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Publications in this series have not been edited; they are released as submitted by the author.

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 southern Ontario. Much of this work is summarized in the Canadian Journal of Earth Sciences, Special Issue: Quaternary geology of southern Ontario and applications to hydrogeology (e.g., Bajc et al, 2018; Burt 2018, Russell et al., 2018). These studies utilized basin analysis techniques to study sediments within this region; however, there is a general lack of information on the regional geochemistry of Quaternary sediments in the area. Geochemical studies are crucial for defining chemical and mineralogical variations within sediments. The geochemistry also supplements sediment description, grain size data, downhole geophysical and stratigraphic correlations (Pullan et al., 2002; Crow et al., 2015a; 2015b; 2017; 2018; Bajc et al, 2015; Burt, 2007; 2014; 2015; 2016; 2017; Burt and Chartrand, 2014; Burt and Russell, 2006; Burt and Webb, 2013). It also provides a geochemical baseline for interpreting host sediment (rock) composition and ambient groundwater chemistry (e.g. Hamilton 2018). Geochemical data collected from cores provide the opportunity to establish a chemo-stratigraphic framework that complements other stratigraphic correlation techniques, such as litho-stratigraphy, event stratigraphy, and biostratigraphy.

The objective of this Open File is to release geochemical data and associated QA-QC data for 1176 surficial sediment samples from 22 continuously cored boreholes from eight geographic areas located in southern Ontario (Fig. 1). These analysis were carried out to provide: 1) an improved understanding of the basin geochemistry as currently available using portable X-ray fluorescence spectrometry (pXRF) data and; 2) to provide a control group for verifying and validating data collected by pXRF. References to background information on drilling methods, graphic logs, lithology, grain size, select carbonate results, and downhole geophysics associated with the borehole geographic areas are listed in Table 1.

Table 1. References for background information on boreholes analysed in this data release

Geographic area	Geology and drilling reference
Brantford-Woodstock	Bajc and Dodge, 2011
Dundas Valley	Marich et al., 2011; Bajc et al., 2018
Niagara Peninsula	Burt, A.K. 2013; 2014; 2015; 2016; 2017; 2018; Crow et al., 2017
Orangeville	Burt and Webb, 2013; Burt and Chartrand, 2014; Burt and Dodge, 2016
Oro	Burt, A.K., 2007; Burt and Russell, 2006; Burt and Dodge, 2011
Pickering	Knight et al., in prep
South Simcoe	Bajc et al., 2015; Crow et al., 2015a
Waterloo	Bajc and Shirota, 2007; Bajc and Hunter 2006

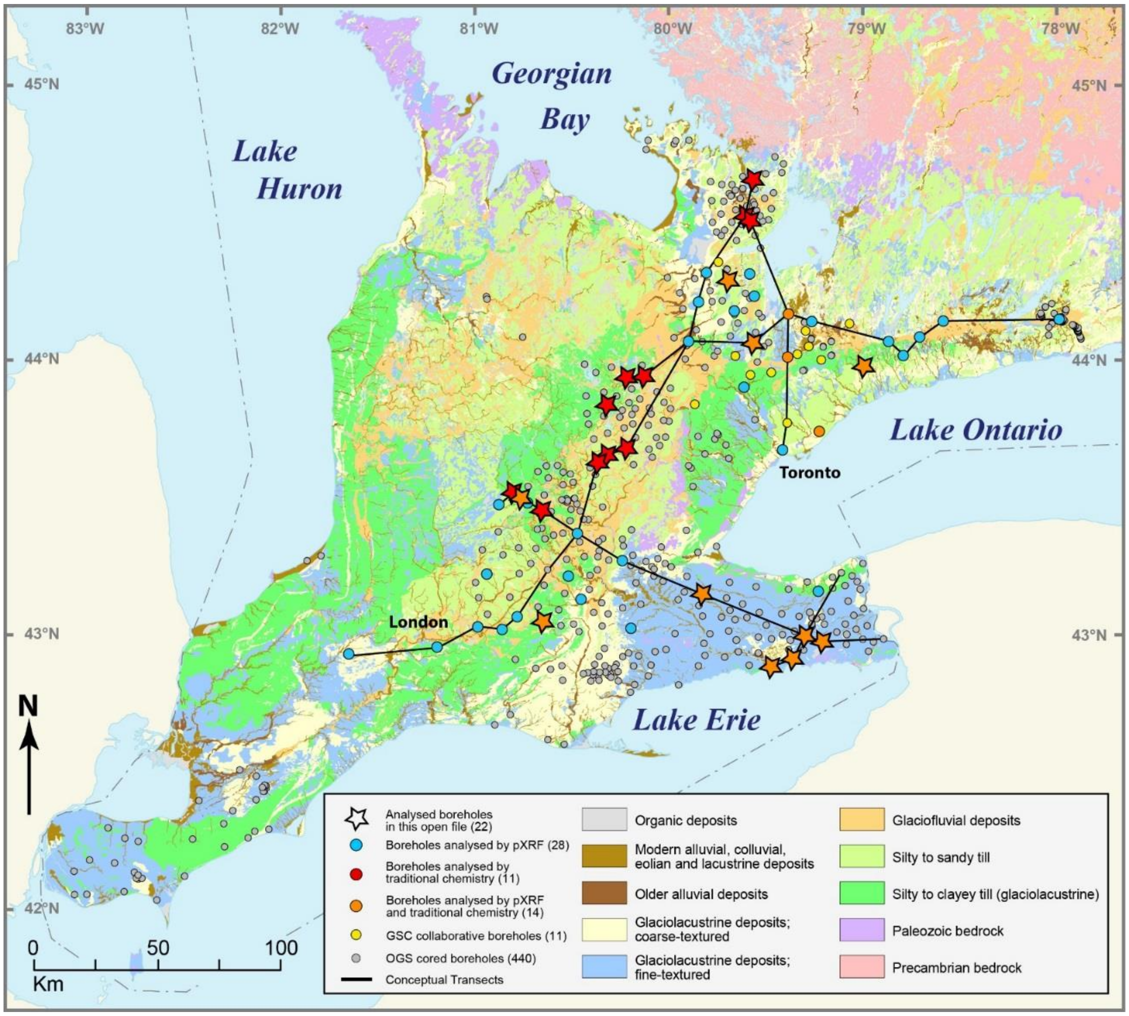

Figure 1: Surficial geology of southern Ontario showing the locations of the analyzed boreholes in relation to other OGS and GSC cored borehole sites. Conceptual transects for this study shown as solid lines. Surficial geology modified from OGS MRD128-Rev, (2010).

2.0 Sample Collection, Processing and Analytical Methods

Boreholes were drilled between 2003-2018 by the Ontario Geological Survey (OGS), Geological Survey of Canada (GSC) and the Conservation Authorities Moraine Coalition (CAMC). A summary of southern Ontario boreholes with geochemical analysis completed as part of a regional geochemical framework including data released in this open file is presented in Table 2. Sediment samples were acquired systematically at a 0.5-1.0 m spacing from borehole cores before being disaggregated and screened using stainless steel sieves to isolate either the silt and clay (<63μm) sized fraction or the silt, clay and very fine sand (<74 μm) sized fraction. Approximately 30 g of material were sent in two sample sets to Bureau Veritas Commodities Canada Ltd. (Vancouver, BC), previously ACME Analytical Laboratories (acquired 2011).

For this study each sample was analysed using 3 different methods, following the protocol of Kjarsgaard et al. (2013a, b). This includes an aqua regia (AQ250) partial digestion, a total/near total 4-Acid (MA250) digestion and a lithium metaborate/tetraborate flux fusion (LF200) digestion. The resultant digestion products by aqua regia and multi-acid were analysed by inductively coupled plasma mass spectrometry (ICP-MS). For flux fusion samples, the fused discs were dissolved in nitric acid before being analysed using inductively coupled plasma emission spectrometry (ICP-ES) for major element as well as ICP-MS for trace element determinations. Elements analysed by each method and the minimum detection limits are listed in Table 3.

Table 2. Summary of southern Ontario boreholes with geochemical analysis completed as part of a regional geochemical framework. Geochemical data from boreholes by pXRF methods are referenced in the right hand column.

Borehole Name	Borehole ID	Easting	Northing	Depth (m)	Source Agency	Number of samples	pXRF	Traditional Chemistry	Reference
Aurora	GSC-BH-AUR-01	626120	4871860	141	GSC	120	120	32	Knight et al., 2015a
Brantford-Woodstock	BW-07-05	504440	4784065	67.2	OGS	44	44	42	Knight et al., 2018d
	BW-07-06	516750	4766800	79.7	OGS	53	53		
	BW-07-07	527089	4764908	61.6	OGS	42	42		
	BW-07-09	510649	4761686	55.1	OGS	40	40		
	BW-07-15	542576	4773875	38.4	OGS	35	35		
	BW-07-17	537484	4783222	61.2	OGS	43	43		
	BW-07-20	559256	4789517	65.8	OGS	34	34		
	BW-08-06	500814	4762673	36.2	OGS	29	29		
Clarington	GSC-BH-CLA	672905	4872453	127	U of Guelph	96	96		Knight et al., 2016d
Dundas Valley	DV-05	541105	4800483	103.1	OGS	60	60	94	Stepner et al. 2018
	DV-06	518276	4814982	78.2	OGS	94	94		
	DV-08	520975	4812880	75.7	OGS	81	80		
Gads Hill	GH-10-01	509313	4812153	56.9	OGS	40	40		Knight et al., 2018c
GTA - Grasshopper	GSC-BH-GHP-01	679505	4879974	139.8	CAMC / GSC	185	185		Knight et al., 2018a
GTA - Kleinburg	GSC-BH-KLN-01	608497	4859678	104.9	CAMC / GSC	162	162		
GTA - Mount Albert	GSC-BH-MTA-01	635892	4886251	98.9	CAMC / GSC	92	92		
GTA - Pontypool	GSC-BH-PON-01	689068	4886446	171.1	CAMC / GSC	150	150		
GTA - Rice Lake	GSC-BH-RLK-01	735964	4887130	181.6	CAMC / GSC	170	170		
High Park	GSC-BH-HPK-01	624104	4834313	43.8	CAMC / GSC	58	58		Knight et al., 2015b

London, Strathroy	GSC-BH-SRY	448621	4751759	68.7	UTRCA / GSC	118	118		Knight et al., 2018b
London, Westminster	GSC-BH-WMR	484324	4754562	70.5	UTRCA / GSC	108	108		
Niagara Peninsula	BH13-NP-2014	628215	4749786	45.7	OGS	47		47	
	BH14-NP-2014	640187	4756676	42.1	OGS	38		38	
	BH27-NP-2014	633076	4758904	51.1	OGS	52		52	
	BH32-NP-2014	619599	4746591	46.4	OGS	41		41	
	BH33-NP-2014	638538	4777117	53.1	OGS		48		
	BH59-NP-2015	591658	4776011	42.2	OGS	39	39	22	
	BH77-NP-2015	562792	4762132	33.25	OGS		27		
Orangeville	BH09-OF-2008	553171	4852413	52.8	OGS	46		46	
	BH20-OF-2009	561002	4863630	22.5	OGS	25		25	
	BH23-OF-2009	568074	4864148	74.4	OGS	66		66	
	BH25-OF-2009	553103	4832245	31.7	OGS	29		29	
	BH27-OF-2009	561045	4834791	46.7	OGS	38		38	
	BH43-OF-2010	549394	4829200	36.7	OGS	43		43	
Oro	BH-30-AKB-2006	612147	4943667	54.9	OGS	66		66	
	BH-32-AKB-2006	609032	4928931	70.5	OGS	61		61	
	BH-37-AKB-2006	610966	4927024	102.1	OGS	94		94	
Pickering	GSC-BH-PIK1	657052	4687962	70.5	GSC/CAMC/ U of Ottawa	97	97	97	
	GSC-BH-PIK2	657052	4687962	12.2	GSC/CAMC/ U of Ottawa	14	14	14	
Purple Woods	GSC-BH-PWD	666973	4878158	151.8	CLOCA / GSC	135	135		Knight et al., 2016b
Queensville	GSC-BH-QUE	626499	4889266	96.2	CAMC / GSC	87	87	32	Knight et al., 2016c
South Simcoe	SS-12-02	602163	4902748	161.2	OGS	98	98	98	
	SS-11-04	586055	4878237	124.4	OGS	86	86		
	SS-11-08	590082	4894188	145.6	OGS	91	91		
	SS-12-03	593299	4906003	91.1	OGS	48	48		Moroz et al., 2018
	SS-12-04	610758	4905514	153.9	OGS	85	85		
	SS-12-07	612194	4877514	95.2	OGS	60	60	60	
	SS-12-08	604560	4890531	68.7	OGS	40	40		
	SS-13-06	612674	4896493	174.4	OGS	138	138		
Warden	2010-WAR	638868	4840084	80.5	CAMC / GSC	119	119	37	Knight et al., 2016c
Waterloo	OGS-03-04	526733	4809858	292	OGS	57		57	
	OGS-03-05	515170	4816991	244	OGS	46		46	

Table 3. List of elements, unit of measurement, and minimum detection limit (MDL) for each of the 3 digestion methods used in the study.

Fusion			**4 Acid**			**Aqua Regia**		
Element	Unit	MDL	Element	Unit	MDL	Element	Unit	MDL
Al2O3	%	0.01	Al	%	0.02	Al	%	0.01
CaO	%	0.01	Ca	%	0.02	Ca	%	0.01
Cr2O3	%	0.002	Fe	%	0.02	Fe	%	0.01
Fe2O3	%	0.04	K	%	0.02	K	%	0.01
K2O	%	0.01	Mg	%	0.02	Mg	%	0.01
MgO	%	0.01	Na	%	0.002	Na	%	0.001
MnO	%	0.01	P	%	0.001	P	%	0.001
Na2O	%	0.01	S	%	0.04	S	%	0.02
P2O5	%	0.01	Ti	%	0.001	Ti	%	0.001
SiO2	%	0.01	Ag	ppm	20	Ag	ppm	2
TiO2	%	0.01	As	ppm	0.2	As	ppm	0.1
LOI	%	0.1	Au	ppm	0.1	Au	ppm	0.2
TOT/C	%	0.02	Ba	ppm	1	B	ppm	20
TOT/S	%	0.02	Be	ppm	1	Ba	ppm	0.5
Ba	ppm	1	Bi	ppm	0.04	Be	ppm	0.1
Be	ppm	1	Cd	ppm	0.02	Bi	ppm	0.02
Ce	ppm	0.1	Ce	ppm	0.02	Cd	ppm	0.02
Co	ppm	0.2	Co	ppm	0.2	Ce	ppm	0.1
Cr	ppm	14	Cr	ppm	1	Co	ppm	0.1
Cs	ppm	0.1	Cs	ppm	0.1	Cr	ppm	0.5
Cu	ppm	5	Cu	ppm	0.02	Cs	ppm	0.02
Dy	ppm	0.05	Dy	ppm	0.1	Cu	ppm	0.01
Er	ppm	0.03	Er	ppm	0.1	Dy	ppm	0.02
Eu	ppm	0.02	Eu	ppm	0.1	Er	ppm	0.02
Ga	ppm	0.5	Ga	ppm	0.02	Eu	ppm	0.02
Gd	ppm	0.05	Gd	ppm	0.1	Ga	ppm	0.1
Hf	ppm	0.1	Hf	ppm	0.02	Gd	ppm	0.02
Ho	ppm	0.02	Ho	ppm	0.1	Ge	ppm	0.1
La	ppm	0.1	La	ppm	0.1	Hf	ppm	0.02
Lu	ppm	0.01	Li	ppm	0.1	Hg	ppm	5
Mo	ppm	1	Lu	ppm	0.1	Ho	ppm	0.02
Nb	ppm	0.1	Mn	ppm	2	In	ppm	0.02
Nd	ppm	0.30	Mo	ppm	0.05	La	ppm	0.5
Ni	ppm	20	Nb	ppm	0.04	Li	ppm	0.1
Pb	ppm	1	Nd	ppm	0.1	Lu	ppm	0.02
Pr	ppm	0.02	Ni	ppm	0.1	Mn	ppm	1
Rb	ppm	0.1	Pb	ppm	0.02	Mo	ppm	0.01
Sc	ppm	1	Pr	ppm	0.1	Nb	ppm	0.02
Sm	ppm	0.05	Rb	ppm	0.1	Nd	ppm	0.02
Sn	ppm	1	Sb	ppm	0.02	Ni	ppm	0.1
Sr	ppm	0.5	Sc	ppm	0.1	Pb	ppm	0.01
Ta	ppm	0.1	Sm	ppm	0.1	Pd	ppm	10
Tb	ppm	0.01	Sn	ppm	0.1	Pr	ppm	0.02
Th	ppm	0.2	Sr	ppm	1	Pt	ppm	2
Tm	ppm	0.01	Ta	ppm	0.1	Rb	ppm	0.1
U	ppm	0.1	Tb	ppm	0.1	Re	ppm	1
V	ppm	8	Th	ppm	0.1	Sb	ppm	0.02
W	ppm	0.5	Tm	ppm	0.1	Sc	ppm	0.1
Y	ppm	0.1	U	ppm	0.1	Se	ppm	0.1
Yb	ppm	0.05	V	ppm	1	Sm	ppm	0.02
Zn	ppm	5	W	ppm	0.1	Sn	ppm	0.1
Zr	ppm	0.1	Y	ppm	0.1	Sr	ppm	0.5
			Yb	ppm	0.1	Ta	ppm	0.05
			Zn	ppm	0.2	Tb	ppm	0.02
			Zr	ppm	0.2	Te	ppm	0.02
						Th	ppm	0.1
						Tl	ppm	0.02
						Tm	ppm	0.02
						U	ppm	0.1
						V	ppm	2
						W	ppm	0.1
						Y	ppm	0.01
						Yb	ppm	0.02
						Zn	ppm	0.1
						Zr	ppm	0.1

3.0 Open File Organization

Geochemical data is located in the Borehole Data subfolder of Appendix A, separated by project title (typically a regional or local name). Data is included in this report as Microsoft Excel workbooks and as .csv text files (in a separate folder). Each workbook contains 2 worksheets: the first detailing sample depths from the borehole and geochemistry; the second contains associated QA/QC results which accompany each borehole. The previously published borehole subfolder in Appendix A contains traditional geochemical data for Aurora (Knight et al., 2015a), Queensville (Knight et al., 2016b), and Warden (Knight et al., 2016c) boreholes.

Geochemical data is separated by digestion method listed in the order of Aqua Reqia, 4-acid and fusion methods. The analytes of interest are listed in Row 2 of the worksheets, directly above the unit of measurement and limit of detection (MDL) for each element. Major element oxide measurements are reported without recalculation to anhydrous form. QA/QC with each borehole includes any duplicate analysis conducted by Bureau Veritas and a full list of laboratory standards and blanks obtained during sample analyses. As samples were analysed in batches by Bureau Veritas, accompanying standards and blanks span a number of boreholes; each workbook contains all standards and blanks which were run as part of a sample group, however it is impossible to identify the specific standards which accompany a subset of samples within the larger analytical group. The GSC included a number of internal standards (file name: Internal QA/QC) with each sample set to ensure data quality, these include a silica blank as well as CANMET Till-1 and Till-4 certified reference materials. Results for the standards remained consistent through analysis and within the range of reported analytical uncertainty for the standards. A data summary Excel worksheet is included in Appendix A. The summary includes fusion data and accompanying 4-acid results for select elements (specifically Cr, Ni, Cu, Zn). Aqua Regia data are excluded from the summary, as there are no accepted values for this digestion technique for the certified reference standards.

4.0 Regional Geochemical Framework

Data presented in this report are part of an ongoing joint initiative with universities, Conservation Authorities, and the Ontario Geological Survey to characterize the geochemistry of subsurface surficial sediments of Southern Ontario. Samples have been analysed from 53 boreholes (Table 2) along two conceptual transects, one orientated east-west and one north-south (Fig. 1). Many of the analyses have been obtained by portable X-ray fluorescence spectrometry and for a subset of samples for comparative research by traditional ICP-ES/MS methods. The subsurface data complements existing surficial geochemical data available for Southern Ontario (e.g. Sharpe et al. 2016). Regional geological context and hydrogeological investigations are found in Bajc and Dodge (2011), Bajc and Shirota (2017), Bajc et al. (2015), Burt and Dodge (2011; 2016).

5.0 Summary

This dataset significantly expands the number of analysed subsurface sediment samples from southern Ontario. Studies such as this one are crucial to characterizing chemical and mineralogical trends within sediment sequences and complement further study. As part of the larger initiative of the Groundwater Geoscience Program at the GSC, this work helps provide context for future site specific studies and encourages further geochemical research. To date, full geochemical analysis has been conducted on ~3700 samples from southern Ontario (see Table 2). This sample set provides reconnaissance coverage of the primary regional stratigraphic units, with specific detail in some regions.

5.0 Acknowledgements

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6.0 References

Bajc, A.F. and Dodge, J.E.P. 2011. Three-dimensional mapping of surficial deposits in the Brantford-Woodstock area, southwestern Ontario; Ontario Geological Survey, Groundwater Resources Study 10, 77p.

Bajc, A.F. and Hunter, J.A. 2006. Results of 2003-2004 overburden drilling programs in the Region of Waterloo, southwestern Ontario; Ontario Geological Survey, Miscellaneous Release-Data 205.

Bajc, A.F. and Shirota, J. 2007. Three-dimensional mapping of surficial deposits in the Regional Municipality of Waterloo, southwestern Ontario; Ontario Geological Survey, Groundwater Resources Study 3, 41p.

Bajc, A.F., Marich, A.S., Priebe, E.H., and Rainsford, D.R.B., 2018. Evaluating the groundwater resource potential of the Dundas buried bedrock valley, southwestern Ontario: an integrated geological and hydrogeological case study. Canadian Journal of Earth Sciences. 1–18. doi:10.1139/cjes-2016-0224.

Bajc, A.F., Mulligan, R.P.M., Rainsford, D.R.B., and Webb, J.L. 2015. Results of 2011–13 overburden drilling programs in the southern part of the County of Simcoe, south-central Ontario. Ontario Geol. Surv. Misc. Release—Data 324.

Burt, A.K., 2007. Results of 2005 and 2006 Oro Moraine drilling program in the Barrie area, central Ontario; Ontario Geological Survey, Miscellaneous Release—Data 227.

Burt, A.K., 2013. The Niagara Peninsula study: A new three-dimensional Quaternary geology mapping project; in Summary of Field Work and Other Activities, 2013, Ontario Geological Survey, Open File Report 6290, p.38-1 to 38-21.

Burt, A.K., 2014. Penetrating Niagara with three-dimensional mapping; in Summary of Field Work and Other Activities, 2014, Ontario Geological Survey, Open File Report 6300, p.32-1 to 32-18.

Burt, A.K., 2015. Quaternary stratigraphy of the Niagara Peninsula revealed with three-dimensional mapping; in Summary of Field Work and Other Activities, 2015, Ontario Geological Survey, Open File Report 6313, p.35-1 to 35-17.

Burt, A.K., 2016. The Niagara Peninsula in three dimensions: A drilling update; in Summary of Field Work and Other Activities, 2016, Ontario Geological Survey, Open File Report 6323, p.30-1 to 30-13.

Burt, A.K., 2017. Digging Deep on the Niagara Peninsula: A Drilling Update; in Summary of Field Work and Other Activities, 2017, Ontario Geological Survey, Open File Report 6333, p.24-1 to 24-16.

Burt, A.K., 2018. Three-dimensional hydrostratigraphy of the Orangeville Moraine area, Southwestern Ontario, Canada. Canadian Journal of Earth Sciences. doi:10.1139/cjes-2017-0077.

Burt, A.K. and Chartrand, J.E. 2014. Interactive graphic borehole logs and hydrostratigraphic correlations, Orangeville–Fergus three-dimensional study area; Ontario Geological Survey, Miscellaneous Release—Data 313.

Burt, A.K. and Dodge, J.E.P. 2011. Three-dimensional modelling of surficial deposits in the Barrie–Oro moraine area of southern Ontario; Ontario Geological Survey, Groundwater Resources Study 11, 125p. [PDF document].

Burt, A.K. and Dodge, J.E.P. 2016. Three-dimensional modelling of surficial deposits in the Orangeville–Fergus area of southern Ontario; report in Ontario Geological Survey, Groundwater Resources Study 15, 155p.

Burt, A.K. and Russell, D.F. 2006. Results of 2004 Oro Moraine drilling program in the Barrie area, central Ontario; Ontario Geological Survey, Miscellaneous Release—Data 198.

Burt, A.K. and Webb, J.L. 2013. Results of the 2008, 2009 and 2010 drilling programs in the Orangeville–Fergus area of southwestern Ontario; Ontario Geological Survey, Miscellaneous Release—Data 303.

Craigie, N., 2017. Principles of elemental chemostratigraphy: A practical user guide. Springer International Publishing. doi:org/10. 1007/978-3-319-71216-1

Crow, H.L., Brewer, K.D., Bajc, A.F., Pugin, A.J.-M., Mulligan, R.P.M., and Russell, H.A.J., 2015a. Downhole geophysical data from two boreholes in the south Simcoe County, Ontario. Geological Survey of Canada, Open File 7883, 18 p. (2 sheets). doi:10.4095/296884.

Crow, H.L., Good, R.L., Hunter, J.A., Burns, R.A., Reman, A., and Russell, H.A.J., 2015b. Borehole geophysical logs in unconsolidated sediments across Canada, Geological Survey of Canada, Open File 7591. doi:10.4095/295753.

Crow, H.L., Olson, L.C., Burt, A.K. and Brewer, K.D. 2017. Downhole geophysical logs in Quaternary sediments of the Niagara Peninsula, southern Ontario; Geological Survey of Canada, Open File 8252, 32p.

Crow, H.L., Hunter, J.A., Olson, L.C., Pugin, A.–J., and Russell, H.A.J., 2018. Borehole geophysical log signatures and stratigraphic assessment in a glacial basin, southern Ontario. Canadian Journal of Earth Sciences. 55: 829–845 (2018) dx.doi.org/10.1139/cjes-2017-0016.

Hamilton, S.M., 2018. The use of wide spectrum groundwater geochemistry in regional groundwater mapping in Ontario, in Regional-scale groundwater geoscience in southern Ontario: an Ontario Geological Survey, Geological Survey of Canada, and Conservation60 Ontario geoscientists open house, compiled by Russell, H.A.J., Ford, D., Priebe, E.H., and Holysh, S. Geological Survey of Canada, Open File 8363.

Jarvis, I., 1991. Sample preparation for ICP-MS, In K.E. Jarvis, A.L. Gray, and S.Houk (eds), Handbook of Inductively coupled plasma-mass spectrometry, pp. 172-224. Blackie, Glasgow.

Jarvis, I. and Jarvis, K.E., 1992. Plasma spectrometry in the earth sciences: techniques, applications and future trends. Chemical Geology, v. 95, p. 1-33.

Kjarsgaard, B.A., Knight, R., Grunsky, E.C., Sharpe, D. R., Kerr, D., Cummings, D.I. and Russell, H.A.J., Kerswill, J. and Wright, D., 2013a. Till Geochemistry Studies, East Arm MERA. Geological Survey of Canada, Open File 7196, p. 313-337.

Kjarsgaard, B.A., Knight, R., Plourde, A.P., Sharpe, D. R. and Lesemann, J.-E., 2013b. Geochemistry of till samples, NTS 75-I, 75-J, 75-O, 75-P (Mary Frances Lake – Whitefish Lake – Thelon River area), Northwest Territories. Geological Survey of Canada, Open File 7351, 28 p. and 3 digital appendices.

Knight, R.D., Sharpe, D.R., and Valiquette, L.J., 2015a. Portable XRF spectrometry, fusion, multi acid, and aqua regia results from the Aurora borehole, Yonge Street Aquifer, southern Ontario; Geological Survey of Canada, Open File 7919.

Knight, R.D., Valiquette, L.J., and Russell, H.A.J., 2015b. Portable XRF spectrometry results from the High Park borehole, southern Ontario; Geological Survey of Canada, Open File 7918.

Knight, R.D., Landon-Browne, A.R.R., and Russell, H.A.J., 2016a. Portable XRF spectrometry of glacial-derived sediment from the Purple Woods borehole, southern Ontario; Geological Survey of Canada, Open File 7921.

Knight, R.D., Valiquette, L.J., and Russell, H.A.J., 2016b. Portable XRF spectrometry, fusion, multi acid, and aqua regia results from the Queensville borehole, Young Street Aquifer, southern Ontario; Geological Survey of Canada, Open File 7855.

Knight, R.D., Coffin, L.M., Valiquette, L.J., and Russell, H.A.J., 2016c. Portable XRF spectrometry, fusion, multi acid and aqua regia results from the Warden borehole, southern Ontario; Geological Survey of Canada, Open File 7922.

Knight, R.D., Landon-Browne, A.R.R., Arnaud, E., and Russell, H.A.J., 2016d. Portable XRF spectrometry results from the Clarington borehole, southern Ontario; Geological Survey of Canada, Open File 7920

Knight, R.D., Stepner, D.A.J., and Russell, H.A.J., 2018a. Chemostratigraphy of glacial-derived subsurface sediments in the Greater Toronto Area, Southern Ontario; Geological Survey of Canada, Open File 8298.

Knight, R.D., Stepner, D.A.J., and Russell, H.A.J., 2018b. Geochemistry of glacial-derived sediment from Strathroy and Westminster boreholes, London, southern Ontario; Geological Survey of Canada, Open File 8312.

Knight, R.D., Bajc, A.F., Moroz, M.J., and Russell, H.A.J., 2018c. Geochemistry of glacially-derived sediment from the Gads Hill Moraine area, Southwestern Ontario; Geological Survey of Canada, Open File 8299.

Knight, R.D., Stepner, D.A.J., Bajc, A.F., and Russell, H.A.J., 2018d. Geochemistry of glacial-derived sediment from boreholes located near Brantford-Woodstock, Southern Ontario; Geological Survey of Canada, Open File 8336.

Ontario Geological Survey, 2010. Surficial Geology of Southern Ontario. Miscellaneous Release – Data 128 – Revised.

Marich, A.S., Priebe, E.H., Bajc, A.F., Rainsford, D.R.B. and Zwiers, W.G. 2011. A geological and hydrological investigation of the Dundas buried bedrock valley, southern Ontario. Ontario Geological Survey, Groundwater Resources Study 12.

Moroz, M.J., Bajc, A.F., Knight, R.D., Mulligan, R.P.M., and Russell, H.A.J., 2018. Geochemistry of sediment cores, South Simcoe, Southern Ontario; Geological Survey of Canada, Open File 8257.

Pullan, S.E., Hunter, J.A., and Good, R.L., 2002. Using downhole geophysical logs to provide detailed lithological and stratigraphic assignment: Oak Ridges Moraine, southern Ontario. Geological Survey of Canada, Current Research, No. 2002-E8, 12 p. doi:10.4095/213689.

Russell, H.A.J., Arnaud, E., Bajc, A.F., and Sharpe, D.R., 2018. Quaternary geology of southern Ontario and applications to hydrogeology; Canadian Journal of Earth Sciences, 55, v–viii. doi:10.1139/cjes-2017-0090.

Sharpe, D.R., Klassen, R.A., Russell, H.A.J., Logan, C.E., Garrett, R.G., 2016. Regional Geochemical Survey of Soil and Sediment in Southern Ontario, in: Russell, H.A.J. and Priebe, E.. (Ed.), Regional-Scale Groundwater Geoscience in Southern Ontario: An Ontario Geological Survey and Geological Survey of Canada Groundwater Geoscience Open House. Geological Survey of Canada, Open File 8022, p. 34. doi:10.4095/297722.

Stepner, D.A.J., Bajc, A.F., Knight, R.D., and Russell, H.A.J., 2018. Geochemistry of glacial-derived sediment cores, Dundas Valley, Southern Ontario; Geological Survey of Canada, Open File 8300.

Totland, M., Jarvis, I., Jarvis, K.E., 1992. Assessment of dissolution techniques for the analysis of geological samples by plasma-spectrometry. Chemical Geology, V. 95, p. 1-2, 35-62.