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1.0 Introduction

Over the past 20 years the Geological Survey of Canada (GSC) and the Ontario Geological Survey (OGS) have carried out numerous studies on the glacial sediments of southeastern Ontario (Fig. 1). Much of the work carried out by the GSC is referenced in a field trip guidebook examining the extent, architecture, sedimentary facies and origin of buried valleys within the Oak Ridges Moraine (ORM) (Sharpe et al., 2013). Although much work has involved sequence stratigraphy and basin analyses of sediments within this region, there is a lack of information on the regional geochemistry of sediments. Results from such studies are helpful for defining chemical and related mineralogical variations within sediments and contributes to information collected by sediment description, grain size data, downhole geophysical and stratigraphic correlations. Geochemical data also provides the opportunity to establish a chemostratigraphic framework that complements other stratigraphic correlation techniques, such as lithostratigraphy and biostratigraphy.

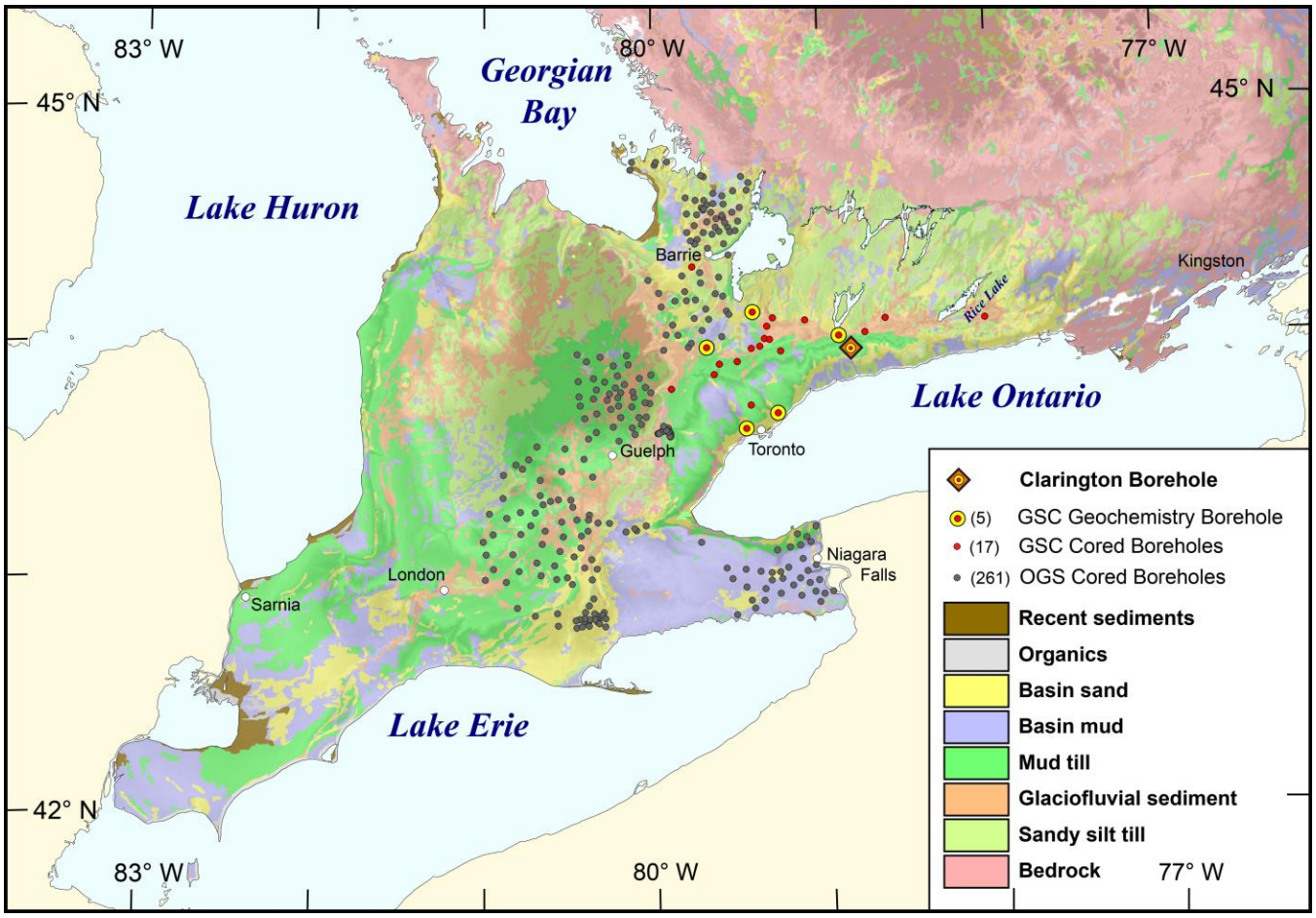

Figure 1: Location of the Clarington borehole with simplified regional geology of southwestern Ontario overlying a DEM. Note the distribution of OGS and GSC stratigraphic boreholes with continuous core descriptions. Geology simplified from Barnett et al., 1991.

For groundwater studies, the collection of sediment geochemistry data is often beyond the scope, and budget of many programs, and is generally not included as a part of routine data collection. Portable X-ray fluorescent (pXRF) spectrometry has proven to be a successful tool to characterize the chemostratigraphy of glacially derived sediments (e.g. Crow et al., 2012; Knight et al., 2015a, b) as well as improving the interpretation of various borehole datasets including downhole geophysics, micropaleontology, and pore water geochemistry (Medioli et al., 2012). Data collected by this method has now become a routine part of borehole studies within the groundwater program at the GSC (Knight et al., 2015a, b, 2012). The method is best suited to unconsolidated or crushed bedrock detritus, and reworked surficial sediments that are <0.063 mm (silt and clay) in size (Plourde et al., 2012, Knight et al., 2012). The resulting data sets provide fundamental information used to define chemical and mineralogical variations within aquifers and aquitards.

The objective of this Open File is to publish the geochemical analyses of 96 samples from a 127 m borehole drilled north of Oshawa, Ontario (Fig. 2) and associated QA-QC data collected using a pXRF spectrometer.

Figure 2: Location of the Clarington, Purple Woods and Grasshopper Road boreholes. Image from Google Earth, 2015.

2.0 Study Area Geological Setting

The Clarington borehole is located on the north side of Oshawa, at easting 672905 and northing 4872453 (UTM NAD 83, Zone 17) with an elevation of ~246m a.s.l., and is 13km north of Lake Ontario, (Fig. 1 and 2). It was drilled between Nov 24, 2014 and Dec 18th, 2014 using a mud rotary/wireline system with core collected in 5 ft runs, placed in PVC tubes, and sealed with tape. Drilling was supervised by Stantec Consulting Limited under contract to HydroOne. The site is located just north of the southern edge of the Oak Ridges Moraine administrative planning boundary, which is delineated approximately by the 245 m elevation contour interval, rather than by site-specific geologic or hydrogeologic characteristics (Stantec, 2014).

The borehole is located south of the Oak Ridges Moraine on a till upland of Newmarket Till (Sharpe et al., 1997). Minor amounts of sand may be present in the area as a discontinuous cover on the Newmarket Till. To the northeast a cluster of streamlined landforms are mapped trending from northeast to southwest. Borehole investigations collected continuous core to the northwest at the Purple Woods Conservation Authority Area (Knight et al., in press; Coffin et al., in press) and northeast at the Grasshopper road site (Sharpe et al., 2003). The Grasshopper site also has a p-wave seismic reflection profile oriented approximately north-south and approximately 3.25 km in length (Sharpe et al., 2003).

Based on shoreline geology, quarry operations and bedrock intercepted in the Purple Woods borehole (Coffin et al., in press) the bedrock in the area is assigned to the Blue Mountain Formation. This is overlain by progressively thicker succession of sediment with distance northward from the Lake Ontario shoreline. At Purple Woods 45 m of probable Thorncliffe equivalent sands are overlain by 69 m of Newmarket Till which in turn is overlain by 34 m of Oak Ridges Moraine sediment. Based on lateral continuity in outcrop along the Lake Ontario shoreline Thorncliffe Formation sediment or equivalents consists of well laminated muds and sands (Brookfield et al., 1982; Martini and Brookfield, 1995). At the Purple Woods borehole Thorncliffe Formation sediment consists of rhythmically bedded muds with only minor, rare sand beds (Coffin et al., in press). A similar mud-dominated succession is documented in the Pontypool continuous core by Russell et al. (2003). Further to the northwest in the Aurora – Newmarket area continuous core intercepting Thorncliffe Formation of the Yonge Street Aquifer forms a fining upward succession interpreted to be a subaqueous fan (Sharpe et al., 2011).

Newmarket Till consists of a massive dense, 10–70 m thick, stony sandy silt diamicton with minor sand-mud inter-beds and stone lines (Sharpe et al., 1997; Boyce et al., 1995) that forms a regional seismo-stratigraphic marker bed due to its high seismic velocity (Pugin et al., 1999; Pullan et al., 2002). The Newmarket Till is generally considered to be an aquitard, however, where exposed at the surface fractures may provide connectivity to inter-beds at depth and may allow recharge to underlying aquifers at a rate of 40 mm/year, (Gerber and Howard 1996). To the north, the Oak Ridges Moraine rises to >300 m elevation asl and can be over 100 metres thick, particularly over buried tunnel valleys that can be locally eroded to bedrock (e.g. Sharpe et al., 2002; 2003).

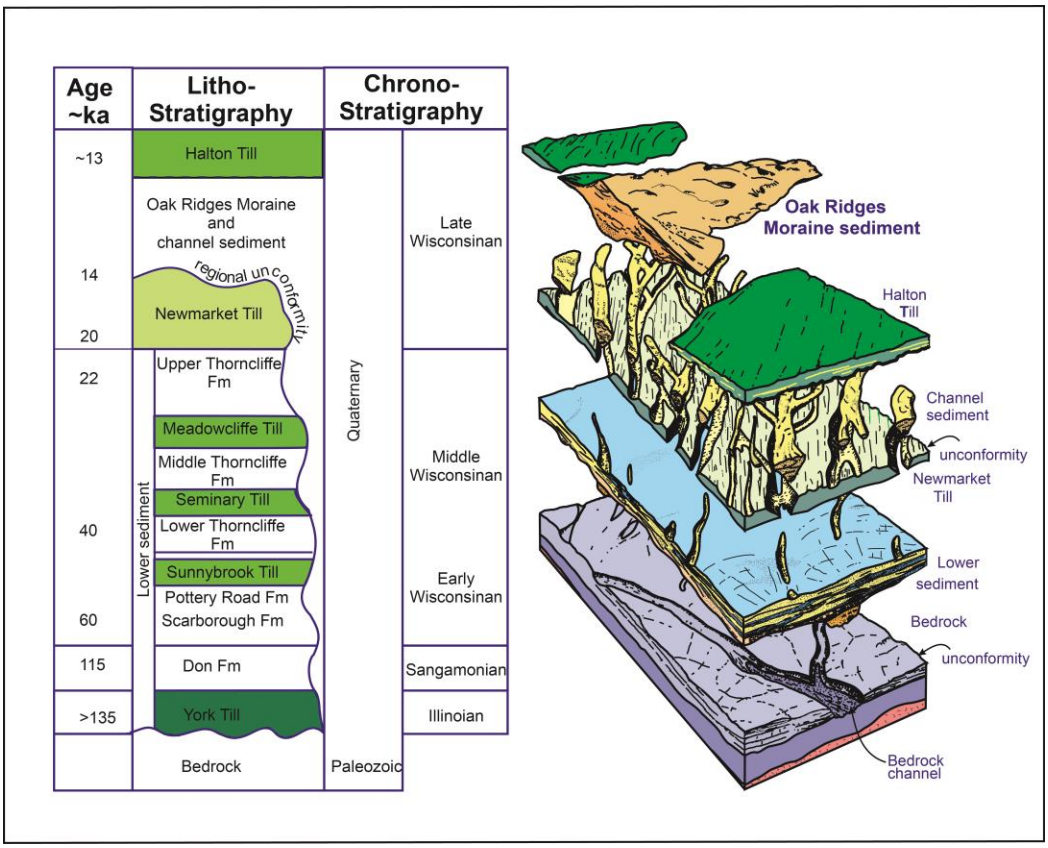

Figure 3: Stratigraphy of the Greater Toronto Area. Modified from Sharpe et al. (2002). Key till units highlighted in green.

3.0 Sample collection, processing and analytical methods

The Clarington borehole is terminated in bedrock and intersects overlying sand and mud that most likely represent sediments of the Thorncliffe Formation, diamicton assigned to the Newmarket Till and shallow surface sand (Fig. 3). Samples for grain size and geochemistry were stored in coolers on site and delivered to the sedimentology lab at the GSC in Ottawa. Grain size was determined for each sample being analysed for geochemistry using a Camsizer particle scanner and a Lecotrac LT100 laser diffractometer. All grains > 2 mm in diameter were removed prior to analysis. These results are only presented in graphic form as clay-silt-sand x-y graphs adjacent to the litho-sediment-stratigraphy log.

Prior to pXRF analyses the sediment was disaggregated and sieved to <63 µm (silt + clay) at the GSC Sedimentology Laboratories in Ottawa. A split of the processed samples were placed in 23 mm diameter plastic vials, to an approximate height of 30 mm, previous studies indicate that this thickness is adequate to satisfy the assumption of an infinitely thick sample (Knight et al., 2015), and sealed with 4 µm Chemplex Prolene thin-film. Portable XRF data were acquired using a handheld Thermo Scientific, Niton XL3t GOLDD spectrometer equipped with Cygnet 50 kV, 2-watt Ag anode X-ray tube and a XL3 silicon drift detector (SDD) with 180,000 counts per second (cps) throughput, mounted to a test stand (Fig. 4).

Figure 4. Example of pXRF spectrometer mounted in a test stand with microcomputer for analysis of processed sediment samples.

Samples collected for pXRF spectrometry were analyzed in both Soil and Mining Modes. Soil Mode uses Compton normalization which is recommended for elements expected to occur with < 1% concentration. Mining Mode uses Fundamental Parameters which is recommended for elements expected to exceed >1% concentration. In order to honor the protocol used for previous borehole studies (Knight et al., 2015a, Knight et al., 2015b, Knight et al., 2012, Plourde et al., 2012), a dwell time of 60 seconds was used for each filter (Main, Low, and High) for a total of 180 seconds per analysis for soil mode. For mining mode a dwell time of 45 seconds was used for each filter (Main, Low, High, and Light) for a total of 180 seconds per analysis. The X-ray energy intensities used to determine elemental concentrations in Soil Mode are listed in Table 1.

3.1 Reproducibility and Precision of Standards

A Teflon blank and a SiO_2 blank were analysed to determine the cleanliness of the pXRF window and sample stand environment. After approximately 10 analyses the operating environment (test stand) was purged with compressed air and wiped clean. Commonly the Teflon blank returns values in the 10's of ppm Ti and may return trace amounts of Mo. The Chemplex Prolene thin-film that separates all samples except the Teflon blank from the spectrometer may contain trace amounts of Ca, P, Fe, Zn, Cu, Zr, Ti and Al. For the SiO_2 blank, Ba, Cs, K, Pd, and S returned values below the recommended limits of detection (< LOD). These elements are not listed as known impurities on the Chemplex Prolene thin-film and most likely represent internal detector noise. Calcium and Fe returned values above the limits

of detection and may be associated with the impurities in Chemplex Prolene thin-film or represent contamination of the thin film.

Table 1: X-ray energy intensities used to determine elemental concentrations in Soil Mode, as provided by Thermo Scientific (2015).

Element	Line	Energy (keV)	Window Low (keV)	Window High (keV)	Filter
Ba	$K\alpha_1$	32.19	31.70	32.70	High
Ca	$K\alpha_1$	3.69	3.50	3.89	Low
Cu	$K\alpha_1$	8.05	7.84	8.24	Main
Fe	$K\alpha_1$	6.40	6.20	6.60	Main
K	$K\alpha_1$	3.31	3.10	3.49	Low
Mn	$K\alpha_1$	5.90	5.70	6.10	Main
Ni	$K\alpha_1$	7.48	7.35	7.67	Main
Rb	$K\alpha_1$	13.39	13.18	13.60	Main
S	$K\alpha_1$	2.31	2.20	2.45	Low
Sr	$K\alpha_1$	14.16	13.95	14.38	Main
Th	$L\alpha_1$	12.97	12.80	13.15	Main
Ti	$K\alpha_1$	4.51	4.21	4.70	Low
V	$K\alpha_1$	4.95	4.80	5.10	Low
Zn	$K\alpha_1$	8.64	8.49	8.83	Main
Zr	$K\alpha_1$	15.77	15.53	15.98	Main

We recommend that the Chemplex Prolene thin-film be replaced on a regular basis to avoid contamination. A study into the precision, accuracy, instrument drift, dwell time optimization and calibration of pXRF spectrometry for reference materials including Till-1, Till-4, and TCA 8010 is available from Knight et al. (2013).

For each element detected in a given standard, the count, minimum value, maximum value, mean, standard deviation, relative standard deviation (%RSD), error and recommended values as determined by traditional wet chemistry methods are listed for both soil and mining mode in Table 2a and b (Till-1), Table 3a and b (Till-4), and Table 4a and b (TCA 8010). The error column contains the difference between the mean and recommended value. Low absolute values in this column indicate that the element is measured accurately; high absolute values indicate that a calibration curve is required to correct the data or that the data are not reliable. As an example Ni values obtained from Till-1 in soil mode have an error of 250% with a recommended value of 24 ppm and a pXRF mean value from 13 analyses of 84 ppm. Similarly, U values obtained from Till-4 in soil mode have an error of 220%. Although care must be taken when interpreting data with a high error, it may be useful to plot these elements to see if their relative changes in chemostratigraphy correlate with those of other more reliable elements. Since chemostratigraphy utilizes the relative changes in concentration, high precision in returned values is more important than accuracy. It is also important to note that the precision and accuracy are affected by concentration. Lower concentrations, especially those near the limit of detection (LOD) tend to result in lower precision, and thus higher %RSD.

3.2 Limit of Detection

Thermo Scientific provides a list of the sensitivity or limits of detection for the pXRF. During analyses the pXRF provides an error of each individual measurement taken throughout the 180 second analysis. For this study the error was recorded as 2 standard deviations. Surprisingly for some elements (e.g. As Cr, Ni, and Th in soil mode) the pXRF returned some analyses lower than the recommended LOD. When this occurred, the point was plotted on the chemostratigraphy graph using the returned number however an arrow and title (LOD) was placed on the x-axis depicting the recommended LOD value. Elements detected by each filter for soil and mining mode and the corresponding lower limits of detection are listed in Table 5a and b.

Table 2a. Summary statistics for Till-1 by pXRF spectrometry (soil mode) for the Clarington borehole.

	Recommended Value (ppm)	Count	Mean (ppm)	%error	Std Dev (ppm)	%RSD	Minimum (ppm)	Maximum (ppm)
As	18	13	24	35.85	23.9	97.67	14	104
Ba	702	13	839	19.48	128.8	15.36	414	903
Ca	19440	13	16386	-15.71	2574	15.71	7844	17427
Co	18	2	139	670	5.6	4.04	135	143
Cr	65	13	28	-56.36	4.0	14.16	20	34
Cu	47	13	63	34.24	45.9	72.81	45	216
Fe	48100	13	40171	-16.48	2110	5.25	33228	41206
K	18429	13	15851	-13.99	2306	14.55	14867	23499
Mn	1420	13	1303	-8.26	255	19.59	456	1400
Mo	2	3	9	336	6.0	69.21	4.8	15.6
Ni	24	13	84	250	10.9	12.97	62	100
Pb	22	13	15	-31.65	9.4	62.24	11	46
Rb	44	13	49	10.88	31.4	64.26	39	153
S	500	4	447	-10.54	216.7	48.44	326	772
Sr	291	13	256	-11.96	46.1	17.99	103	272
Th	5.6	12	7.5	34.30	10.9	145.34	3.01	42
Ti	5990	13	5264	-12.12	225.2	4.28	4615	5542
U	2.2	12	7.6	245	2.6	33.98	4.9	15
V	99	13	164	66	15.6	9.50	138	187
W	1	3	81	8020	72.7	89.49	36	165
Zn	98	13	87	-10.92	8.1	9.28	64	95
Zr	502	13	547	8.93	39.3	7.19	425	574

Table 2b. Summary statistics for Till-1 by pXRF spectrometry (mining mode) for the Clarington borehole.

	Recommended Value (ppm)	Count	Mean (ppm)	%error	Std Dev (ppm)	%RSD	Minimum (ppm)	Maximum (ppm)
As	18	13	24	31.66	2.07	8.75	21	27
Ba	702	13	715	1.92	20.9	2.92	676	741
Ca	19440	13	17603	-9.45	448	2.55	16814	18435
Cu	47	11	26	-43.84	4.12	15.60	19.07	33
Fe	48100	13	48571	0.98	384	0.79	48074	49435
K	18429	13	17446	-5.33	806	4.62	16439	18341
Mn	1420	13	1357	-4.43	63	4.61	1263	1444
Pb	22	13	19	-13.29	1.86	9.77	16	22
Rb	44	13	21	-52.06	0.38	1.78	20	22
S	500	13	631	26.16	74	11.80	529	802
Sr	291	13	217	-25.40	2.19	1.01	214	221
Th	6	13	17	206	4.11	24.00	11	28
Ti	5990	13	4891	-18.35	289	5.91	4487	5418
Zn	98	13	100	1.66	4.45	4.47	93	107
Zr	502	13	441	-12.17	6.26	1.42	433	451

Table 3a. Summary statistics of Till-4 by pXRF spectrometry (soil mode) for the Clarington borehole.

	Recommended Value (ppm)	Count	Mean (ppm)	%error	Std Dev (ppm)	%RSD	Minimum (ppm)	Maximum (ppm)
As	111	11	105	-5.04	2.6	2.42	100	108
Ba	395	11	459	16.27	17.5	3.81	431	489
Ca	8934	11	7905	-11.51	102.9	1.30	7786	8140
Cr	53	11	21	-60.78	3.5	17.03	14	28
Cu	237	11	213	-10.18	4.8	2.27	206	224
Fe	39700	11	33131	-16.55	243	0.73	32758	33528
K	26980	11	23692	-12.19	223	0.94	23430	24163
Mn	490	11	449	-8.29	16	3.57	4256	482
Mo	16	11	16	2.47	1.4	8.68	15	19
Ni	17	11	57	235	10.1	17.73	43	75
Pb	50	11	41	-17.54	1.7	4.05	39	44
Rb	161	11	151	-6.46	1.4	0.93	147	153
S	800	11	642	-19.73	75.7	11.79	517	735
Sr	11	11	106	860	1.5	1.39	103	108
Th	17.4	11	42	141	1.2	2.73	40	43
Ti	4840	11	4633	-4.27	39.3	0.85	4565.	4688
U	5	11	16	220	4.1	25.50	9	23
V	67	11	127	90.00	11.4	8.98	110	146
W	204	11	178	-12.62	9.3	5.21	160	190
Zn	70	11	67	-4.02	3.4	4.98	63	73
Zr	385	11	429	11.35	11.7	2.72	415	456

Table 3b. Summary statistics of Till-4 by pXRF spectrometry (mining mode) for the Clarington borehole.

	Recommended Value (ppm)	Count	Mean (ppm)	%error	Std Dev (ppm)	%RSD	Minimum (ppm)	Maximum (ppm)
As	111	13	139	25.60	4.55	3.27	132	146
Ba	395	13	388	-1.86	21.86	5.64	345	429
Ca	8934	13	8643	-3.26	384	4.44	8022	9391
Cu	237	13	216	-9.03	5.97	2.77	207	226
Fe	39700	13	40802	2.78	244	0.60	40397	41135
K	26980	13	25949	-3.82	297	1.14	25581	26566
Mn	490	11	302	-38.38	23.22	7.69	268	333
Mo	16	13	11	-32.04	1.10	10.09	9.38	14
Pb	50	13	52	3.12	3.78	7.33	45	58
Rb	161	13	80	-50.27	0.76	0.95	79	82
S	800	13	1531	91.41	88.2	5.76	1392	1783
Sr	109	13	86	-21.47	1.64	1.92	83	88
Th	17.4	13	24	36.15	3.35	14.15	17	28
Ti	4840	13	4388	-9.33	448	10.21	3701	5310
U	5	11	6	11.16	0.85	15.35	4.4	7.0
W	204	13	217	6.37	22.7	10.47	168	245
Zn	70	13	70	0.40	3.65	5.19	63	76
Zr	385	13	342	-11.29	11.13	3.26	327	366

Table 4a. Summary statistics of TCA 8010 by pXRF spectrometry (soil mode) for the Clarington borehole.

	Recommended Value (ppm)	Count	Mean (ppm)	%error	Std Dev (ppm)	%RSD	Minimum (ppm)	Maximum (ppm)
As	5.45	12	6.48	18.87	0.99	15.34	4.97	8.20
Ba	549	12	724	31.92	11.6	1.60	704	742
Ca	15509	12	13924	-10.22	166	1.19	13607	14247
Co	7.9	2	74.2	839.18	7.2	9.69	69	80
Cr	48.4	12	15.3	-68.29	4.8	31.05	11.8	28
Cu	28	12	29	5.32	3.7	12.48	25	36
Fe	20290	12	13981	-31.09	106	0.76	138101	14112
K	19094	12	15779	-17.36	231	1.47	154089	16097
Mn	310	12	307	-0.93	12.6	4.10	293	327
Ni	17.2	12	62	262.85	7.7	12.34	48	75
Rb	53.6	12	49	-8.81	1.1	2.33	47	51
Sr	310	12	265	-14.53	2.0	0.77	260	268
Th	5.1	12	3.9	-23.12	0.8	20.28	2.8	5.3
Ti	2578	12	2478	-3.89	53.7	2.17	2385	2585
U	1.1	12	7.0	538.79	1.6	23.25	4.6	9.5
V	49	12	76	55.47	4.4	5.75	71	86
W	0.5	2	30	5855.00	3.7	12.33	27	32
Zn	31.9	12	33	2.76	3.0	9.06	28	38

Table 4b. Summary statistics of TCA 8010 by pXRF spectrometry (mining mode) for the Clarington borehole.

	Recommended Value (ppm)	Count	Mean (ppm)	%error	Std Dev (ppm)	%RSD	Minimum (ppm)	Maximum (ppm)
As	5.45	10	7.38	35.37	1.08	14.67	5.75	8.8
Ba	549	13	517	-5.82	21.45	4.15	485	554
Ca	15509	13	14737	-4.98	438	2.97	13988	15566
Fe	20290	13	19424	-4.27	205	1.06	19045	19793
K	19094	13	17351	-9.13	347	1.99	16755	17803
Pb	12.2	13	10	-14.91	1.50	14.41	7.8	13.2
Rb	53.6	13	26	-50.67	0.61	2.32	25	27
Sr	310	13	216	-30.26	2.07	0.96	213	221
Th	5.1	10	13.9	171.63	1.25	9.01	12.1	16
Ti	2578	12	2361	-8.43	138	5.85	2134	2612
Zn	31.9	13	36.3	13.81	2.44	6.72	31	39

Table 5a. Elements detected in the Clarington borehole with corresponding detection limits for the pXRF using two matrix configurations and the filters used to detect these elements in Soil mode, Thermo Scientific (2015).

Element	Matrix		Filter
	SiO_2	SiO_2 + Fe +Ca	
Ba	35	45	Low
Ca	40	N/A	Low
Cu	10	13	Low
Fe	25	N/A	Main
K	45	150	Low
Mn	35	50	Main
Ni	25	30	Main
Rb	3	3	Main
S	75	275	Low
Sr	3	3	Low
Ti	20	60	Low
V	10	25	Low
Zn	7	10	Main
Zr	3	4	Main

Table 5b. Elements detected in the Clarington core with corresponding detection limits for the pXRF using two matrix configurations and the filters used to detect these elements in Mining mode, Thermo Scientific (2015). *indicated LOD when used with He.

Element	Matrix		Filter
	SiO_2	SiO_2 + Fe +Ca	
Ba	35	40	High
Ca	50	N/A	Low
Cu	12	15	Main
Fe	35	N/A	Main
K	40	N/A	Low
Mn	60	65	Main
Ni	25	30	Main
Rb	3	3	Main
S	70/55*	90/75*	Light
Sr	3	3	Main
Ti	10	20	Main/Low
V	10	20	Main/ Low
Zn	8	15	Main
Zr	3	3	Main

4.0 Results and Surficial Chemostratigraphy

The pXRF data are interpreted using single element trends from the base to the top of the borehole.
In Soil Mode fourteen elements (Ba, Ca, Cu, Fe, K, Mn, Ni, Rb, S, Sr, Ti, V, Zn, and Zr) were detected in sufficient quantities to produce meaningful results using the pXRF spectrometer. In Mining Mode fifteen elements (Al, Ba, Ca, Fe, K, Mn, Pb, Rb, S, Si, Sr, Th, Ti, U, Zn, and Zr) were detected in sufficient quantities to produce meaningful results using the pXRF spectrometer. Results are presented in Appendix A and displayed graphically in Appendix B. Bivariate plot comparing soil mode to mining mode for twelve elements (Ba, Ca, Fe, K, Mn, Rb, S, Sr, Th, Ti, Zn, and Zr) are also displayed graphically in Appendix B. For some elements (e.g. Ca, Fe, K, Zr) there is very little difference between data collected in either mode, however sulphur in mining mode displays increased concentrations from 6 meter to 50 meters in depth. For the bivariate plots, a one-to-one relationship is plotted as a dashed green line. Linear regression lines determined by the least squares approach to the data are displayed on the figures in black. Due to 'clusters' of points within the dataset, the regression lines are more dependent on the location of the clusters, rather than the overall shape of the data. For strongly 'clustered' data, the regression lines occasionally deviated from the expected trend. Where this occurred (S, Th, Ti, and Zn) a reduced major axis regression (RMA), as described by York (1966) that assumes there are errors to both y and x data was also carried out. The RMA regression line is plotted as a blue line on the bivariate plots in Appendix B. Due to the similarity of results obtain from both modes the data presented below will be referring to soil mode.

Although all analyses are carried out on the <0.063 mm (silt and clay) size fraction the variability of silt and clay in each sample may affect the pXRF results. Other than a few horizons between 60 and 70 meters in depth the clay content of sediment from the Clarington borehole is below 20% and often below 10% or even less as is the case between 65 and 80 meters in depth. For zircon, pXRF results must be interpreted with consideration of glacial processes. Due to placer type concentration in glacial fluvial systems a heavy mineral such as zircon is preferentially concentrated in sand compared to till were the mineral is more evenly distributed. This accounts for the variation in zircon concentrations from 78 meters to the base of the borehole even though only the <0.063 mm (silt and clay) size fraction is being analysed. For Ba, Ca, and K, there is an increase in concentration from the base of the hole upwards through the first few meters. Other than the silty clay horizon between 105 and 113 meters there is very little variability in Rb or Sr throughout the core sediments regardless of the analyzed sample being glacial fluvial or till in origin. The silty clay horizon between 105 and 113 meters displays a marked decrease in Ba, Ti V, and Zr with a corresponding increase in Ca, Sr, and Zn. This silty clay horizon differs from the spike in clay at a depth of 65 meters where there is an increase in Ba, Fe, and V. For many elements (e.g. Fe, Mn, V), the Thorncliffe Formation sediments display a greater variation in elemental concentration compared to the overlying Newmarket Till.

The Newmarket Till displays increased concentrations of Ca, K and S from 5 to 52 meters in depth compared to the underlying till. The sand horizon at a depth of 52 to 54 meters displays an increase in Ba, Fe, Mn, Ni, Ti, V, and Zr. Elemental concentrations in the upper few meters of the borehole reflect modern anthropogenic landscape practices.

5.0 Summary

This geochemical study expands the range of sediments that has been analyzed as part of a study to characterize surficial sediment aquifers and aquitards across Canada. Core geochemistry assessed within a regional stratigraphic framework and within borehole geochemical trends suggest that the provenance of the Clarington core sediment was relatively consistent for both the sand and diamicton as depositional processes did not partition sediment to impart a strong change in geochemical signal. The possibility exists that for the <0.063 mm size fraction the Thorncliffe sediments were either incorporated into the matrix of the Newmarket Till or that both sediments had the same provenance. The silty clay horizon at a depth of 105 to 115 m does display a provenance change compared to the other sediments encountered in the borehole.

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