.89	58.6	<0.02	12	0.6	24.1	<10	<2
FRAME 1FR-20.0 CM		5.1	1.63	<0.1	0.32	1.78	23.3	0.6	<0.05	12.0	10.94	60.5	<0.02	12	0.7	23.5	<10	4
FRAME 1FR-20.2 CM		5.2	1.50	<0.1	0.34	1.89	24.1	0.7	<0.05	13.2	10.78	57.2	<0.02	8	0.6	23.7	<10	3
FRAME 1FR-20.5 CM		5.1	1.48	0.1	0.34	1.83	23.3	0.6	<0.05	13.5	11.20	57.9	<0.02	10	0.6	24.9	<10	2
FRAME 1FR-21.0 CM		5.3	1.47	<0.1	0.33	1.76	22.5	0.7	<0.05	12.5	10.39	57.4	<0.02	1	0.4	23.4	<10	2
FRAME 1FR-21.5 CM		5.1	1.40	0.1	0.32	1.75	21.3	0.6	<0.05	12.8	10.38	54.9	<0.02	8	0.7	23.9	<10	<2
FRAME 1FR-22.0 CM		4.6	1.52	<0.1	0.30	1.70	22.0	0.7	<0.05	12.2	10.23	57.8	0.03	5	0.7	22.3	<10	4
FRAME 1FR-22.5 CM		4.6	1.61	<0.1	0.34	1.91	22.0	0.6	<0.05	12.9	10.95	58.7	0.02	8	0.7	23.5	<10	<2
FRAME 1FR-23.0 CM		4.2	1.43	<0.1	0.28	1.76	20.3	0.6	<0.05	12.8	10.64	59.5	0.03	8	0.5	19.7	<10	2
FRAME 1FR-23.5 CM		4.6	1.55	<0.1	0.30	1.95	22.1	0.7	<0.05	13.3	12.30	65.4	<0.02	8	0.6	21.3	<10	<2
FRAME 1FR-24.0 CM		4.4	1.56	<0.1	0.29	1.92	20.6	0.6	<0.05	12.4	12.49	65.6	0.03	9	0.6	21.6	<10	<2
FRAME 1FR-24.5 CM		4.4	1.53	<0.1	0.27	1.80	20.9	0.5	<0.05	12.2	12.04	65.1	0.02	5	0.8	19.6	<10	<2

Supplementary Table 1-3 (cont.)

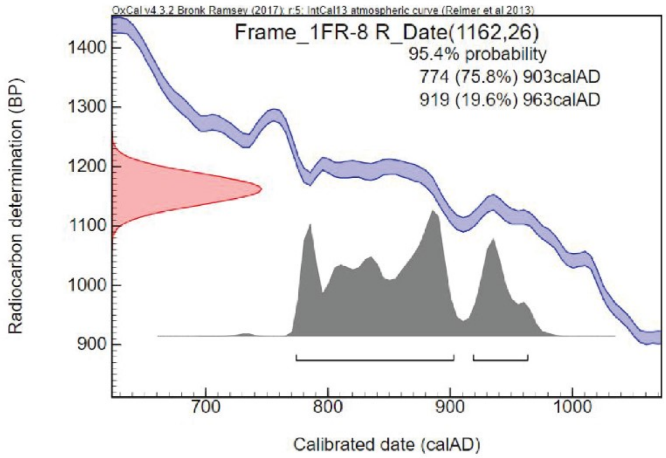
	Analyte	Ga	Cs	Ge	Hf	Nb	Rb	Sn	Ta	Zr	Y	Ce	In	Re	Be	Li	Pd	Pt
	Unit	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPB	PPM	PPM	PPB	PPB
Lab ID (depth)	MDL	0.1	0.02	0.1	0.02	0.02	0.1	0.1	0.05	0.1	0.01	0.1	0.02	1	0.1	0.1	10	2
FRAME 1FR-25.0 CM		4.7	1.51	<0.1	0.30	1.84	20.8	0.6	<0.05	11.6	12.09	66.5	<0.02	5	0.7	20.1	<10	<2
FRAME 1FR-25.5 CM		4.5	1.53	<0.1	0.32	1.75	20.8	0.7	<0.05	11.8	12.12	67.4	<0.02	6	0.6	18.9	<10	<2
FRAME 1FR-26.0 CM		4.4	1.53	<0.1	0.27	1.84	21.1	0.6	<0.05	11.9	11.56	65.5	<0.02	11	0.6	19.4	<10	3
FRAME 1FR-26.5 CM		4.6	1.54	<0.1	0.33	1.72	22.0	0.6	<0.05	12.0	11.90	67.8	<0.02	6	0.7	21.3	<10	<2
FRAME 1FR-27.0 CM		4.9	1.61	<0.1	0.34	2.03	22.9	0.6	<0.05	13.7	12.70	64.2	0.02	2	0.7	22.7	<10	<2
FRAME 1FR-27.5 CM		4.0	1.42	<0.1	0.27	1.80	20.7	0.5	<0.05	13.2	11.05	54.4	0.03	16	0.4	20.6	<10	<2
FRAME 1FR-28.0 CM		3.9	1.38	<0.1	0.26	1.71	19.0	0.6	<0.05	12.1	10.45	51.3	<0.02	9	0.5	18.9	<10	<2
FRAME 1FR-28.5 CM		4.0	1.33	<0.1	0.28	1.67	18.5	0.4	<0.05	11.3	10.33	48.0	<0.02	16	0.7	18.0	<10	3
FRAME 1FR-29.0 CM		3.6	1.33	<0.1	0.29	1.68	18.5	0.5	<0.05	11.2	10.07	45.3	0.02	10	0.5	18.0	<10	<2
FRAME 1FR-29.5 CM		3.6	1.30	<0.1	0.25	1.54	17.9	0.5	<0.05	10.7	14.03	73.9	0.03	5	0.5	17.5	<10	<2
FRAME 1FR-30.0 CM		3.7	1.35	<0.1	0.27	1.67	18.8	0.5	<0.05	10.6	13.92	75.0	0.03	3	0.5	17.6	<10	<2
FRAME 1FR-30.5 CM		4.0	1.37	<0.1	0.33	1.73	19.4	0.5	<0.05	11.8	10.68	51.9	<0.02	5	0.6	19.0	<10	4
FRAME 1FR-31.0 CM		4.2	1.36	<0.1	0.32	1.80	21.4	0.6	<0.05	12.7	11.44	54.2	0.02	8	0.6	19.0	<10	2
FRAME 1FR-31.5 CM		4.4	1.48	<0.1	0.33	1.89	21.2	0.6	<0.05	13.4	11.53	58.5	<0.02	8	0.4	20.2	<10	<2
FRAME 1FR-32.0 CM		4.7	1.57	<0.1	0.40	2.01	22.5	0.6	<0.05	14.3	12.07	60.4	0.03	6	0.7	21.8	<10	<2
FRAME 1FR-32.5 CM		4.7	1.70	<0.1	0.42	2.07	24.2	0.6	<0.05	14.6	12.29	65.6	0.03	6	0.7	22.9	<10	<2
FRAME 1FR-33.0 CM		5.0	1.70	<0.1	0.37	2.14	25.0	0.7	<0.05	15.1	12.38	66.9	0.03	7	0.5	23.6	17	<2
FRAME 1FR-33.5 CM		4.9	1.74	<0.1	0.35	2.13	25.8	0.7	<0.05	15.2	13.02	70.9	0.03	3	0.6	23.6	14	3
FRAME 1FR-34.0 CM		5.3	1.80	<0.1	0.39	2.08	27.4	0.7	<0.05	15.3	12.55	70.0	0.03	10	0.8	25.7	<10	<2
FRAME 1FR-34.5 CM		5.4	1.84	<0.1	0.35	1.99	27.5	0.8	<0.05	15.0	12.36	68.1	<0.02	8	0.7	24.7	10	<2
FRAME 1FR-35.0 CM		5.1	1.79	<0.1	0.37	1.95	27.9	0.6	<0.05	14.4	11.81	68.3	0.02	14	0.9	24.0	<10	<2
FRAME 1FR-35.5 CM		5.7	1.96	<0.1	0.36	2.15	28.5	0.8	<0.05	15.5	12.60	71.1	0.03	9	0.4	26.8	<10	5
FRAME 1FR-36.0 CM		5.8	1.90	<0.1	0.36	2.20	30.0	0.7	<0.05	16.1	12.92	67.3	0.03	5	0.7	26.5	<10	3
FRAME 1FR-36.5 CM		6.0	2.02	<0.1	0.39	2.24	30.6	0.8	<0.05	16.8	13.04	71.3	<0.02	2	0.8	27.6	<10	3
FRAME 1FR-37.0 CM		6.0	1.93	<0.1	0.33	2.06	30.0	0.7	<0.05	16.8	12.94	72.6	0.02	10	0.7	25.8	<10	<2
FRAME 1FR-37.5 CM		6.1	1.98	<0.1	0.40	2.27	30.0	0.8	<0.05	17.2	13.04	73.8	0.04	7	0.8	30.0	<10	<2
FRAME 1FR-38.0 CM		5.8	1.96	<0.1	0.41	1.99	31.3	0.7	<0.05	16.3	12.89	73.5	0.03	8	0.8	29.1	<10	3
FRAME 1FR-38.5 CM		6.0	2.00	<0.1	0.44	2.08	31.2	0.8	<0.05	16.8	12.93	73.7	0.03	3	0.8	28.4	<10	<2
FRAME 1FR-39.0 CM		5.9	1.93	<0.1	0.41	2.12	31.7	0.8	<0.05	16.5	12.59	71.2	0.03	20	0.7	28.2	<10	<2
FRAME 1FR-39.5 CM		6.4	1.98	<0.1	0.35	1.89	31.3	0.8	<0.05	16.0	12.16	71.1	0.03	6	0.6	28.3	<10	<2
FRAME 1FR-40.0 CM		5.7	1.84	<0.1	0.33	1.71	30.3	0.8	<0.05	15.3	11.28	63.9	0.04	10	0.7	29.6	<10	<2
FRAME 1FR-40.5 CM		6.0	1.99	<0.1	0.36	1.92	32.9	0.8	<0.05	16.5	12.20	70.4	0.03	8	0.8	30.4	<10	<2
FRAME 1FR-41.0 CM		6.5	2.11	<0.1	0.39	1.81	33.6	1.0	<0.05	17.2	11.99	74.2	0.04	3	0.6	32.2	<10	<2
FRAME 1FR-41.5 CM		6.5	2.11	<0.1	0.50	1.77	33.3	0.9	<0.05	18.1	12.31	74.1	<0.02	9	0.9	32.7	<10	<2
FRAME 1FR-42.0 CM		6.7	2.18	<0.1	0.34	1.71	33.8	0.8	<0.05	17.6	12.08	75.6	0.03	5	0.6	32.8	<10	<2

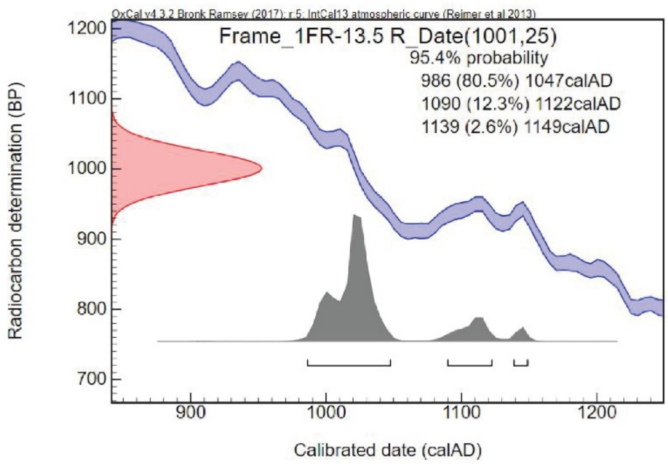
Supplementary Table 1-3 (cont.)

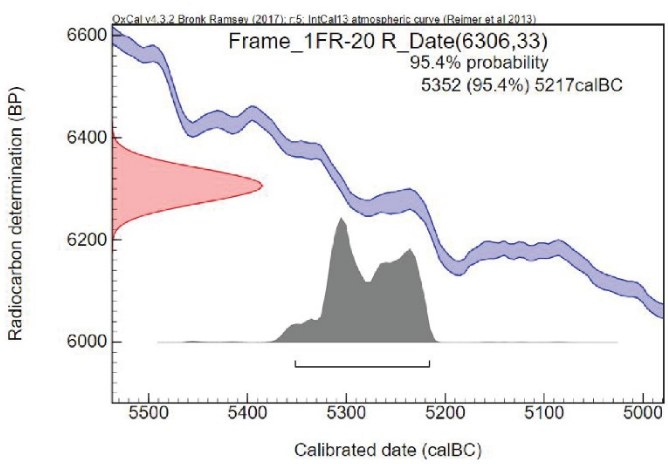
	Analyte	Ga	Cs	Ge	Hf	Nb	Rb	Sn	Ta	Zr	Y	Ce	In	Re	Be	Li	Pd	Pt
	Unit	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPB	PPM	PPM	PPB	PPB
Lab ID (depth)	**MDL**	0.1	0.02	0.1	0.02	0.02	0.1	0.1	0.05	0.1	0.01	0.1	0.02	1	0.1	0.1	10	2
FRAME 1FR-42.5 CM		6.3	2.18	<0.1	0.37	1.56	32.7	0.8	<0.05	16.1	11.76	69.5	0.03	8	0.7	31.2	<10	3
FRAME 1FR-43.0 CM		6.2	2.15	<0.1	0.33	1.49	32.3	0.8	<0.05	15.5	11.99	71.3	0.03	2	0.6	31.9	<10	<2
FRAME 1FR-43.5 CM		6.0	2.00	<0.1	0.38	1.52	30.9	0.9	<0.05	16.6	11.80	69.4	0.04	3	0.8	31.8	<10	4
FRAME 1FR-44.0 CM		5.9	1.97	<0.1	0.33	1.51	30.8	0.7	<0.05	16.1	11.10	63.6	<0.02	6	0.7	30.3	<10	<2
FRAME 1FR-44.5 CM		5.7	1.94	<0.1	0.42	1.41	29.7	0.8	<0.05	16.4	10.67	62.5	0.03	1	0.9	29.5	<10	2
FRAME 1FR-45.0 CM		6.1	2.03	<0.1	0.39	1.50	30.5	0.8	<0.05	18.6	11.66	66.2	0.03	11	0.6	31.1	<10	<2
FRAME 1FR-45.5 CM		6.3	2.05	<0.1	0.38	1.51	32.9	0.8	<0.05	18.7	11.64	66.4	0.03	13	0.6	31.4	<10	<2
FRAME 1FR-46.0 CM		6.4	2.23	<0.1	0.47	1.46	34.0	0.9	<0.05	18.5	11.56	69.5	<0.02	7	0.7	34.1	14	<2
FRAME 1FR-46.5 CM		6.9	2.16	<0.1	0.45	1.39	32.9	0.9	<0.05	19.4	11.43	67.0	0.02	5	0.5	32.4	<10	<2
FRAME 1FR-47.0 CM		6.7	2.20	<0.1	0.44	1.47	33.9	0.8	<0.05	19.7	11.24	67.5	0.02	2	0.8	34.1	<10	3
FRAME 1FR-47.5 CM		6.8	2.11	<0.1	0.49	1.50	33.6	0.9	<0.05	19.0	11.56	67.3	0.03	10	0.8	32.2	<10	<2
FRAME 1FR-48.0 CM		6.4	2.08	<0.1	0.43	1.38	31.9	0.8	<0.05	18.8	11.64	65.4	0.03	11	0.7	31.3	<10	<2
FRAME 1FR-48.5 CM		6.0	2.07	<0.1	0.42	1.33	31.0	0.9	<0.05	18.5	11.15	65.4	0.03	19	0.6	30.4	<10	<2
FRAME 1FR-49.0 CM		6.2	2.01	<0.1	0.46	1.29	31.4	0.8	<0.05	17.8	11.35	63.5	0.02	12	0.6	30.9	14	3
FRAME 1FR-49.5 CM		6.5	2.23	<0.1	0.46	1.31	33.6	0.8	<0.05	19.2	11.55	65.3	0.05	7	0.8	32.7	<10	<2
FRAME 1FR-50.0 CM		6.8	2.29	<0.1	0.42	0.96	33.6	0.9	<0.05	18.2	11.19	63.9	0.03	3	0.8	33.6	<10	2
FRAME 1FR-50.5 CM		6.7	2.31	<0.1	0.42	1.02	33.9	0.9	<0.05	18.9	10.95	63.5	0.02	12	0.7	34.5	<10	<2
FRAME 1FR-51.0 CM		7.2	2.27	<0.1	0.50	1.04	35.3	0.9	<0.05	19.7	11.20	64.7	0.02	11	0.5	34.3	<10	<2
FRAME 1FR-51.5 CM		7.0	2.32	<0.1	0.51	0.94	35.6	1.0	<0.05	19.6	11.44	68.8	0.04	14	0.7	35.2	<10	4
FRAME 1FR-52.0 CM		6.9	2.25	<0.1	0.44	0.89	34.3	0.9	<0.05	18.5	10.64	66.5	0.02	8	0.7	33.9	<10	4
FRAME 1FR-52.5 CM		7.3	2.33	<0.1	0.34	0.87	35.5	0.9	<0.05	19.6	11.34	67.3	0.02	11	0.8	34.4	<10	<2
FRAME 1FR-53.0 CM		7.2	2.22	<0.1	0.48	0.90	33.3	0.8	<0.05	19.6	10.73	66.1	0.02	5	0.7	33.6	<10	6
FRAME 1FR-53.5 CM		6.3	2.11	<0.1	0.43	0.90	31.9	1.0	<0.05	19.2	10.57	64.6	0.03	3	1.0	31.7	15	3
FRAME 1FR-54.0 CM		6.5	2.13	<0.1	0.44	0.85	33.0	0.9	<0.05	19.4	10.81	63.1	0.04	3	0.7	32.3	<10	<2
FRAME 1FR-54.5 CM		6.6	2.12	<0.1	0.52	0.84	32.9	0.9	<0.05	21.2	10.88	66.3	0.04	9	0.6	31.8	<10	<2
FRAME 1FR-55.0 CM		6.2	2.04	<0.1	0.51	0.68	30.6	0.8	<0.05	19.2	10.16	62.1	0.02	7	0.7	32.3	<10	<2
FRAME 1FR-55.5 CM		6.5	2.08	<0.1	0.57	0.63	33.2	0.8	<0.05	21.1	10.67	63.9	0.03	7	0.6	32.6	<10	3
FRAME 1FR-56.0 CM		6.6	2.04	<0.1	0.56	0.59	32.9	0.7	<0.05	21.1	10.40	60.0	0.03	3	0.5	33.0	<10	3
FRAME 1FR-56.5 CM		6.6	2.04	<0.1	0.50	0.49	33.0	0.8	<0.05	21.1	10.62	62.5	<0.02	5	0.6	33.1	<10	<2
FRAME 1FR-57.0 CM		6.8	2.13	<0.1	0.59	0.50	32.9	0.9	<0.05	21.8	10.66	66.5	0.03	7	0.6	33.6	<10	<2
FRAME 1FR-57.5 CM		7.1	2.08	<0.1	0.54	0.54	33.9	0.9	<0.05	20.8	10.79	67.8	0.03	7	0.8	33.7	<10	<2
FRAME 1FR-58.0 CM		7.0	2.05	<0.1	0.50	0.53	31.5	0.8	<0.05	21.6	10.52	63.9	0.03	3	0.9	32.0	<10	4
FRAME 1FR-58.5 CM		7.1	1.98	0.1	0.58	0.52	34.6	0.9	<0.05	22.8	10.66	65.0	<0.02	3	0.7	33.1	<10	2
FRAME 1FR-59.0 CM		7.7	2.20	0.1	0.57	0.55	35.1	0.9	<0.05	23.5	11.56	65.6	<0.02	2	1.0	32.6	26	<2
FRAME 1FR-59.5 CM		7.5	2.11	<0.1	0.48	0.52	33.2	0.9	<0.05	23.4	11.12	68.9	0.02	3	0.6	31.8	<10	<2
FRAME 1FR-60.0 CM		7.4	2.13	<0.1	0.51	0.55	37.7	1.0	<0.05	24.0	11.41	67.3	0.02	2	0.8	34.7	<10	<2

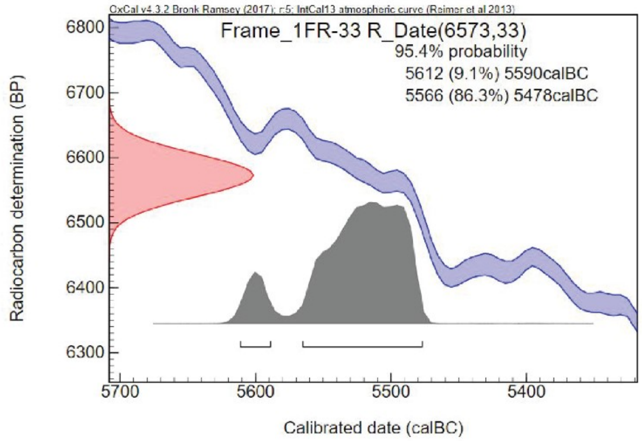
Appendices

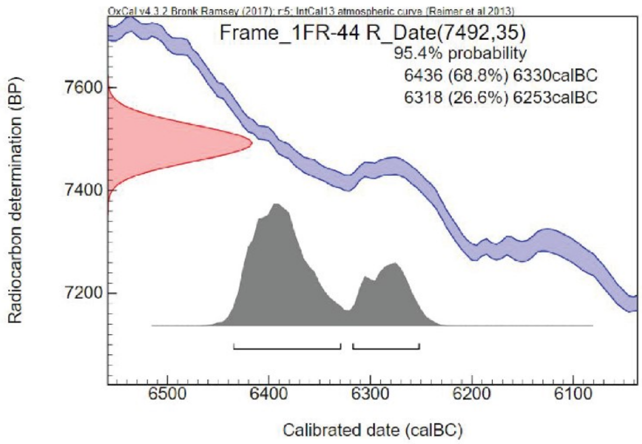
**Appendix A - ** Carbon 14 Calibration curves

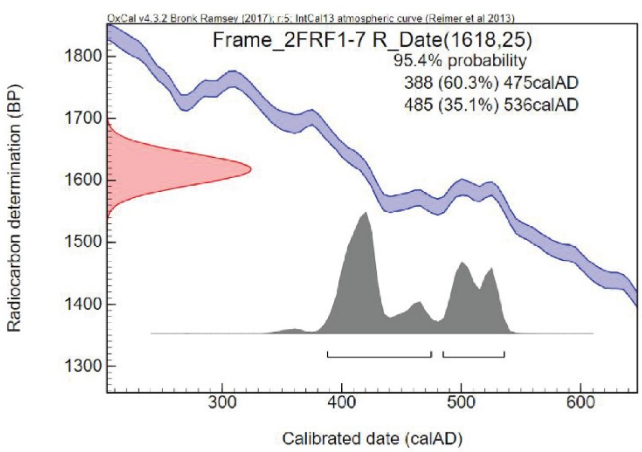


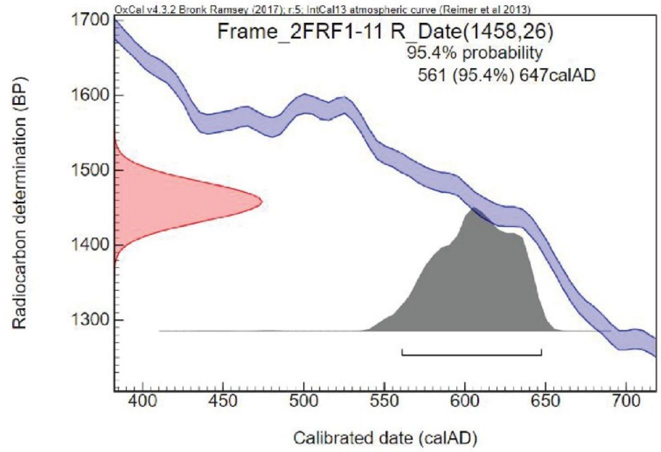


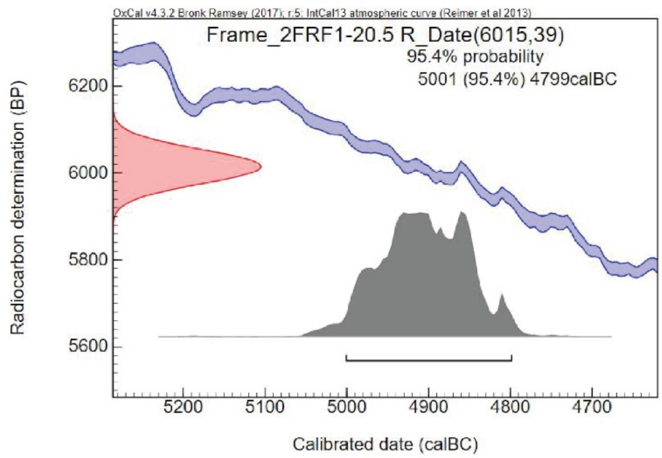


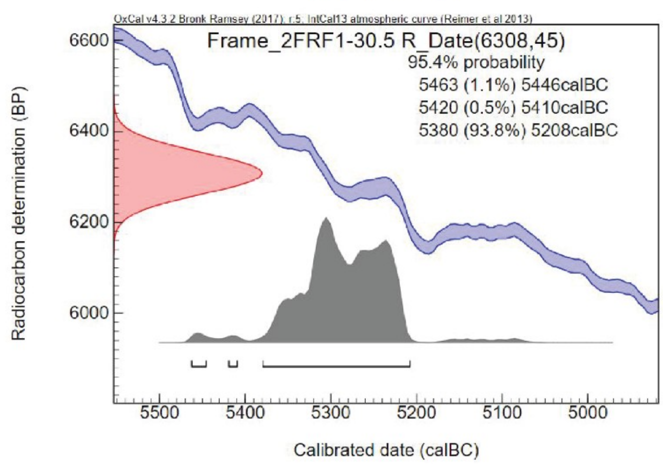

OxCal v4.3.2 Bronk Ramsey (2017); r:5; IntCal13 atmospheric curve (Reimer et al 2013)
Frame_1FR-33 R_Date(6573,33)
95.4% probability
5612 (9.1%) 5590calBC
5566 (86.3%) 5478calBC
Radiocarbon determination (BP)
6800
6700
6600
6500
6400
6300
5700
5600
5500
5400
Calibrated date (calBC)


OxCal v4.3.2 Bronk Ramsey (2017); r:5; IntCal13 atmospheric curve (Reimer et al 2013)
Frame_1FR-44 R_Date(7492,35)
95.4% probability
6436 (68.8%) 6330calBC
6318 (26.6%) 6253calBC
Radiocarbon determination (BP)
7600
7400
7200
6500
6400
6300
6200
6100
Calibrated date (calBC)

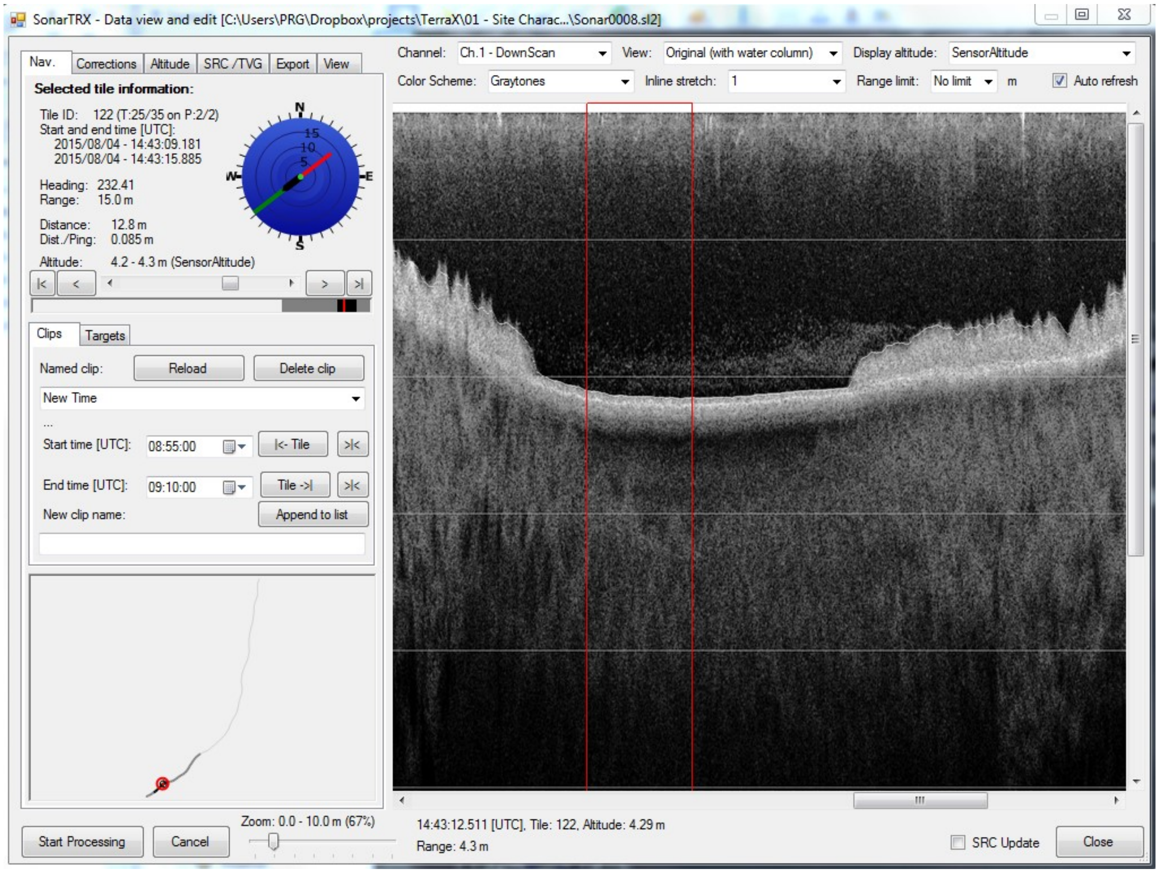

OxCal v4.3.2 Bronk Ramsey (2017); r:5; IntCal13 atmospheric curve (Reimer et al 2013)
Frame_2FRF1-7 R_Date(1618,25)
95.4% probability
388 (60.3%) 475calAD
485 (35.1%) 536calAD
Radiocarbon determination (BP)
1800
1700
1600
1500
1400
1300
300
400
500
600
Calibrated date (calAD)


OxCal v4.3.2 Bronk Ramsey (2017); r:5; IntCal13 atmospheric curve (Reimer et al 2013)
Frame_2FRF1-11 R_Date(1458,26)
95.4% probability
561 (95.4%) 647calAD
Radiocarbon determination (BP)
1700
1600
1500
1400
1300
400
450
500
550
600
650
700
Calibrated date (calAD)


OxCal v4.3.2 Bronk Ramsey (2017); r:5; IntCal13 atmospheric curve (Reimer et al 2013)
Frame_2FRF1-20.5 R_Date(6015,39)
95.4% probability
5001 (95.4%) 4799calBC
Radiocarbon determination (BP)
6200
6000
5800
5600
5200
5100
5000
4900
4800
4700
Calibrated date (calBC)


OxCal v4.3.2 Bronk Ramsey (2017); r:5; IntCal13 atmospheric curve (Reimer et al 2013)
Frame_2FRF1-30.5 R_Date(6308,45)
95.4% probability
5463 (1.1%) 5446calBC
5420 (0.5%) 5410calBC
5380 (93.8%) 5208calBC
Radiocarbon determination (BP)
6600
6400
6200
6000
5500
5400
5300
5200
5100
5000
Calibrated date (calBC)

Appendix B - Data view using the SonarTRX software in Graytones colour scheme.



Appendix C - Table: Sediment thickness throughout Frame lake L1-L5, including Water Depth (WD), as measured from Sonar data through SonarTRX.

Section	Latitude	Longitude	WD	L1	L2	L3	L4	L5
B3T001	62.453479	-114.393571	0.800	0.025	0.025	0.025	0.100	0.100
B3T003	62.453539	-114.393260	0.900	0.050	0.025	0.025	0.150	0.175
B3T005	62.453629	-114.392937	0.900	0.050	0.025	0.025	0.125	0.150
B3T007	62.453721	-114.392531	1.000	0.050	0.025	0.025	0.125	0.150
B3T009	62.453770	-114.392128	0.900	0.050	0.025	0.025	0.125	0.150
B3T011	62.453767	-114.391679	1.200	0.050	0.025	0.025	0.100	0.125
B3T014	62.453831	-114.391063	1.400	0.050	0.025	0.025	0.100	0.125
B3T021	62.454084	-114.389709	1.700	0.025	0.025	0.025	0.075	0.100
B3T028	62.454285	-114.388243	1.600	0.025	0.015	0.020	0.050	0.075
B3T031	62.454434	-114.387670	1.300	0.025	0.025	0.025	0.075	0.100
B3T035	62.454539	-114.386825	1.100	0.025	0.025	0.025	0.075	0.100
B3T038	62.454582	-114.386199	1.100	0.050	0.025	0.025	0.100	0.150
B3T042	62.454759	-114.385468	1.000	0.050	0.025	0.025	0.100	0.150
B3T044	62.454853	-114.385130	1.000	0.050	0.025	0.025	0.125	0.150
B3T046	62.454958	-114.384800	1.000	0.050	0.025	0.025	0.125	0.150
B3T049	62.455060	-114.384211	1.000	0.050	0.025	0.025	0.125	0.075
B3T052	62.455060	-114.383537	0.900	0.050	0.025	0.025	0.150	0.150
B3T056	62.455030	-114.382642	1.200	0.050	0.025	0.025	0.150	0.150
B3T059	62.455005	-114.382001	1.000	0.050	0.025	0.025	0.150	0.175
B3T063	62.455050	-114.381177	1.100	0.050	0.025	0.025	0.100	0.125
B3T066	62.455097	-114.380578	1.000	0.025	0.025	0.025	0.100	0.125
B3T070	62.455175	-114.379723	0.900	0.025	0.025	0.025	0.075	0.100
B3T072	62.455244	-114.379356	0.700	0.025	0.025	0.025	0.075	0.100
B3T074	62.455317	-114.379012	0.900	0.050	0.025	0.025	0.075	0.100
B3T077	62.455433	-114.378519	0.800	0.025	0.025	0.025	0.075	0.100
B5T000	62.455525	-114.395340	0.700	0.025	0.025	0.050	0.200	0.250
B5T003	62.455656	-114.394946	0.800	0.025	0.025	0.050	0.200	0.250
B5T007	62.455928	-114.394382	0.900	0.025	0.025	0.050	0.200	0.250
B5T010	62.456154	-114.393975	0.900	0.025	0.025	0.050	0.200	0.250
B5T014	62.456375	-114.393366	1.300	0.050	0.025	0.025	0.150	0.175
B5T017	62.456509	-114.392814	1.300	0.050	0.025	0.025	0.100	0.125
B5T021	62.456624	-114.392050	1.300	0.025	0.025	0.025	0.075	0.100
B5T024	62.456670	-114.391421	1.500	0.050	0.025	0.025	0.100	0.125
B5T028	62.456879	-114.390720	1.300	0.050	0.025	0.025	0.100	0.125
B5T031	62.460646	-114.387847	0.700	0.050	0.025	0.050	0.175	0.200
B5T032	62.457020	-114.389923	3.200	0.025	0.025	0.025	0.075	0.100
B5T036	62.456959	-114.389097	5.600	0.025	0.025	0.025	0.075	0.100
B5T042	62.457138	-114.387889	4.600	0.025	0.025	0.025	0.150	0.175
B5T042	62.461181	-114.385961	0.600	0.050	0.025	0.050	0.125	0.200
B5T049	62.457506	-114.386702	2.600	0.025	0.025	0.025	0.125	0.150
B5T052	62.457610	-114.386111	2.100	0.025	0.025	0.025	0.125	0.175
B5T056	62.457831	-114.385477	1.500	0.025	0.025	0.025	0.125	0.175
B5T059	62.458007	-114.385021	1.200	0.025	0.025	0.025	0.125	0.175
B5T063	62.458261	-114.384482	1.000	0.025	0.025	0.025	0.125	0.175
B5T066	62.458464	-114.384205	0.800	0.025	0.025	0.025	0.100	0.125
B5T069	62.458558	-114.383686	0.800	0.025	0.025	0.025	0.100	0.125
B7T000	62.459540	-114.392885	0.800	0.050	0.025	0.050	0.175	0.200
B7T004	62.459653	-114.392406	0.900	0.050	0.025	0.050	0.175	0.200
B7T007	62.459780	-114.391892	0.900	0.050	0.025	0.050	0.175	0.200
B7T010	62.459989	-114.391561	1.000	0.050	0.025	0.050	0.200	0.225
B7T014	62.460154	-114.390907	0.900	0.050	0.025	0.050	0.175	0.200
B7T017	62.460227	-114.390321	0.900	0.050	0.025	0.050	0.200	0.250

Appendix C Table (cont.)

Section	Latitude	Longitude	WD	L1	L2	L3	L4	L5
B7T021	62.460308	-114.389559	0.800	0.050	0.025	0.050	0.125	0.200
B7T024	62.460402	-114.389034	0.800	0.050	0.025	0.050	0.125	0.200
B7T028	62.460528	-114.388334	0.800	0.050	0.025	0.050	0.150	0.200
B7T035	62.460812	-114.387184	0.700	0.050	0.025	0.050	0.150	0.175
B7T038	62.460988	-114.386686	0.800	0.050	0.025	0.050	0.150	0.175
T000	62.460625	-114.387002	0.875	0.050	0.025	0.025	0.075	0.100
T001	62.460536	-114.387114	0.875	0.050	0.025	0.025	0.100	0.125
T002	62.460438	-114.387181	1.025	0.050	0.025	0.025	0.100	0.150
T003	62.460346	-114.387209	1.000	0.050	0.025	0.025	0.125	0.150
T004	62.460241	-114.387213	1.025	0.050	0.025	0.025	0.125	0.150
T005	62.460153	-114.387215	0.900	0.050	0.025	0.025	0.100	0.150
T006	62.460067	-114.387204	0.925	0.050	0.025	0.025	0.075	0.125
T007	62.459977	-114.387190	1.000	0.050	0.025	0.025	0.075	0.125
T008	62.459879	-114.387195	1.175	0.050	0.025	0.025	0.075	0.125
T009	62.459789	-114.387241	1.175	0.050	0.025	0.025	0.050	0.100
T010	62.459699	-114.387313	0.950	0.050	0.025	0.025	0.050	0.100
T011	62.459611	-114.387369	1.000	0.050	0.025	0.025	0.050	0.100
T012	62.459532	-114.387434	1.025	0.050	0.025	0.025	0.075	0.100
T013	62.459438	-114.387520	1.025	0.050	0.025	0.025	0.050	0.100
T014	62.459344	-114.387566	0.975	0.050	0.025	0.025	0.050	0.100
T015	62.459246	-114.387578	0.975	0.050	0.025	0.025	0.050	0.075
T016	62.459150	-114.387590	1.100	0.050	0.025	0.025	0.050	0.100
T017	62.459047	-114.387594	1.250	0.050	0.025	0.025	0.050	0.100
T018	62.458941	-114.387617	1.550	0.050	0.025	0.025	0.050	0.100
T019	62.458846	-114.387636	1.725	0.050	0.025	0.025	0.050	0.100
T020	62.458746	-114.387657	2.600	0.050	0.025	0.025	0.050	0.100
T021	62.458660	-114.387694	2.850	0.050	0.025	0.025	0.050	0.100
T022	62.458560	-114.387732	3.150	0.050	0.025	0.025	0.100	0.150
T023	62.458470	-114.387749	3.450	0.050	0.025	0.025	0.125	0.150
T024	62.458377	-114.387808	3.800	0.050	0.025	0.025	0.100	0.150
T025	62.458292	-114.387872	4.125	0.050	0.025	0.025	0.100	0.125
T026	62.458207	-114.387921	4.400	0.050	0.025	0.025	0.100	0.125
T027	62.458118	-114.387965	4.725	0.050	0.025	0.025	0.100	0.125
T028	62.458028	-114.388003	4.975	0.050	0.025	0.025	0.100	0.125
T029	62.457933	-114.388032	5.200	0.050	0.025	0.025	0.100	0.125
T030	62.457842	-114.388074	5.300	0.050	0.025	0.025	0.100	0.125
T031	62.457745	-114.388098	5.350	0.075	0.025	0.025	0.100	0.125
T032	62.457652	-114.388120	5.375	0.075	0.025	0.025	0.100	0.125
T033	62.457553	-114.388129	5.300	0.050	0.025	0.025	0.100	0.125
T034	62.457448	-114.388125	5.200	0.075	0.025	0.025	0.100	0.125
T035	62.457349	-114.388121	5.050	0.075	0.025	0.025	0.100	0.125
T036	62.457248	-114.388102	4.900	0.100	0.025	0.025	0.125	0.125
T037	62.457145	-114.388095	4.825	0.100	0.025	0.025	0.100	0.150
T038	62.457052	-114.388094	4.775	0.100	0.050	0.025	0.100	0.150
T039	62.456958	-114.388143	4.825	0.100	0.025	0.025	0.100	0.150
T040	62.456872	-114.388193	4.850	0.100	0.025	0.025	0.100	0.125
T041	62.456775	-114.388243	4.750	0.100	0.025	0.025	0.100	0.100
T042	62.456685	-114.388280	4.575	0.100	0.025	0.025	0.100	0.100
T043	62.456592	-114.388365	3.050	0.100	0.050	0.025	0.075	0.125
T044	62.456496	-114.388442	2.550	0.050	0.050	0.025	0.075	0.125
T045	62.456412	-114.388524	3.300	0.050	0.025	0.025	0.100	0.150
T046	62.456318	-114.388617	3.500	0.075	0.050	0.025	0.100	0.150

Appendix C Table (cont.)

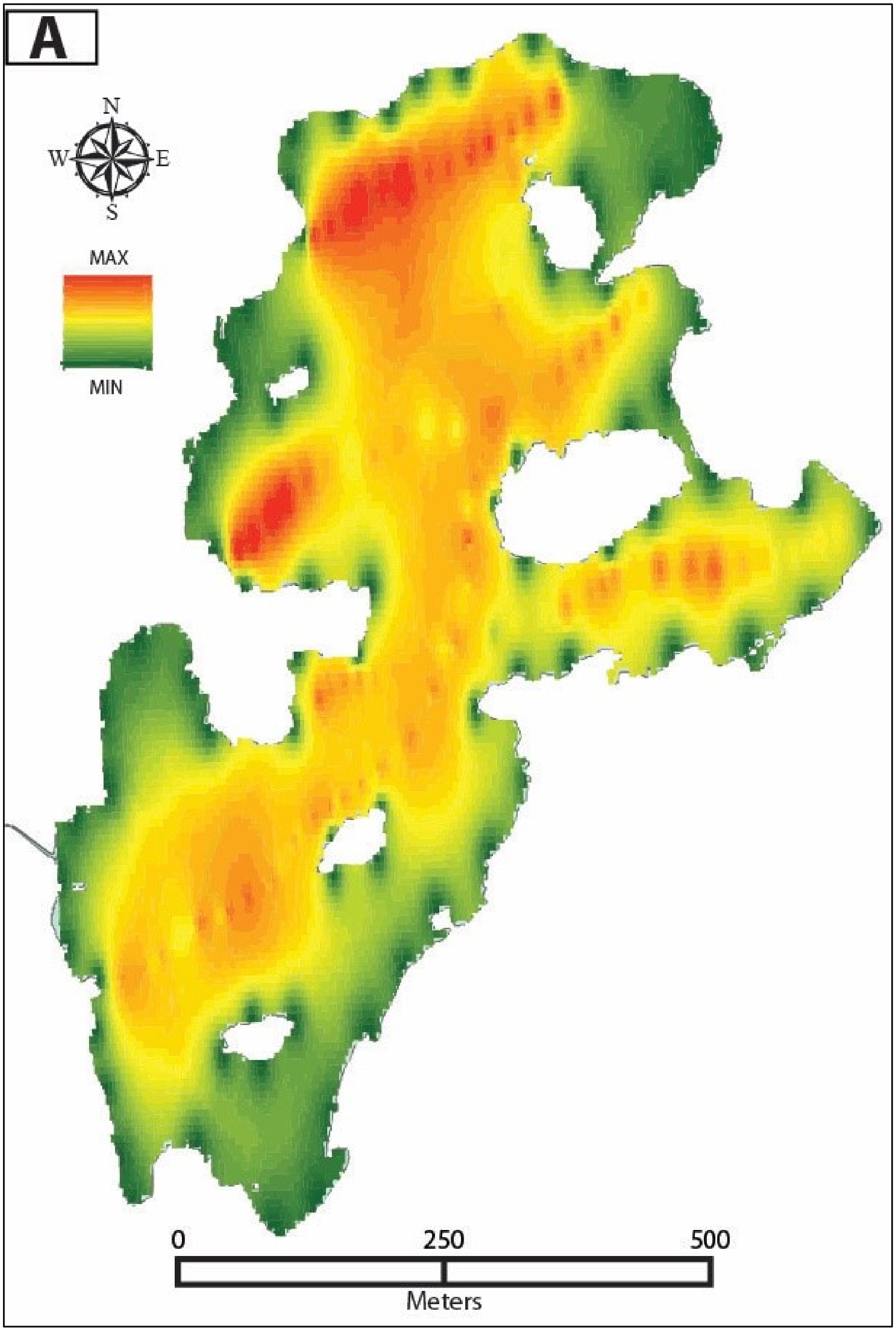
Section	Latitude	Longitude	WD	L1	L2	L3	L4	L5
T047	62.456236	-114.388689	3.500	0.050	0.025	0.025	0.100	0.150
T048	62.456147	-114.388750	3.375	0.050	0.025	0.025	0.100	0.150
T049	62.456075	-114.388798	3.425	0.050	0.050	0.025	0.050	0.100
T050	62.456001	-114.388836	3.800	0.050	0.050	0.025	0.050	0.100
T051	62.455917	-114.388850	3.925	0.050	0.050	0.025	0.050	0.100
T052	62.455839	-114.388879	4.000	0.050	0.050	0.025	0.075	0.075
T053	62.455760	-114.388910	3.950	0.050	0.050	0.025	0.075	0.125
T054	62.455668	-114.388932	3.925	0.100	0.050	0.025	0.075	0.125
T055	62.455580	-114.388925	3.650	0.100	0.050	0.025	0.100	0.150
T056	62.455486	-114.388889	3.250	0.100	0.050	0.025	0.125	0.175
T057	62.455390	-114.388861	2.500	0.050	0.025	0.025	0.100	0.125
T058	62.455269	-114.388834	2.250	0.075	0.025	0.025	0.100	0.125
T059	62.455170	-114.388849	2.250	0.050	0.025	0.050	0.100	0.150
T060	62.455075	-114.388873	2.025	0.075	0.025	0.025	0.100	0.125
T061	62.454979	-114.388932	1.725	0.050	0.025	0.025	0.100	0.125
T062	62.454904	-114.388973	1.700	0.050	0.025	0.025	0.075	0.100
T063	62.454810	-114.389049	1.625	0.050	0.025	0.025	0.075	0.125
T064	62.454733	-114.389104	1.550	0.050	0.025	0.025	0.075	0.100
T065	62.454645	-114.389163	1.575	0.050	0.025	0.025	0.075	0.125
T066	62.454542	-114.389204	1.550	0.050	0.025	0.025	0.075	0.125
T067	62.454449	-114.389241	1.550	0.050	0.025	0.025	0.075	0.125
T068	62.454354	-114.389256	1.525	0.075	0.025	0.025	0.100	0.125
T069	62.454260	-114.389317	1.550	0.050	0.025	0.050	0.100	0.150
T070	62.454173	-114.389372	1.550	0.050	0.025	0.050	0.100	0.150
T071	62.454082	-114.389433	1.500	0.050	0.025	0.025	0.075	0.100
T072	62.453997	-114.389525	1.525	0.050	0.025	0.025	0.100	0.125
T073	62.453906	-114.389646	1.425	0.075	0.025	0.025	0.075	0.100
T074	62.453821	-114.389760	1.400	0.050	0.025	0.025	0.100	0.125
T075	62.453730	-114.389876	1.325	0.050	0.025	0.025	0.100	0.125
T076	62.453651	-114.389964	1.400	0.050	0.025	0.050	0.100	0.150
T077	62.453565	-114.390066	1.450	0.100	0.025	0.025	0.100	0.125
T078	62.453472	-114.390142	1.225	0.050	0.025	0.025	0.075	0.125
T079	62.453367	-114.390205	1.300	0.050	0.025	0.025	0.100	0.125
T080	62.453276	-114.390303	1.300	0.100	0.025	0.025	0.100	0.100
T081	62.453196	-114.390405	1.325	0.050	0.025	0.025	0.100	0.125
T082	62.453111	-114.390523	1.000	0.050	0.025	0.025	0.100	0.125
T083	62.453026	-114.390648	1.150	0.100	0.025	0.025	0.100	0.125
T084	62.452942	-114.390782	1.300	0.100	0.025	0.025	0.100	0.125
T085	62.452877	-114.390954	1.225	0.075	0.025	0.025	0.100	0.100
T086	62.452801	-114.391115	1.425	0.050	0.025	0.025	0.075	0.100
T087	62.452722	-114.391290	1.300	0.075	0.025	0.025	0.075	0.100
T088	62.452653	-114.391453	1.650	0.075	0.025	0.025	0.100	0.100
T089	62.452581	-114.391618	1.875	0.100	0.025	0.025	0.100	0.100
T090	62.452502	-114.391773	1.825	0.050	0.025	0.025	0.075	0.100
T091	62.452447	-114.391963	1.800	0.050	0.025	0.025	0.075	0.100
T092	62.452379	-114.392136	1.800	0.100	0.025	0.025	0.100	0.100
T093	62.452314	-114.392305	1.625	0.075	0.025	0.025	0.075	0.100
T094	62.452253	-114.392483	1.450	0.075	0.025	0.025	0.100	0.100
T095	62.452205	-114.392682	1.050	0.100	0.025	0.025	0.100	0.100
T096	62.452163	-114.392870	1.000	0.050	0.025	0.025	0.075	0.100
T097	62.452122	-114.393077	0.975	0.100	0.025	0.025	0.100	0.150
T098	62.452082	-114.393259	0.975	0.100	0.025	0.025	0.100	0.100

Appendix C Table (cont.)

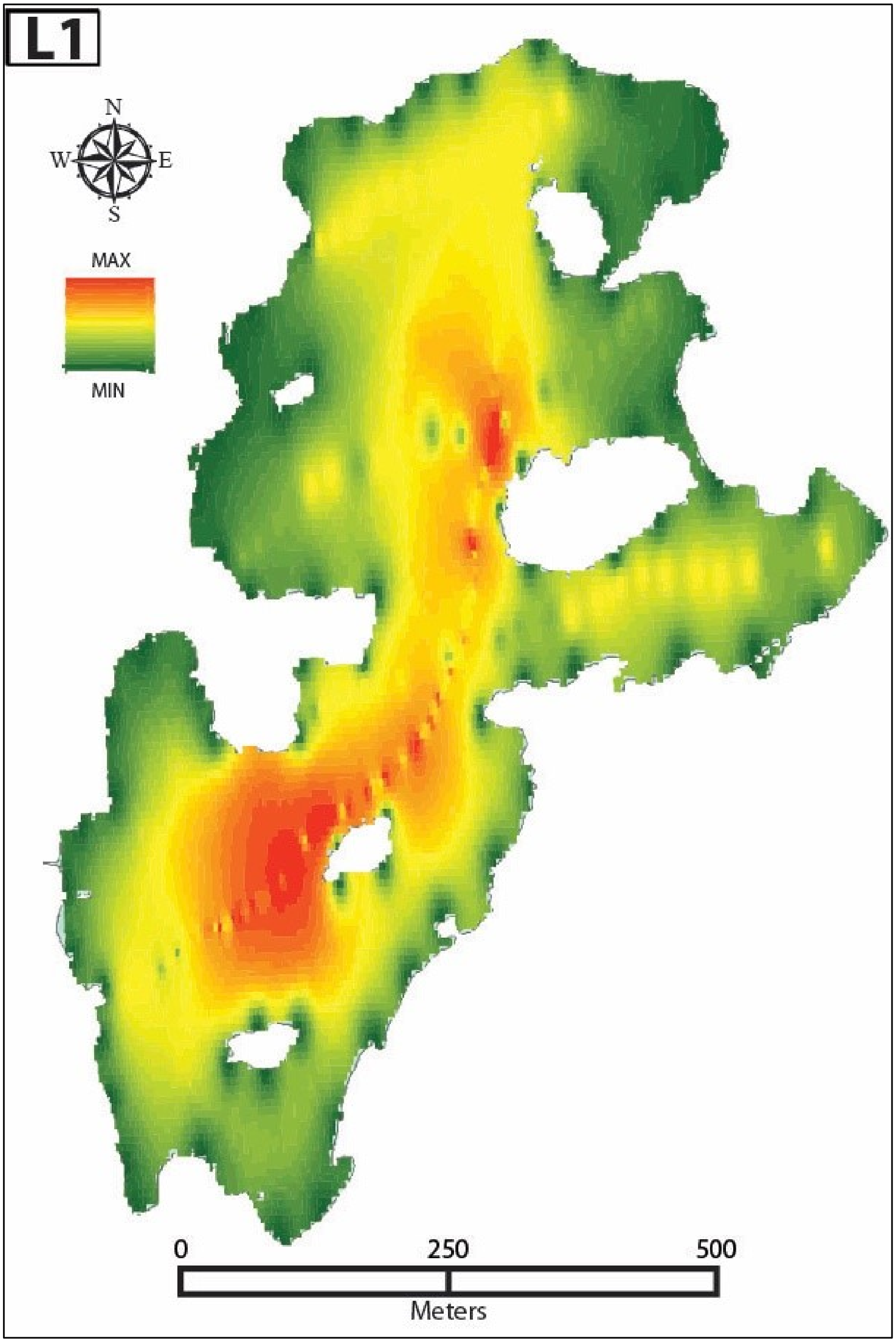
Section	Latitude	Longitude	WD	L1	L2	L3	L4	L5
T099	62.452036	-114.393414	1.100	0.100	0.025	0.025	0.100	0.125
T100	62.451978	-114.393555	1.000	0.100	0.025	0.025	0.100	0.125
T101	62.451924	-114.393700	0.925	0.100	0.025	0.025	0.075	0.100
T102	62.451852	-114.393837	1.100	0.100	0.025	0.025	0.075	0.100
T103	62.451778	-114.393973	1.350	0.050	0.025	0.025	0.075	0.100
T104	62.451698	-114.394095	1.200	0.100	0.025	0.025	0.100	0.100
T105	62.451612	-114.394208	1.050	0.100	0.025	0.025	0.050	0.100
T106	62.451533	-114.394324	1.075	0.100	0.025	0.025	0.050	0.100
T107	62.451461	-114.394424	1.200	0.100	0.025	0.025	0.075	0.100
T108	62.451383	-114.394517	1.050	0.100	0.025	0.025	0.050	0.075
T109	62.451295	-114.394635	1.075	0.075	0.050	0.025	0.075	0.100
T110	62.451215	-114.394771	1.200	0.100	0.025	0.025	0.100	0.125
T111	62.451143	-114.394936	0.975	0.100	0.025	0.025	0.075	0.100
T112	62.451078	-114.395115	1.025	0.075	0.025	0.025	0.100	0.150
T113	62.451034	-114.395304	1.025	0.075	0.050	0.025	0.100	0.125
T114	62.450978	-114.395491	0.925	0.100	0.050	0.025	0.125	0.150
T115	62.450917	-114.395664	1.000	0.075	0.050	0.025	0.100	0.125
T115	62.450886	-114.395753	0.950	0.075	0.050	0.025	0.100	0.125
T116	62.450854	-114.395832	1.150	0.100	0.075	0.025	0.075	0.100
T116	62.450826	-114.395928	1.350	0.075	0.025	0.050	0.100	0.150
T117	62.450799	-114.396028	1.325	0.125	0.075	0.050	0.075	0.125
T117	62.450772	-114.396129	1.250	0.050	0.025	0.050	0.075	0.100
T118	62.450749	-114.396231	1.350	0.050	0.025	0.050	0.075	0.100
T118	62.450735	-114.396345	1.625	0.050	0.025	0.050	0.075	0.100
T119	62.450723	-114.396448	1.550	0.100	0.050	0.025	0.075	0.075
T119	62.450710	-114.396573	1.950	0.050	0.050	0.050	0.075	0.125
T120	62.450701	-114.396682	2.250	0.075	0.025	0.025	0.100	0.150
T120	62.450688	-114.396800	2.750	0.075	0.050	0.025	0.100	0.150
T121	62.450673	-114.396896	3.050	0.075	0.050	0.025	0.100	0.150
T121	62.450653	-114.397019	4.025	0.050	0.050	0.025	0.050	0.125
T122	62.450629	-114.397104	4.250	0.050	0.025	0.025	0.050	0.100
T122	62.450599	-114.397208	4.350	0.065	0.015	0.026	0.050	0.094
T123	62.450562	-114.397303	4.350	0.050	0.025	0.025	0.050	0.100
T123	62.450522	-114.397407	4.350	0.050	0.025	0.025	0.050	0.100
T124	62.450488	-114.397480	4.250	0.050	0.025	0.025	0.050	0.100
T124	62.450441	-114.397582	4.225	0.050	0.025	0.025	0.050	0.100
T125	62.450410	-114.397661	3.575	0.025	0.050	0.025	0.075	0.100
T125	62.450366	-114.397746	3.450	0.050	0.050	0.025	0.050	0.125
T126	62.450336	-114.397823	3.225	0.050	0.050	0.025	0.050	0.125
T126	62.450290	-114.397921	3.300	0.050	0.025	0.025	0.125	0.125
T127	62.450250	-114.398004	2.825	0.050	0.025	0.025	0.125	0.125
T127	62.450221	-114.398102	2.650	0.025	0.050	0.025	0.075	0.100
T128	62.450190	-114.398203	2.425	0.025	0.050	0.025	0.075	0.100
T128	62.450164	-114.398295	2.325	0.050	0.050	0.025	0.050	0.125
T129	62.450132	-114.398390	2.925	0.050	0.050	0.025	0.050	0.125
T129	62.450105	-114.398483	2.225	0.050	0.025	0.025	0.125	0.125
T130	62.450085	-114.398559	2.775	0.050	0.025	0.025	0.125	0.125
T130	62.450060	-114.398650	2.750	0.050	0.025	0.025	0.125	0.125
T131	62.450038	-114.398744	2.625	0.050	0.025	0.025	0.125	0.125
T131	62.450018	-114.398829	2.425	0.050	0.025	0.025	0.125	0.125
T132	62.450001	-114.398904	2.175	0.050	0.025	0.025	0.125	0.125
T132	62.449988	-114.398969	1.975	0.050	0.025	0.025	0.125	0.125
T133	62.449977	-114.399025	1.700	0.050	0.025	0.025	0.125	0.150

Appendix D - Full size map view of IDW interpolation.

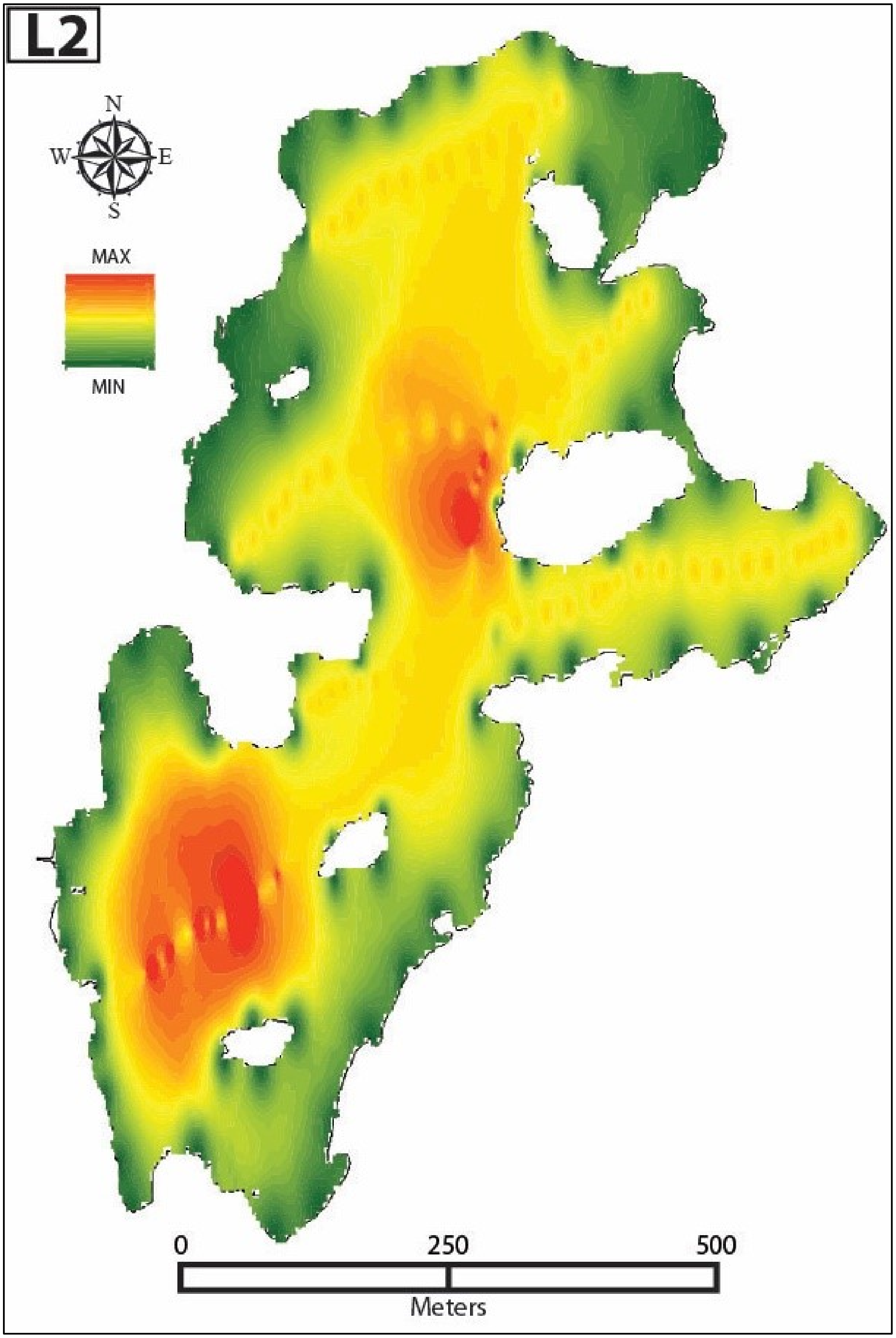
D.1 Total contaminated sediment IDW thickness Map.



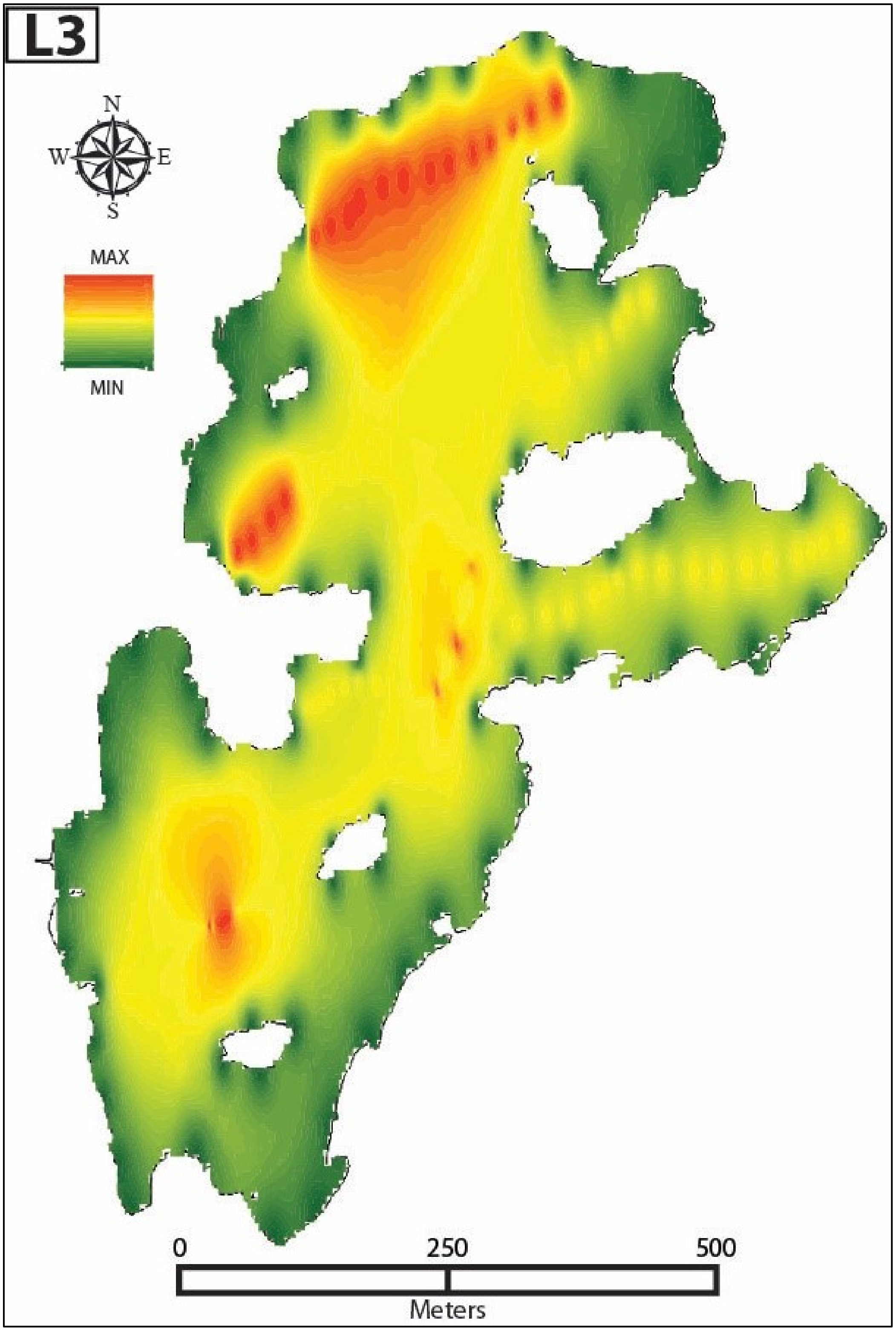
D.2 L1 contaminated sediment IDW thickness Ma



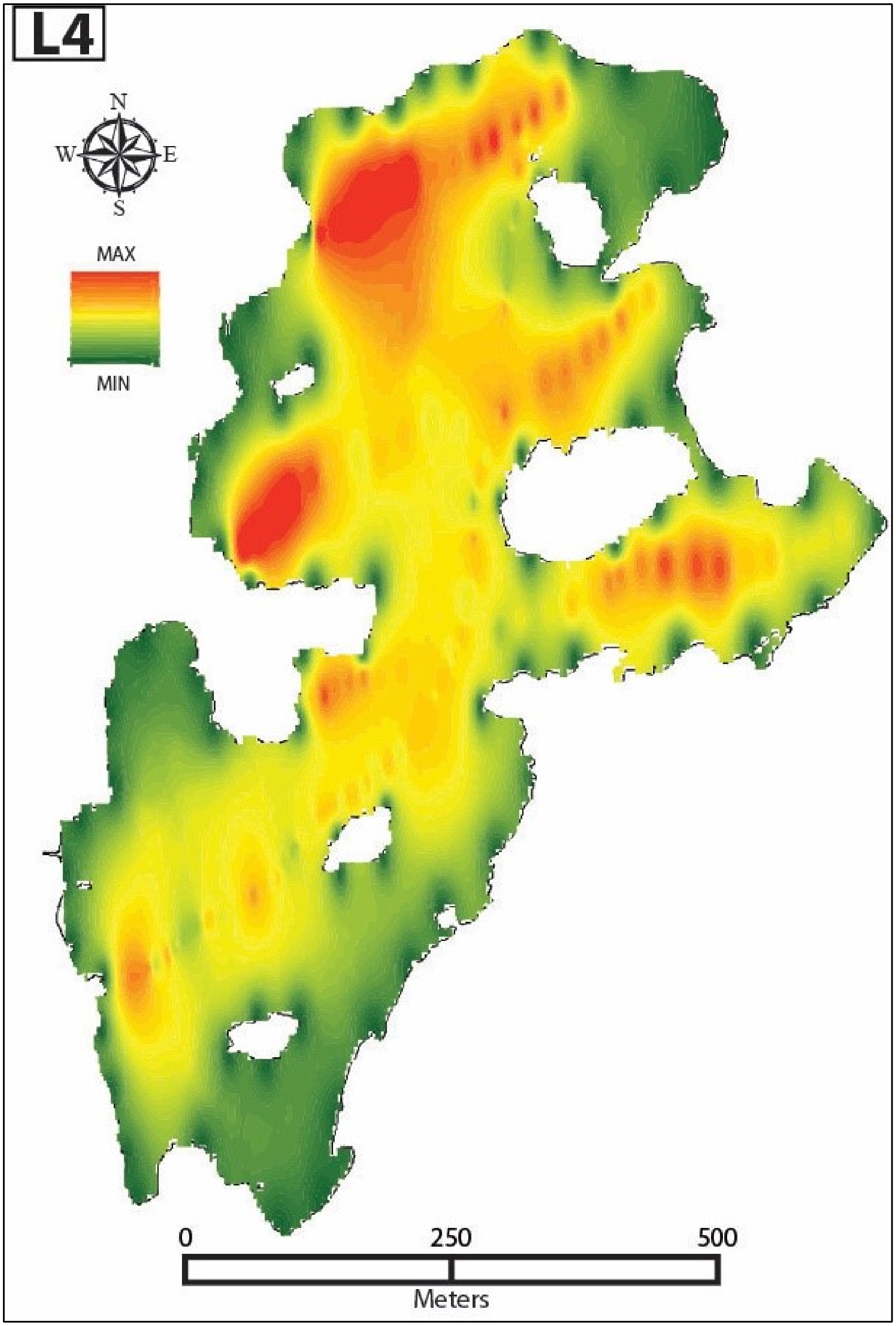
D.3 L2 contaminated sediment IDW thickness Map.



D.4 L3 contaminated sediment IDW thickness Map.



D.5 L4 contaminated sediment IDW thickness Map.



D.6 L5 contaminated sediment IDW thickness Map.