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Ontario

Ontario Geological Survey
Open File Report 6356

Report of Activities, 2018 Resident Geologist Program

Southern Ontario Regional Resident Geologist Report: Southeastern Ontario and Southwestern Ontario Districts and Petroleum Operations

2019

Ontario

ONTARIO GEOLOGICAL SURVEY

Open File Report 6356

Report of Activities, 2018
Resident Geologist Program

Southern Ontario Regional Resident Geologist Report:
Southeastern and Southwestern Districts and Petroleum Operations

by

A.C. Tessier, P.S. LeBaron, A.C. Smith, D.A. Laidlaw, P. Bousquet and L. Fortner

2019

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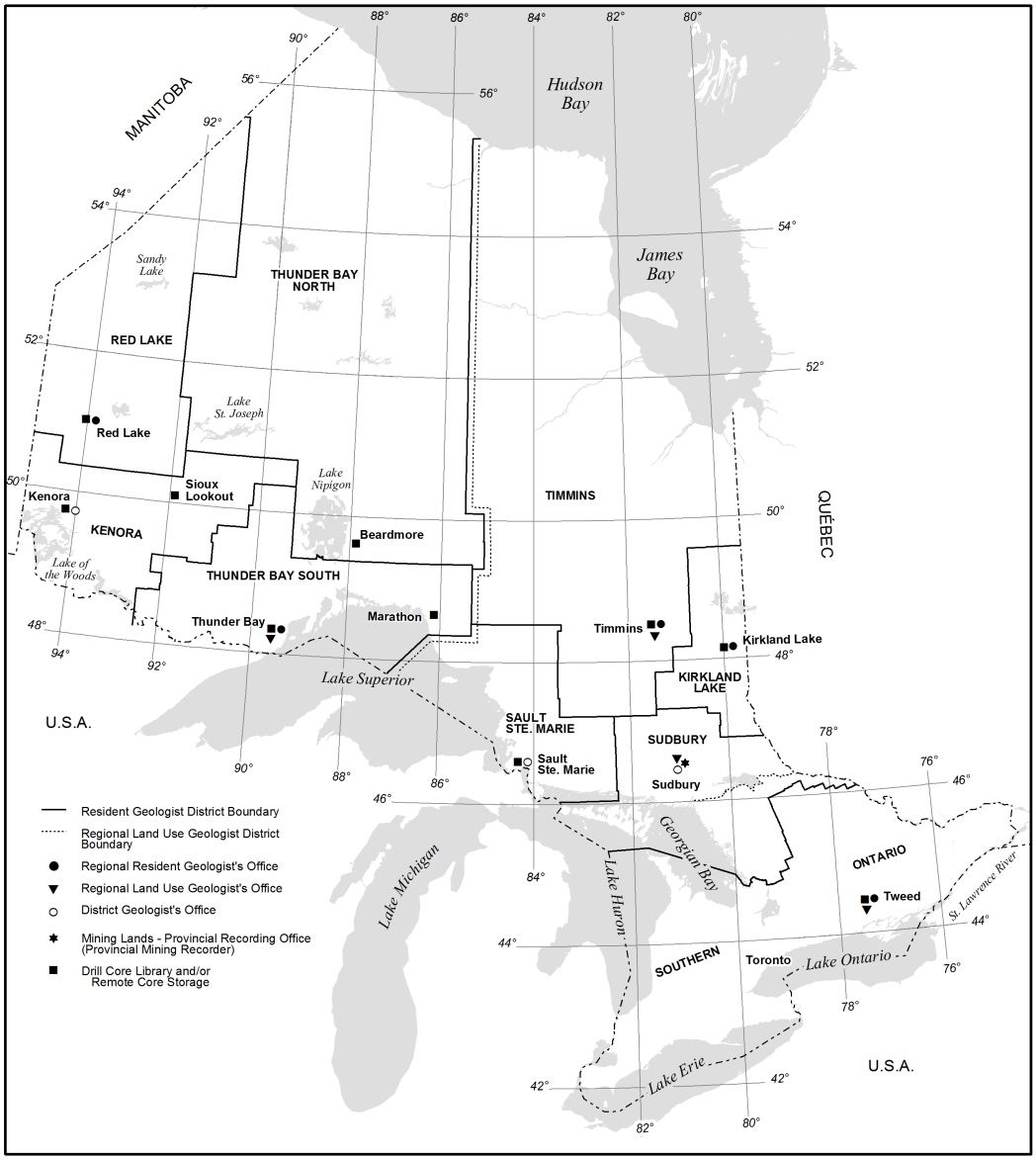

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ONTARIO GEOLOGICAL SURVEY

RESIDENT GEOLOGIST PROGRAM

REPORT OF ACTIVITIES—2018

SOUTHERN ONTARIO
REGIONAL RESIDENT GEOLOGIST REPORT

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INTRODUCTION

The Southern Ontario Region comprises the Southeastern Ontario and Southwestern Ontario districts and encompasses the most populous part of the province and the country. The Region also includes both the provincial and national capitals. The region stretches over 800 km and is bordered by the Canada–United States border in the west, the south and the southeast, through the southern Great Lakes (Lakes Huron, Erie and Ontario) and along the St. Lawrence River. To the east and northeast, the region is bordered by the provincial border between Quebec and Ontario. The northern boundary of the region cuts through Georgian Bay, and then eastward north of Lake Simcoe, including Algonquin Park and neighbouring townships.

Geologically, Paleozoic sedimentary rocks cover the southern and parts of the easternmost portions of the district, whereas Proterozoic metamorphic rocks of the Central Metasedimentary Belt and Central Gneiss Belt of the Grenville Province occupy the northern and parts of the eastern portions. Consequently, the region hosts some of the most diverse and productive geology in the province of Ontario.

Production from mines and quarries continued throughout southern Ontario, within both the Grenville Province metamorphic terrane and in the Paleozoic sedimentary rocks of the Region. With the exception of salt mining and brine field operations in Goderich and Windsor, and the Hagersville gypsum mine, all mining operations within the Paleozoic sedimentary rocks are for commodities the development of which is designated under the *Aggregate Resources Act* administered by the Ministry of Natural Resources and Forestry. Nevertheless, these operations are covered within this Report of Activities.

Both map and ground staking ceased in Ontario on January 8, 2018 and were replaced by a province-wide online staking system on April 10, 2018, when the Mining Lands Administration System (MLAS) (www.mndm.gov.on.ca/en/mines-and-minerals/mining-act/mining-lands-administration-ontario) was launched by the Ministry of Northern Development and Mines (MNDM)[‡]. This online self-service system provides access to mining claim registration and lands management and replaced traditional ground-staking methods. It marked the completion of the *Mining Act* modernization in support of the ministry's Mineral Development Strategy.

[‡] *Ministry of Northern Development and Mines (MNDM) from January to June 29, 2018; Ministry of Energy, Northern Development and Mines (ENDM) from June 29, 2018.*

In 2018, a total of 163 claims, covering 6794.4 ha, were recorded electronically in southern Ontario. Compared to the previous year, 11 more claims were recorded in 2018, but the area covered by these 163 claims decreased by nearly 54% compared to the claims staked in 2017. The decrease may be the result of the 3-month hiatus in staking (from January 8 to April 10, 2018) but could also be because the new cells available for staking online are considerably smaller than before the new system (allowing for a more targeted staked area). Figure 3 shows the claim staking activity for southern Ontario in 2018.

Tables 13 through 21 provide details on currently inactive mineral deposits with identified resources and past-producing mineral occurrences. Please note that unless otherwise stated, the resource figures presented in these tables and elsewhere in this report refer to historical resources that are not compliant with National Instrument (NI) 43-101.

The authors note that all Web addresses referenced were accessed in December 2018 and January 2019, unless otherwise noted.

In addition, Universal Transverse Mercator (UTM) co-ordinates are provided in Zone 18, using North American Datum 1983 (NAD83), unless stated otherwise.

MINING ACTIVITY

During 2018, there were 104 mineral extraction operations in southern Ontario, including 60 dimension stone quarries, 14 specialty aggregate producers (for pavement, decorative and/or coloured, metallurgical flux, lime and high-density concrete), 8 industrial mineral operations, 9 cement producers quarries, 7 brick producers quarries, 4 trap rock producers (one of which also produces the raw material for mineral wool and another produces wollastonite), and 2 gemstone and mineral specimen sites. All of Ontario's production of salt, gypsum, natural gas and petroleum, shale (for brick), lime/dolime, cement, nepheline syenite, high-purity calcium carbonate, and the majority of dimension stone, sand and gravel comes from the Southern Ontario Region.

For a complete listing of mining activity and locations of operating mines and mills in southern Ontario, please refer to Tables 1 and 2 and Figures 1 and 2. There are also many limestone aggregate quarries in operation that are too numerous to include in the list of mining activity.

New estimates for 2018 suggest that approximately 9000 people were directly employed in mineral extraction and on-site processing plants in southern Ontario in 2018. These figures do not take into account the indirect jobs created by the mineral industry. In 2018, Ontario's non-metallic mineral production was valued at $2.4 billion—representing 24% of the total value of mineral production in the province. Five of the top 10 commodities produced in Ontario in 2018 were non-metallic minerals and most of this production came from southern Ontario mines and quarries. In 2018, approximately 17% of Ontario's total mineral wealth came from southern Ontario. This number is down from 25% last year because cement is now categorized as a manufactured product♦. (S. Jessome, Mineral Sector Analysis and Promotion Unit, ENDM, written communication, March 2019)

♦*This is based on the Natural Resources Canada categorization for the collection and analysis of data for the "Annual Statistics: Mineral Production of Canada, by Province and Territory". This re-categorization has resulted in the value of the mineral products used to create cement now being recorded only as mineral production. Mineral production values are the values of the minerals without value-added manufacturing (i.e., "cement" being the value-added product).*

Wollastonite

CANADIAN WOLLASTONITE – ST. LAWRENCE DEPOSIT

Canadian Wollastonite (www.canadianwollastonite.com) is a privately held mining company incorporated in the province of Ontario. The company owns just over 220 ha of patent title property, encompassing a large portion of the St. Lawrence wollastonite deposit north of Kingston near the community of Seeley's Bay. Canadian Wollastonite began production in 2013 and the mine has been in continuous operation since.

Canadian Wollastonite currently processes run-of-mine ore products that are sold into metallurgical, agricultural and environmental applications. In 2017–2018, the company developed an effective beneficiation process and expects to construct a beneficiation plant in 2020 which will allow it to supply high-grade, high-aspect wollastonite and high-grade diopside products starting late 2020 (B. Vasily, Canadian Wollastonite, personal communication, December 2018).

Research and development, and marketing are an important part of Canadian Wollastonite's business:

- Since production began in 2013, the company won approval for use of its primary ancillary ore—orthogneiss—as a Superpave™ aggregate in highway road construction. The deposit is the southernmost approved source of Superpave™ aggregates in Ontario and is well situated to supply the eastern Ontario market.
- In 2014, the company successfully introduced wollastonite (calcium silicate) and diopside (calcium magnesium silicate) products into the local Ontario horticultural market, as well as into the northeastern United States as a single source of calcium, magnesium and silica.
- In 2016, the mine's primary ancillary ore—orthogneiss—was approved for use as Class 1 and 2 Railway Ballast.
- In 2016–2017, the company conducted research into the use wollastonite as a means to sequester phosphorus and heavy metals in tertiary water systems, municipal water treatment, municipal storm water management, and in multiple industrial applications.
- In 2017, the company received a $450 000 research and development grant over 3 years to study and optimize plant growth and health through improved silicon absorption.
- In 2017–2018, the company was also working with a dimension stone company to investigate the use of the ore as a high-quality polished stone (B. Vasily, Canadian Wollastonite, personal communication, December 2018).

Nepheline Syenite

COVIA HOLDINGS CORPORATION – NEPHTON AND BLUE MOUNTAIN MINES

On December 12, 2017, Unimin (a subsidiary of privately owned, Belgium-based, SCR-Sibelco NV) announced that it was merging with Fairmont Santrol, a United States-based, leading provider of high-performance sand used by oil and gas exploration and production companies. The merger, completed on June 1, 2018, formed Covia Holdings Corporation that trades on the New York Stock Exchange under the symbol CVIA (Covia Holdings Corporation, news release, June 1, 2018).

Nepheline has been mined in the Havelock area for 84 years, with the Nephton Mine beginning in 1935 and Blue Mountain Mine in 1955. Unimin purchased the site in 1989 and has mined there ever since. The site currently employs approximately 200 workers.

Nepheline is used in the production of glass, ceramics, paint, fillers, insulation, abrasives and adhesives. It is used to lower the melting temperature of glass and ceramics, thus saving energy, extending the life of furnaces and reducing emissions. It also increases the quality and toughness of the glass, making it more resistant to breakage.

Approximately 75% of the revenue from the Blue Mountain and Nephton operations comes from the paint industry, in which nepheline reduces the need for volatile organic compounds (VOCs) and accounts for nearly 1/3 in weight of the final product (M. Clarkson, Unimin Canada Ltd, personal communication, January 2018).

At the end of 2017, Unimin received final approval for the expansion and modernization of the Blue Mountain operation. On January 3, 2018, Unimin Canada announced that it was going ahead with the project to "improve the site's environmental footprint and support continued mining, manufacturing, and employment at the facility for many more decades. The modernization will enable the optimization of new technologies and practices to reduce noise, dust, lighting, use of water [and] electricity" (Unimin Canada Ltd., news release, January 3, 2018 [accessed March 22, 2019]).

Construction started in January 2018 and is expected to be completed in early 2020. Upon completion, "Blue Mountain's sister operation at Nephton will be closed", affecting approximately 100 employees. "During the modernization, the Nephton facility will remain fully operational" (Unimin Canada Ltd., news release, January 3, 2018 [accessed March 22, 2019]).

The nepheline syenite deposit at Blue Mountain and Nephton strikes over 8 km with a width of 1.7 km. To date, the deposit has been defined to a depth of approximately 175 m and is open at depth. In 2018, the mine extracted approximately 1.3 million tons from the Nephton Mine, which translated into 640 000 short tons of nepheline syenite products (Photo 1). At current production rates, the mine reserves stand at 20 to 25 years, and the Inferred resources are estimated to last 80 years (M. Clarkson, Unimin Canada Ltd., personal communication, January 2018).

The Blue Mountain Mine is considered a "world-class" deposit. It is the only nepheline syenite mine in North America and there are only 2 others in the world, located in Russia and Norway.

Photo 1. Panoramic view of the Covia Holdings Corporation Blue Mountain open pit, looking northeast. Note the processing plant at the far right of the photo. Photo by A.C. Tessier, June 2017 (Resident Geologist's Files, Southern Ontario Region, Tweed).

Salt

Salt production began in Ontario in 1866. There are extensive beds of rock salt found in the Silurian Salina Group (formerly Formation) rocks in parts of southwestern Ontario, west of London. Although there were numerous historical producers in southwestern Ontario, only a few produced more than 100 000 t of salt from brine well operations (Hewitt 1962).

Salt is the only Ontario mineral commodity for which the market and production are directly controlled by weather. Salt for de-icing is extracted from underground operations, as warranted by the market demand.

Provincial and municipal governments are the main market for de-icing salt. The Ontario Ministry of Transportation reports that its salt usage varies from 500 000 to 600 000 tons of salt annually, depending on winter weather conditions (Environment Canada 2012).

In 2018, Ontario produced an estimated 6.5 million tonnes (Mt) of salt valued at an estimated $239 million, representing 52% of the total salt production in Canada by value. Although the production of salt increased from 6.1 to 6.5 Mt between 2017 and 2018, the value has diminished from $331 million to $239 million as the price of salt went down sharply in 2018. Salt remains one of the top 10 minerals produced in Ontario by value of production. (S. Jessome, Mineral Sector Analysis and Promotion Unit, ENDM, written communication, March 2019)

Sifto Canada Corporation and the K+S Windsor Salt Ltd each operate underground mines, brine fields operations and evaporation plants in Goderich and Windsor, respectively. Rock salt from the underground mines is used mostly for road de-icing, for feedstock and in industry, where it is used in making a wide variety of products, including chemicals, plastics and glass. Food-grade and chemical-grade salt are produced from the brine and/or evaporation operations (Sangster et al. 2013).

SIFTO CANADA CORP. – GODERICH MINE AND EVAPORATION PLANT

Sifto Canada Corporation (www.siftocanada.com) is a subsidiary of the United States-listed public company, Compass Minerals International, Inc. (www.compassminerals.com) that trades on the New York Stock Exchange under the symbol CMP.

The Goderich salt mine, located 1800 feet under Lake Huron, is the largest underground salt mine in the world. It has operated since 1959 (having been acquired by Compass Minerals in 1990), has produced over 150 Mt of salt and has defined resources for an additional 120 years of production. The mine produces about 23 000 t of salt per day. About 80% of production is used as road salt for communities around the Great Lakes and along the St. Lawrence Seaway. The remainder is trucked to the Compass Minerals plant less than 4 km away, to be packaged as refined salt for water softener or as sidewalk de-icing salt for distribution and sale at retailers in North America. The salt is also sold in bulk to manufacturers that make plastics, detergents, disinfectants and other important products (*from* www.compassminerals.com).

The Goderich plant has operated since 1867, after an unsuccessful search for oil uncovered a vast bed of rock salt under Goderich. Using mechanical evaporation, the plant produces high-purity, fine- and coarse-grained salt products in packages and in bulk for commercial, agricultural and industrial applications. On July 16, 2018, Compass Minerals announced that a collective bargaining agreement had been reached with its employees at the Goderich Mine, ending an 11-week strike (Compass Minerals International, Inc., news release, July 16, 2018). Sifto Canada currently employs 470 people at its Goderich facilities (Ontario Mining Association, Ontario Mining and Exploration Directory 2018, www.oma.on.ca).

K+S WINDSOR SALT LIMITED – OJIBWAY MINE AND EVAPORATION PLANT

K+S Windsor Salt Limited (www.windsorsalt.com) is a subsidiary of Chicago-based Morton Salt (www.mortonsalt.com), which in turn is a subsidiary of K+S AG (www.k-plus-s.com), a global chemical company based in Germany and publicly traded on the Frankfurt Stock Exchange under the symbol SDF.

K+S Windsor Salt is the largest salt producer in Canada and extracts both rock salt from its underground Ojibway Mine and vacuum salt from its nearby brine evaporation plant in Windsor. The Ojibway Mine employs over 230 people and has been in operation since 1955. The mine uses a traditional mining method of drill, blast and muck and is currently mining salt at a level of 290 m beneath the city. The salt produced at the mine is sold as de-icing and industrial salts that are distributed throughout the Great Lakes region. The Windsor evaporation plant produces table salt, pool salt, water softeners and a wide range of products for industrial use. The facility has been in operation since 1928 and currently employs over 100 people (http://windsorsalt.com/careers/).

The Ojibway Mine is in the midst of an expansion, announced in July 2016, to deepen the mine another 400 feet and extend the mine life another 47 years to 2063. As announced in 2016, the $60 million expansion plan is in year 3 of 5 (K+S Windsor Salt, news release, July 25, 2016).

The Ojibway Mine produces approximately 2.5 Mt of salt per year. Another 200 000 to 250 000 t of salt are produced annually at the Windsor evaporation plant, where reserves are sufficient for over 20 years (M. Soave, K+S Windsor Salt, personal communication, June 2017).

Gypsum

CGC INC. – HAGERSVILLE MINE

CGC Inc., a subsidiary of United States-based USG Corporation, is an industry-leading manufacturer of building products and innovative solutions, including products for walls, ceiling, flooring, sheathing and roofing.

CGC Inc. (www.usg.com) runs a fully integrated operation in Hagersville, Ontario, transforming the raw product of its mine, on-site into gypsum wallboard (Photo 2) and shipping directly from the site by rail throughout Canada. Gypsum mined in Hagersville also replaces, in part, synthetic gypsum that is currently imported from the US for use in CGC's wallboard plants.

Photo 2. A series of rollers move Sheetrock® brand wallboard panels from the kiln (left), where they are dried, to the take-off area, where they are labeled and stacked (right). Photos courtesy of CGC Canada (January 2019).

Production of gypsum in Hagersville started in the early 1930s and reserves are sufficient for another 45 to 50 years of mining. The gypsum bed mined by CGC ranges in thickness from 0.8 to 1.2 m at approximately 30 m depth. The mine is accessed through a vertical shaft, and a decline that allows ore to be brought out on conveyor to an on-site wallboard plant. The operations employ about 90 full-time workers (M. Horner, CGC Inc., personal communication, September 2018).

Brick and Shale

In 2018, there were 3 companies operating clay brick or tile plants and a total of 6 shale quarries in southwestern Ontario, all of which extract Queenston Formation shale as raw material. The total value of clay products manufactured in Ontario in 2018 is estimated at $122 million, from the revised figure of $129 million in 2017. (S. Jessome, Mineral Sector Analysis and Promotion Unit, ENDM, written communication, March 2019)

Meridian Brick Ltd. (www.meridianbrick.com) was created in January 2017, through a joint venture between Boral Bricks and Forterra Brick Ltd. The company operates 3 brick plants in Burlington and 1 plant in Aldershot, with shale quarries located at Niagara-on-the-Lake, Burlington and Aldershot. Meridian is Canada's largest brick manufacturer, accounting for about 55% of Canada's total brick production. Meridian Brick employs approximately 164 people at its 3 clay brick plants and 4 quarries in Burlington (Ontario Mining Association, Ontario Mining and Exploration Directory 2018, www.oma.on.ca).

The company owns the Aldershot, Burlington and Tansley quarries near Burlington, permitted for annual extraction of 999 999 t, 195 000 t and 300 000 t, respectively. The company also owns the Niagara Quarry near Niagara-on-the-Lake, where permits allow for an annual extraction of 450 000 t (www.ontario.ca/environment-and-energy/find-pits-and-quarries).

Brampton Brick Ltd. (www.bramptonbrick.com) operates North America's single largest clay brick plant in Brampton, with production capacity of 300 million units per year. The plant employs about 75 people. The company reported that revenues for the first 9 months of 2018 grew by 5% to $125.6 million, from $119.7 million for the same period in 2017. The increased revenues for that period are the result of higher residential starts and the strength of landscape shipments in the first half of 2018 in Canada and the United States (Brampton Brick Limited, news release, November 7, 2018).

The company is permitted to extract 540 000 t of Queenston Formation shale annually at its Cheltenham Quarry near Brampton (Photo 3). The company also owns the Hungry Hollow quarries near Lambton Shores, approximately 50 km northeast of Sarnia, where 2 small quarries are permitted for a combined 40 000 t of extraction (www.ontario.ca/environment-and-energy/find-pits-and-quarries).

For a number of years, Brampton Brick has owned a portion of the Norval deposit.

- In 2002, the "Northwest Brampton Shale Resources Review", initiated by the City of Brampton, recommended to reduce the area designated as the "Norval Deposit of Queenston Shale" from 1377 to 180 ha. Brampton Brick purchased a 35 ha portion of the deposit, located approximately 10 km west of Brampton and proposed to create an excavation area of 9.35 ha ("Brampton Brick Limited, Norval Quarry Site Plan", www.brampton.ca).
- In 2014, the Municipality of Brampton denied the re-zoning application (City of Brampton, "Norval Quarry Re-Zoning Application", www.brampton.ca [accessed February 16, 2018]) and Brampton Brick appealed the decision.
- In September 2017, the Regional Municipality of Peel voted to oppose approval of the Norval Quarry at a proposed hearing with the Ontario Municipal Board (Council of the Regional

Municipality of Peel, Meeting, September 28, 2017, www.peelregion.ca (Minutes, p.293-294) [accessed March 22, 2019]). The company continued to appeal the decision.

- In April 2018, the City of Brampton announced "a settlement has been reached between the City of Brampton and Brampton Brick that has resulted in the complete withdrawal of the rezoning and licensing applications and Ontario Municipal Board appeals. The City's development file on this matter is now closed." (www.brampton.ca/EN/Business/planning-development/projects-studies/Pages/Norval-Quarry-Re-Zoning.aspx)

Jazbrick, a Canadian company with its head office in Rexdale, operates the Century Brick Ltd. plant in Hamilton and the Rexdale Brick plant in Rexdale. Shale for the brick operations is quarried by Limehouse Clay Products Ltd. at the Halton Hills quarries near Georgetown (www.jazbrick.com). The quarries are permitted for combined extractions of 40 000 t of shale annually.

Cement

There are 8 quarries and 6 modern processing plants in southern Ontario between Kingston in the southeast and St. Marys in the southwest. All plants are also operating quarries on site. Production figures for 2018 cement production in southern Ontario are unavailable at this time. (S. Jessome, Mineral Sector Analysis and Promotion Unit, ENDM, written communication, March 2019)

With the exception of Federal White Cement, each company has port facilities for Great Lakes shipping. The Bath, Picton, Bowmanville and Mississauga plants export significant production to the United States. Combined, the companies have 11 cement kilns with a total clinker production capacity of over 7.5 Mt per year.

Since 2010, cement demand has grown steadily in North America, with an annual rate of 2.2% in 2018 (www.statista.com).

Photo 3. The Cheltenham Quarry of Brampton Brick Ltd. showing the red shale of the Queenston Formation with minor interbeds of blue, carbonate-rich shale. The blue material is incorporated and homogenized with the red, iron oxide–rich material to ensure proper firing of the bricks. Photo by P.S. LeBaron, June 2017 (Resident Geologist's Files, Southern Ontario Region, Tweed).

ST. MARYS CEMENT CANADA INC. – ST. MARYS AND BOWMANVILLE

St. Marys Cement Inc. (www.stmaryscement.com) is a subsidiary of Votorantim Cimentos (www.votorantimcimentos.com), which is part of the Votorantim Group, a privately held, and one of the largest, industrial conglomerates in Latin America. St. Marys Cement operates limestone quarries and cement plants at Bowmanville and St. Marys. The company employs a total of 245 people at its Ontario facilities.

In August 2018, CBM Aggregates, a division of St. Marys Cement, announced its decision, after reviewing the results of rock-quality testing, to not move forward with a proposed underground mine adjacent to its Bowmanville Quarry and underneath Lake Ontario (http://bowmanvilleexpansion.ca).

LAFARGE CANADA INC. – BATH

Lafarge Canada Inc. (www.lafarge-na.com) is a subsidiary of Lafarge North America and is, in turn, a subsidiary of LafargeHolcim (www.lafargeholcim.com), an international manufacturer of building materials based in Switzerland, which trades on the Swiss Exchange under the symbol SIX. Lafarge operates a cement plant in Bath, near Kingston, where they employ 105 people and produce 1.1 million tons of cement per year. Lafarge also operates 3 nearby quarries to supply the Bath cement plant, the most important of which is the Bath limestone quarry (on site with the cement plant). Two small, nearby quarries, located just west and northwest of Gananoque, also supply silica to the cement plant as needed.

The company reported a 4.1% increase in North American net sales of cement, aggregates and ready-mix concrete in the first 9 months of 2018 as compared to the same period in year 2017 (LafargeHolcim, news release, October 26, 2018). There are no public figures reported for the Bath site.

Lafarge and subsidiaries also operate over 100 quarries, pits and other operations in southern Ontario producing aggregate, concrete, cement and fly-ash cement.

CRH CANADA GROUP INC. – MISSISSAUGA AND COLBORNE

CRH Canada Group Inc. (www.crhcanada.com) is a subsidiary of CRH plc (www.crh.com), an international group of diversified building materials businesses headquartered in Dublin, Ireland, which trades on the Irish Stock Exchange under the symbol CRG, and on the London Stock Exchange and New York Stock Exchange under the symbol CRH. CRH Canada operates a cement plant and adjacent shale quarry in Mississauga. Limestone is supplied to this cement plant from the company's Ogden Point quarry located on Lake Ontario at Colborne. These operations employ a total of 181 people.

CRH also operates 16 aggregate pits and quarries, 27 concrete plants, 4 "Redimix" plants and 7 asphalt plants in southern Ontario.

LEHIGH CEMENT COMPANY – PICTON

Lehigh Cement Company is a subsidiary of Lehigh Hanson Canada, which is part of Heidelberg Cement (www.heidelbergcement.com), a German multinational building materials company trading on the Frankfurt Stock Exchange under the symbol HEI. Lehigh Cement operates a limestone quarry and cement plant at Picton that was formerly operated by Essroc Canada Inc.

The Picton Plant is 1 of 6 plants in North America operated by Lehigh. The plant and quarry have been in continuous operation since 1958. The north quarry, north of highway 49 and accessed through a tunnel underneath the highway, opened in 1982. Lehigh extracts 5000 tons of limestone (and lesser shale) per

day, 365 days a year from the north quarry. Reserves stand at 58 years at the current rate of extraction and the resource is sufficient for over 100 years (D. Wight, Lehigh Cement, personal communication, 2017).

The Picton Plant produces both Portland and Masonry cement. The plant is located along Lake Ontario and ships the majority of its production from the facility by company-owned ships. The company also ships bulk and packaged product by truck. The plant's market area is the Great Lakes region of Canada and the United States. Annual production capacity of the facility is approximately 1.2 million tons of clinker and approximately 1.3 million tons of finished product. The facility is currently producing approximately 900 000 tons of finished product. The Picton facility employs 136 employees (D. Wight, Lehigh Cement, personal communication, 2017).

FEDERAL WHITE CEMENT LTD. – WOODSTOCK

Federal White Cement Ltd. (www.federalwhitecement.com) is a privately held Canadian company based in Embro, Ontario. The company operates a specialized white architectural cement plant in Embro, near Woodstock, using limestone from its newly acquired quarry southwest of Woodstock. The company employs 50 to 60 people.

Table 1. Mining activity in the Southeastern Ontario District in 2018 (keyed to Figure 1).

No.	Company/Individual (Mine or Quarry Name)	Township(s) (Commodity)	Mining Activity
1	2065342 Ontario Ltd. (Simpson Lake Quarry)	Ashby (Marble)	White, dolomitic marble is quarried and shipped to Coloured Aggregates plant in Marmora for the production of specialty aggregate.
2	Aecon Construction and Materials Ltd.	Gloucester, Marmora, Cavendish (Dolomitic sandstone)	Dolomitic sandstone from the Ottawa Quarry in Gloucester Township is produced from the lower member of the March Formation (11 m thick) for use in pavement aggregate. Limestone aggregate is produced from the site of the former Marmoraton iron mine in Marmora Township. Burgundy coloured granite and limestone are quarried in Cavendish Township for use as crushed stone aggregate and decorative stone.
3	Attia Quarries	Minden (Granite)	Stone is quarried for use as landscaping, dimension, flag and masonry stone.
4	Aqua Rose Gems and Minerals (Beryl Pit / Rose Quartz Pit)	Lyndoch (Gemstones, mineral specimens)	Quarrying operations for rose quartz, beryl, feldspar, lyndochite, amazonite, cleavelandite, peristerite, columbite, fluorite and bertrandite. Two quarries are in operation: the Beryl Pit and the Rose Quartz Pit, which charge a fee for mineral collecting.
5	Canadian Wollastonite (St. Lawrence Mine)	Pittsburgh, Leeds and Lansdowne (Wollastonite)	Wollastonite skarn rock is produced and marketed as an agricultural soil additive. Gabbro is also being quarried and used in Superpave™ aggregate.
6	CRH Canada Group Inc. (Ogden Point Quarry)	Cramahe (Limestone, cement)	The quarry has been in production since 1959. It produces between 1.9 and 2.1 Mt of limestone per year. Crushed stone from the quarry is shipped by lake to the company's cement plant in Mississauga. The quarry employs 20 people.
7	COCO Paving	Kingston (Limestone)	The Elginburg Quarry near Kingston produces 500 000 t of limestone annually. This company has 12 operating quarries throughout eastern Ontario including Green Valley, Kemptville, Brockville, Iroquois, Napanee and Verona. They produce a range of products from fine aggregate to armour stone. Their stone has been used in shoreline protection projects along the St. Lawrence Seaway, including a $3.5 million breakwater and a marina project in Prescott.
8	Danford Construction Ltd. (Tweed Quarry)	Elzevir, Hungerford (Granite-gneiss)	Granite-gneiss is extracted, crushed and approved for use in Superpave™ aggregates. It is also marketed by Color Aggregates Inc.
9	Danford Granite Ltd. (Bridgewater Trap Rock Mine)	Elzevir (Trap Rock)	In 2017, 60 000 t of crushed basalt/gabbro were shipped and approved for mineral wool manufacturing by Roxul Inc., Milton. In 2017, Danford plans to expand quarry production in 2018. Metabasalt is also quarried for use as railway ballast.

No.	Company/Individual (Mine or Quarry Name)	Township(s) (Commodity)	Mining Activity
10	Drain Bros. Excavating Ltd. (Havelock Quarry)	Belmont, Dummer, Methuen (Basalt, limestone, granite)	Basalt is extracted for use as trap rock from the Havelock Quarry in Belmont township. Limestone and granite are quarried for aggregate in Dummer and Methuen townships, respectively.
11	Dufferin Aggregates	Harvey (Limestone)	Grey limestone is extracted from the Buckhorn Quarry for use as armour stone, landscaping stone and crushed stone.
12	Lehigh Cement *(formerly Essroc Canada Inc.)* (Picton Quarry)	Sophiasburg (Cement)	A cement plant and on-site limestone quarry with an annual production of slightly less than 1 000 000 t. This is one of the largest cement plants in North America and employs 160 people.
13	Ferromin Inc. (Tomclid Iron Mine)	South Canonto (Magnetite)	Magnetite is mined and crushed as high-density aggregate for use in heavy concrete applications, including radiation shielding.
14	Galway Ridge Resources Inc.	Harvey (Limestone)	Limestone is quarried to produce flagstone, split-face building stone and armour stone
15	I.K.O. Industries Ltd. (I.K.O. Quarry)	Madoc (Trap Rock)	Since 1991, I.K.O. Industries Ltd. has operated a trap rock quarry east of Madoc on the south side of Highway 7. The quarry is located within a ridge of grey to black, fine-grained, agglomeratic metavolcanic rock. An on-site mill and colouring plant produce roofing granules, which are trucked to the company's asphalt shingle manufacturing plant in Brampton. In addition to roofing granules, stone from the quarry is crushed to produce HL-1 aggregate (asphalt road surfacing mix). The quarry is licenced under the Aggregate Resources Act to produce up to 1 Mt per year.
16	JC Rock (Crookston Quarry)	Huntingdon (Limestone)	Historical producer; in 2010, dimension stone was removed for restoration project in Belleville.
17	Jeff Parnell Contracting Limited	Galway (Limestone)	Natural and dimension-cut armour stone, rockery stone, garden stone, natural surface steps and natural and dimensional flagstone.
18	John Bacher Construction Limited	McClintock (Granite, gneiss)	Building stone, flagging stone and landscaping stone.
19	Johnston Quarry	Galway (Limestone)	Gull River Formation limestone is removed for use as landscaping stone, flagstone and building stone.
20	Kawartha Cut Stone.	Harvey (Limestone)	Limestone is quarried to produce armour stone, flagstone, veneer, sills and ledgerock; custom cutting facility in Brechin.
21	Lafarge Canada Inc. (Bath, Brockville, Bearbrook and Hawthorne quarries)	Ernestown, Elizabethtown, Gloucester (Cement, dolomitic sandstone, limestone)	In Ernestown Township, the company operates a cement plant and on-site limestone quarry with a capacity to produce 1 Mt of cement annually. Silica used in the production of cement is extracted from the company's Potsdam sandstone quarry in Pittsburgh Township, as well as from recycled foundry sands. In Elizabethtown Township, dolomitic sandstone from the lower member of the March Formation (at least 19 m thick) is used for road aggregate. Markets are served in the Brockville, Prescott and Cardinal areas. Limestone of lower member Gull River Formation, upper member Bobcaygeon Formation and the lower member of the March Formation (11 m thick) is quarried for use as high-quality aggregate in Gloucester Township.
22	McFadyen's Stone Quarry	Finlayson (Gneiss)	Flagstone, building stone, armour stone, guillotine cut ashlar, sawn thinstone veneer and custom guillotine, hearths and pier caps.
23	Miller Paving Ltd.	Carden (Limestone)	This quarry east of Brechin produces grey limestone for use as aggregate, architectural stone, landscaping/armour stone, asphalt limestone, crushed limestone and manufactured sand.
24	MRT Aggregates Inc. (MRT Traprock)	Methuen (Trap Rock)	Metagabbro is quarried and crushed on site for use as premium aggregate for HL-1 purposes. A portable crusher is moved on site as required. Production began in December 2002 and, in 2003, production totalled 100 000 t. The product is used by Miller Paving and also sold outside the company.
25	Omya Canada Inc. (Tatlock Quarry)	Darling (Calcite)	Calcitic marble is mined to produce high-purity, fine-grind calcite for fillers with terrazzo chips and landscaping stone as secondary products. Annual production is 250 000 tons and quarry reserves currently stand at over 5 000 000 tons.
26	Princess Sodalite Mine	Dungannon (Sodalite)	Decorative stone, landscaping stone, mineral specimens including fee for collecting.
27	Redstone Quarries	Galway, Harvey, Cavendish (Limestone, sandstone)	Beige limestone and red sandstone are quarried for weathered landscaping stone and armour stone blocks.

No.	Company/Individual (Mine or Quarry Name)	Township(s) (Commodity)	Mining Activity
28	Rideauview Contracts Ltd. (Ellisville, McCallum, Petworth, Rideauview, Sloan and Battersea quarries)	Rear of Leeds & Lansdowne, Storrington, Portland (Sandstone, limestone, granite)	Sandstone is produced for flagstone, granite blocks and masonry stone from the Ellisville Quarry in Rear of Leeds and Lansdowne Township. Limestone from the McCallum and Petworth quarries (in Storrington and Portland townships, respectively) is quarried for building restoration and new construction. In Storrington Township, red and cream sandstone are quarried for the production of ashlar, flagstone and landscaping stone at the Rideauview and Sloan quarries and red granite is quarried at the Battersea Quarry.
29	Rigbe's Quarry	Harvey (Limestone)	Buff limestone is removed for use as weathered armoury and rockery, crushed aggregates and landscape stone.
30	Stonescape Quarry	Harvey (Limestone)	Limestone flagstone and ledgerock are quarried north of Buckhorn.
31	T. Pluard (Elite Blue)	Chandos (Marble)	A blue grey metasedimentary rock is extracted for a variety of uses including armour stone, landscaping stone and dimension stone
32	Covia Holdings Corporation *(formerly Unimin Canada Ltd.)* (Blue Mountain Quarry)	Methuen (Nepheline syenite)	Nepheline syenite is mined from a quarry and is processed in 2 mills at Nephton and Blue Mountain, respectively. Magnetite is produced as a by-product. Production rate is 2500 tons per day. The quarry opened in 1955 and employs 152 people.
33	Upper Canada Stone Co. Ltd. (Pink Marble, Royal Green Marble, Madoc White Marble, Medium Buff Marble, Black Marble, Blue-Grey Marble, Light-Buff Marble and Kingston Red Granite quarries)	Madoc, Huntingdon, Marmora, Rear of Leeds and Lansdowne (Marble, granite)	In Madoc, Huntingdon and Marmora townships, several colours of fine-grained marble are quarried for use as landscaping stone, dimension stone, terrazzo and decorative aggregate. In Rear of Leeds and Lansdowne Township, red granite is produced for precast concrete panels, pavers, split block, spun concrete poles and landscaping.

Table 2. Producing mines and quarries in the Southwestern Ontario District* in 2018 (keyed to Figure 2).

No.	Company/Individual (Mine or Quarry Name)	Township(s) (Commodity)	Mining Activity
1	A & A Natural Stone Ltd. (A & A Quarry)	Keppel (Dolostone)	Grey dolostone is produced for use as flagstone, landscape stone and specialty aggregate.
2	Arriscraft International Inc. (Adair Marble Quarries)	Albemarle (Dolostone)	Dolostone is produced for use as architectural stone.
3	Attia Quarries (Rama and Seabright quarries)	Rama (Dolostone)	Stone is quarried for use as landscaping, dimension, flag and masonry stone.
4	Block and Stone Resource Group Inc.	Amabel (Dolostone)	Dolostone is quarried for use as dimension stone.
5	Brampton Brick Ltd. (Cheltenham and Hungry Hollow North quarries)	Chinguacousy, Williams (Shale)	Queenston Formation shale is extracted for use in the company's brick plant.
6	Bruce Peninsula Stone Ltd. (Lindsay, Wiarton and Mar quarries)	Lindsay, Amabel, Albemarle (Dolostone)	Dolostone is produced for landscaping and building stone products.
7	Carmeuse Lime Canada Ltd. (Beachville Quarry)	Zorra (Limestone)	Limestone is extracted, crushed and processed in on-site lime plant.
8	CGC Inc. (Hagersville Mine)	Oneida (Gypsum)	An on-site wallboard plant utilizes gypsum from the mine.
9	Compass Minerals International. Inc (Goderich Mine and brine fields)	Goderich (Salt, salt in brine)	This is the largest underground salt mine in the world. The company also produces salt from an adjacent brine field operation. Most production is distributed via Great Lakes shipping. 2017 was the final year of a 3-year, $150 million project to re-line shaft walls in the 600 m deep mine.
10	Credit Valley Quarries Co. Ltd.	Caledon, Chinguacousy (Sandstone, limestone)	Sandstone is extracted for construction and landscaping applications. The stone has been used in many notable buildings including Toronto's Old City Hall and the Ontario Legislature (Queen's Park).
11	CRH Canada Group Inc. (Mississauga Quarry and Ogden Point Quarry)	Toronto (Shale)	CRH Canada Group Inc. operates a cement plant and adjacent shale quarry. Limestone is shipped to the plant from Ogden Point quarry on Lake Ontario at Colborne. *(formerly Holcim Canada Inc.)*

No.	Company/Individual (Mine or Quarry Name)	Township(s) (Commodity)	Mining Activity
12	Cut Above Natural Stone (Cut Above Natural Stone Quarry)	Rama (Limestone)	Buff brown, white, light to dark grey limestone is quarried for use as armour stone, cubical weathered wallstone, flagstone and random slabs.
13	Dufferin Aggregates (Flamborough Quarry)	West Flamborough (Dolostone)	Dolostone is produced for use as armour, landscaping and crushed stone.
14	E.C. King Contracting Ltd. (Sydenham Quarry)	Sydenham (Dolostone)	High-purity dolostone is crushed for construction aggregate and agricultural lime.
15	Ebel Quarries Inc. (Ebel and Arnold Property quarries)	Amabel (Dolostone)	Light and dark brown and black dolostone is produced for use as flagstone, landscaping stone, slabs, steps and wallstone.
16	Fowler Construction Company Limited (Fleming Quarry)	Rama (Gneiss)	Granitic gneiss is quarried for use as flagstone, building, landscaping, masonry and crushed stone.
17	Georgian Bay Marble and Stone (Cook Quarry)	Amabel (Dolostone)	Dolostone is produced for use as landscaping stone, steps and building stone.
18	Hilltop Stone and Supply Inc. (Hilltop Quarry)	Esquesing (Sandstone)	Grey and buff sandstone is quarried for use as flagstone, masonry stone and dimension stone.
19	Hope Bay Quarry Inc.	Albemarle (Dolostone)	Dolostone is produced for use as flagstone, aggregate and armour stone.
20	Jazbrick (Georgetown Quarry)	Esquesing (Shale)	Queenston Formation shale is extracted for use in the company's brick plant. *(formerly Century Brick Ltd.)*
21	Lafarge Canada Inc. (Dundas and Woodstock quarries)	West Flamborough, Zorra (Dolostone, limestone)	Dolostone is crushed for use as high-quality aggregate and steel-making flux. Limestone is extracted and crushed for aggregate from quarry near the site of a former cement plant.
22	Limberlost Stone Inc. (Limberlost Quarry)	Albemarle (Dolostone)	Light and dark brown and grey dolostone is quarried for use as flagstone, landscaping stone, steps, slabs, coping and coursing.
23	Meridian Brick Ltd. (Aldershot, Burlington and Niagara-on-the-Lake quarries)	East Flamborough, Niagara (Shale)	Queenston Formation shale is extracted for use in the company's brick plant. *(formerly Forterra Brick Ltd.)*
24	Owen Sound Ledgerock Ltd. (Owen Sound, Senesun and Wiarton quarries)	Keppel, Amabel (Dolostone)	Dolostone is produced for use as custom-cut and architectural cut stone, masonry, ledgerock wallstone, marble tiles and slabs and landscape stone.
25	Rice and McHarg Ltd. (Rice and McHarg Quarry)	Esquesing (Sandstone)	Grey and buff sandstone is produced for use as flagstone, masonry and landscaping stone.
26	Rockleith Quarry Ltd. (Rockleith Quarry)	Orillia (Limestone)	Beige, tan and blue-gold limestone and dolomitic limestone is produced for use as dimensional building stone.
27	Speiran Quarries Ltd. (Speiran Quarry)	Rama (Limestone)	The quarry is operated by Gott Natural Stone '99 Inc. White limestone is produced for use as flagstone, landscaping stone, waterfall slabs, retaining wall blocks and steps.
28	St. Marys Cement Inc. (Bowmanville and St. Marys quarries)	Darlington, Blanshard (Limestone)	Limestone is quarried and processed at cement plant complexes in Bowmanville and St. Marys.
29	K+S Windsor Salt Ltd. (Ojibway Mine and brine fields)	Sandwich (Salt, salt in brine)	Underground workings are adjacent to international border. The company also produces salt from an adjacent brine field operation. In 2018, the company continued a multi-year, $300 million investment in the mine and brine fields, expected to add 45 years of mine life beyond the current 10-year projection.
30	Wiarton Stone Quarry Inc. (Wiarton Stone Quarry)	Amabel (Dolostone)	Light brown, grey-beige and black dolostone is quarried for use as flagstone, steps, waterfall stone and curbing stone.

**All oil and gas production in Ontario occurs in the Southwestern Ontario District. For information on oil and gas exploration and development activity in Ontario in 2018, please refer to the report of the Petroleum Operations Section (this volume).*

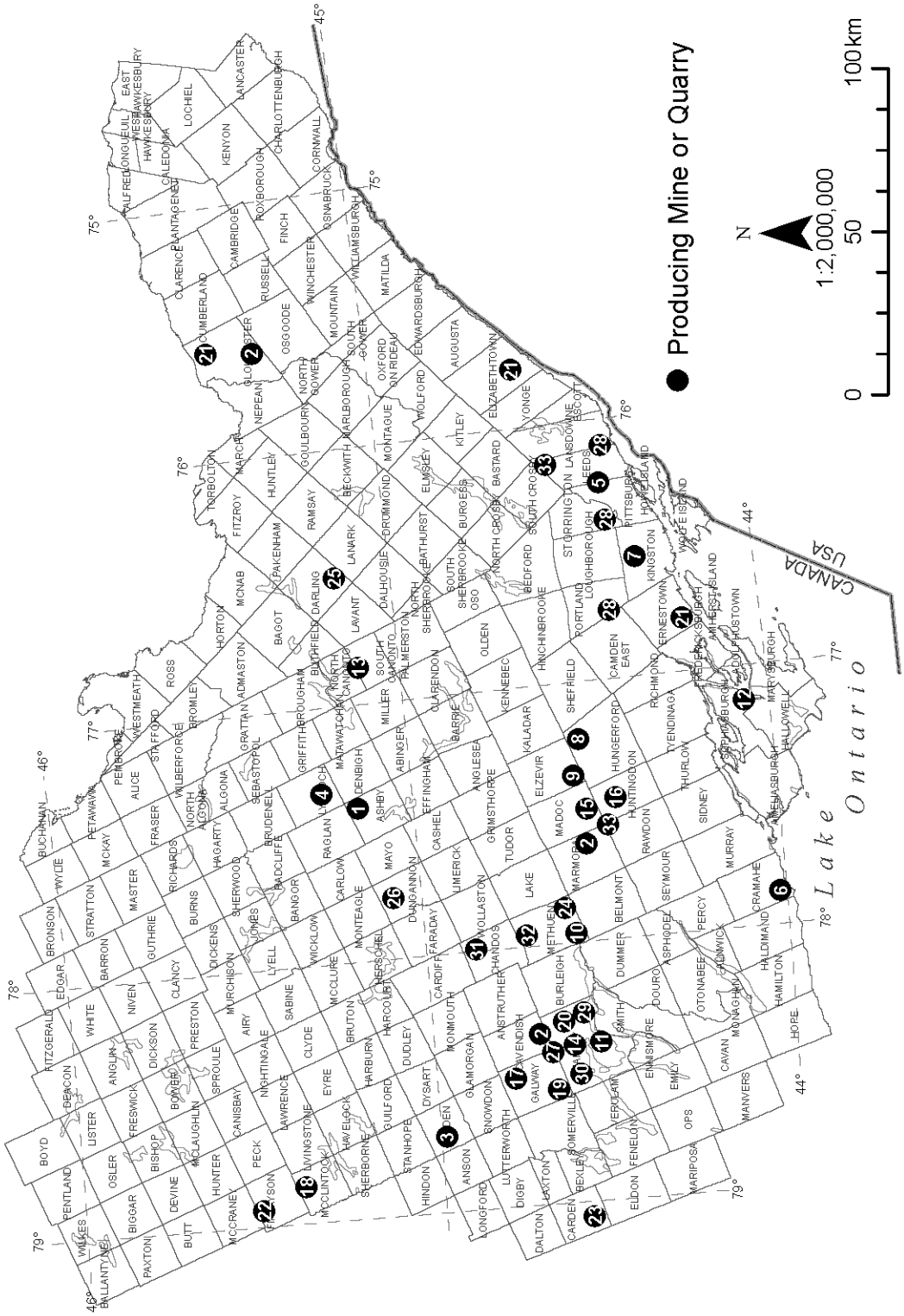

Figure 1. Mining activity in the Southeastern Ontario District in 2018 (keyed to Table 1).

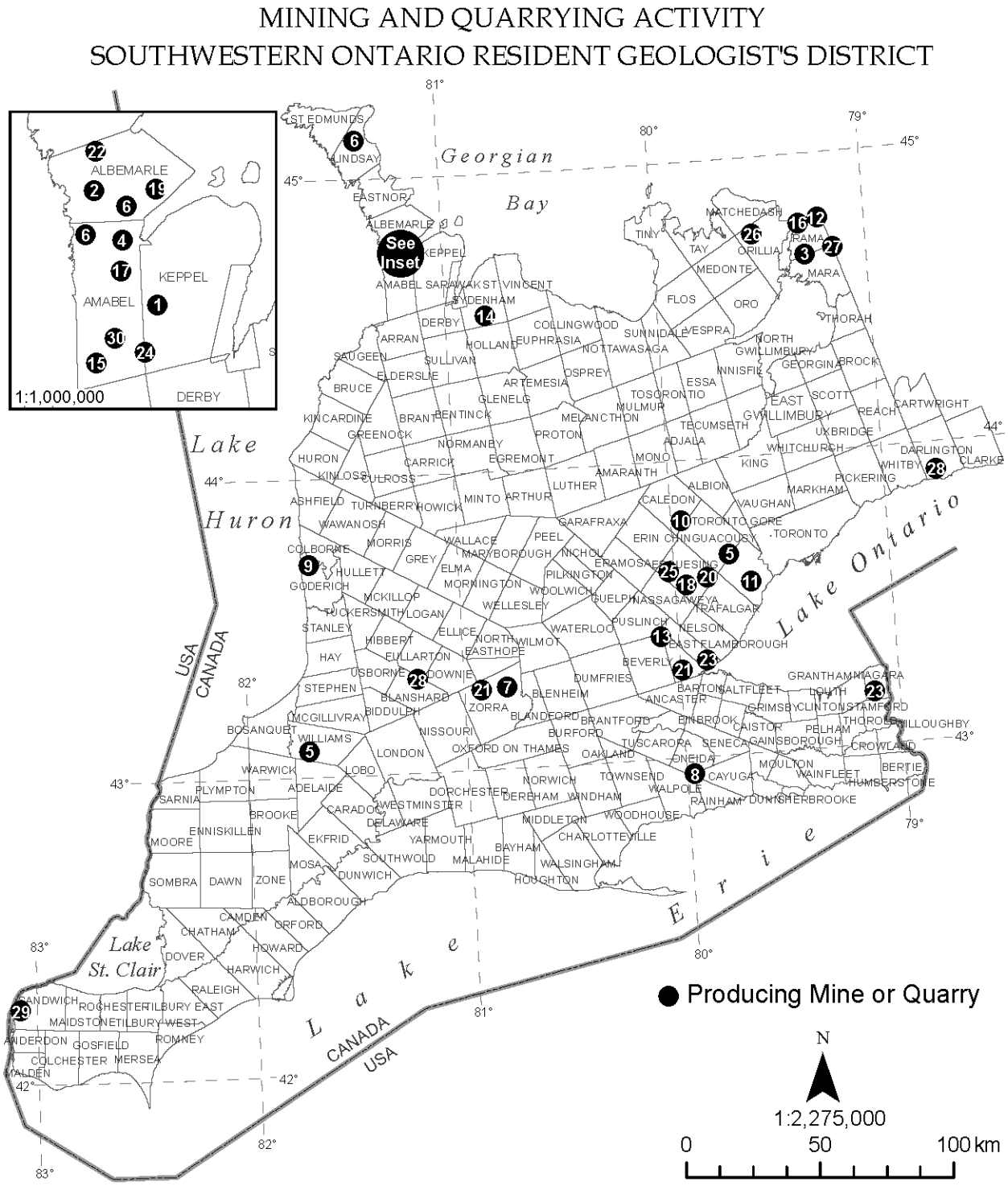

Figure 2. Producing mines and quarries in the Southwestern Ontario District in 2018 (keyed to Table 2).

Dimension and Building Stone

Almost all of southern Ontario's dimension stone production comes from Cambrian and Paleozoic strata. Individual producers are listed in Tables 1 and 2 and the main centres of production are described below.

WIARTON AREA QUARRIES

The Wiarton area on the Bruce Peninsula in southwestern Ontario is the centre of the province's dimension-stone industry. As of 2018, 21 quarries in the County of Bruce and 3 quarries in the neighbouring County of Grey produce dimension stone under the *Aggregate Resources Act* for building, landscaping and flagstone markets. Several other quarries in both counties produce dolostone aggregate and can provide armour stone on demand.

The majority of the quarries in this area are within the Eramosa Member of the Middle Silurian Amabel Formation, which is a grey-brown to black, laminated dolostone interbedded with light brown, thin to thick-bedded dolostone. The stone is sufficiently hard to take a good polish and, although not technically a marble, is often referred to as "Eramosa Marble" in the dimension stone trade (Rowell 2015).

Rowell (2012) identifies provincially significant bedrock resources in the County of Bruce and provides details of national and provincial parks, and physical, cultural and environmental constraints on development, including the Niagara Escarpment Plan, which limit development of resources within that area for dimension stone and aggregate.

ORILLIA AREA QUARRIES

In Rama Township near Orillia, 8 companies operate dimension-stone quarries in Paleozoic limestone of the Gull River Formation. Each of the companies has some form of on-site processing to split and/or cut stone to customer specifications. Both white-weathering, micritic limestone and, to a lesser extent, beige-weathering dolostone from the Gull River Formation are extracted from the Orillia area quarries for use as landscape, masonry and armour stone. The quarries at Longford, opened in the 1880s and now inactive, were well known for both limestone (Longford Stone) and dolostone (Rama Stone) used in the construction of many historic buildings in Toronto, Peterborough and Orillia (Parks 1912; www.historicplaces.ca).

PETERBOROUGH AREA QUARRIES

There has been a long history of dimension-stone production in the Peterborough area. In 2018, 7 companies operated 8 dimension-stone quarries in the Peterborough area.

In 4 of the quarries, Paleozoic limestone of the Gull River Formation is extracted for a variety of applications, including landscape, masonry and armour stone. Thick-bedded limestone of the overlying Bobcaygeon Formation is also quarried and used primarily as aggregate and armour stone. The Parnell Quarry in Galway Township is located on a contact between Paleozoic sedimentary rock and Proterozoic metamorphic rock of the Canadian Shield. In addition to Gull River Formation limestone, dolostone and deep red ("wine") granite have been quarried at this site. At the Pluard quarry in Chandos Township, a blue-grey interlayered marble and amphibolite unit is quarried by W. Brown to produce "Elite Blue" dimension stone (W. Brown, personal communication, 2018).

Drain Bros. Excavating Ltd. – New Dimension Stone Processing Plant

In 2018, Drain Bros. Excavating Ltd. completed construction of a new dimension-stone processing plant on the site of their trap rock quarry and plant at Havelock, near Peterborough. The following information was provided by the company (C. Brown, Drain Bros. Excavating Ltd., personal communication, February 2019).

The facility contains a large 120-inch diameter diamond saw, a smaller 5-axis CNC (Computer Numerical Control) programmable saw, hydraulic guillotines and recently added polisher. The plant was opened for business in December 2018, processing stone from the company's limestone quarry in the Buckhorn area. Drain Bros. is currently expanding its stone sources to include their Smith limestone quarry, Belmont Rose granite quarry and the Havelock basalt quarry. Current products include armour stone, landscaping stone, steps, jumbo flag stone, and full bed depth building stone. With the addition of the new polisher, future products will include polished, honed and antique surfaces for both exterior and interior uses. The range of product sizes will allow almost all stone to be utilized, and any remaining waste will be crushed for aggregate.

The large saw operates on a computer-guided, mobile frame that will allow automatic cutting of multiple blocks within an area of 16 by 60 feet. The plant operates year-round and adds 12 full-time jobs to the 22 positions currently existing at the Havelock trap rock and ethanol operations.

The products are marketed directly from the Havelock site and through a second distribution centre in Stouffville.

KINGSTON AREA QUARRIES

Quarrying of limestone as building stone in the Kingston area began in the early 1800s and the industry expanded rapidly during construction of the Rideau Canal from 1826 to 1832 (www.rideauinfo.com). Kingston limestone, white-weathering, micritic limestone of the Gull River Formation, is a prominent feature of many government buildings, churches and the buildings of Queen's University and the Royal Military College.

Rideauview Contracts Ltd. operates the only 2 quarries that currently produce limestone dimension stone: the Petworth Quarry, 25 km northwest of Kingston, and the McCallum Quarry, 10 km northeast of Kingston on the Battersea Road. In 2016, the company acquired a permit to expand the Petworth Quarry to the north, doubling the surface area of the quarry. Stone from the Petworth Quarry was used in 2017–2018 in the restoration of buildings at the Royal Military College in Kingston (B. Jackson, personal communication, January 2019).

SANDSTONE QUARRIES

Sandstone of the Whirlpool Formation (Lower Devonian) has been quarried in the Brampton area since 1840. Locally known as Credit Valley stone, it was used in the construction of many notable projects in Toronto, including Old City Hall, the Ontario Legislature (Queen's Park), pillars at Union Station, and the Timothy Eaton Memorial Church.

Two quarries continue to produce sandstone in the Brampton area. Credit Valley Quarries Co. Ltd. and Hilltop Stone and Supply Inc. produce sandstone for new projects and for the restoration of many historic sandstone buildings in the Greater Toronto Area (www.historicplaces.ca). Products include split-face ashlar, flagstone, random wall stone and landscaping stone.

In southeastern Ontario near Kingston, Nepean Formation (Cambrian) sandstone is quarried by Rideauview Contracts Ltd. and processed as dimension stone in a variety of finishes for stone veneer, lintels, headers, steps, stone blocks and archways. The stone is used for restoration projects in Canada and the United States, including ongoing restoration of the Parliament Buildings in Ottawa and the restoration of locks on the Rideau Canal (B. Jackson, personal communication, January 2019).

Trap Rock

There are 5 companies operating trap rock quarries in southeastern Ontario, 4 located near Highway 7 between Peterborough and Tweed and 1 at Seeleys Bay, north of Kingston. Products include roofing granules, high-performance aggregate, railway ballast, and raw material for mineral wool production.

Drain Bros. Excavating Ltd. quarries metabasalt near Havelock for use as railway ballast, filter stone, high-performance aggregate, roofing granules and mineral wool raw material. The company has on-site crushing facilities.

MRT Aggregates Inc. operates a quarry in metagabbro about 20 km north of Havelock. The company produces crushed stone on site for use as high-performance aggregate and railway ballast.

I.K.O. Industries Ltd. quarries a fine-grained, massive, intermediate rock, classified as andesite, for the production of roofing granules. The company has an on-site crushing and colourizing plant. The granules are shipped to the company's Brampton plant for manufacturing asphalt shingles.

Danford Granite Ltd. operates the Bridgewater trap rock quarry, about 4 km north of Highway 7, between Madoc and Tweed. The company has opened quarries in both high-iron gabbro and high-magnesium gabbro. The former has been tested and approved as railway ballast and road aggregate; the latter has been developed as a source of raw material for mineral wool manufacturing. In 2015, as part of an evaluation of the high-magnesium zone, the company conducted a resampling program on archived diamond-drill core, stored at the ENDM Tweed Drill Core Library, from a past talc exploration program on the property. The company shipped 30 000 t of gabbro to Roxul Inc. in Milton for mineral wool manufacturing tests in 2015. The results were positive and the company has progressively increased shipments to 80 000 t in 2018. Waste rock from the operation in the form of undersize material, totalling about 20 000 t per year, is sold as general construction aggregate. The company also operates several bedrock aggregate quarries in eastern Ontario and employs 25 permanent and 25 seasonal workers (A. Danford, Danford Granite Ltd., personal communication, January 2019).

Canadian Wollastonite produces trap rock from a body of mafic orthogneiss that is in contact with the wollastonite-bearing skarn of the St. Lawrence wollastonite mine at Seeleys Bay. The material has been approved by the Ministry of Transportation for use as a high-strength, high-friction surface aggregate in major highway construction. The stone is also suitable for use in high-strength concrete, as railway ballast, and as rip-rap and gabion stone (www.canadianwollastonite.com).

Calcium Carbonate (Marble)

OMYA CANADA INC. – TATLOCK QUARRY

Omya Canada Inc. (www.omya.com) is a subsidiary of Omya AG, a privately held global producer of industrial minerals headquartered in Switzerland. Worldwide, Omya AG produces mainly fillers and pigments derived from calcium carbonate and dolomite. Omya AG is also a worldwide distributor of specialty chemicals.

The company extracts white calcitic marble from a high-purity zone at the Tatlock Quarry in Darling Township. The marble is shipped to the company's processing plant in Perth for production of ground calcium carbonate products that are used primarily in the paint, paper and plastic industries. The Tatlock Quarry is permitted for a maximum annual extraction of 4 000 000 t. Together, the Tatlock Quarry and Perth processing plant employ about 92 permanent workers (R. Hughes, Omya Canada Inc., personal communication, December 2018).

EXPLORATION ACTIVITY

Assessment files received for the Southern Ontario Region are listed in Table 3. Exploration activity is listed in Table 4 and the locations of exploration projects are shown in Figure 3. It should be noted that the number of assessment files received does not reflect the amount of exploration work that is carried out in the Southern Ontario Region. The reason is that the vast majority of exploration work in southern Ontario is carried out on private land where claim holders are not required to submit assessment work.

In 2018, most of the exploration activities and expenditures in the Southern Ontario Region were focussed on nickel-cobalt-copper, graphite, gold and zinc as described below.

Use of the outdoor Drill Core Library in Tweed as an exploration tool has increased in recent years, as funding has been lacking for major field exploration projects. This trend continued in 2018 with a major core relogging and pulp resampling program conducted by Pancontinental Resources Corporation, which was designed to bring the historical resource estimate on the company's McBride nickel-cobalt-copper project to compliance with National Instrument 43-101.

Table 3. Assessment files received in the Southeastern Ontario District in 2018.

Abbreviations

ASSAY ..... Assaying and analysis
DHRLG ..... Drill core relogging
DHRSMP ..... Drill core resampling
GEOL ..... Geological survey / mapping
MAGSUS ..... Magnetic susceptibility
PROSP ..... Prospecting
PTRNCH ..... Bedrock trenching
ROCK ..... Rock sampling

Township/Area	Company Filing Report	Year	Work Performed (Value)	Credits Applied	AFRO Number	Resident Geologist Office File Designation
Cardiff	Skead Holdings Ltd.	2017	ASSAY, PROSP, ROCK ($8,607)	2016–2017	2.58405	Cardiff #278
Cardiff	Skead Holdings Ltd.	2017	DHRSMP ($4,505)	2016–2017	2.58403	Cardiff #279
Denbigh	CJP Exploration Inc.	2017	MAGSUS ($5,114)	2017	2.58378	Denbigh #13
Denbigh	CJP Exploration Inc.	2018	ASSAY, DHRSMP, DHRLG ($3,647)	2017–2018	2.58408	Denbigh #14
Glamorgan	Crushcor Ltd.	2017	GEOL, ROCK, ASSAY ($1,073)	2014–2017	2.58108	Glamorgan #36
Grimsthorpe	Union Glory Gold Ltd.	2017	PTRNCH ($13,010)	2017	MLAS #16727	Grimsthorpe #98
Limerick	Hastings Highlands Resources Ltd.	2017	GEOL ($15,396)	2017	2.58243	Limerick #28
Monmouth	Skead Holdings Ltd.	2017	DHRSMP ($5,110)	2016–2017	2.58441	Monmouth #188
Snowdon	Skead Holdings Ltd.	2018	ASSAY, DHRSMP ($11,989)	2017–2018	2.58451	Snowdon #28

Table 4. Exploration activity in the Southeastern Ontario District in 2018 (keyed to Figure 3).

Abbreviations

DHRLG ..... Drill core relogging
GCHEM ..... Geochemical
GEOL ..... Geological survey / mapping
LC ..... Line cutting
MAG ..... Magnetic / magnetometer survey
PCOMP ..... Compilation and interpretation – diamond drilling
PROSP ..... Prospecting by licence holder
ROCK ..... Rock sampling
SOIL ..... Soil sampling

No.	Company/Individual (Stock Symbol) Property Name	Township/Area (Commodity)	Exploration Activity
1	Cobalt-Frontenac Exploration Cobalt Frontenac project	Barrie (Au)	PROSP, SOIL
2	Earth Resources Ltd. Bobcaygeon Graphite prospect	Cavendish (Graphite)	PROSP
3	Pancontinental Resources Corporation (TSX-V: PUC) *(formerly Pancontinental Gold Corporation)* McBride project	Limerick (Ni, Cu, PGE)	DHRLG, ROCK, GCHEM, LC, GEOL
4	J. Martin, J. Andreana Black Mountain property	Matawatchan (Graphite)	MAG, PROSP
5	R. Waring Waring Creek property	Anglesea (Au)	PROSP
6	Mountain Grove Minerals Inc. Olden Wollastonite property	Olden (Wollastonite)	PCOMP

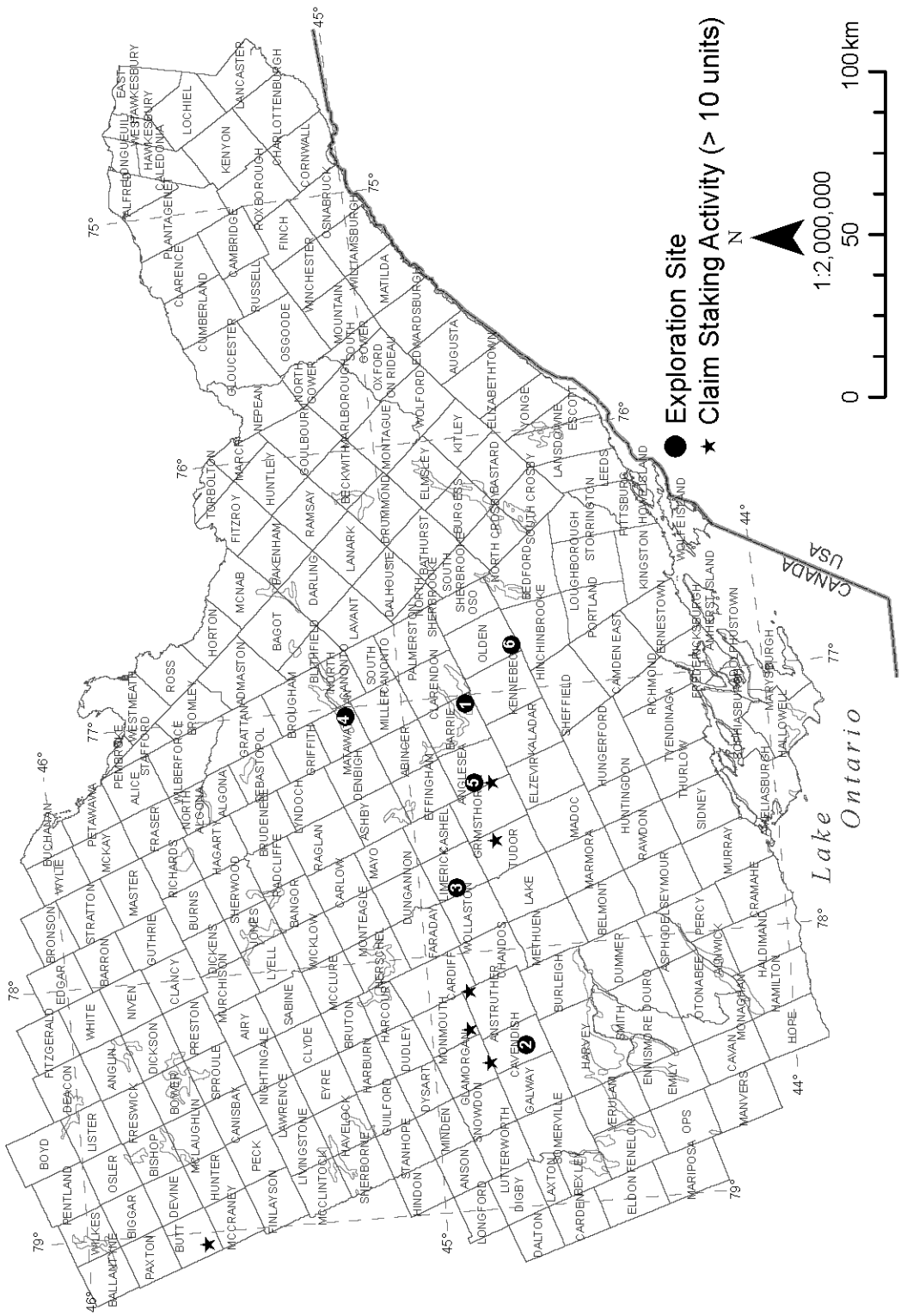

Figure 3. Exploration activity in the Southeastern Ontario District in 2018 (keyed to Table 4).

Nickel-Cobalt-Copper

PANCONTINENTAL RESOURCES CORPORATION – McBRIDE PROJECT

Pancontinental Resources Corporation (www.panconresources.com; formerly Pancontinental Gold Corporation) entered into an option agreement with Hastings Highlands Resources Limited in April 2018 to earn up to 76% of the McBride nickel-cobalt-copper project (Pancontinental Resources Corporation, news release, April 26, 2018).

The project is located in Limerick Township and was historically known as the "Macassa copper-nickel deposit". The deposit was discovered in the 1960s and diamond drill tested with more than 90 holes by Macassa Gold Mines Limited and Long Lac Minerals Limited. In 1971, Long Lac estimated a resource of 5.1 Mt, consisting of 3.9 Mt grading 0.82% Ni, 0.054% Co and 0.25% Cu in the North zone and 1.2 Mt grading 0.30% Ni, 0.03% Co and 0.14% Cu in the South zone (Malczak, Carter and Springer 1985).

The company provided the following summary of the 2018 exploration program (Pancontinental Resources Corporation, news release, July 31, 2018):

- "Retained P&E Mining Consultants Inc. to produce an updated, independent NI 43-101 Resource Estimate.
- Produced a comprehensive digital database of all historic drill core, sample reject and downhole survey data from more than 80 historic diamond drill holes.
- Re-boxed and re-logged more than 20,000 metres of historic diamond drill core housed at the government core storage facility in Tweed, Ontario.
- Cut 70 kilometres of lines, and restored the Project grid from historical work conducted in the 1960s, 1970s and 2004 by Macassa Mines, Long Lac Minerals, and Limerick Mines.
- Commenced in-depth geological mapping of entire core block covered by the Project grid, 30% of which has been completed to date.
- Commenced soil sampling and geochemistry analysis to build on previous soil geochemistry work conducted at the North Zone, South Zone and Southern Extension.
- Commenced interpretation of historic airborne geophysical surveys conducted by Long Lac Minerals.
- Commenced environmental and social impact baseline studies.
- Commenced local community and Alderville First Nation consultations."

Gold

R. WARING – WARING MINERALS GOLD PROPERTY

Prospector R. Waring continued exploration of his gold prospects in the area of the Partridge Creek shear zone in western Anglesea and eastern Grimsthorpe townships (R. Waring, Prospector, personal communication, January 2019). The geology of the area was mapped by Easton (2001) and the location of the Partridge Creek shear zone is shown on that map.

Gold mineralization occurs in several locations on the property within sulphide-bearing, rusty, smoky quartz veins within sheared metavolcanic rocks, possibly associated with second-order structures along the Partridge Creek shear zone (Poulsen 2016). The focus of exploration to date has been the areas of the Main, North and South occurrences, shown in Figure 4. Shallow-dipping, extensional quartz veins at the Main showing have assayed 20 g/t Au (Dowhaluk 1990) and 66 g/t Au (Waring 2016). Waring (2016) also reported assays of 13.3 g/t Au from the North showing and 1.38 g/t Au from the South showing. Also of interest at the South showing is the presence of native bismuth in a quartz vein that assayed >10 000 ppm Bi (R. Waring, Prospector, personal communication, January 2019).

In 2018, Mr. Waring staked additional claims covering the United Reef Petroleums gold occurrence about 2 km northwest of the area shown in Figure 4 (R. Waring, Prospector, personal communication, 2018). Previous work by Beesley (1999) on the United Reef property gave results of up to 4.5 g/t Au from a sericite-altered quartz porphyry with a stockwork of narrow quartz veinlets and anomalous values of up to 0.27 g/t Au from a lean, siliceous iron formation. A mineralized section of the same iron formation also returned 4 g/t Au in 2018 (R. Waring, Prospector, personal communication, January 2019).

Other work completed on the property in 2018 included stripping and channel sampling. Results are pending and will be submitted in an assessment work report early in 2019 (R. Waring, Prospector, personal communication, January 2019).

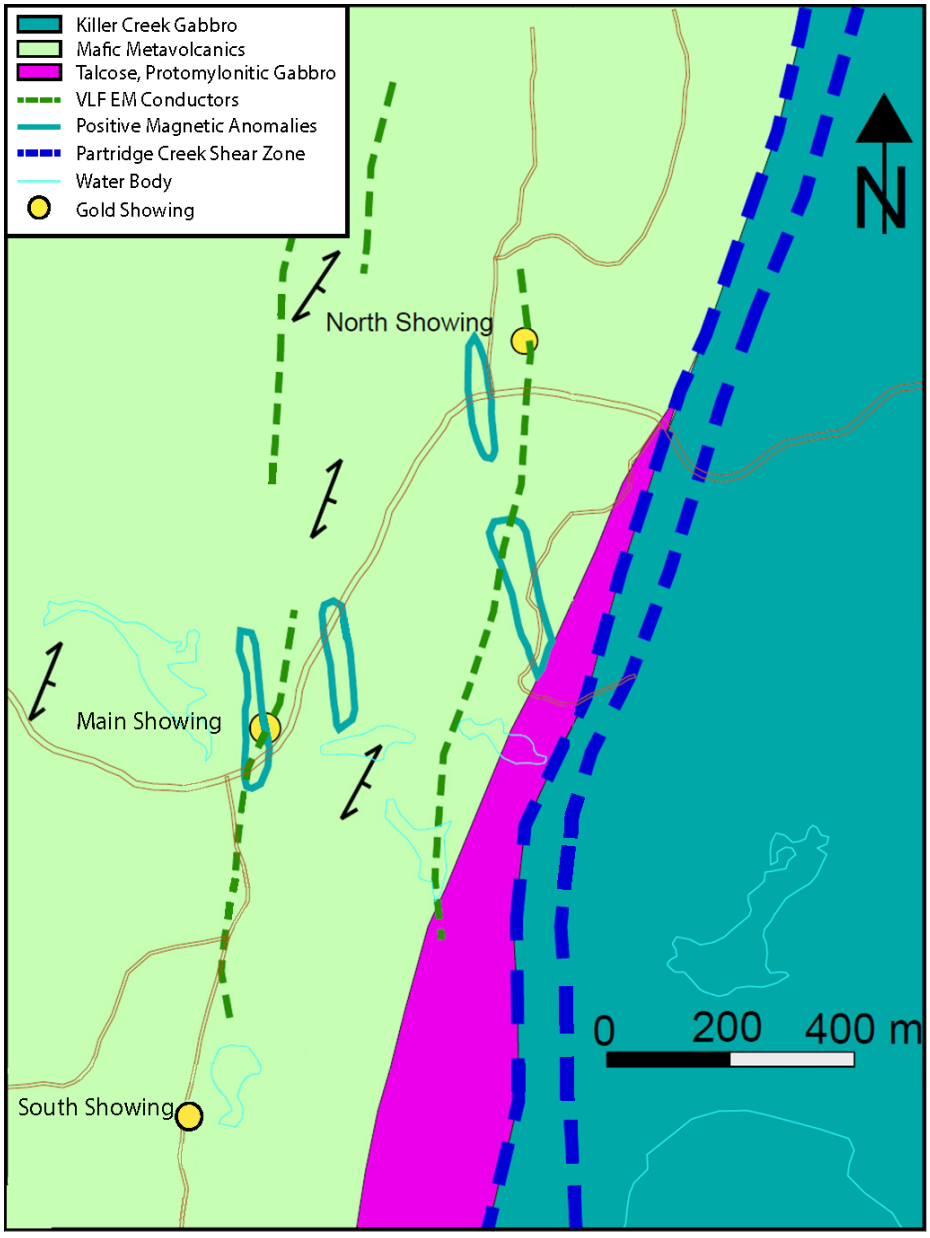

Figure 4. Geology in the area of the Main gold showing, Waring Minerals property, Anglesea Township (*modified from* Poulsen 2016). Geological contacts *from* Easton (2001). Geophysical (VLF–EM) conductors and positive magnetic anomalies *from* Dowhaluk (1990). The location of the Main showing is UTM 315488E 4966754N, NAD83, Zone 18.

COBALT FRONTENAC GOLD INC. – COBALT–FRONTENAC PROJECT

In September 2018, Cobalt Frontenac Gold Inc. staked 1 claim comprising 25 cells along the south side of Big Gull Lake in concessions I and II, lots 4 to 13 in Barrie Township (G. Smith, Cobalt Frontenac Gold Inc., personal communication, November 2018). The claim covers the Cobalt–Frontenac gold occurrence, discovered prior to 1939 and consisting of quartz veins with pyrite, pyrrhotite and sphalerite in a shear zone in massive greenstone about 400 feet (122 m) north of the contact with Flinton Group metaconglomerates (Meen 1944).

Homestake Mineral Development Company explored the property from 1986 to 1989, completing soil geochemical, geological, magnetic and VLF–EM surveys. Additional work was recommended to follow up on anomalous gold values in soil (Lloyd and Bending 1989). There is no record of the follow-up work having been completed.

M. Forget conducted soil and lithogeochemical sampling over the property in 2011. Historical trenches were located and sampled, including a zone of up to 30% pyrrhotite several metres wide. No significant gold values were reported and the claims were allowed to lapse (Forget 2012).

In November–December 2018, Cobalt Frontenac Gold Inc. collected 421 soil samples for Mobile Metal Ion analysis, covering approximately 1.5 km of strike length of the unconformity between mafic metavolcanic and metasedimentary rocks of the Grenville Supergroup to the north and conglomerates and quartz-rich metasedimentary rocks of the Flinton Group to the south. A reconnaissance geological survey was also completed, including locating and sampling old trenches (G. Smith, Cobalt Frontenac Gold Inc., personal communication, January 2019).

Graphite

J. MARTIN AND J. ANDREANA – BLACK MOUNTAIN GRAPHITE PROJECT

Prospectors J. Martin and J. Andreana continued to prospect their graphite property in Matawatchan and Miller townships. The original two-claim group (20 cells after conversion) was staked in 2016 based on new graphite occurrences discovered during mapping by the Ontario Geological Survey (Duguet, Duparc and Mayer 2015). After prospecting along strike to the south in March 2018 and confirming the presence of graphite, an additional 41 single-cell claims were added to the original group to cover a total of 9 km of strike length of the favourable, graphite-bearing units.

Ground magnetic and resistivity surveys were done in the northern part of the claim group in 2017. In 2018, the claim holders conducted prospecting, Beep Mat and VLF–EM surveys in the central and southern parts of the property. Several new graphite showings were identified within a belt of quartz-rich, arkosic metasedimentary rocks containing accessory pyrite, biotite, phlogopite, feldspar and garnet. The more sulphide-rich material commonly weathers to a gossan and was mapped by Duguet, Duparc and Mayer as “rusty schist” (*see* Duguet, Duparc and Mayer 2018: map unit 9g).

A composite sample of graphitic schist from the central part of the property was submitted for graphite liberation and flake size and/or quality testing (J. Martin, Prospector, personal communication, January 2019).

The property is described in further detail in this report (*see* “Property Examinations” “Black Mountain Graphite Prospect, Matawatchan and Miller Townships”).

Wollastonite

Mountain Grove Minerals is pleased to have completed a NI 43-101 report at the Hawley wollastonite property in Olden Township and, based on encouraging results therein, intends to continue its work on the project in 2019 (A. Opekar, personal communication, January 2019).

Zinc

In 2018, Skead Holdings Ltd. filed an assessment report on the results of a relogging and sampling program of historical diamond-drill core from the Salerno Lake zinc prospect in Snowdon Township. Core from 34 diamond-drill holes stored at the Drill Core Library in Tweed was sampled and analyzed to check for zinc oxide mineralization that may have been missed in the original sampling program, and for possible indicator elements. The Salerno Lake prospect is a marble-hosted zinc deposit with an historical (not NI 43-101–compliant) resource of 1.1 Mt averaging 5.8% Zn (Soever 1980). No significant new zinc mineralization or indicators of zinc mineralization were identified (MacGregor 2018).

The Salerno Lake property was one of 26 marble-hosted zinc occurrences visited by the Southern Ontario Resident Geologist office staff in 2018. Observations from this study are described in more detail in this report (*see* "Property Examinations" "Carbonate-Hosted Zinc Deposits, Grenville Province, Southern Ontario").

Rare Earth Elements and Lithium

CJP Exploration Inc. submitted an assessment report on relogging and sampling of historical diamond-drill core in January 2018. The company owns the Simon property in Denbigh Township, a copper-zinc deposit of about 300 000 t averaging 1.1% Cu and 4% Zn in several zones (Taner 2008). Core drilled in 2008 by Adroit Resources Inc. is stored at the company's facilities in Larder Lake. Two pegmatite dikes that were intersected in drill holes were sampled and analyzed for trace elements, including rare earth elements and lithium. No enrichment in rare earth elements or lithium was detected (Ploeger 2018).

RESIDENT GEOLOGIST STAFF AND ACTIVITIES

The Southern Ontario Regional Resident Geologist's office, located in Tweed, is the only Resident Geologist Program office south of the French River. The office is staffed by A.C. Tessier, *P.Geo*., *P.Eng.,* Regional Resident Geologist; P.S. LeBaron, *P.Eng*., District Geologist; D.A. Laidlaw, *P.Geo.*, Regional Land Use Geologist; and A.G. Smith, District Geological Assistant.

Summer Experience Program (SEP) student, A. Taylor, provided field season support.

The Resident Geologist Program monitors, stimulates and facilitates mineral exploration and the sustainable development of Ontario's mineral resources. Program services and functions are grouped into key areas including

- geological advisory services
- provision of public access to geoscience databases and other resource materials
- documentation of mineral exploration and development activity
- geoscience for land-use planning
- public education

The Southern Ontario Regional Resident Geologist's office also provides support to the ministry's Mineral Development and Lands Branch–Mining Lands Section front-counter client services and works with the ENDM Indigenous Consultation and Partnerships Branch to assist in fostering relations between the mineral industry and First Nation communities.

The Southern Ontario Regional Resident Geologist's office in Tweed offers public access to a complete library of Ontario Geological Survey publications for southern Ontario and a technical library of related publications. Diamond-drill core from industry and government projects across southern Ontario is available for examination by appointment.

Special Projects

In 2018, a collection of polished dimension-stone tiles from sampling programs collected by Resident Geologist Program staff throughout the province in the 1980s was transferred from a storage location in Sudbury to the Southern Ontario Regional Resident Geologist's office in Tweed. Most of the samples are from locations in the Southern Ontario Region. The District Geological Assistant and the SEP student catalogued and created images of the samples as part of a program to create a database of Ontario dimension stone prospects. This project will continue into 2019.

There are over 6000 mineral occurrences in southern Ontario documented in the Mineral Deposit Inventory (MDI) database (Ontario Geological Survey 2018a). Staff of the Southern Ontario Regional Resident Geologist's office work with the Mineral Deposit Compilation Geoscientist—Northeastern Ontario on an ongoing basis to ensure the integrity of the database. Site investigations to confirm the presence and accurate location of MDI data points are an essential part of the process. During the 2018 field season, visits were made to 44 MDI locations in southeastern Ontario and 6 sites in southwestern Ontario.

Many of the field visits were done as part of a field- and research-based project on "Carbonate-Hosted Zinc Deposits of Southern Ontario: 2018 Study" undertaken by staff of the Southern Ontario Resident Geologist's office, which is described in "Property Visits" in this report. The property visit reports were compiled as a guide for a field trip that was provided by the Southern Ontario Resident Geologist's office staff to representatives from industry and academia in October 2018.

Staff of the Southern Ontario Resident Geologist's office mapped the underground workings at the mica-phosphate Silver Queen Mine at Murphy's Point Provincial Park near Perth. A map and field guide are currently being prepared.

From September 2017 to April 2018, the Regional Resident Geologist co-supervised, with Dr. G. Olivo of Queen's University, a fourth-year Queen's University Geological Engineering Design Project on exploration for zinc in the Grenville Province of southern Ontario. A summary of the project, supplemented with 2018 field work by Southern Ontario Resident Geologist's office staff, is included in this report under "Recommendations for Exploration: Zinc Prospectivity of Southern Ontario: New Exploration Targets". The Regional Resident Geologist is also co-supervising, with Dr. G. Olivo, a BSc (Honours) thesis project by R. Culver of Queen's University on the Salerno Lake zinc deposit in southeastern Ontario. Access to drill core from the deposit, stored at the Drill Core Library in Tweed, was provided by staff of the Southern Ontario Resident Geologist's office.

The District Geologist and the District Geological Assistant attended 2 meetings in Bancroft to discuss the possible development of an Earth Sciences Centre in the town of Bancroft. The project, a joint proposal by the Town of Bancroft and the Municipality of North Hastings and the Algonquins of Ontario, will feature educational displays and activities on various aspects of Earth sciences, including geoscience and the history of Indigenous Peoples in the area. The proponents have requested input from the Resident Geologist Office on geoscience resource material.

The District Geological Assistant participated in the development and implementation of the Ontario Mineral Exploration Information System (OMEIS), through the OMEIS working group. The first phase of OMEIS focussed on the collation, editing and updating of Assessment File Research Imaging (AFRI) and Diamond Drill Hole (DDH) data in one central database that is accessible via the Intranet to RGP staff. As a result, assessment files are made available to clients online in OGSEarth and GeologyOntario in a timelier manner than previously. Other unique, archival and donated materials stored in RGP offices across Ontario are being catalogued in consideration of incorporating them into OMEIS in the future.

First Nations Interactions

In 2018, the Regional Resident Geologist offered a prospecting course to the Algonquins of Ontario. As a result of scheduling and logistical concerns (location, travel considerations), the course was not held and has been deferred to 2019.

Mineral Shows, Presentations, Outreach and Field Trips

In February, the Regional Resident Geologist and the District Geologist organized a meeting for southern Ontario prospecting and mining clients in Belleville at which instruction was provided by Mining Lands staff on the use of the new Mining Lands Administration System (MLAS).

In March, the Regional Resident Geologist and the District Geologist assisted at the Ontario Pavilion and the Resident Geologist Program booth at the Prospectors and Developers Association of Canada (PDAC) Annual Convention. The District Geologist presented a talk entitled, “Commodities of the Future: Explore Ontario”.

In April, the Regional Resident Geologist presented a poster and sample display at the Ontario Prospectors Exploration Showcase in Thunder Bay and gave a presentation entitled “Southern Ontario Mining District: What’s happening, the pros and cons of working there and what to explore for...”.

In May, June and August, the Regional Resident Geologist and the District Geologist provided field trips on the gold deposits of southern Ontario to staff of Crown William Mining Corporation, Agnico Eagle Mines Limited, Osisko Mining Corporation, McEwan Mining Inc., Orix Geoscience, Iamgold Corporation, and the Geological Survey of Canada.

In July, the District Geologist gave presentations on “Ontario Geological Survey – Role and Responsibility” and “Geoscience, Minerals and Land Use Planning in Ontario” to a delegation from the China Ministry of Lands and Resources at Queen’s University.

In August, staff of the Southern Ontario Resident Geologist’s Office presented a poster and sample display booth at the 4-day Bancroft Gemboree and gave daily presentations on “The Mines of Southern Ontario”. The District Geologist also provided field trips for the Niagara Peninsula and the Buffalo geological societies. Staff of the Southern Ontario Resident Geologist’s office also organized a field trip in the Perth–Carleton Place areas, led by Dr. R.M. Easton of the Ontario Geological Survey, for the Southern Ontario Prospectors Association.

In September, the District Geologist presented a poster and sample display at the Ancaster Mineral Show and gave presentations on “The Mines of Southern Ontario” to over 200 elementary school students and their teachers.

In October, staff of the Southern Ontario Resident Geologist's office hosted a workshop and field trip on "The Carbonate-Hosted Zinc Deposits of Southern Ontario." The workshop included presentations by the Regional Resident Geologist, District Geologist, guest speakers from industry and academia and examination of cut and polished samples and diamond-drill core from southern Ontario occurrences. The two-day field trip included examinations of surface exposures at the former Long Lake zinc mine near Kaladar and the Cadieux zinc deposit near Renfrew, as well as several smaller occurrences and roadside outcrops.

Drill Core Storage Site

The Resident Geologist's Office maintains an off-site diamond-drill core storage compound on Hunt Road, approximately 2 km south of Tweed. In addition to core stored on traditional core racks, the site houses over 210 000 m of irreplaceable drill core from southern Ontario, of which about 157 000 m are stacked on pallets and 53 000 m are stored in racks. A smaller collection of core stored in both outdoor and indoor racks is located at the Resident Geologist Office facility in Tweed.

In 2018, a major relogging and sampling program on diamond-drill core stored at the off-site Drill Core storage site was completed by Pancontinental Resources Corporation as part of their exploration program on the McBride nickel-copper-cobalt project, Limerick Township. To bring the historical resource figures to NI 43-101 standards, the company relogged all historical drill core and resampled pulps from previous sampling programs. The company moved relevant historical core from pallets to core racks, reboxing any that were in poor condition.

Other work completed at the Drill Core Library in 2018 included the following:

- A core sampling program by R. Culver and Dr. G. Olivo on the Salerno Lake zinc deposit as part of R. Culver's BSc (Honours) thesis project at Queen's University.
- Core examination and sampling by the Regional Resident Geologist as part of a regional study on carbonate-hosted zinc deposits. Cores from the Long Lake, Salerno Lake, Ardoch, Grandad and Pharaoh occurrences were examined and displayed for a field trip.

Brushing out and clearing debris from the off-site drill core storage area was also carried-out as part of an ongoing maintenance program, as was installation of 4 new sets of metal core racks.

Table 5 provides a five-year summary of program activity.

Table 5. Program activity statistics (five-year summary) for the Southern Ontario Regional Resident Geologist's office.

Activity	2014	2015	2016	2017	2018
Field Investigations / Property Visits	39	36	27	57	52
Field Trips Given / Field Guides Written	3	6	7	10	10
MDI* Records Revised	64	351	456	441	0
Presentations to Ministry of Municipal Affairs and Housing, Ministry of Natural Resources and Forestry, Ministry of Aboriginal Affairs	17	7	6	7	?
Clients Visits to RGP–Tweed Office	232	263	226	184	182
Drill Core Library Users (Person-days)	40	69	283	59	179
Client Communications / Interactions (Presentations, Poster Sessions)	>3000	>3000	>3000	>3000	>3000

**Ontario Geological Survey (2018a).*

PROPERTY EXAMINATIONS

In 2018, a total of 52 properties in the Southern Ontario Region were visited by Resident Geologist Program staff; these visits are listed in Table 6. Three of the sites include multiple occurrences, shown in the footnotes to the table.

Table 6. Property visits conducted by the Southern Ontario District Geologist and staff in 2018 (keyed to Figures 5 and 6).

Number	Client – Occurrence	Township
1	Belmont Marble	Belmont
2	Brockville area	Elizabethtown
3	Nyrstar – Cadieux zinc prospect	Admaston
4	J. Martin – Centennial Lake property	Matawatchan
5	J. Chandler – Chandler	Tudor
6	Clarendon	Clarendon
7	Crown William – Mono prospect	Madoc
8	Dingman prospect	Marmora
9	Egan Chutes Provincial Park	Dungannon
10	Frontenac Lead Mine	Loughborough
11	J. Chandler – Glanmire	Tudor
12	Bertus Industrial Limited – Griffith marble prospect	Griffith
13	Drain Brothers Excavating Limited – Havelock Quarry	Belmont
14	Highway 41 & Harlowe Road quartz-carbonate	Anglesea
15	Highway 41, Tooey's Hill rockcut	Brougham
16	Kaladar Area zinc occurrences (4 sites)*	Kaladar
17	A. Dubblestein/M. Forget – Little–Bryan	Lyndoch
18	Long Lake Mine	Olden
19	Sherritt International – Madoc Talc Mine	Huntingdon
20	MRT Aggregates Inc. – Methuen Quarry	Methuen
21	Newfoundout sulphide occurrence	Grattan
22	Northgate B	Lutterworth
23	Ore Chimney prospect	Barrie
24	Ore Mountain prospect	Barrie
25	Perth Feldspar Quarry	Bathurst
26	Pharoah – Clyde River	Lanark
27	Skead Holdings Ltd. – Salerno Lake	Glamorgan
28	Murphy's Point Provincial Park – Silver Queen Mine	Burgess
29	Slave Lake	Sheffield
30	Wilkinson	Hinchinbrooke
31	Zinc 506 belt occurrences east (5 sites)**	Clarendon
32	Zinc 506 belt occurrences west (6 sites)***	Barrie
	Southwestern Ontario District	
33	Fonthill Pit	Pelham
34	CGC Inc. – Hagersville Gypsum Mine	Oneida
35	Queenston Quarry	Niagara
36	Wainfleet Wetlands	Wainfleet
37	Vineland Quarries	Clinton
38	Vinemount Quarries	Saltfleet
	Outside Southeastern Ontario and Southwestern Ontario Districts	
39	Sphinx Resources – Bryson Dam occurrence	Grand Calumet Island, Quebec
40	Sphinx Resources – zinc project	Grand Calumet Island, Quebec

**Kaladar area zinc occurrences sites visited and sampled include Macfarlands Lake, Spry, Beaver Pond and Shirtcliff.*
***Zinc 506 belt occurrences east sites visited and sampled include Ardoch breccia, James Mine, Ardoch folded roadcut, Road Fork Zinc and Johnson West.*
****Zinc 506 belt occurrences west sites visited and sampled include Cook, Kashwakamak, Hardie West (Grandad), International, Mazinaw and sample 1012.*

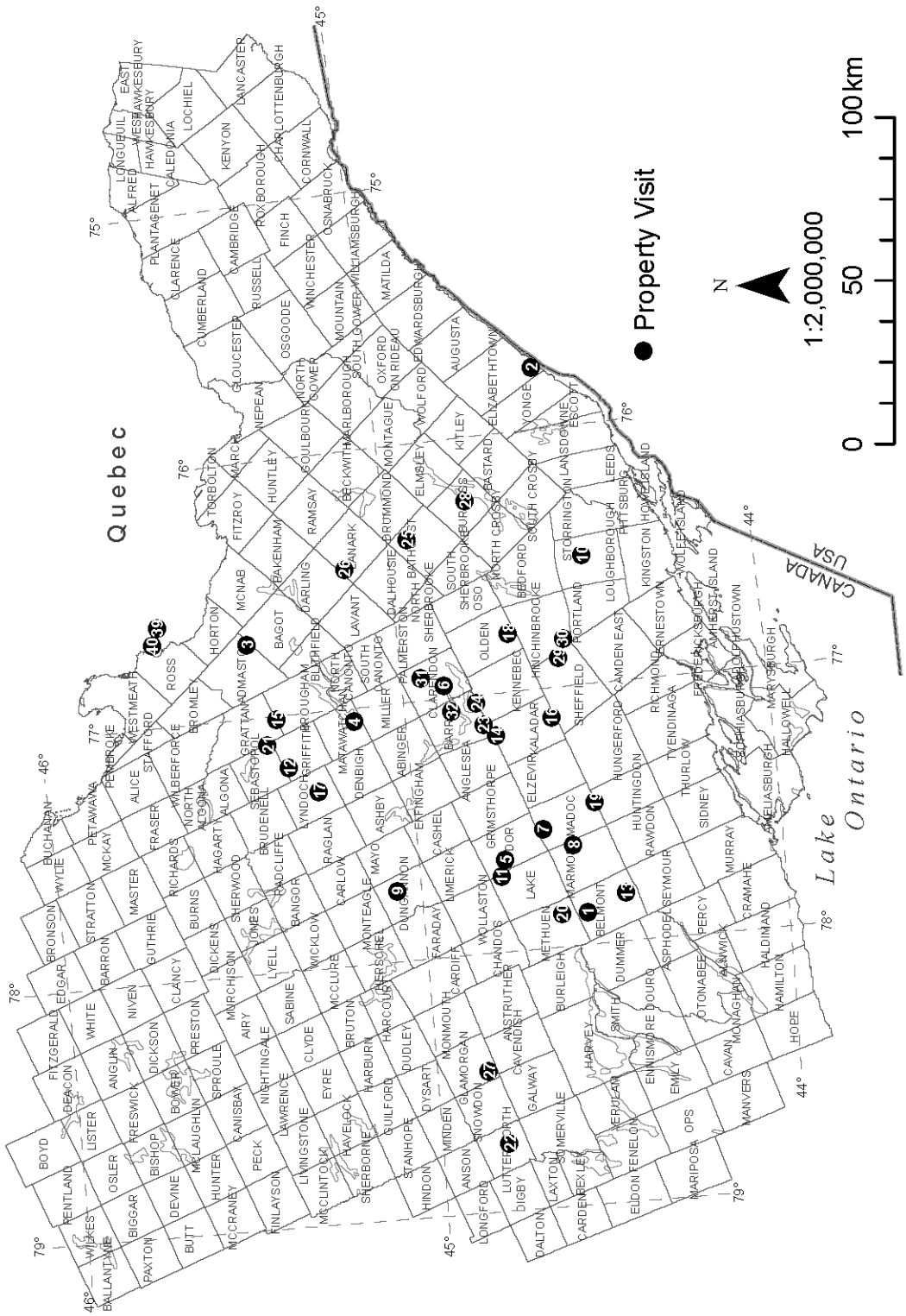

Figure 5. Property visits in the Southeastern Ontario District in 2018 (keyed to Table 6).

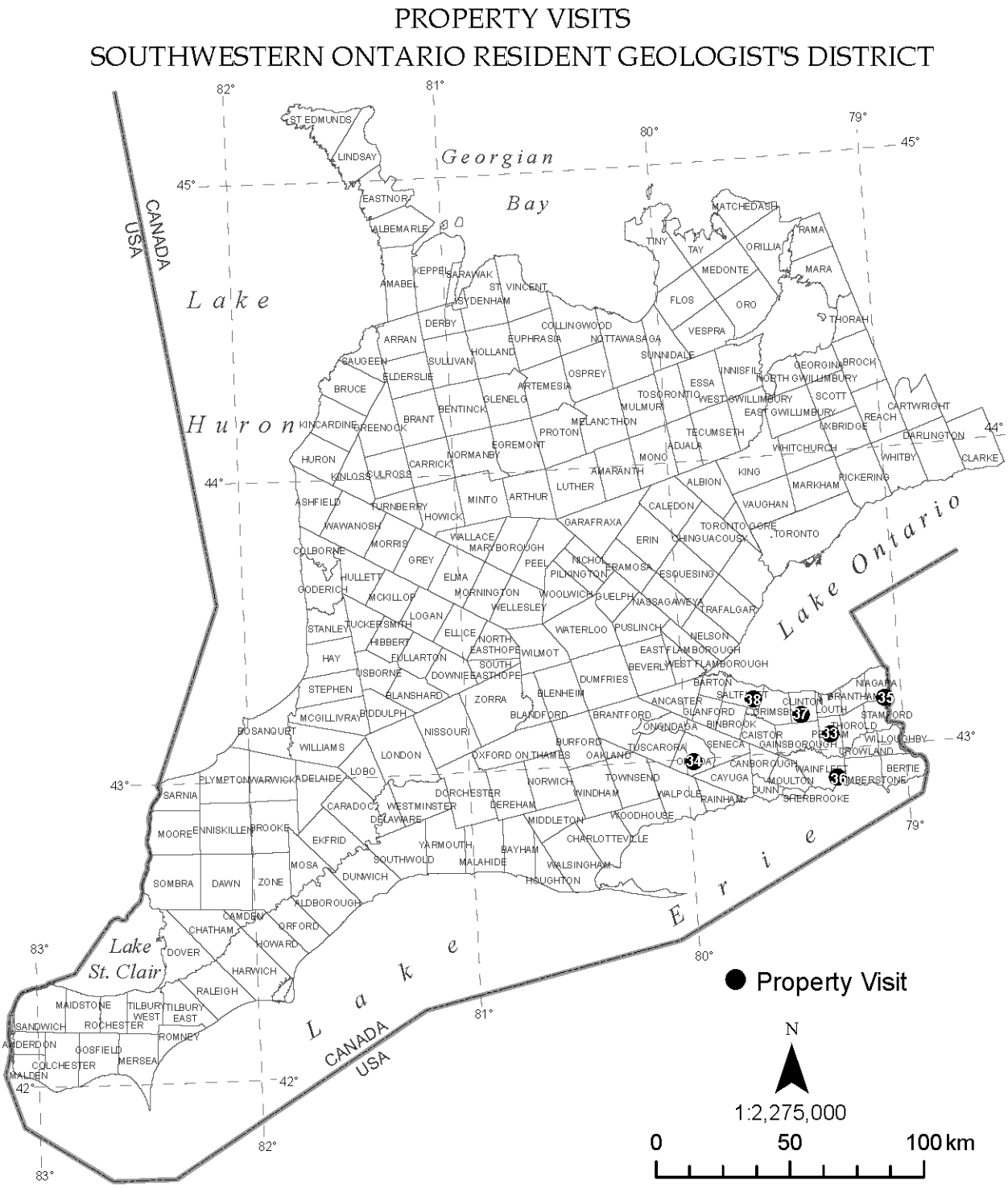

Figure 6. Property visits in the Southwestern Ontario District in 2018 (keyed to Table 6).

Carbonate-Hosted Zinc Deposits, Grenville Province, Southern Ontario

INTRODUCTION

Several stratiform, marble-hosted zinc deposits and many smaller occurrences are known within the Composite Arc Belt and Frontenac–Adirondack Belt of the Grenville Province in southeastern Ontario, southwestern Quebec and northwestern New York State.

Active exploration is currently being carried out for marble-hosted zinc in southwestern Quebec and northwestern New York, but not in southern Ontario. In fact, the last "systematic" exploration programs for zinc in southern Ontario date back to the 1970s and the last active exploration project ended in 1996 at the Cadieux zinc deposit (Roger and Turcotte 1997).

In 2018, staff at the Southern Ontario Resident Geologist's office focussed its field work on documenting the known marble-hosted zinc occurrences of the Grenville Province in southern Ontario. A total of 26 zinc occurrences were visited in the Composite Arc Belt in Ontario and 2 in Quebec (also within the Composite Arc Belt). The objectives of the field work were

- to relocate the occurrences (some of which dated from the 1930s)
- to document the occurrences and their geological context with the benefit of the most recent work by the Ontario Geological Survey (i.e., geological mapping and tectonic subdivisions)
- to sample the occurrences
- to investigate the presence of possible non-sulphide zinc mineralization
- to raise awareness about the exploration potential for zinc in the Grenville Province in southern Ontario (*see also* "Recommendations for Exploration" "Zinc Prospectivity in Southern Ontario: New Exploration Targets")

In this section, a summary of our findings will be presented with a focus on the carbonate-hosted zinc occurrences in southern Ontario. Zinc deposits that are considered to be volcanogenic in origin and minor zinc-lead-fluorite-barite occurrences that are hosted by post-Ordovician calcite veins are also documented in the Central Metasedimentary Belt, but are not discussed herein.

METHODOLOGY

The Mineral Deposit Inventory (MDI) database (Ontario Geological Survey 2018a) was consulted for the area covering the Central Metasedimentary Belt of southern Ontario. Occurrences that listed zinc as a primary commodity were selected for further investigation. Priority was given to MDI records that are listed as occurrences, prospects or past-producing mines. Discretionary occurrences were only visited when located in the immediate area of more reliable occurrences. The Abandoned Mines Information System (AMIS) database was also consulted to locate any possible old exploration or mine workings, such as old exploration trenches and shafts near the MDI occurrences. In addition to the occurrences listed in the MDI records, 2 roadcuts were also sampled where previous workers had reported traces of sphalerite ("Roadcut – fold" and "Roadcut – breccia").

In the field, UTM co-ordinates from both MDI and AMIS records were identified. In most cases, an extensive exploration of the area was required to locate the mineral occurrence. Of the 24 MDI mineral occurrences visited, 17 were relocated, but, for 3 of those occurrences (Clarendon, Beaver Pond and Kashwakamak), no evidence of zinc mineralization could be found (Tables 7 and 8). Figure 7 shows the distribution of the carbonate-hosted zinc deposits visited within the Grenville Province, during the course of this study.

Field-testing for non-sulphide zinc mineralization was done using "zinc zap", a dithizone solution that turns red when in contact with zinc-bearing minerals.

GENERAL GEOLOGY OF THE COMPOSITE ARC BELT, GRENVILLE PROVINCE, SOUTHERN ONTARIO

The Grenville Province of Ontario is subdivided into the Central Gneiss Belt to the northwest and the Central Metasedimentary Belt to the southeast (Easton 1992). Carr et al. (2000) further subdivided the Central Metasedimentary Belt into the Composite Arc Belt, in southern Ontario and Quebec, and the Frontenac–Adirondack Belt that extends from southern Ontario into New York (*see* Figure 7). The following descriptions are summarized from Easton (1992) and Carr et al. (2000).

The Central Gneiss Belt consists largely of quartzofeldspathic gneisses, primarily orthogneiss with lesser paragneiss, of upper amphibolite to granulite facies. The gneisses are 1800 to 1600 million years old and were intruded by plutonic rocks at 1500 to 1400 Ma.

The Central Metasedimentary Belt is a major accumulation of supracrustal rocks intruded by various suites of plutonic rocks that can be divided into several lithotectonic terranes based upon the nature of the supracrustal rocks and metamorphic grades, which range from greenschist to granulite facies. These terranes are thought to represent a sequence of accreted terranes that may have been separated by hundreds of kilometres along a more extensive continental margin. In southern Ontario, the Central Metasedimentary Belt is further subdivided into the Composite Arc Belt and the Frontenac terrane by Carr et al. (2000) based on the age of the rocks, and their structural, metamorphic and magmatic history (Figures 7 and 8).

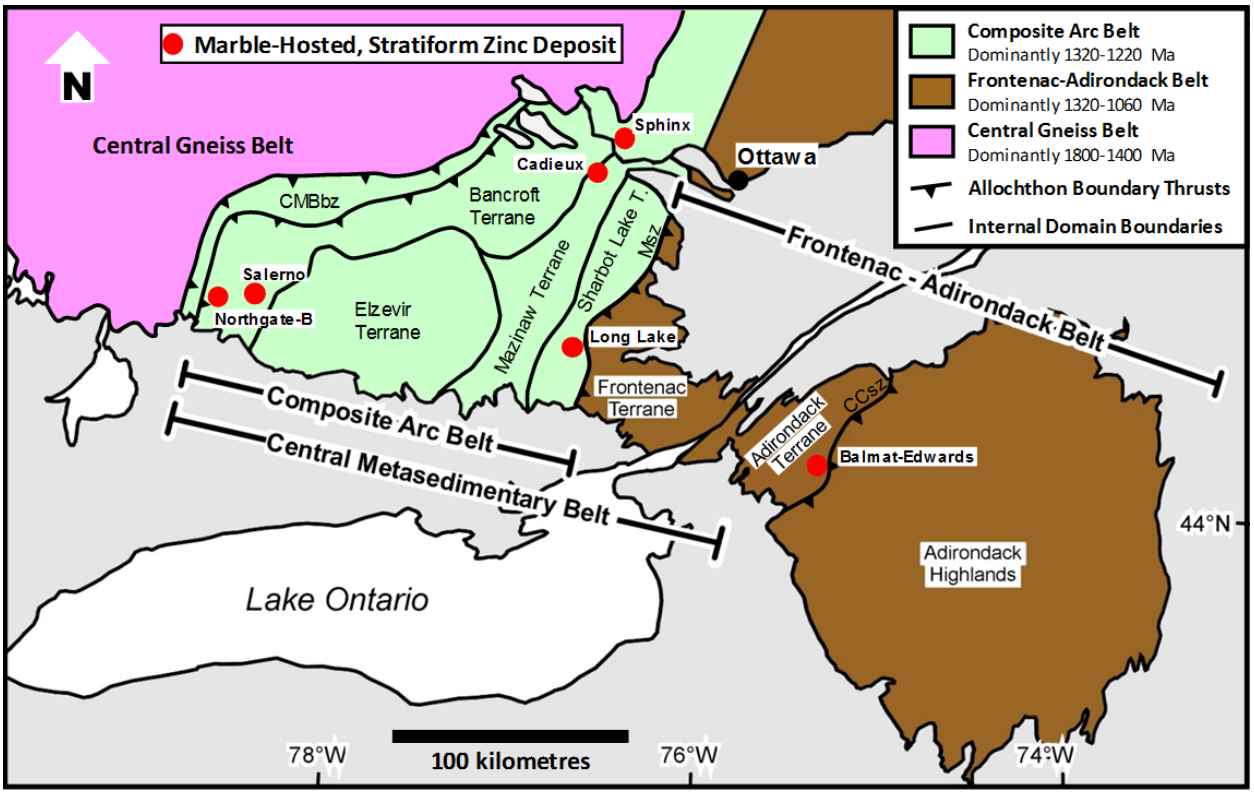

Figure 7. Locations of major marble-hosted zinc deposits and prospects within the Central Metasedimentary Belt of Ontario, Quebec and New York (*modified after* Easton 2017). Abbreviations: CCsz, Carthage–Colton shear zone; CMBbz, Central Metasedimentary Belt boundary zone; Msz, Maberly shear zone.

Table 7. List of zinc occurrences visited and associated MDI (Ontario Geological Survey 2018a) records.

MDI Number Occurrence Name	Township	Primary Commodity	Secondary Commodity	Type* of Occurrence	Location Listed in MDI**			Location in Field**			Field Co-ordinate Marker
					Zone	Easting (m)	Northing (m)	Zone	Easting (m)	Northing (m)	
31C14SE00138 Cook, H.F.	Barrie	Cu, Au, Pb, Ag, Zn	Cd, Hg	O	18	332041	4966067	18	332096	4966059	Field co-ordinates from main trench under powerline
31C14SE00147 Kashwakamak	Barrie	Au, Pb, Zn	Cu	O	18	336600	4967265	18	336355	4967429	Field co-ordinates from the main trench
31C14SE00152 Mazinaw	Barrie	Pb, Zn	Sb, Bi, Cu, Au, Ag	O	18	336168	4970157	18	336083	4970043	Partial waste/ore pile located where shaft used to be underneath the powerline
31C14NE00050 Sample 1012	Clarendon	Zn	—	O	18	340487	4972683	18	340487	4972683	No sign of mineralization or trenching at MDI site
31C15NW00160 Clarendon	Clarendon	Pb, Zn	Ag	O	18	345566	4975716	18	345571	4975706	Old shallow trenches and pits located, but no mineralization
31C14SE00150 International / Barrie Syndicate	Barrie	Pb, Zn	Cu, Au, Ag	O	18	337415	4971019	18	337480	4970923	Partial waste/ore pile located where shaft used to be underneath the powerline
31C15NW00266 Road Fork	Clarendon	Zn	Cu	O	18	347678	4976623	18	347669	4976666	No sign of mineralization or trenching at MDI site
31F01SW00033 Clyde River / Pharaoh	Lanark	Zn	Pb, Ag	O	18	384351	4997268	18	384117	4997610	Trenches have all been filled in. Field co-ordinates correspond to a mineralized boulder
N/A Roadcut – fold	Clarendon	trace sphalerite	—	n/a	n/a	n/a	n/a	18	347507	4977467	Not an MDI record
N/A Roadcut – breccia	Clarendon	trace sphalerite	—	n/a	n/a	n/a	n/a	18	346241	4977954	Not an MDI record
31C15NW00188 James	Clarendon	Cu, Pb	Au, Ag, Zn	O	18	349229	4979626	18	349054	4979534	Several trenches, stripped outcrops and 2 shafts located. Field co-ordinates correspond to the westernmost shaft
31C15NW00172 Ardoch / James Mine	Clarendon	Au, Zn	n/a	O	18	351323	4980860	18	351344	4980843	Field co-ordinates correspond to a trench, but no mineralization was found. Selco drill-hole DU-4: 2.60% Zn over 2.28 m is collared at 351327E 4980631N
31C15NW00278 Johnson West	Clarendon	Pb, Zn	n/a	O	18	352378	4981223	–	–	–	No sign of mineralization or trenching at MDI site
31C14NE00035 Pearse	Clarendon	Zn-Mica	Ag	DO	18	340859	4973454	–	–	–	No sign of mineralization or trenching at MDI site
31C11SE00093 Spry	Kaladar	Zn	—	P	18	333416	4941714	18	332582	4941597	Field co-ordinates correspond to main mineralized trench. No sign of mineralization or trenching at MDI co-ordinates
31C11SE00119 Shirtcliff	Kaladar	Zn	—	DO	18	331577	4940023	–	–	–	No sign of mineralization or trenching at MDI site

MDI Number Occurrence Name	Township	Primary Commodity	Secondary Commodity	Type* of Occurrence	Location Listed in MDI**			Location in Field**			Field Co-ordinate Marker
					Zone	Easting (m)	Northing (m)	Zone	Easting (m)	Northing (m)	
31C11SE00120 McFarlands Lake	Kaladar	Zn	—	DO	18	331977	4940723	–	–	–	No sign of mineralization or trenching at MDI site
31C11SE00065 Beaver Pond	Kaladar	Au, Ag, Zn	Sb, Cu, Pb	O	18	332393	4941094	18	332393	4941094	Old filled-in trench, but no sign of mineralization at MDI site
31C10SW00046 Slave / Lennox Mine	Sheffield	Zn	Cu, Pb	P	18	350582	4936690	18	350501	4936834	Field co-ordinates correspond to an old, partially filled-in exploration pit (or shaft) with mineralized waste/ore pile
31C10SW00065 Wilkinson	Hinchinbrooke	Zn	Cd, Cu, Pb, Ag	O	18	353871	4934629	18	353816	4934765	Field co-ordinates correspond to the main mineralized trench
31D15SW00068 Northgate-B	Lutterworth	Zn	—	O	17	676096	4963721	17	675959	4963302	Field co-ordinates from the area where grab samples from Jackson and Soever (1993) were located
31D15SW00064 Northgate-A	Lutterworth	Zn	—	O	17	675654	4962571	17	675522	4962497	Could not locate old trenches. Sampled marble
31D15SE00128 Salerno – Sulpetro 1991	Snowdon	Zn	—	P	17	697432	4969638	17	697673	4970566	MDI31D16SW00120 is wrongly labelled as the “Salerno Lake” occurrence. Field co-ordinates correspond to pad for drill-hole S-14
31C14SE00042 Grandad / Hardie	Barrie	Zn, Pb, Ag	Au	O	18	339359	4972425	18	339197	4972235	Field co-ordinates correspond to main mineralized trench
31C10NW00016 Long Lake	Olden	Zn	Pb, Ag	PP	18	359617	4949985	18	359534	4949941	Field co-ordinates correspond to adit entrance
31F07NE00063 Cadieux / Renprior	Admaston	Zn, Pb	n/a	DPR	18	366281	5030255	18	366609	5030782	Field co-ordinates correspond to trenches where the Swamp zone is exposed at surface

**Types of occurrences: DO = Discretionary Occurrence; O = Occurrence; P = Prospect; PP = Past Producer; DPR = Developed Prospect with Reserves.*
***Locations provided as UTM co-ordinates using NAD83.*

Table 8a. List of zinc occurrences visited and comments on host rocks (*see* Table 8b for assays).

Occurrence Name	Grab Sample No.	Sample Location*			Host Rock
		Zone	Easting (m)	Northing (m)	
H.F. Cook	Cook-1	18	332096	4966059	Variably silicated dolomitic marble and marble breccia. Flinton Group?
	Cook-2	18	332096	4966059	
	Cook-3	18	332096	4966059	
	Cook-4	18	332132	4966083	
Kashwakamak	Kash-1-1	18	336355	4967429	Locally silicified and brecciated dolomitic marble. Flinton Group
	Kash-1-2	18	336355	4967429	
Mazinaw	Maz-WP	18	336238	4970144	Massive to well-bedded and locally brecciated dolomitic and calcitic marble. Flinton Group
	Maz-1	18	336238	4970144	
	Maz-West	18	336083	4970043	
	Maz-East	18	336366	4970170	
Sample 1012	S1012-1	18	340487	4972683	Rusty schist (calcitic and dolomitic shale). Flinton Group
	S1012-2	18	340487	4972683	
Clarendon	Clarendon-1	18	345571	4975706	Massive to bedded calcitic marble, intercalated with rusty slate/schist. Flinton Group
	Clarendon-2	18	345614	4975688	
	Clarendon-3	18	345614	4975688	
	Clarendon-4	18	345614	4975688	
	Clarendon-5	18	345602	4975654	
International / Barrie Syndicate	Inter-1-A	18	337480	4970923	Massive calcitic and dolomitic marble in contact with rusty slate/schist. Flinton Group
	Inter-1-B	18	337480	4970923	
	Inter-1-C	18	337480	4970923	
Road Fork	Fork-1	18	347669	4976666	Calcitic marble with rusty schist/slate. Flinton Group
Clyde River / Pharaoh	Clyde-1	18	384212	4997784	Well-bedded calcitic and dolomitic marble with calc-silicates. Grenville Supergroup
	Clyde-3	18	384230	4997703	
	Clyde-4.1	18	384117	4997610	
	Clyde-4.2	18	384117	4997610	
Roadcut – fold	Fold-1	18	347507	4977467	Well-bedded calcitic marble with phlogopite. Flinton Group
	Fold-2	18	347507	4977467	
Roadcut – breccia	Breccia-1	18	346241	4977954	Brecciated calcitic marble with phlogopite. Flinton Group
	Breccia-2	18	346241	4977954	
James	James-A1	18	349006	4979514	Sequence of siliceous, tremolitic marble, calcitic marble and siliceous rusty gneiss. Flinton Group
	James-A2	18	349006	4979514	
	James-A3	18	349006	4979514	
	James-A4	18	349033	4979520	
	James-A5	18	349054	4979534	
	James-P1	18	349083	4979543	
	James-P2	18	349081	4979541	
	James-P3	18	349146	4979553	
	James-P4	18	349111	4979563	
Ardoch / James Mine	Ardoch-1	18	351344	4980843	Well-banded dominantly calcitic marble (locally dolomitic) intercalated with biotite pelitic schist. Flinton Group?
	Ardoch-2	18	351344	4980843	
	Ardoch-3	18	351344	4980843	
	Ardoch-4	18	351334	4980828	
	Ardoch-5	18	351334	4980828	
Johnson West	Johnson-1	18	352425	4981228	Pelitic schist. Flinton Group

**Locations provided as UTM co-ordinates using NAD83.*

Both the Composite Arc Belt and Frontenac terrane are believed to represent a sequence of accreted volcanic arc and marginal basins that amalgamated at *circa* 1160 Ma (Carr et al. 2000). The absolute age of the supracrustal rocks within the Frontenac terrane is unclear largely because of high-grade metamorphism (granulite to upper amphibolite).

In the Composite Arc Belt, volcanism and sedimentation was coeval with the emplacement of tonalitic plutonic rocks and occurred from about 1300 to 1250 Ma. Regional metamorphic grade within the Composite Arc Belt, ranges from upper greenschist to amphibolite. Supracrustal rocks of age 1300 to 1250 Ma within the Central Metasedimentary Belt are referred to as the Grenville Supergroup.

In both the Composite Arc Belt and Frontenac terrane, the metasedimentary succession includes considerable thicknesses of carbonate sediments, not seen in the Central Gneiss Belt or in older greenstone belts of the Southern and Superior provinces in northern Ontario. Easton (2017) considers the Central Metasedimentary Belt to be analogous to an Archean greenstone belt with carbonates rather than wackes as a major component of the sedimentary sequence. The carbonate metasedimentary rocks can be separated into 2 broad subdivisions: platform–slope environments and volcanic island–slope environments.

Table 8a, ***continued.***

Occurrence Name	Grab Sample No.	Sample Location*			Host Rock
		Zone	Easting (m)	Northing (m)	
Spry	Spry-C-1	18	332582	4941597	Well-bedded sequence of siliceous dolomitic marble (hosting the zinc), dolomitic marble and calcitic marble. Grenville Supergroup
	Spry-C-2	18	332582	4941597	
	Spry-C-3	18	332582	4941597	
	Spry-C-4	18	332582	4941597	
	Spry-C-5	18	332582	4941597	
	Spry-C-6	18	332582	4941597	
	Spry-C-7	18	332582	4941597	
	Spry-C-8	18	332582	4941597	
Slave	Slave-3	18	350501	4936834	Massive calcitic marble (very locally dolomitic), intercalated with amphibole-biotite-plagioclase gneisses within the Hinchinbrooke Granite. Grenville Supergroup
	Slave-4	18	350501	4936834	
	Slave-5	18	350501	4936834	
	Slave-6	18	350501	4936834	
	Slave-7	18	350501	4936834	
Wilkinson	Wilk-1	18	353816	4934765	Massive dolomitic marble. Grenville Supergroup
	Wilk-2	18	353816	4934765	
Northgate-B	NG-A1	17	675959	4963302	Massive dolomitic marble containing variable amounts of serpentine, diopside and tremolite (up to 15–50% combined). Grenville Supergroup
	NG-P1	17	675934	4963293	
	NG-P2	17	676054	4963240	
	NG-P3	17	676134	4963370	
	NG-P4	17	676068	4963318	
Northgate-A	NG-P5	17	675522	4962497	Same as Northgate-B
Salerno – Sulpetro 1991	–	17	697673	4970566	Massive to well-bedded dolomitic marble. Grenville Supergroup
Grandad / Hardie	–	18	339197	4972235	Dolomitic marble at contact with argillite. Flinton Group
Long Lake	–	18	359534	4949941	Calcitic marble xenolith. Grenville Supergroup
Cadieux / Renprior	Swamp-1	18	366609	5030782	Sequence of silicated dolomitic marble with dolomitic marble and lesser calcitic marbles. Grenville Supergroup
	Swamp-2	18	366609	5030782	
	Zone A	18	366573	5030828	
	Electrode zone	18	366549	5030840	
	M.E. zone	18	366526	5030791	
	Road zone-1	18	366429	5030766	
	Road zone-2	18	366427	5030777	

**Locations provided as UTM co-ordinates using NAD83.*

Table 8b. Assays of samples collected and information about historical assays or resources (*see* Table 8a for sample locations and descriptions of host rocks).

Occurrence Name	Grab Sample No.	Assays from this Study							Historical Assays or Resources
		Cu (ppm)	Pb (ppm)*	Zn (ppm)	Zn (%)*	Ag (ppm)	Ag (oz/t)*	Au (oz/t)	
H.F. Cook	Cook-1	1784	17095	164807			5.9	<0.016	Trench result: 6% Zn, 0.6% Cu, 5% Pb, 7 oz/t Ag and 0.05 oz/t Au over 1.2 m (Barron 1985)
	Cook-2	<7	236	3879			0.8	0.042	
	Cook-3	928	477	293		13		<0.016	
	Cook-4	<7	<14	137		3		0.022	
Kashwakamak	Kash-1-1	911	<14	319		5		<0.016	2.42 g/t Au over 0.6 m (MDI)
	Kash-1-2	31	<14	76		3		<0.016	
Mazinaw	Maz-WP	29	1368	6026		5		<0.016	2300 ppm As, 2700 ppm Sb, 179 ppm Cu, 5800 ppm Pb and 6.5% Zn (grab sample 79TC6; Malczak, Carter and Springer 1985)
	Maz-1	20	<14	60		<2		<0.016	
	Maz-West	32	834	10262		5		<0.016	
	Maz-East	33	102	245		4		<0.016	
Sample 1012	S1012-1	14	21	105		3		<0.016	No data
	S1012-2	37	26	110		3		<0.016	
Clarendon	Clarendon-1	<7	<14	11		4		<0.016	No data
	Clarendon-2	<7	<14	28		4		<0.016	
	Clarendon-3	12	<14	20		4		<0.016	
	Clarendon-4	<7	<14	14		4		<0.016	
	Clarendon-5	10	<14	21		4		<0.016	
International / Barrie Syndicate	Inter-1-A	3608	<14	306		18		<0.016	No data
	Inter-1-B	1431	<14	338		12		<0.016	
	Inter-1-C	944	<14	63		5		<0.016	
Road Fork	Fork-1	<7	<14	16		5		<0.016	No data
Clyde River / Pharaoh	Clyde-1	<7	<14	44		3		<0.016	In drill hole: 1.1% Zn/3.65 m, including 5.08% Zn/0.3 m; 3.96% Zn/1.5 m; and 1.65% Zn/1.5 m (Selco Limited 1976)
	Clyde-3	<7	<14	167		3		<0.016	
	Clyde-4.1	<7	<14	11		3		<0.016	
	Clyde-4.2	<7	<14	71112		3		<0.016	
Roadcut – fold	Fold-1	26	<14	30		5		<0.016	No data
	Fold-2	84	<14	68		5		<0.016	
Roadcut – breccia	Breccia-1	10	<14	61		5		<0.016	No data
	Breccia-2	11	<14	23		5		<0.016	
James	James-A1	242	<14	71		5		<0.016	0.80 oz/t Au, 12.6 oz/t Ag, 1.6% Cu and trace Pb and Zn in a grab sample (Barron 1985)
	James-A2	2452	<14	131		11		0.032	
	James-A3	77	<14	140		4		<0.016	
	James-A4	978	14	79		17		<0.016	
	James-A5	4864	75	169			5.1	0.28	
	James-P1	261	19	62		8		<0.016	
	James-P2	1490	17	90			0.5	0.04	
	James-P3	10423	17	1440			3.9	0.098	
	James-P4	67	<14	48		4		<0.016	
Ardoch / James Mine	Ardoch-1	<7	<14	28		–		–	In drill hole: 2.60% Zn over 2.28 m (Jackson 1979)
	Ardoch-2	12	<14	38		–		–	
	Ardoch-3	<7	<14	14		–		–	
	Ardoch-4	11	<14	25		–		–	
	Ardoch-5	30	<14	15		–		–	
Johnson West	Johnson-1	14	<14	15		<2		<0.016	No data

**Locations provided as UTM co-ordinates using NAD83.*

Platform–slope environments include abundant quartz arenites and thick sequences of dolomitic and calcitic marbles, most common in the Bancroft and Frontenac terranes, in which metavolcanic rocks are rare to absent. At the basin margins, interlayering of silicate and carbonate metasedimentary rocks are common and may indicate favourable environments for SEDEX-type mineralization. Basin margin environments are characterized by the development of metamorphic mineral assemblages, including talc, tremolite, wollastonite and diopside.

Volcanic island–slope carbonates occur in the volcanic-dominated environments, including the Elzevir, Mazinaw and Sharbot Lake terranes. In the proximal environment, stromatolitic dolomite reefs develop adjacent to the arc volcanoes and, with associated black shales, may represent favourable sites for zinc mineralization. Dolomitic stromatolites may be common in both environments, but are not readily recognizable outside the lower grade metamorphic area of the Elzevir terrane.

Table 8b, *continued*.

Occurrence Name	Grab Sample No.	Assays from this Study							Historical Assays or Resources
		Cu (ppm)	Pb (ppm)*	Zn (ppm)	Zn (%)*	Ag (ppm)	Ag (oz/t)*	Au (oz/t)	
Spry	Spry-C-1	181	<14	111785			<0.1	<0.016	Chip samples: 3.88% Zn over 5.0 m, 1.02% Zn over 75 cm, 15.40% Zn over 60 cm, 12.4% Zn over 30 cm (Carter 1984)
	Spry-C-2	190	<14	98034			<0.1	<0.016	
	Spry-C-3	42	<14	12427			<0.1	<0.016	
	Spry-C-4	124	<14	1300			<0.1	<0.016	
	Spry-C-5	64	<14	151956			<0.1	<0.016	
	Spry-C-6	32	<14	159113			<0.1	<0.016	
	Spry-C-7	<7	<14	174			<0.1	<0.016	
	Spry-C-8	178	<14	183671			1.9	<0.016	
Slave	Slave-3	211	<14	117229		5		<0.016	Grab samples: 19.6% Zn and 44.4% Zn (Malczak, Carter and Springer 1985)
	Slave-4	118	<14	223642			<0.1	<0.016	
	Slave-5	56	<14	56980			<0.1	<0.016	
	Slave-6	13	<14	84118			<0.1	<0.016	
	Slave-7	118	19	75030			<0.1	<0.016	
Wilkinson	Wilk-1	473	421	186257			<0.1	<0.016	No data
	Wilk-2	235	108	98343			<0.1	<0.016	
Northgate-B	NG-A1	54	47	8251			<0.1	<0.016	Grab samples from 2.17% to 5.43% Zn (Jackson and Soever 1993)
	NG-P1	<7	<14	305			<0.1	<0.016	
	NG-P2	7	<14	105			<0.1	<0.016	
	NG-P3	<7	<14	73			<0.1	<0.016	
	NG-P4	161	331	8793			<0.1	<0.016	
Northgate-A	NG-P5	9	<14	65			<0.1	<0.016	No data
Salerno – Sulpetro 1991	–	–	–	–		–		–	Drilled prospect: 797 500 t @ 6.3% Zn (Soever 1979)
Grandad / Hardie	–	–	–	–		–		–	Drill hole: 4.89% Zn, 1.26% Pb, 1.07 oz/t Ag over 4.88 m (Sharpley 1984)
Long Lake	–	–	–	–		–		–	1973–1974 production: 94 631 t @ 11.3% Zn
Cadieux / Renprior	Swamp-1	26	38		4.69	–		–	Historical resource: 1.45 Mt @ 8.8% Zn and 0.8% Pb (Roger 1996)
	Swamp-2	43	340		8.19	–		–	
	Zone A	13	16		19.64	–		–	
	Electrode zone	41	<14		13.05	–		–	
	M.E. zone	19	25		8.52	–		–	
	Road zone-1	53	375		6.90	–		–	
	Road zone-2	56	1.37%		12.67	–		–	

**Results reported as parts per million (ppm) unless otherwise specified.*

In the Composite Arc Belt, deposition of the Grenville Supergroup supracrustal rocks was followed by plutonism and subsequent metamorphism and deformation, including the Elzevirian Orogeny at 1230 to 1180 Ma. The Elzevirian Orogeny was followed by a period of extension and erosion during which rocks of the Flinton Group (<1150 Ma) were deposited uncomformably upon the Grenville Supergroup assemblage, prior to the amalgamation of the Frontenac terrane with the Composite Arc Belt. As a result, Flinton Group sediments are not present in the Frontenac terrane. Later deformation during the Ottawan Orogeny (1120–1050 Ma, the culmination of the "Grenville Orogeny") resulted in some complex infolding of the Flinton Group within the Grenville Supergroup.

Easton and Ford (1991) suggest a fluvial–lacustrine environment for deposition of the Flinton Group, with deposition controlled by rift valleys, perhaps explaining the preservation of the Flinton Group in narrow, linear, synformal belts: the Fernleigh syncline, the Kaladar–Barrie belt, and the Clare River synform (Figure 9). With evolution of the rift valleys, sedimentation changed from coarse clastics (conglomerates, quartzites and pelitic schists of the Bishop Corners Formation) to pelitic schists and carbonates of the overlying Myers Cave Formation. The carbonates of the Myers Cave Formation include dolomitic and calcitic marbles, dolomitic conglomerates and breccias, and pyritic, graphitic rusty schists.

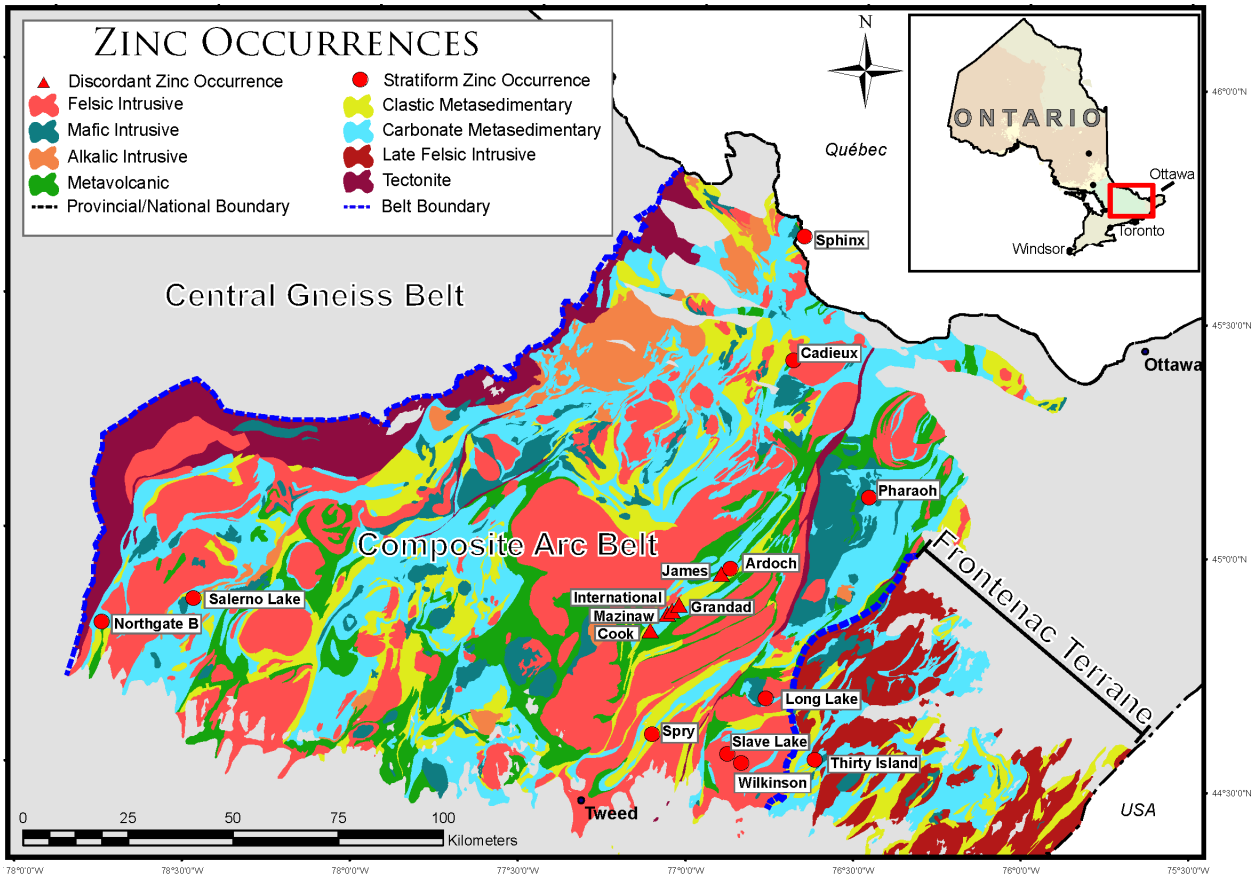

Figure 8. Geology map showing the locations of the carbonate-hosted zinc occurrences visited during this study in southern Ontario (geology *from* Ontario Geological Survey 2011).

BACKGROUND

Gauthier and Brown (1986) suggest that, on a regional scale, the Grenville Province zinc deposits of Quebec, Ontario and New York are located along 2 major structural lineaments, the Central Metasedimentary Belt boundary zone and the Carthage–Colton mylonite zone, which border the Central Metasedimentary Belt and define a first-order basin hosting the metasedimentary rocks of the Grenville Supergroup (*see* Figure 7). The eastern zone includes the Balmat–Edwards zinc deposits of New York and the gold-zinc deposits of Montauban in Quebec. Along the western basin–margin lineament are the Salerno Lake and Northgate-B deposits in Ontario and the Maniwaki–Gracefield zinc deposits of the Mont Laurier Basin in Quebec.

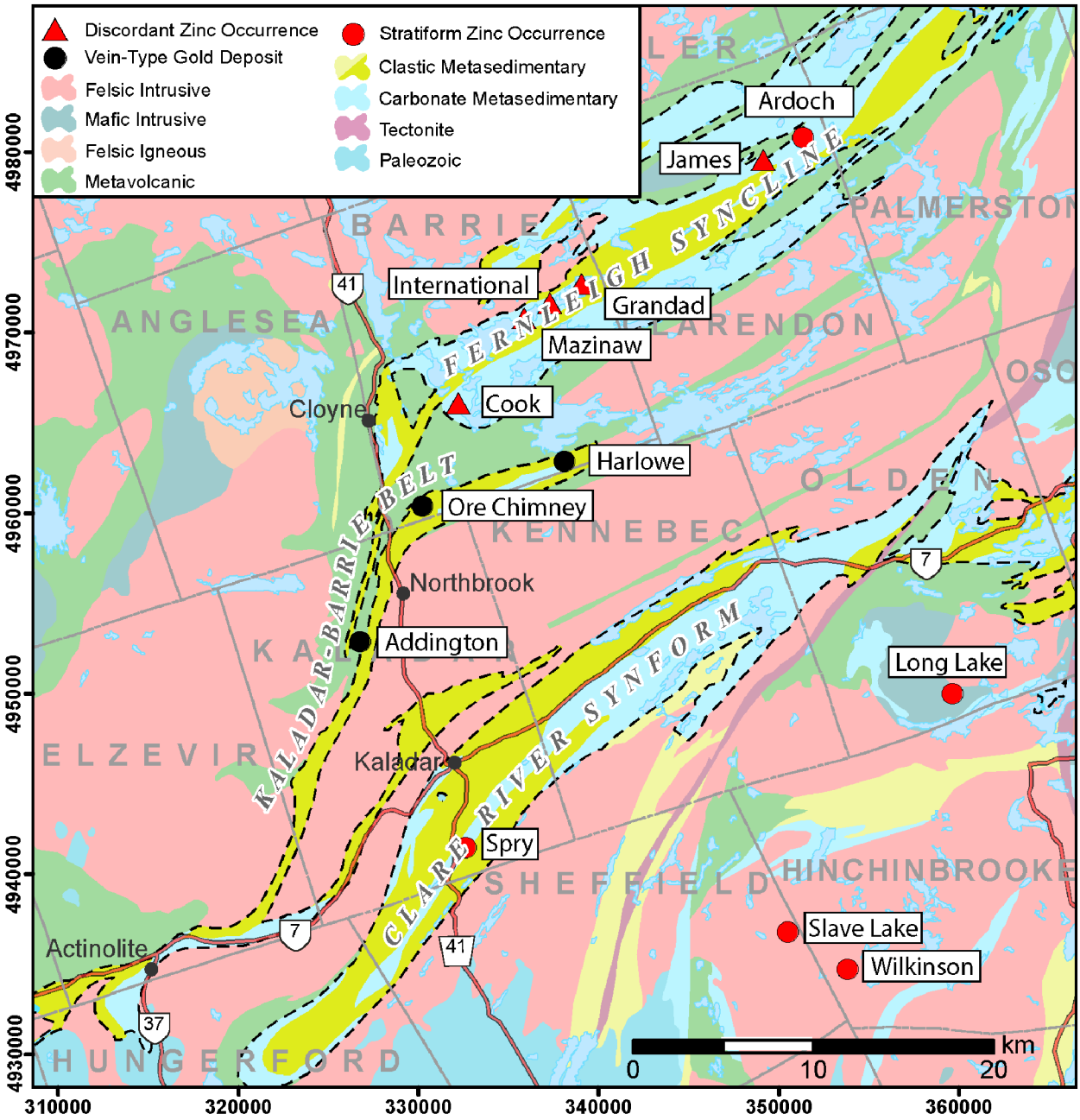

Figure 9. Locations of predominantly Flinton Group metasedimentary belts (lime green with dashed contacts) with marble-hosted zinc occurrences and vein-type gold occurrences; geology *from* Ontario Geological Survey (2011).

Other deposits within the Composite Arc Belt such as the Long Lake zinc mine, Slave Lake prospect and Wilkinson occurrence, located in the Sharbot Lake terrane and the Cadieux deposit in the Mazinaw terrane of southeastern Ontario, may represent a similar style of mineralization associated with a second-order carbonate basin of the Central Metasedimentary Belt. These regional aspects combined with the stratiform nature of mineralization at the deposits are consistent with models of sediment-hosted, submarine exhalative (SEDEX) mineralization associated with basin–margin faults.

Zinc occurrences in the Central Metasedimentary Belt have traditionally been documented as stratiform and hosted within marbles of the Grenville Supergroup (1300–1250 Ma) (Sangster 1970; Carter 1980, 1984; Malczak, Carter and Springer 1985). The larger zinc deposits of the Central Metasedimentary Belt which include the Balmat–Edwards deposits (New York), the Cadieux deposit (Ontario), the Long Lake deposit (Ontario) and the Sphinx deposit (Quebec) belong to this type. Mineralization consists predominantly of pyrite and sphalerite, lesser galena and pyrrhotite as conformable, massive to disseminated layers within carbonate-rich metasedimentary rocks. Adjacent host rocks are calcitic to dolomitic marbles near the transition from siliceous clastic metasedimentary rocks (quartzite and arkose) to carbonate-dominated sedimentary rocks, commonly with calc-silicate assemblages including tremolite-actinolite, diopside, quartz and graphite.

More recently, non-sulphide zinc mineralization has also been documented near the town of Bryson, Quebec, about 20 km north of the Cadieux prospect in Ontario (Larivière and Gauthier 2007). The new non-sulphide zinc occurrence is hosted by dolomitic marbles rich in diopside and forsterite, exhibiting retrograde metamorphism into serpentine nodules. Both serpentine and magnetite grains in these occurrences reacted positively to “zinc zap”. X-ray diffraction and microprobe studies indicated that the serpentine, which can constitute up to 40% of the mineralized marble unit, contains up to 2 weight % zinc oxide. The zincian serpentine is interpreted as a retrograde metamorphic product of willemite.

During the course of this study, in Ontario, the presence of non-sulphide zinc mineralization has been indicated by “zinc zap” testing at the Northgate-B occurrence (Photo 4) and the Wilkinson occurrence, located 15 km south of the town of Minden and 14 km west of the village of Godfrey, respectively. Further studies are required to better identify the source of zinc (other than sphalerite) at these occurrences.

This field study highlights the occurrence of zinc mineralization in both the marbles of the older Grenville Supergroup (deposited at 1300–1250 Ma) and the marbles of the younger Flinton Group (<1150 Ma).

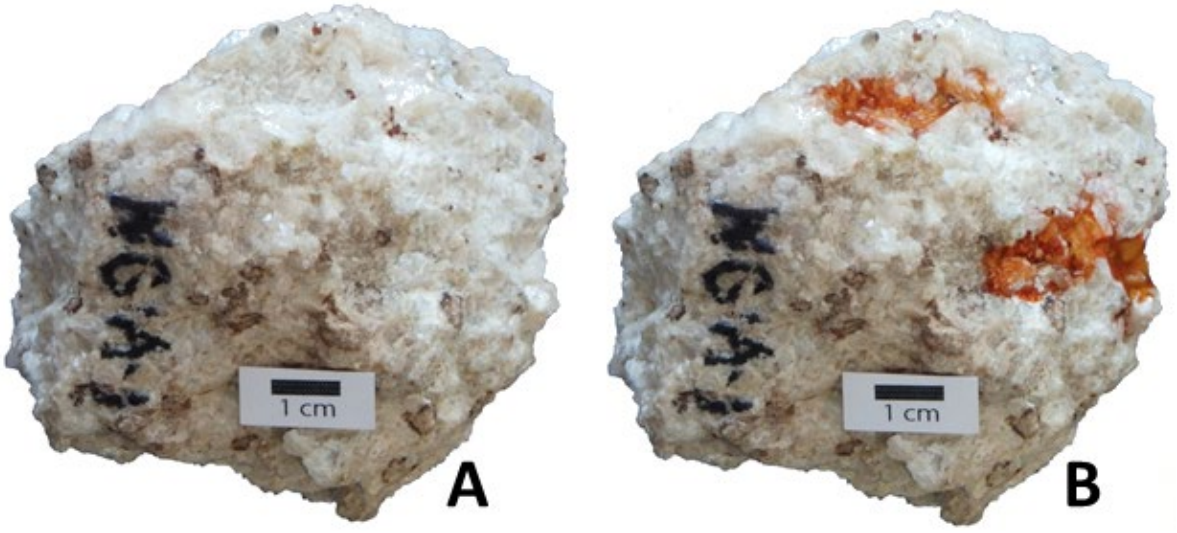

Photo 4. Non-sulphide zinc mineralization of the Northgate-B occurrence, sample NG-A1 (dolomitic marble): **A**) the sample before application of “zinc zap”, and **B**) showing a positive reaction to “zinc zap” (orange areas). Sample assayed 0.8% Zn.

CARBONATE-HOSTED ZINC DEPOSITS OF SOUTHERN ONTARIO: 2018 STUDY

Of the 26 zinc occurrences visited in 2018, only 14 are deemed significant (i.e., >2% Zn values were obtained in assays or reported in historical records). Two main types of carbonate-hosted zinc mineralization were identified: the traditional stratiform zinc deposits and discordant zinc–polymetallic vein–breccia type deposits.

Stratiform Zinc Deposits

The largest zinc deposits of the Central Metasedimentary Belt, found to date, are stratiform. The large deposits of the Balmat–Edwards district in New York and the Long Lake, Cadieux and Salerno deposits of southern Ontario belong to this category of stratiform, carbonate-hosted zinc deposits and are believed to be of SEDEX origin (Easton and Fyon 1992). The Sphinx deposit in Quebec is also considered to be of SEDEX origin (M. Gauthier, Sphinx Resources Ltd., personal communication, 2018). Smaller deposits and occurrences of this type in southern Ontario consist of the Northgate-B, Slave Lake, Wilkinson, Pharaoh, Spry, Ardoch and Thirty-Island Lake occurrences and prospects. The stratiform zinc deposits of all sizes are typically “zinc only” with very minor lead and are generally silver poor.

The mineralization of the larger deposits consists of massive to disseminated sulphides with dominantly sphalerite, commonly pyrite and pyrrhotite in varying amounts, and lesser galena (Photo 5). At Long Lake, minor amounts of chalcopyrite and hematite are also present. In the smaller stratiform zinc deposits, sphalerite is generally the only sulphide with very minor pyrite (Photo 6). The mineralization is either disseminated or in thin centimetre-scale bands parallel to bedding and/or banding within the marble (*see* Photos 5 and 6).

These deposits occur both in Grenville Supergroup and Flinton Group marbles, although only the Spry and Ardoch occurrences are believed to be hosted by Flinton Group marbles. Host rocks consist of both calcitic and dolomitic marbles with a calc-silicate component. At the Cadieux and Salerno deposits, anhydrite and gypsum were also documented (*see* Photo 5). Gypsum was also encountered during this field study at the Spry prospect. Calc-silicate alteration of the marbles is common, with diopside, serpentine and tremolite being the most common alteration minerals. Calc-silicate alteration is most extensive in the larger deposits, forming a larger halo surrounding the mineralization and a thicker section of the stratigraphy. Non-sulphide zinc mineralization was only observed in the stratiform zinc deposits at the Northgate-B and Wilkinson occurrences. Zincite is documented at the Spry prospect (MDI records: Ontario Geological Survey 2018a).

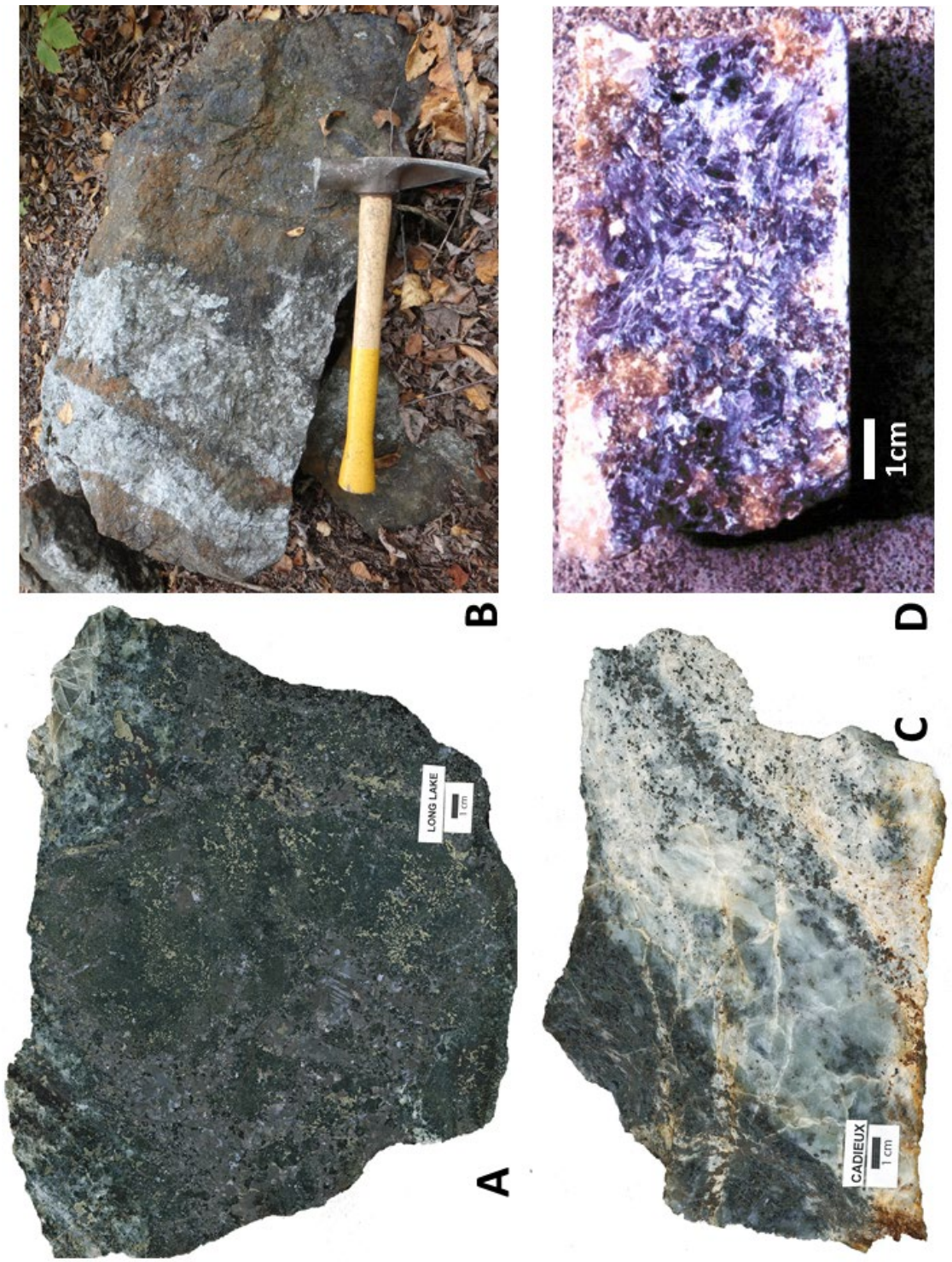

Photo 5. Stratiform zinc mineralization of the Long Lake Mine showing the sphalerite + pyrite + pyrrhotite + hematite assemblage of **A**) the massive ore; **B**) the banded mineralization; C) the banded mineralization in the Cadieux "Road zone" (note the mineralization is sphalerite-only at that locality); and **D**) an anhydrite sample in NQ-core from the Cadieux "Swamp zone" (*from* Gauthier, Corriveau and Chouteau 2004).

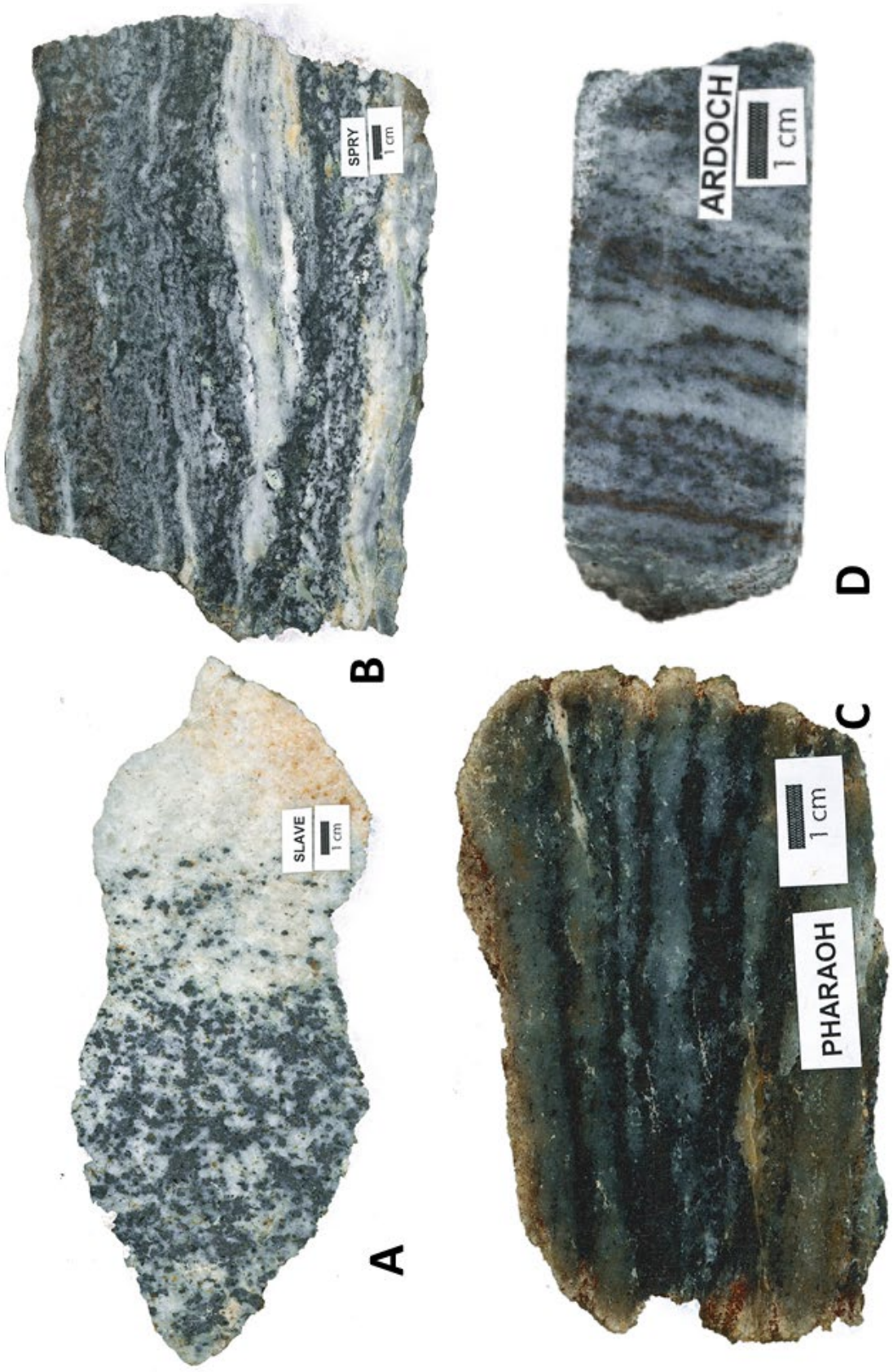

Photo 6. Stratiform zinc mineralization of the **A**) Slave Lake and **B**) Spry prospects and the **C**) Pharaoh and **D**) Ardoch occurrences. The sphalerite-only mineralization is disseminated in bands of up to 30 cm at Slave Lake, whereas banding (enhanced by deformation) is millimetre- to centimetre-size at Spry, Pharaoh and Ardoch.

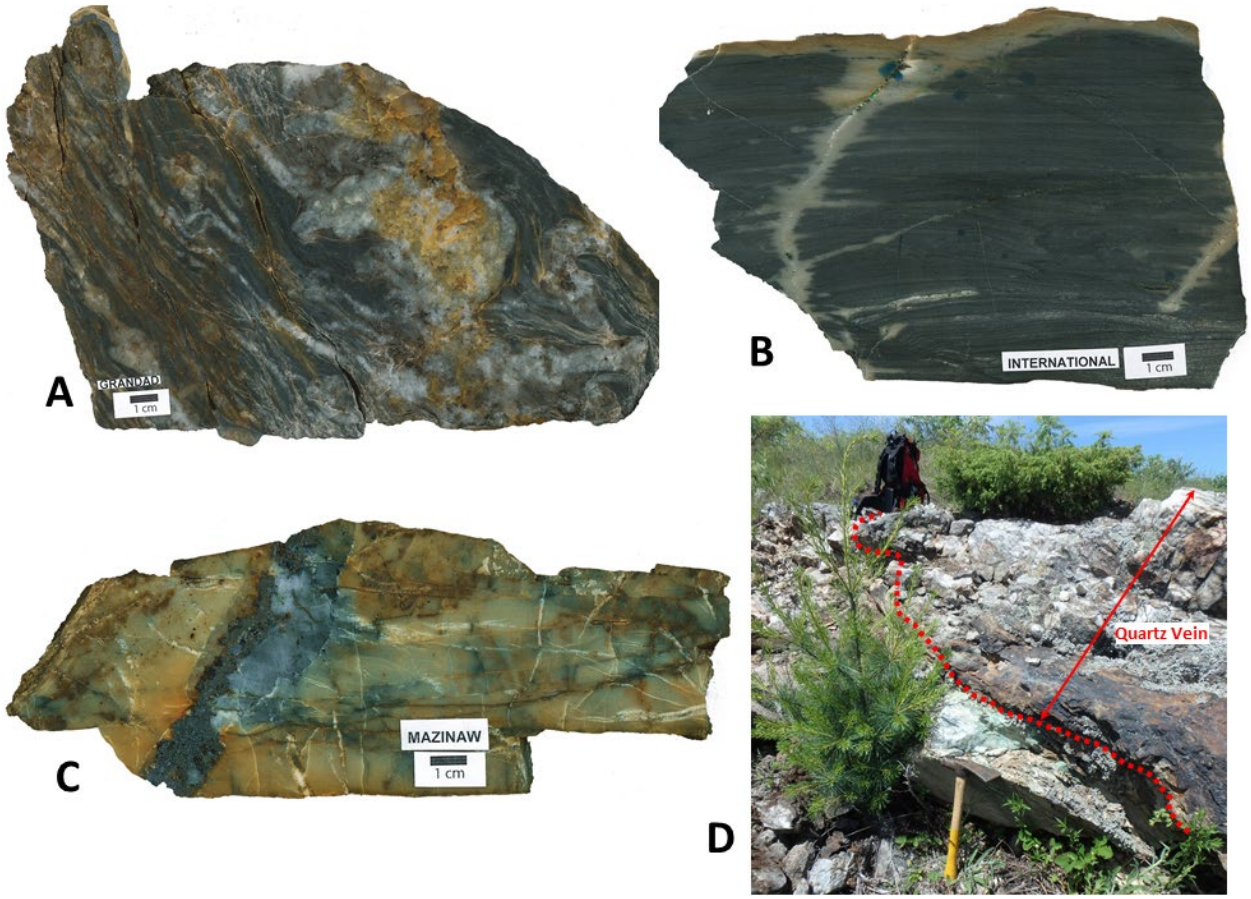

Photo 7. Samples showing the discordant zinc-polymetallic vein-type mineralization from the **A**) Grandad, **B**) International, **C**) Mazinaw and **D**) James occurrences. Mineralization ranges from iron-carbonate veinlets to metre-scale quartz veins. At the International and James occurrences, the veins and veinlets appear to be late to post deformation.

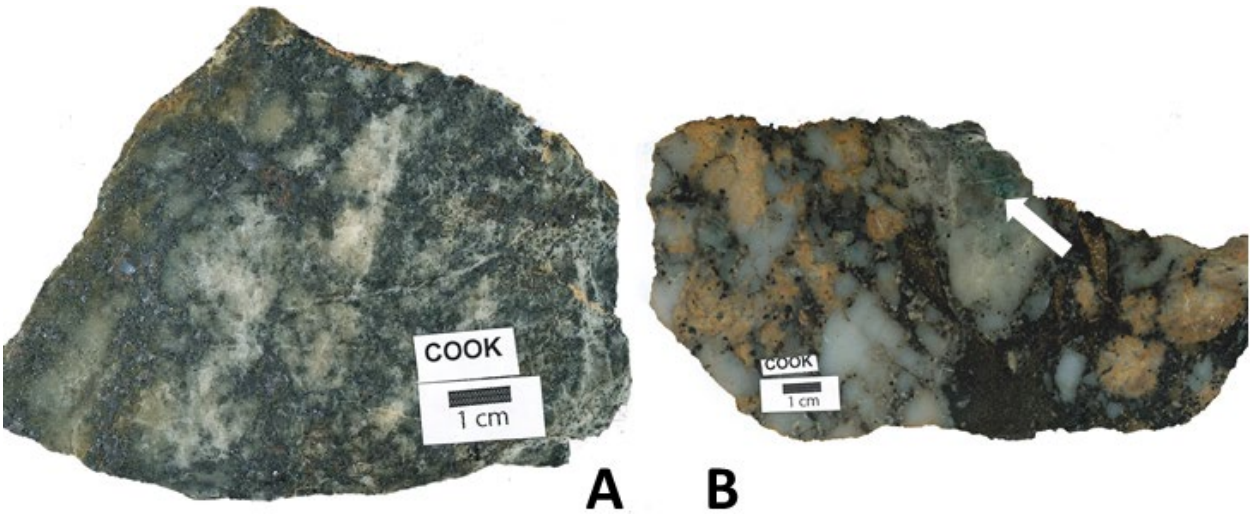

Photo 8. Samples showing the breccia-type discordant zinc-polymetallic at the Cook prospect: **A**) strongly mineralized pod where the matrix consists of sphalerite, galena, minor pyrite, pyrrhotite and chalcopyrite; and **B**) weakly mineralized breccia with sugary-white dolomitic and iron-carbonate fragments. Note the malachite staining within a white dolomitic fragment (arrow).

Polymetallic Vein–Breccia-Type Zinc Deposits

Polymetallic discordant zinc mineralization was only observed in the Flinton Group marbles, typically near the contact with fine-grained clastic metasedimentary rocks. Host rocks are either dolomitic or calcitic marbles that are locally banded and commonly brecciated with quartz and carbonate matrix. In addition to zinc, the mineralization often shows anomalous copper (Cook, International and James) and is typically silver rich and, locally, gold rich (Cook, James and Grandad). The Cook and Grandad occurrences also returned significant lead assay results.

The mineralization consists of discordant quartz-calcite-tremolite veins, veinlets and stringers, of varying widths (<1 cm at International to 1 m at James), and containing varying amounts of sphalerite, pyrite, galena, chalcopyrite, tetrahedrite and malachite (Photo 7). At the International occurrence, azurite is also present in iron-carbonate veinlets where the majority of the veinlets are parallel to foliation, but others show distinct alteration halos of centimetre scale and appear to be late deformation (*see* Photo 7).

Although breccias are the dominant host rocks, only at the Cook prospect are the breccias mineralized. At the Cook prospect, mineralization occurs within a discordant hydrothermally brecciated dolomitic marble. The breccia is typically monolithic with fine-grained, sugary textured, white to buff, subrounded to angular fragments of up to 7 cm in size (Photo 8). Some fragments show a pinkish-orange alteration possibly as a result of iron-carbonate alteration. The fine-grained matrix is brown to black. Fine-grained black porphyroblasts of biotite (likely metasomatism) occur in both matrix and fragments (although more commonly within the matrix). Fine-grained sulphide mineralization occurs within the matrix, but, locally, some fragments show disseminations of green copper-carbonate staining. Pods of semi-massive sulphide mineralization are observed within the dolomitic breccia. Within these pods, the mineralization consists of fine-grained honey-coloured translucent sphalerite with galena, trace chalcopyrite and locally trace pyrite (*see* Photo 8).

Polymetallic zinc occurrences occur over a 20 km strike length within the Fernleigh syncline close to the fold axial plane and at the same stratigraphic level (*see* Figure 9). They are the Cook, Mazinaw, International, Grandad and James occurrences. Although they are individually discordant, they are stratabound when considered together. The occurrences show many similarities with the gold and polymetallic vein-type deposits and occurrences that are spatially associated with the unconformity between the Grenville Supergroup metavolcanic rocks and overlying Flinton Group clastic metasedimentary rocks in the Kaladar–Barrie belt (*see* Figure 9) (i.e., the Addington, Ore Chimney and Harlowe occurrences).

CONCLUSION

Two types of carbonate-hosted zinc mineralization were identified from this study: the traditional stratiform deposits of possible SEDEX origin and discordant polymetallic vein–breccia-type deposits (of possible epithermal origin?).

Although the stratiform zinc deposits are more common within the Grenville Supergroup marbles, the Spry and Ardoch occurrences appear to be hosted by marbles of the Flinton Group. This implies 2 ages of stratiform carbonate-hosted zinc deposits: those hosted by the Grenville Supergroup marbles (1300–1250 Ma) and those hosted by Flinton Group marbles (<1150 Ma). Both ages of stratiform deposits are considered largely “zinc only” with only low lead and silver values.

Discordant vein–breccia-type polymetallic deposits have only been identified within the Flinton Group marbles. Although these small deposits are individually discordant, they are stratabound when considered together and may represent remobilized mineralization from a larger source.

Future recommended studies include the following:

- petrographic work and mapping to better document non-sulphide zinc mineralization and its potential;
- geochemical and petrographic work to better discriminate between Grenville Supergroup and Flinton marbles. The recent recognition of Flinton Group metasedimentary rocks close to the Cadieux deposit (Easton 2009) suggests that more stratiform zinc deposits may be of Flinton age.

Black Mountain Graphite Prospect, Matawatchan and Miller Townships

On September 18, 2018, the District Geologist accompanied prospectors J. Martin and J. Andreana on an examination of their graphite prospect in Matawatchan and Miller townships. All UTM co-ordinates reported in the following description are provided using NAD83 in Zone 18.

LOCATION AND ACCESS

The Black Mountain project area is located 70 km east of Bancroft and 60 km south of Pembroke. The claim group extends toward the southwest from the eastern end of Centennial Lake in Matawatchan Township to Trapper Lake in Miller Township (Figure 10). The project is named after "Black Mountain", a topographic high within the original claim block near the southeastern end of Centennial Lake (J. Martin, Prospector, personal communication, September 2018).

Access to the southern part of the property is via Highway 41 to Vennachar Junction; east on the Vennachar Road; northeast on Matawatchan Road; and south on Quackenbush Road to the hydro transmission line at the southern end of Trapper Lake. To access the central and northern parts of the property, return to Matawatchan Road and follow it to the east and north to Aird Lake Road; at the termination of Aird Lake Road, walk on a bush road across private land (permission required) around the northern end of Aird Lake to the claim group. From there, ATV trails branch north to Centennial Lake and south to Montserrat Lake.

EXPLORATION HISTORY

Mineral exploration began in the Bancroft to Pembroke area in the mid-1800s. Several magnetite deposits achieved minor production of iron between 1868 and 1930 and molybdenum was produced from numerous small deposits from 1890 to 1942 (Carter, Colvine and Meyn 1980).

Industrial minerals, such as corundum, feldspar, apatite, garnet, mica, talc and graphite, were also produced in the late 1800s to mid-1900s. Of these, graphite was the most important. The Black Donald graphite mine in Brougham Township, about 11 km northeast of the Black Mountain property, was discovered in 1889 and was Canada's largest graphite producer until the mine closed in 1954 (Storey and Vos 1981a).

Exploration activity for graphite in southeastern Ontario increased from 2009 to 2012, as the use of graphite in batteries and other high-technology fields increased (Sangster et al. 2014). Two exploration companies conducted airborne geophysical surveys in Brougham, Matawatchan and several nearby townships. In Lyndoch Township, ground checking of coincident magnetic and time-domain electromagnetic (TDEM) anomalies confirmed the presence of graphite-pyrrhotite–bearing siliceous metasedimentary rocks adjacent to marble units (Malcolm graphite prospect, Lyndoch Township, Sangster et al. 2016).

In 2015, geological mapping by the Ontario Geological Survey identified several new graphite occurrences in the Centennial Lake area (Duguet, Duparc and Mayer 2015). There are no records of previous mineral exploration on the Black Mountain property.

In 2016, prospectors J. Martin and J. Andreana located graphite mineralization south of Centennial Lake, based on the report by Duguet, Duparc and Mayer (2015), and staked 2 claims for a total of 20 cells in Matawatchan Township. Prospecting, sampling, and ground magnetic and resistivity surveys were done on the claims in 2017. After prospecting along strike to the south in March 2018 and confirming the presence of graphite, an additional 41 single-cell claims were added to the original group, extending the coverage of the graphitic units into Miller Township. In 2018, the claim holders conducted prospecting, Beep Mat and VLF–EM surveys in the central and southern parts of the property. A composite sample of graphitic schist from the central part of the property was submitted to Activation Laboratories, Ancaster, Ontario, for graphite liberation and flake size–quality testing (J. Martin, Prospector, personal communication, January 2019).

REGIONAL GEOLOGY

The following geological description is summarized *from* Duguet, Duparc and Mayer (2015), unless otherwise noted.

The Black Mountain graphite prospect is located in the Centennial Lake area of the Black Donald domain in the northeastern part of the Central Metasedimentary Belt of the Grenville Province. The geology of the area is shown on a compilation map of the Denbigh area (Lumbers and Vertolli 2001) and on more recent field-based maps of the Black Donald Lake area (Duguet, Ma and Whitney 2017) and the Centennial Lake area (Duguet, Duparc and Mayer 2018). The location and geology of the Black Mountain property is shown in Figure 10.

The geology of the Centennial Lake area is subdivided into 3 lithostructural units: the Western, Central, and Eastern units. The Black Mountain property lies within the Eastern unit, which is represented by a major, northeasterly trending synform centred on Centennial Lake. The lithological succession, from bottom to top, consists of migmatitic metapelitic rocks, amphibolites, calc-silicate schists and gneisses, and calcitic and dolomitic marbles. Dolomitic marbles in the Centennial Lake area are clean, white to grey, coarse grained and massive. They are in stratigraphic contact with siliciclastic units that include rusty schists that host graphite-pyrrhotite mineralization (Duguet, Duparc and Mayer 2018: unit 9g).

In the Black Donald Lake area, Duguet, Whitney and Ma (2014) identified 2 continuous bands of siliciclastic rocks consisting of stromatic metatexite, calc-silicate rocks, and rusty schists containing pyrrhotite, pyrite and graphite. The bands are interpreted to belong to the same unit, repeated by folding. One band is exposed on the north shore of Black Donald Lake and the other, located along the south side of the lake, hosts the Black Donald graphite mine. A simplified sketch of the siliciclastic and marble units is shown in Figure 12 to illustrate the spatial association of graphite mineralization on the Black Mountain property and the Black Donald graphite mine with these units along the eastern limb of the Centennial Lake synform. Figure 13 shows the magnetic trends of the lithologies and supports the geological interpretation.

The pyrrhotite-graphite–bearing units show up as coincident magnetic high and conductivity anomalies on airborne surveys conducted by Standard Graphite Corporation in the Black Donald Lake area (Desaulniers 2013). On the Renfrew aeromagnetic survey (Ontario Geological Survey 2014), the magnetic highs delineate the Centennial Lake synform (Figure 11) and can be followed for over 30 km to the northeast. Duguet, Duparc and Mayer (2015) report 5 new graphite occurrences associated with sulphide-rich schists and gneisses in the Centennial Lake map area, all located on the edges of regional magnetic anomalies.

GEOLOGY OF THE BLACK DONALD GRAPHITE MINE

A brief description of the geology of the Black Donald graphite mine is included here to illustrate the potential for graphite mineralization along the Black Donald Lake–Centennial Lake trend of interlayered carbonate and clastic metasedimentary rocks, as shown in Figure 12. The following description is summarized from Hewitt (1965) unless otherwise noted.

The Black Donald Mine is Canada's largest historical producer of graphite, having produced 77 244 t of graphite from its opening in 1896 to closure in 1954. The graphite ore zone forms a conformable unit within a marble-quartzite-paragneiss sequence. The ore is underlain by a 5 to 7 m thick quartzite and limy-quartzite, rich in pyrite and pyrrhotite and rusty-brown weathering, below which is a sequence of white to grey marble at least 60 m thick. The ore is overlain by siliceous marble containing diopside, tremolite, scapolite, quartz and phlogopite. The main gangue minerals in the ore zone are calcite, calc-silicates and chlorite.

The ore zone at surface strikes northeasterly and dips vertically and can be traced over a strike length of about 240 m. Average width of the zone is about 6 m, with a maximum width of 21 m at the northeastern end. Spence (1920) reported the average grade of the ore zone as 65% graphite, but, during the last decade of operations, the average grade was 25 to 30% graphite (Hewitt 1965). At depth, it was discovered that the strata were folded into a small, subhorizontally oriented, S-shaped drag fold, plunging about 20% to the northeast and cut off to the west by a vertical fault (Figure 14). The most favourable zones within the orebody, with respect to thickness and grade, were along the limbs of the synclinal portion of the drag fold.

The entire mine site was flooded in the mid-1960s following construction of the Mountain Chute Hydroelectric Dam on the Madawaska River, creating Black Donald Lake and Centennial Lake.

PROPERTY GEOLOGY

The claims straddle a central unit of migmatitic, felsic to intermediate gneiss that contains subunits of quartzite to quartzofeldspathic gneiss and rusty schist (*see* Figure 10: unit 5). This unit coincides with a linear magnetic anomaly shown in Figure 11. Flanking, and locally interlayered with, the siliceous gneisses and schists are bands of carbonate metasedimentary rocks, predominantly calcitic marbles with narrow dolomitic lenses. Layering in the metasedimentary rocks, as observed in outcrops in the southern and central parts of the claim group, strikes 030° and dips vary from 70° west to 80° east.

A cross section from east to west across one of the graphitic zones at the southern end of the property (Photo 9) is as follows (graphite percentages are visual estimates only):

- footwall: banded quartz-biotite and quartz-feldspar-biotite gneiss, minor garnet and trace pyrite
- graphite zone: quartz-feldspar-biotite-phlogopite schist containing 1 to 3% fine- to medium-grained flake graphite; moderate to strong gossan on weathered surface; one 0.3 m-wide band containing 10% graphite and minor disseminated pyrite
- hanging wall: quartz-feldspar-biotite gneiss, weathers grey, no visible sulphides or graphite

Coarse-grained, white, calcitic marble was observed to the west of the felsic gneiss unit in the vicinity of Trapper Lake. The marble contains minor tremolite, phlogopite and a trace of graphite.

In the central zone of the property, 2 areas were examined: east of Montserrat Lake (UTM 337400E 4998000N), about 3 km northeast along strike from the Trapper Lake zone; and east of Aird Lake (UTM 338200E 4999340N), an additional 1.5 km along strike to the northeast. In both areas, the graphitic, rusty schist, quartz-feldspar-biotite gneiss and calcitic marble were observed. The graphite content of the schist is consistent, visually estimated at 3 to 5%, within a medium-grained, equigranular, pale grey to pale yellow-brown, quartz-rich metasedimentary rock containing accessory feldspar, biotite, muscovite,

phlogopite and pyrite (Photo 10). The mica content varies and can result in a high visual estimate of graphite content. The results of graphite analysis for 9 grab samples taken during this property examination are shown in Table 9 (samples analyzed by Activation Laboratories, Ancaster).

In 1 location east of Montserrat Lake (UTM 3374054E 4997992N), the graphitic zone is exposed on the east side of a ridge that drops about 20 m to a swamp that trends parallel to the ridge. Graphitic schist was also observed 30 m to the west, indicating a potential width of 30 m of graphitic schist, overlain by quartz-biotite gneiss to the west.

The northern claims were not visited during this property examination, but samples collected by the prospectors from the northern 4 rows of claim cells, shown on Figures 10 to 13, were examined by the District Geologist in 2017. Samples of quartz-biotite gneiss, quartz-feldspar-biotite gneiss, and rusty, quartz-feldspar-phlogopite schist containing up to 7% graphite (visual estimate) and minor pyrite were collected and are consistent with lithologies observed in the remainder of the property. One sample (JM-17-13) from the north zone, in the vicinity of a graphite occurrence reported by Duguet, Duparc and Mayer (2015), assayed 2.77% graphite (assayed by Activation Laboratories for the District Geologist, November 2017).

Table 9. Locations and graphite content of samples taken during the property examination, September 2018.

Sample	Location	Easting* (m)	Northing* (m)	Graphite (%)
BM-18-1	South zone	336472	4995235	2.24
BM-18-2	South zone	336475	4995234	3.29
BM-18-3	Central zone	338192	4999337	2.86
BM-18-4	Central zone	338200	4999338	3.16
BM-18-5	Central zone	338166	4999470	3.32
BM-18-7	Central zone	338107	4999456	3.37
BM-18-9	Central zone	337471	4998112	1.67
BM-18-10	Central zone	337405	4997992	3.27
BM-18-11	Central zone	337410	4997913	3.47
JM-17-13	North zone	338691	5000863	2.77

**Locations provided as UTM co-ordinates using NAD83.*
Graphite analyses by Activation Laboratories, Ancaster, Ontario.

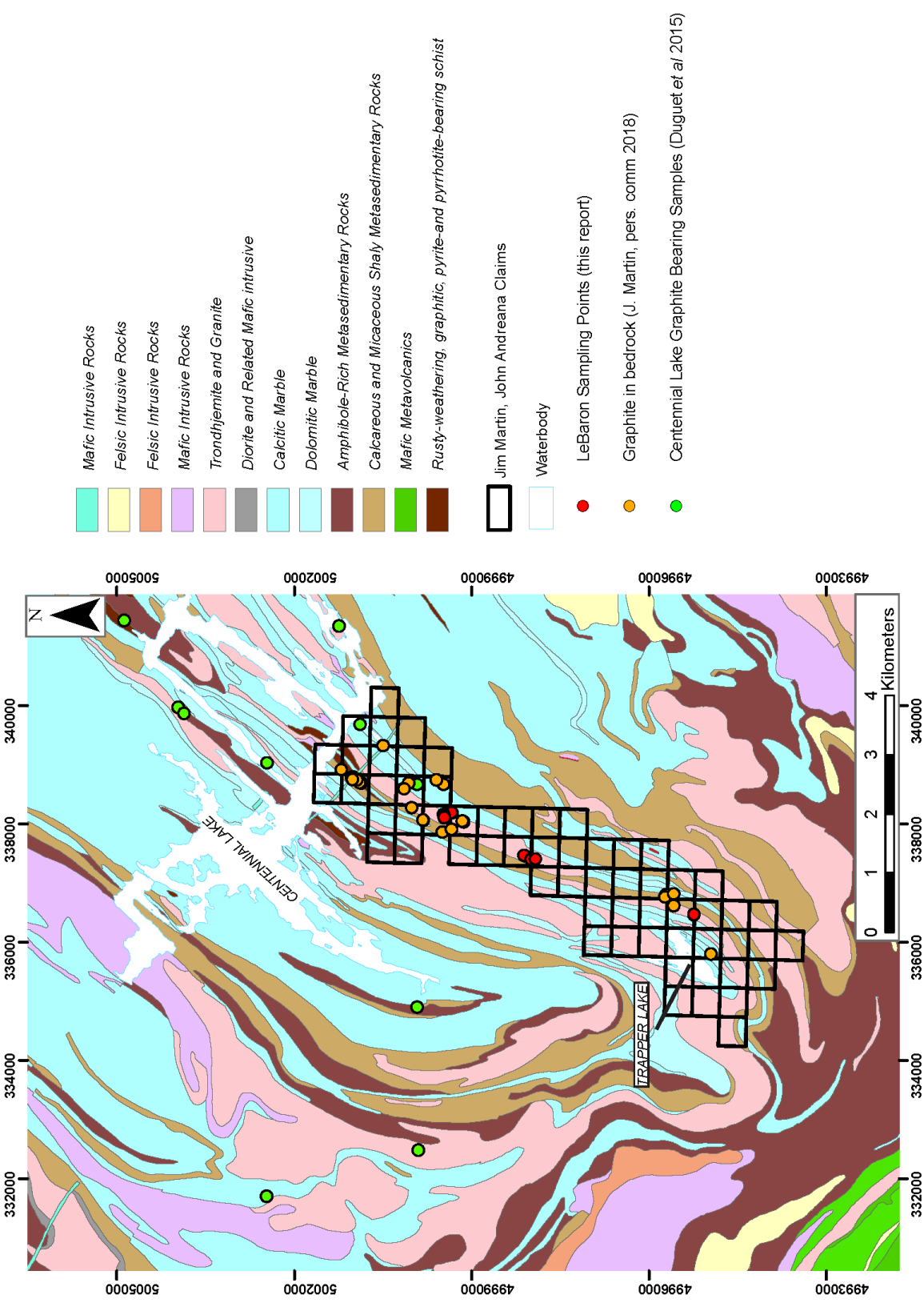

Figure 10. Geological map of the Centennial Lake area, showing locations of the Black Mountain property and graphite occurrences (geology *from* Lumbers and Vertolli 2001).

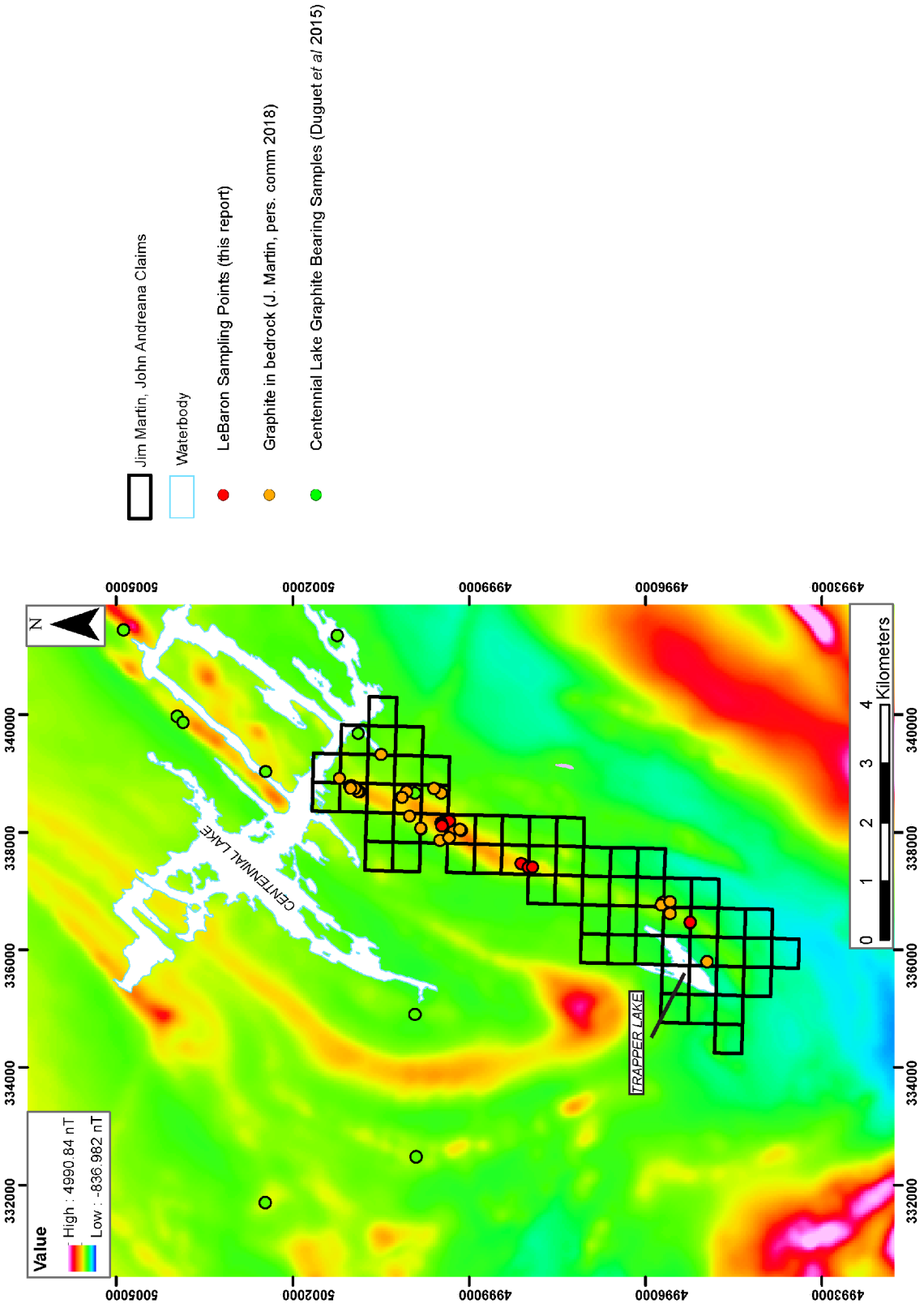

Figure 11. Airborne magnetic survey map of the Centennial Lake area, showing locations of the Black Mountain property and graphite occurrences (magnetic survey *from* Ontario Geological Survey 2014).

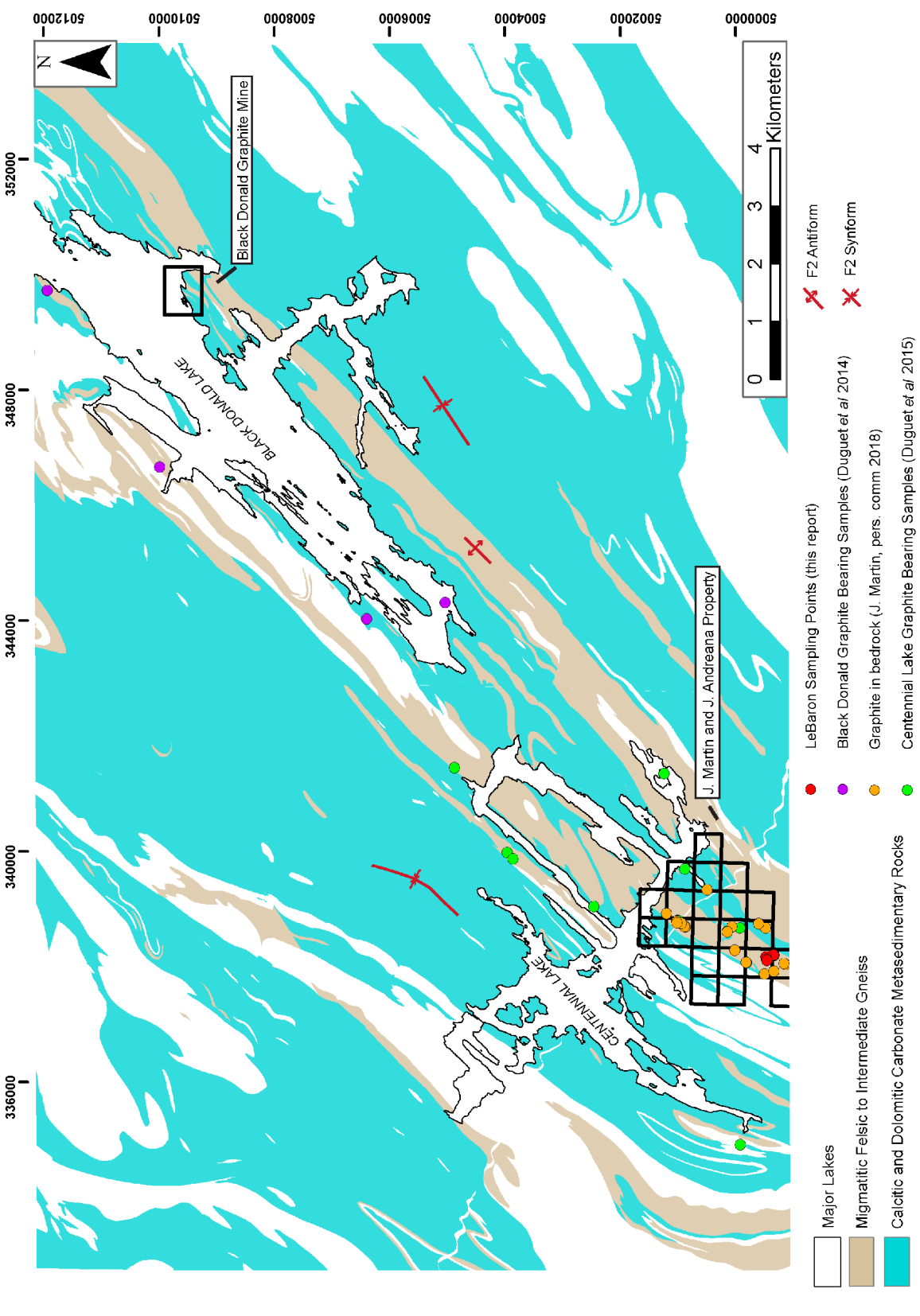

Figure 12. Simplified geological map of the Centennial Lake–Black Donald Lake area, showing locations of the Black Mountain graphite prospect and the Black Donald Mine (geology *after* Lumbers and Vertolli 2001).

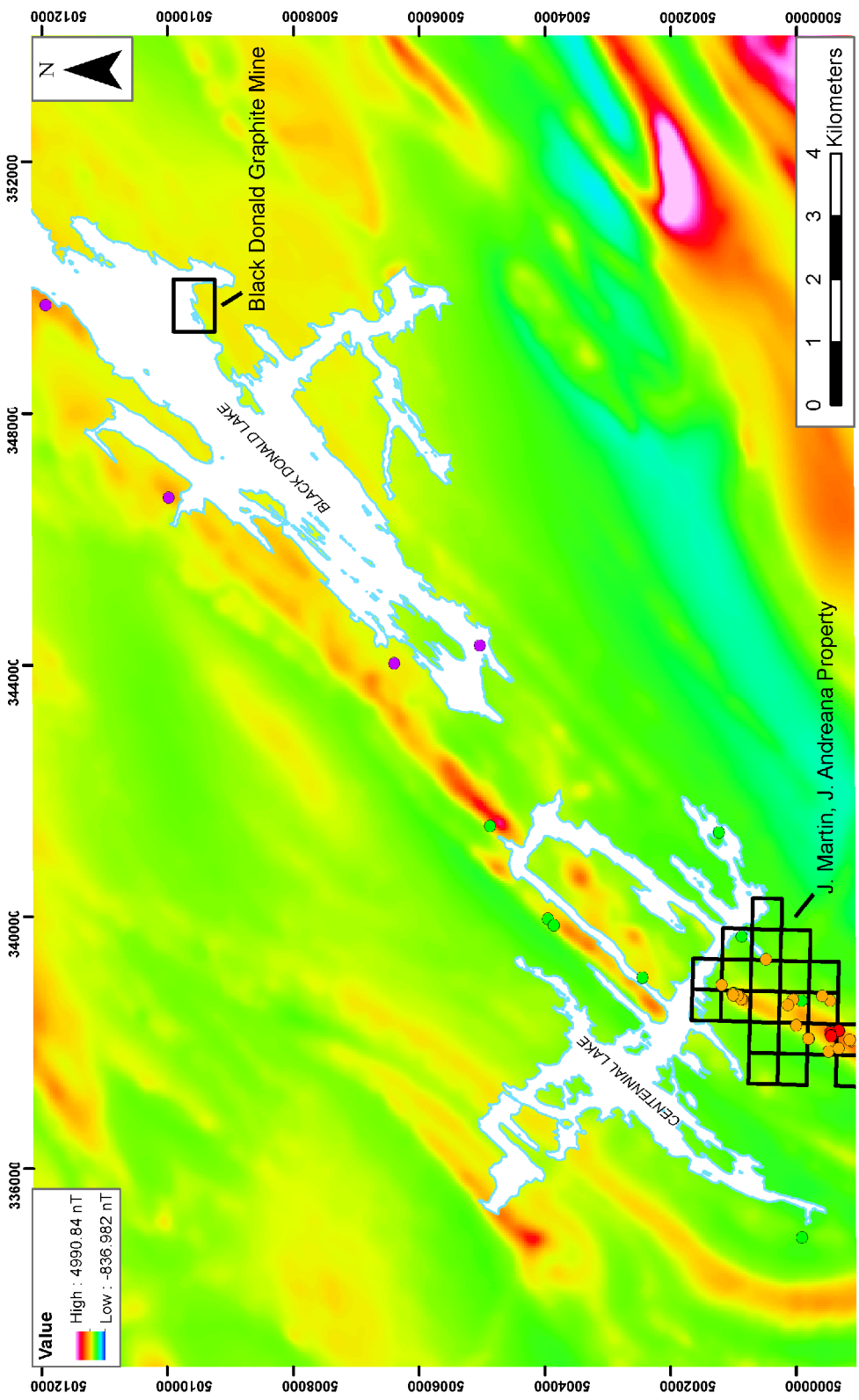

Figure 13. Airborne magnetic survey map of the Centennial Lake–Black Donald Lake area, showing locations of the Black Mountain graphite prospect (J. Martin, J. Andreana property) and the Black Donald Mine (magnetic survey *from* Ontario Geological Survey 2014).

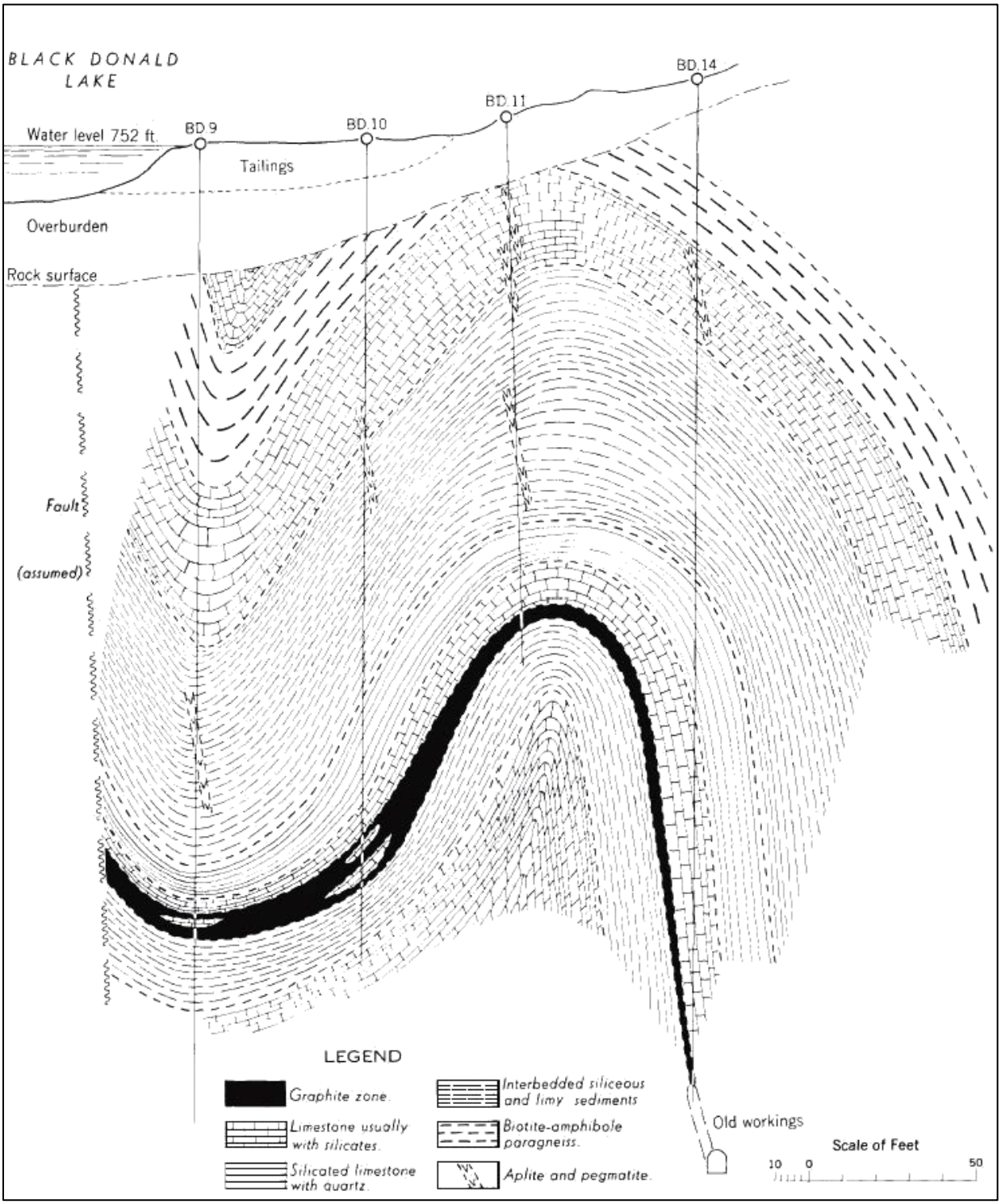

Figure 14. Vertical cross section through the Black Donald Mine, looking northeast (*from* Hewitt 1965).

Photo 9. Prospector J. Andreana examining the contact zone between graphitic, rusty schist underlying barren, quartz-feldspar-biotite gneiss (top left corner, grey-weathering, no gossan). Location is east of Trapper Lake, in the southern part of the Black Mountain graphite property (UTM 336472E 4995235N).

Photo 10. Sample BM-18-11 showing disseminated, grey graphite flakes in quartz-rich metasedimentary rock; white, highly reflective grains are muscovite and/or phlogopite. Graphite content is 3.47% (analysis by Activation Laboratories; *see* Table 10).

SUMMARY

Graphitic schist with flake graphite content in the range of 2 to 3.5% has been identified in one or more units of siliceous metasedimentary rocks near the contact with carbonate metasedimentary rocks over a strike length of about 7.5 km on the Black Mountain claim group. Preliminary prospecting indicates width of the zones up to 30 m, measured where graphite mineralization occurs at the top of a steep ridge that drops into a linear swamp. It is possible that graphite mineralization continues below the swamp, as at the Malcolm graphite prospect 25 km to the northwest in a similar geological setting (Sangster et al. 2016).

Canada's largest past-producing graphite mine, the Black Donald Mine, is located 13 km along strike to the northeast from the Black Mountain property, where the deposit is associated with rusty, pyrite-pyrrhotite-graphite–bearing schists and calc-silicates near the contact with carbonate metasedimentary rocks, similar to the graphite mineralization on the Black Mountain property.

The bands of sulphide-graphite mineralization are evident as magnetic highs and time-domain electromagnetic anomalies on airborne geophysical surveys. However, non-conductive, non-magnetic zones of disseminated graphite may also be present in adjacent marbles and may respond to induced polarization geophysical surveys.

Fold structures along the larger trend of graphite-bearing rocks may have concentrated or thickened the mineralization in dilation zones within the structures, as occurs at the Black Donald Mine. Detailed mapping of the favourable units may indicate minor fold structures or faults that are potential targets for higher grade or larger zones of mineralization.

The presence of sulphide-bearing, rusty schists associated with transitional zones between carbonate and siliciclastic metasedimentary rocks also indicates a favourable environment for potential SEDEX-type zinc mineralization, as presented in this report under "Recommendations for Exploration", "Zinc Prospectivity in Southern Ontario: New Exploration Targets".

RECOMMENDATIONS FOR EXPLORATION

Zinc Prospectivity in Southern Ontario: New Exploration Targets

Note: The following recommendation is modified from *Tessier, LeBaron and Smith (2019).*

PREFACE

The recommendations and conclusions herein are based, in part, on the results of Brearton et al. (2018), a fourth-year geological engineering design project at Queen's University developed to identify targets for zinc exploration in southern Ontario. The students were co-supervised by Dr. G. Olivo, Professor of Economic Geology at Queen's University, Kingston, Ontario, and A.C. Tessier, Southern Ontario Resident Geologist.

The study's recommendations were supplemented with additional insight from field work carried out during the 2018 field season by the Southern Ontario Resident Geologist's office staff. The full report (Brearton et al. 2018) is available at the Resident Geologist's office in Tweed.

INTRODUCTION

Exploration for zinc in southern Ontario has been dormant since 1998.

The objective of this project was to identify target areas for zinc exploration in southern Ontario within the Composite Arc Belt and the Frontenac Belt of the Grenville Province (Figure 15). This project used publicly available data, including geological, geochemical and geophysical survey data, as well as information in the Mineral Deposit Inventory (MDI) database (Ontario Geological Survey 2018a), to vector towards targets for zinc mineralization.

The parameters favourable for the presence of zinc mineralization were compiled from literature on sedimentary exhalative (SEDEX), Mississippi valley–type (MVT), volcanogenic massive sulphide (VMS), skarn and silicate zinc deposits—occurrences of which all occur in the Grenville Province.

There are several known zinc deposits in the study area and in neighbouring jurisdictions (*see* Figure 15). The deposits include the Deer Lake, Calumet (Quebec) and Simon deposits, believed to be of VMS origin; and the Cadieux deposit (1.45 Mt at 8.8% Zn and 0.8% Pb, non–NI 43-101 compliant), Salerno Lake deposit (797 000 t at 6.3% Zn, non–NI 43-101 compliant) and Long Lake past-producing mine (94 631 short tons at 11.6% Zn; 1974–1976), thought to be of SEDEX origin. The world-class Balmat–Edwards zinc mining district in the Adirondack Belt of northern New York is located less than 35 km from the southeast border of Ontario. The district has been in operation since 1903. Past production and reserves contained 45 Mt at an average grade of 9.4% Zn (Whelan, Rye and deLorraine 1984). Empire

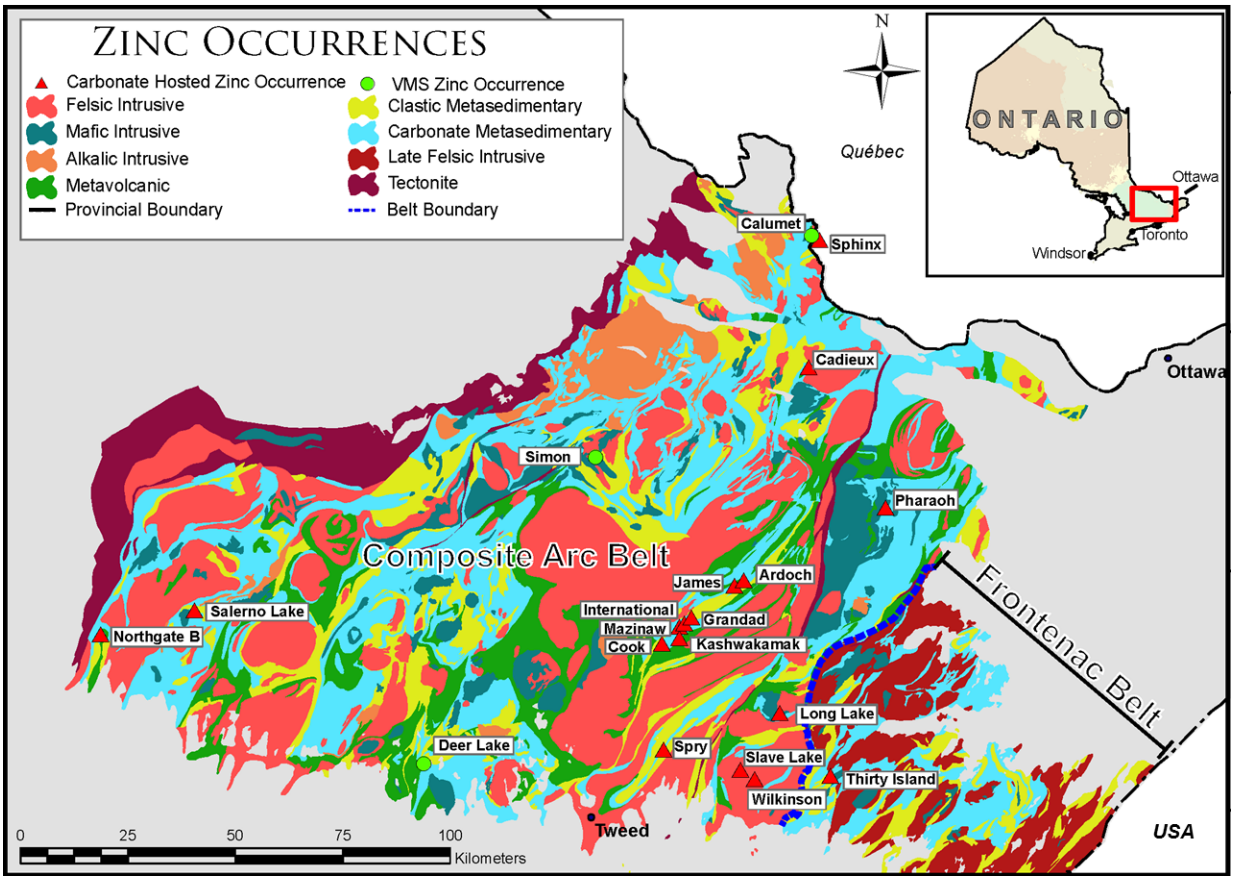

Figure 15. Geological map showing the Composite Arc Belt and Frontenac Belt of the Grenville Province (geology *from* Ontario Geological Survey 2011) and the location of zinc deposits and occurrences (data *from* Ontario Geological Survey 2018a). Note that Calumet and Sphinx are 14 km north of the Quebec–Ontario border.

State Mines reopened the Balmat Mine and mill in 2017. A number of smaller, yet significant, zinc occurrences also occur in the study area, such as the Spry, Cook, Ardoch, Pharaoh, 30 Island Lake, Northgate B, Slave Lake and Wilkinson occurrences, which are carbonate-hosted stratiform or stratabound occurrences and the Mazinaw, International, Kashwakamak, Grandad and James polymetallic occurrences (Zn, Pb, Cu, Ag, ±Au) that are, individually, of a hydrothermal crosscutting nature (vein-filling), but are collectively stratabound (i.e., occurring at the same stratigraphic level).

METHODOLOGY

Publicly available geochemical data from the Ontario Geological Survey (OGS) and the Geological Survey of Canada (GSC) were incorporated into the study and included lithogeochemical analyses of rock samples, lake and stream sediment samples, and geochemistry of lake water and groundwater. Concentrations of deposit-specific pathfinder elements were compared on a magnitude basis to determine anomalous concentrations that may be indicative of zinc mineralization. These elements included zinc, lead, copper, cobalt, cadmium, arsenic, gold, silver, manganese, iron, barium, beryllium and sulphur.

Magnetic, gravimetric, electromagnetic and radiometric geophysical surveys were all considered for the project. Magnetic and gravimetric surveys were deemed most effective to compare known zinc prospects with potential mineralization targets because of their wide coverage and spatial resolution. These geophysical methods were also employed to identify the geological framework necessary for target identification.

A raster analysis was conducted for the aforementioned geochemical and geophysical data to identify common anomalies between data sets that were favourable for zinc mineralization. Each data set considered for the raster analysis was weighted depending on its favourability for zinc mineralization and was then combined into a single cumulative raster in the form of a heat map. Raster heat maps were then produced for each sought-after deposit type to identify target areas (Figure 16).

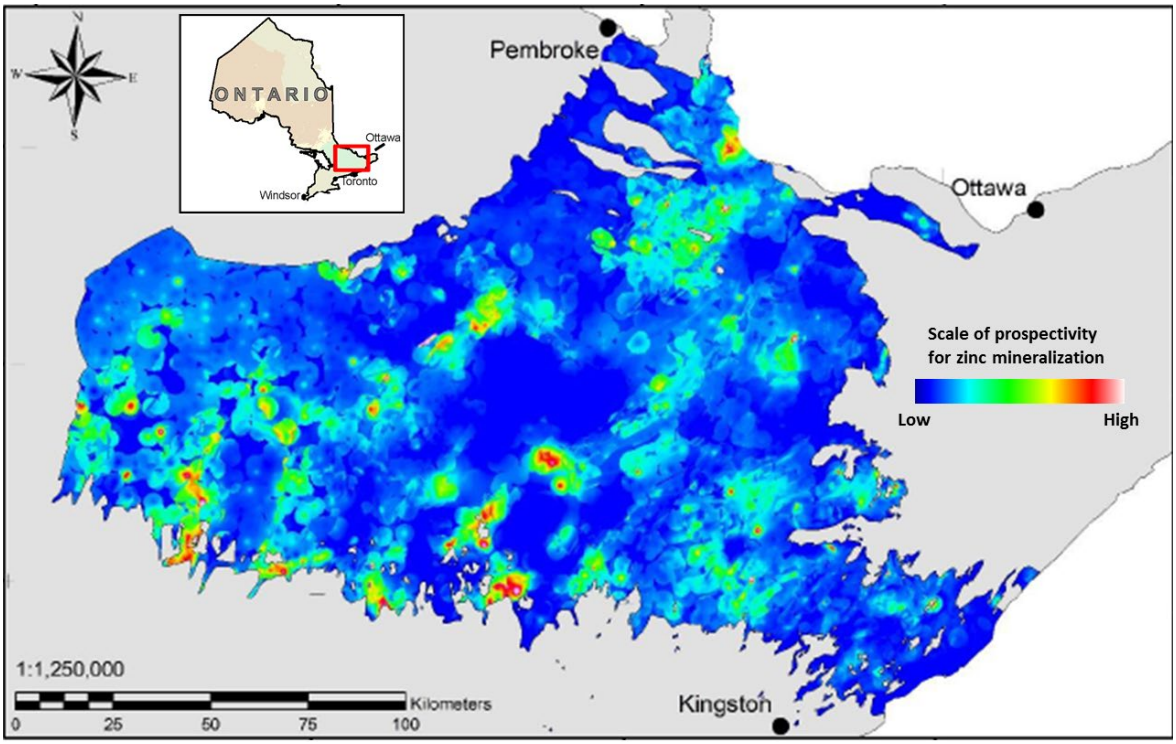

Figure 16. Example of a cumulative raster heat map using exploration parameters for SEDEX-type zinc deposits for southern Ontario. Similar heat maps were also produced for Mississippi Valley–type and volcanogenic massive sulphide silicate zinc and zinc-lead skarn deposit types (*from* Brearton et al. 2018).

Once the targets were identified, a geological investigation at the local scale was carried out using data from geological maps and reports published by the OGS. These maps were used to ensure geological validity for any given target identified by the raster analysis and, at this stage of the study, many targets were eliminated based on the geology where the anomaly occurred. Information from the MDI database (Ontario Geological Survey 2018a) was used to validate the raster analysis method in areas of known zinc deposits, providing insight about local mineralization in the assessment of each target.

RESULTS

It came as no surprise that cumulative raster heat maps generated for the different deposit types outlined similar target areas. For example, the presence of zinc and lead are top indicators of all genetic types of zinc mineralization and appear on the heat map for all deposit types.

The cumulative raster analysis proved successful at identifying several areas of known zinc mineralization, such as the Cadieux deposit and the Northgate B, Deer Lake, Simon, Spry, 30 Island Lake, Ardoch and Pharaoh occurrences. These areas are considered as excellent targets.

Several noteworthy zinc deposits and prospects that were not identified as targets by the cumulative raster analysis include the Long Lake past producer, the Salerno Lake deposit and the Cook, Slave and Wilkinson occurrences. A lack of geochemical data in the Salerno Lake area may account for why the Salerno Lake deposit was not identified as a target. The Long Lake past producer, the Slave occurrence and the Wilkinson occurrence all occur in small xenoliths of marble within larger intrusive bodies that may have masked their geophysical and, perhaps, their geochemical signature. It is unclear why the Cook occurrence was not specifically outlined; however, the northeast part of the marble belt that hosts the Cook occurrence was identified as a target by the raster analysis (specifically the Ardoch area).

A total of 40 targets were initially selected using the cumulative raster heat maps. Nine of the most favourable targets were then selected based on a preliminary assessment that examined the cumulative raster values, geological setting attributes and known mineral occurrences (Figure 17; Table 10). Eight additional medium-priority areas were outlined (*see* Figure 17) and several more targets were downgraded to lower priority targets mostly because of their potential social and environmental challenges.

PRELIMINARY ECONOMIC STUDY

A preliminary economic study for zinc deposits in southern Ontario was also carried out during this project (Brearton et al. 2018). The objective of the study was to define a target size that can be economically mined in southern Ontario. The recent re-opening of the Empire State Mine (Balmat District, New York) has considerably changed the economics of such a proposition because deposits no longer must be “stand-alone” operations. The mill operated at Balmat has a capacity of 5000 tonnes per day and is currently underutilized. It should be noted that the zinc mineralization of the Long Lake zinc mine was milled at Balmat in 1974–1976 after a preconcentration to approximately 20% Zn (Wolff 1982).

A financial model was also generated using the Empire State Mine in the Balmat–Edwards district of northern New York as an analogue. The model predicts that deposits smaller than 700 000 t would not require a mill, with the ore being transported to the Empire State Mill for processing. In this case, the distance to Empire State Mine and the grade of the ore are significant factors in operating costs to consider for the success of the project (Figure 18).

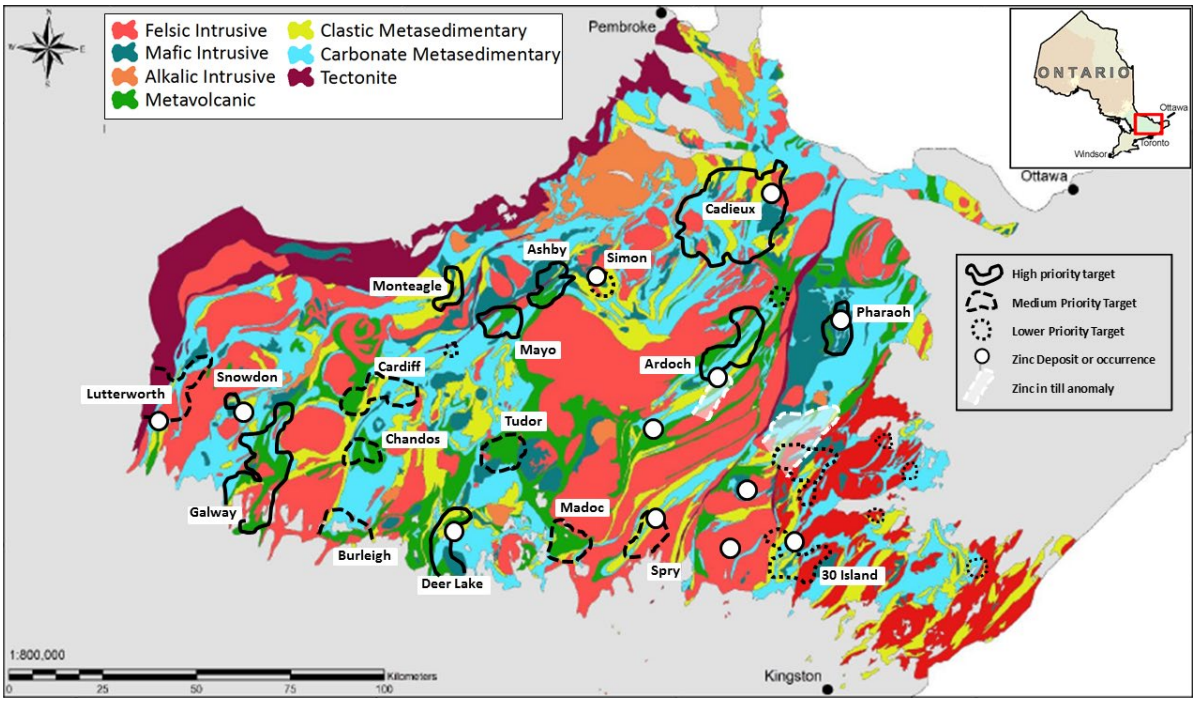

Figure 17. Geological map of the Composite Arc Belt and Frontenac Belt (Grenville Province) showing the target areas defined by the cumulative raster analysis of this project. Zinc in till data *from* Kettles and Shilts (1996).

Table 10. List of high-priority targets defined by the cumulative raster analysis. Known mineralization data *from* Ontario Geological Survey (2018a).

Target	Township(s)	Area Dimension (approximate)	Dominant Lithologies	Known Zinc Mineralization	Target Type
Cadieux	Admaston, Brougham, Gratton	20 × 20 km	Marbles and clastic metasedimentary rocks intruded by granitoids and gabbros	Cadieux deposit 1.45 Mt @ 8.8% Zn and 0.8% Pb	SEDEX-MVT
Pharaoh	Lanark, Dalhousie	12 × 6 km	Marbles intruded to the west by the Lavant gabbro	Pharaoh prospect (7.1% Zn in boulder) (up to 3.96% Zn/1.5 m drill hole)	SEDEX-MVT
Ardoch	Clarendon, Palmerston, South Canonto	18 × 5 km	Tightly folded marbles with clastic metasedimentary rocks and mafic metavolcanic rocks	Ardoch occurrence (2.60% Zn/2.28 m in drill hole) (Zn anomaly in till to south)	SEDEX-MVT (-VMS?)
Ashby	Ashby, Raglan	10 × 5 km	Folded mafic to felsic metavolcanic rocks with marbles	None known	VMS-SEDEX-MVT
Mayo	Mayo	7 × 7 km	Folded mafic to felsic metavolcanic rocks with marbles	None known	VMS-Zn-Pb skarn
Monteagle	Monteagle	8 × 2 km	Marbles, granitoids and minor clastic amphibole-rich metasedimentary rocks	None known	Zn-Pb skarn
Snowdon	Snowdon	2 × 2 km	Marbles and clastic metasedimentary rocks	None known, but proximal to Salerno deposit (797 000 t @ 6.3% Zn)	SEDEX-MVT
Deer Lake	Belmont, Marmora	15 × 5 km	Marbles, clastic metasedimentary rocks and mafic metavolcanic rocks	Deer Lake deposit (0.1–1.13% Zn in drill hole)	VMS-SEDEX-MVT
Galway	Harvey, Galway, Cavendish	28 × 7 km	Metavolcanic belt with minor marbles and clastic metasedimentary rocks intruded by granitoids	None known, except a few minor occurrences (Zn in till anomaly)	VMS-SEDEX-MVT

Abbreviations: *MVT, Mississippi Valley–type; SEDEX, sedimentary exhalative; VMS, volcanogenic massive sulphide.*

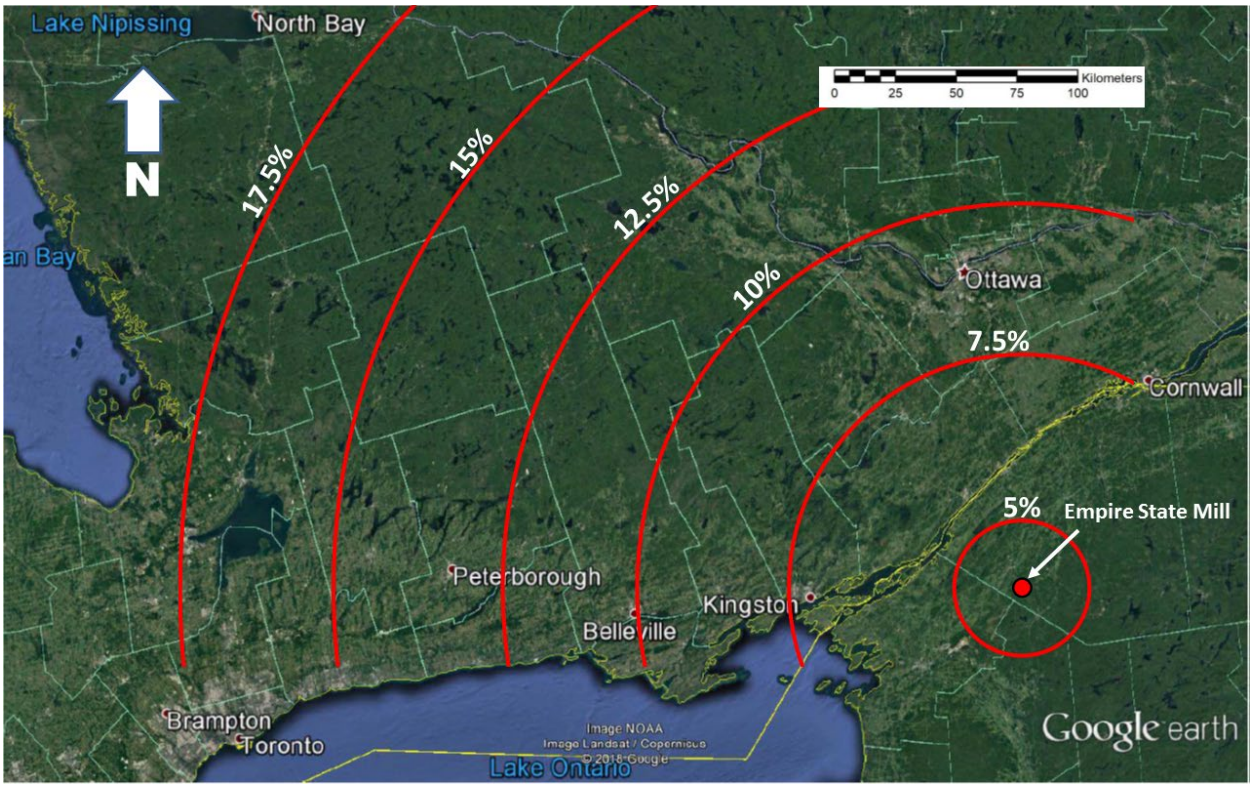

Figure 18. Contour map showing the minimum grade required for a 500 000 t deposit without a mill to be economic when shipping ore to the Empire State Mine mill in New York (*modified from* Brearton et al. 2018). Base image *from* Google Earth™ mapping service.

CONCLUSION

With the world-class Balmat–Edwards Mine (45 Mt of 9.4% Zn) situated in the Grenville Province of New York, less that 35 km from the Ontario border, the potential for zinc mineralization in the Grenville Province of southern Ontario is undeniable. Furthermore, the reopening of the Balmat Mine and mill by Empire State Mines in 2017 provides infrastructure to the area that favourably changes the economic parameters needed to bring a mine into production in southern Ontario.

The raster analysis approach presented herein for zinc exploration in the Composite Arc Belt and the Frontenac Belt of southern Ontario was successful at identifying most of the existing zinc deposits and occurrences in the area. The method also identified 40 new areas of interest for zinc exploration. Following validation and prioritization, a total of 9 targets were selected as highly favourable (*see* Table 10; *see* Figure 17). These new targets are even more exciting because there has been no exploration for zinc in southern Ontario over the last 2 decades.

High-Purity Marble Deposits, Southeastern Ontario: Industrial Mineral Potential

Note: The following recommendation is modified from *LeBaron and Smith (2019).*

INTRODUCTION AND MARKET OUTLOOK

Marble belts of the Central Metasedimentary Belt of the Grenville Province in southeastern Ontario (Figure 19) contain deposits of high-purity calcitic and dolomitic marble that are currently quarried as sources of mineral filler for the paint, paper, plastics and pharmaceutical industries and for terrazzo, decorative stone and landscaping stone.

Precipitated calcium carbonate ("PCC") and ground calcium carbonate ("GCC") are used primarily as filler and extender material in the paper, paint and plastics industries, but are also important in construction (drywall and joint compounds), adhesives, rubber, food, pharmaceuticals and animal feedstock. In North America, the ground calcium carbonate segment held the largest market share in 2017, accounting for nearly 81% of the calcium carbonate market. The calcium carbonate market in North America is projected to grow at a compound annual growth rate of close to 5% from 2018 to 2022 (www.businesswire.com/news/home/20180421005042/en/Calcium-Carbonate-Market-North-America---Market).

White marble deposits are the most abundant sources of high-purity, high-brightness carbonate, providing additional physical properties, such as stiffness, colour and opacity. Brightness, particle size and chemical purity are the properties of carbonate fillers that are crucial in industrial uses.

High-purity, high-brightness dolomitic marble can substitute as a less costly alternative to calcitic marble in some applications, such as joint compounds, vinyl floor tiles, grouts, exterior plasters and stucco, asphalt roofing and cast polymers (manufactured marble tiles and countertops).

The key points identified in a recent study of the global calcium carbonate market are the following for the forecast period from 2017 to 2025 (Grand View Research, March 2017, www.grandviewresearch.com/press-release/global-calcium-carbonate-market):

- The global calcium carbonate demand is expected to reach 180.1 Mt by 2025 (from 113.7 Mt in 2016) at an estimated compound annual growth rate of 5.3% from 2017 to 2025.
- Approximately 50% of the global calcium carbonate demand in 2016 was accounted for by the paper industry and is expected to continue as the leading market over the forecast period.
- The paints and coatings segment is expected to register a compound annual growth rate of 5.9% in terms of revenue over the forecast period.
- Reducing resin content permits significant cost savings on raw materials by replacing about 40% of plastic with calcium carbonate.

SOUTHERN ONTARIO PRODUCTION AND PROSPECTS

Locations of producers, significant prospects and known occurrences of high-purity calcitic and dolomitic marble are shown in Figure 19. The locations of occurrences shown in Figure 19 were obtained from a search of the Ontario Geological Survey's Mineral Deposits Inventory (MDI) database for "high-purity marble" (Ontario Geological Survey 2018a).

The only current producer of ground calcium carbonate from southern Ontario marble is Omya Canada Inc. White, calcitic marble is extracted from a high-purity zone about 85 m wide at the company's Tatlock Quarry in Darling Township and trucked to the company's processing plant at Perth. In high-

demand years, the company quarries about 650 000 t from the deposit, which is estimated to contain an additional 5 Mt of reserves. Various grades and sizes of dry ground and slurry calcium carbonate are produced for use in the paper, paint and plastics industries.

High-purity dolomitic marble was quarried for magnesium metal production in Ross Township at Haley Station near Renfrew. The deposit consisted of a 75 m wide zone of coarsely crystalline dolomite containing less than 1% impurities (chondrodite, talc, tourmaline and tremolite) and was quarried over a strike length of over 700 m (LeBaron and MacKinnon 1990). The quarry and plant were operated, originally by Dominion Magnesium Limited and later by Timminco Metals, for a total of 63 years before ceasing production in 2007.

Two other properties in southeastern Ontario host significant drill-indicated reserves (not NI 43-101–compliant) of high-purity marble. The Whitney calcite property in Belmont Township, explored by Preussag Canada Ltd. and Northumberland Mines Ltd. between 1975 and 1980, contains 1.9 Mt of high-calcium marble and 4.7 Mt of calcitic/dolomitic marble, both zones containing less than 0.5% SiO_2 + Fe_2O_3 and averaging 93% brightness (LeBaron and MacKinnon 1990). The Lockwood property in Elzevir Township, explored by Omya in 1974 using diamond drilling, is estimated to contain 3 Mt of white, high-calcium marble averaging less than 2% acid insoluble content. The footwall of the calcitic zone is a 50 m thick dolomitic zone, visually estimated to contain less than 3% impurities (LeBaron and MacKinnon 1990).

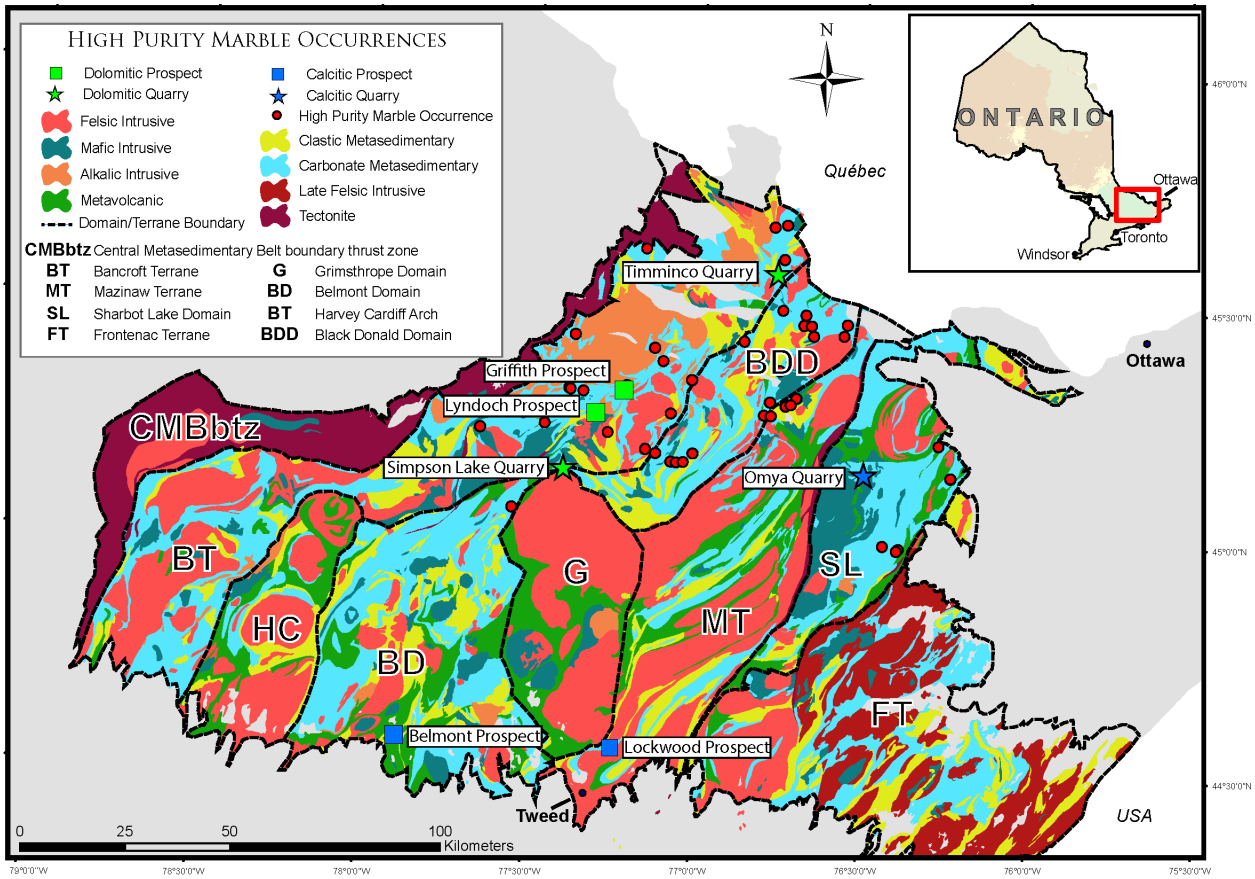

Figure 19. Geology of the Central Metasedimentary Belt (major marble belts shown in pale blue) and locations of high-purity marble quarries, prospects and occurrences, southeastern Ontario; geology *from* Ontario Geological Survey (2011) and locations *from* Ontario Geological Survey (2018a).

AREAS RECOMMENDED FOR EXPLORATION

Although there is potential for the discovery of high-purity marble in all marble belts of southeastern Ontario, the following areas are recommended for exploration.

Lanark–Darling–Ramsay Townships Area

This wide marble belt contains several occurrences of high-purity carbonate and hosts the Omya deposit at Tatlock. Mapping in the Perth and Carleton Place areas by Easton (2015, 2016, 2018) identified abundant clean, high-brightness, low silica content, calcitic and dolomitic marbles of the Sharbot Lake domain (*see* Figure 19) as having industrial mineral potential. Major oxide content of samples reported by Easton (2015, 2018) are listed in Table 11.

Lyndoch–Griffith–Brougham Townships Area

This belt of interlayered calcitic and dolomitic marbles within the Bancroft terrane contains zones of high purity and brightness (LeBaron and MacKinnon 1990). White, dolomitic marble is quarried at Simpson Lake in Ashby Township (*see* Figure 19) and shipped to the Coloured Aggregates Inc. plant in Marmora for production of specialty aggregates for the construction industry.

Exploration work since 2014 has identified high-purity white dolomitic marble in Lyndoch Township (Lyndoch prospect, *see* Figure 19; Forget 2014). The analytical results of 2 white, dolomitic marble samples (ML-18 and ML-21), collected about 800 m apart along strike at the Lyndoch prospect, are provided in Table 11. Similar results were reported by LeBaron and MacKinnon (1990) from coarse-grained, white dolomitic marble from the Griffith prospect (*see* Figure 19; Photo 11).

Table 11. Major oxide geochemistry of selected high-purity marble samples from southeastern Ontario.

Sample Number	15RME-0099 [1]	15RME-0104 [1]	17RME-0093 [2]	18RME-0048 [2]	18RME-0049 [2]	18RME-0134 [2]	ML-18 [3]	ML-21 [3]
Easting (m)	390814	390376	387011	403327	403266	400528	317805	319173
Northing (m)	4983444	4983029	4984174	5000135	5000202	5007834	5015362	5015789
Rock Name	Dolomite marble	Calcite marble	Dolomite marble	Dolomitic calcite marble	Dolomite marble	Dolomitic calcite marble	Dolomite marble	Dolomite marble
SiO_2 (wt %)	0.18	0.40	0.23	0.65	0.39	0.85	0.70	0.33
TiO_2	0.01	0.01	<0.01	<0.01	<0.01	<0.01	0.003	0.001
Al_2O_3	0.16	0.12	0.06	0.11	0.17	0.24	0.06	0.05
Fe_2O_3 total	0.20	0.12	0.10	0.07	0.15	0.16	0.08	0.33
MnO	0.020	0.003	0.025	0.003	0.051	0.017	0.056	0.034
MgO	21.02	4.64	20.67	3.11	19.50	3.81	22.05	21.25
CaO	30.39	51.10	29.71	51.02	31.50	50.82	31.32	31.92
Na_2O	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.01	0.01
K_2O	0.03	0.05	0.01	0.02	0.01	0.06	0.02	<0.01
P_2O_5	0.01	0.010	0.018	0.004	<0.002	0.011	0.01	<0.01
CO_2	46.07	42.57	45.44	43.97	45.92	43.78	N/A	N/A
S	N/A	N/A	0.004	<0.003	<0.001	<0.003	N/A	N/A
LOI	47.42	44.40	47.39	43.98	47.11	44.10	44.82	46.83
Total	99.44	100.86	98.15	98.98	98.84	100.07	99.13	100.80
CaO/MgO	1.45	11.0	1.4	16.4	1.6	13.3	N/A	N/A

**Locations provided as UTM co-ordinates using NAD83 in Zone 18.*
Sources: [1]Easton (2015); [2]Easton (2018); [3]Forget (2014).

Ross–Horton Townships Area

Several marble prospects and past producers are located in Ross and Horton townships. According to Easton (2013), the area east of the Ross fault, a north-south fault that marks a major change in bedrock geology and magnetic trends, represents a down-dropped block that preserves calcitic and dolomitic marbles of lower metamorphic grade than is typical in this part of the Central Metasedimentary Belt. These relatively high-purity marbles are the result of deposition in a carbonate basin with a low influx of siliciclastic and volcaniclastic material.

Belmont–Madoc–Hungerford–Elzevir Townships Area

Several occurrences exhibit adjacent zones of high-purity calcitic and dolomitic marble in the Belmont domain, an area of relatively low-grade metamorphism (LeBaron and MacKinnon 1990). High-purity prospects, such as the Belmont (*see* Figure 19), indicate that there are localized zones with potential for industrial mineral development.

In addition to the potential for specialty products from high-purity marbles, lower grades of both calcitic and dolomitic marble have potential applications as terrazzo, decorative aggregate, dimension stone and lower specification mineral fillers.

The geology and geochemistry of Grenville Province marble belts and specific prospects are documented in the following Ontario Geological Survey reports:

- *Industrial Minerals of the Pembroke–Renfrew Area, Part 1: Marble* (Storey and Vos 1981b)
- *Geochemistry of Grenville Marble in Southeastern Ontario* (Grant, Papertzian and Kingston 1989)
- *Precambrian Dolomite Resources in Southeastern Ontario* (LeBaron and MacKinnon 1990)
- *High-Purity Calcite and Dolomite Resources of Ontario* (Kelly 1996)

Photo 11. Stripped outcrop area of high-purity, white, dolomitic marble, Griffith prospect; inset shows close-up view of uniform, coarse grain size; photos by P.S. LeBaron, 2016.

OGS ACTIVITIES AND RESEARCH BY OTHERS

Geological mapping and related projects in southern Ontario by staff of the Earth Resources and Geoscience Mapping Section, Ontario Geological Survey, continued during the 2018 field season.

In the eastern part of the Central Metasedimentary Belt, Grenville Province, two 1:50 000 scale bedrock mapping projects were completed: a two-year mapping project in the Carleton Place area and a single-year compilation map project in the Renfrew area. Details of the projects are presented in the following articles, published in *Summary of Field Work and Other Activities, 2018* (Ontario Geological Survey 2018b):

- Precambrian Geology and Mineral Potential of the Carleton Place Area, Grenville Province; by R.M. Easton
- Precambrian Geology of the Renfrew Area, Northeastern Central Metasedimentary Belt, Grenville Province; by M. Duguet

Other OGS studies related to Paleozoic geology and energy studies, Quaternary geology, aggregate resources and groundwater resources in southern Ontario were in progress in 2018. Detailed descriptions of the following projects are included in *Summary of Field Work and Other Activities, 2018* (Ontario Geological Survey 2018b):

Paleozoic Geology and Energy Studies

- Paleozoic Geology of Eastern Ontario; by C. Béland Otis
- Identification and Mapping of Alkali–Carbonate Reactive Layers in the Gull River Formation, Near Kingston, Ontario; by K.E. Hahn and C.A. MacDonald

Groundwater Studies

- Last Phase of Subsurface Data Collection for Three-Dimensional Mapping in the Central Part of the County of Simcoe, Southern Ontario; by R.P.M. Mulligan
- First Phase of Regional Groundwater Systems Mapping in the County of Simcoe, Southern Ontario; by E.H. Priebe, A.F. Bajc, A.K. Burt and R.P.M. Mulligan
- Update on Geological Survey of Canada Activities in 2017–2018 Related to the Ontario Geological Survey Groundwater Collaboration in Southern Ontario; by H.A.J. Russell

Surficial Mapping and Sampling

- Aggregate Resources in the Regional Municipality of Niagara, Southern Ontario; by K.E. Hahn

Several other OGS publications related to geoscience projects in southern Ontario were released in 2018 and are listed, with other publications acquired in 2018 for the Southern Ontario Resident Geologist Office library, in Table 12.

University Research and Collaborations

The following information was provided to the Southern Ontario Regional Resident Geologist's office concerning research projects by faculty and graduate students of various accredited universities, which were in progress or were published in 2018 and in early 2019. This section is not a comprehensive summary of university research in the Southeastern Ontario and Southwestern Ontario districts, as it is based solely on information provided directly by university researchers.

- Dr. I.D. Clark (University of Ottawa) led a program studying Paleozoic strata at the Bruce Nuclear site on the eastern margin of the Michigan Basin, where the Nuclear Waste Management Organization proposes a deep geological repository for low- and intermediate-level waste. In 2018, a post-doctoral research project, with J. Jautzy, was in progress to characterize the organic carbon compounds in Ordovician shales where a paleo-bioreactor produced methane prior to the infiltration of Silurian brines (Jautzy et al. 2018).

  The program includes a study of the sulphur system using SIMS analysis of ^{34}S in framboidal and tabular pyrite to determine their mode of formation, and measurement of isotopes of noble gases to evaluate the age of the brines based on the ingrowth of radiogenic isotopes of xenon, argon and neon.

- Dr. W. Shotyk and Dr. I.D. Clark (University of Ottawa) are studying old (pre-nuclear) groundwater in an artesian glacial outwash aquifer in Elmvale, near Midland, Ontario. This aquifer hosts groundwater with some of the lowest levels of trace metals yet measured in groundwater and is a model study of metal attenuation during recharge through natural soils. The various components of this research focus on the exceedingly low levels of heavy metals, the origin and age of the groundwater, and the physical flow system that generates and protects this resource.

- Dr. W.M. Schwerdtner (University of Toronto) and Dr. T. Rivers (Memorial University of Newfoundland) continued, in 2018, their studies of Grenvillian structures in the western Ottawa River gneiss complex, Algonquin Park, Lake of Bays and French River regions. For a presentation at the Geological Association of Canada–Mineralogical Association of Canada annual meeting in Quebec City in May 2019, they have submitted an abstract entitled "Structural similarities between the Ottawa River Gneiss Complex, western Grenville Province, and the Tertiary Shuswap Complex, southern Canadian Cordillera".

- A. Hicks, under the supervision of Dr. R. Amos (Carleton University) began a MSc thesis project on the geochemistry and geochemical structure of waste rock at the former Ore Chimney gold mine near Cloyne, Ontario, to study the long-term oxidation processes that release metals into the pore waters and effluent waters of the waste rock pile. Preliminary work at the abandoned mine site recorded elevated concentrations of dissolved metals, with notably high concentrations of cadmium and zinc in the waste rock pore waters. Field work will consist of sampling vertical profiles in 3 excavations across the waste rock piles. High-resolution hard-rock geochemical analysis, coupled with pore water and groundwater chemistry should provide insights into the chemical and physical processes responsible for the release and transport of dissolved metals, and how these processes may change over multi-decade timescales.

- A fourth-year Queen's University Geological Engineering Design Project, entitled "Zinc Exploration in Southern Ontario", co-supervised by Dr. G. Olivo (Queen's University) and A.C. Tessier (Southern Ontario Regional Resident Geologist), was completed in April 2018 by students H. Brearton, N. Elliot, P. Marty and E. Wynands. The project consisted of an office-based study compiling all regional geological, geophysical and geochemical data that are available for samples collected within the Central Metasedimentary Belt and Frontenac terrane. The data were converted into a raster analysis of the study area to generate target areas for sedimentary exhalative (SEDEX), volcanogenic massive sulphide (VMS), skarn, Mississippi Valley-type (MVT) and silicate zinc deposits.

- R. Culver began an undergraduate honours thesis on the Salerno Lake zinc deposit in Snowdon Township, under the co-supervision of Dr. G. Olivo at Queen's University and A.C. Tessier (Southern Ontario Regional Resident Geologist, ENDM) in the fall of 2018. The project attempts to decipher the stratigraphic sequence through petrography and lithogeochemistry.

Table 12. Publications received by the Southern Ontario District Geologist office in 2018 (publications of particular interest to the Southern Ontario District are shown in bold).

Title	Author(s)	Type and Year of Publication
A Framework for the Conservation of Ontario's Earth Science Features	C. Blackburn, D.N. Webster, P.J. Barnett, D.W. Cowell and M.J. Buck	Ministry of Natural Resources and Forestry, 2017
Geological, Geochemical and Geophysical Data Related to the Black Donald Lake Area, Grenville Province	M. Duguet	Ontario Geological Survey, Miscellaneous Release—Data 350, 2018
Geological, Geochemical and Geophysical Data Related to the Centennial Lake Area, Grenville Province	M. Duguet	Ontario Geological Survey, Miscellaneous Release—Data 356, 2018
Geospatial Distribution of Selected Chemical, Bacteriological and Gas Parameters Related to Groundwater in Southern Ontario	L.M. Colgrove and S.M. Hamilton	Ontario Geological Survey, Groundwater Resources Study 17, 2018
High-Resolution Seismic Reflection Profiles for Groundwater Studies in Simcoe County, Southern Ontario	A.J.-M. Pugin, B. Dietiker, R.P.M. Mulligan, H.L. Crow, K. Brewer, T. Cartwright, D.R.B. Rainsford, A.F. Bajc, D.R. Sharpe and H.A.J. Russell	Ontario Geological Survey, Open File Report 6347, 23p., 2018
Index to Maps, Bedrock Geology, 1991–2017	Ontario Geological Survey	Ontario Geological Survey, scale 1:1 000 000, 2018
Index to Maps, Surficial Geology, 1991–2017	Ontario Geological Survey	Ontario Geological Survey, scale 1:1 000 000, 2018
Metallogeny of Base Metal, Gold and Iron Deposits of the Grenville Province of Southeastern Ontario (unpublished)	A.L. Sangster	PhD thesis, 355p., Queen's University, 1970
Miscellaneous Paper 177 (Supplement 2011–2017)	Ontario Geological Survey	Ontario Geological Survey, Miscellaneous Paper 177, 134p., 2018
Miscellaneous Paper 178 (Supplement 2011–2017)	Ontario Geological Survey	Ontario Geological Survey, Miscellaneous Paper 178, 375p., 2018
Ontario Specific Gravity Data for Bedrock Samples Acquired from 1970 to 2014	D.R.B. Rainsford, A. Carter-McAuslan and L.C. Ashick-Stinson	Ontario Geological Survey, Miscellaneous Release—Data 371, 2018
Paleozoic Geology of the Dunnville Area, Southern Ontario	D.K. Armstrong	Ontario Geological Survey, Preliminary Map P.3810, scale 1:50 000, 2018
Petrogenesis of the Bissett Creek Flake Graphite Deposit: Implications for Regional Graphite Mineralization Models in the Grenville Province, Ontario	C.R. Drever	MSc thesis, 284p., University of Waterloo, 2018
Precambrian Geology of the Centennial Lake Area, Grenville Province.	M. Duguet, Q. Duparc and C. Mayer	Ontario Geological Survey, Preliminary Map P.3807, scale 1:20 000, 2018
Report of Activities 2017, Resident Geologist Program, Kirkland Lake Regional Resident Geologist Report: Kirkland Lake and Sudbury Districts	P.J. Chadwick, A.S. Péloquin, J. Suma-Momoh, C.M. Daniels, P. Bousquet, A.C. Wilson, N. Sabiri and N. Szumylo	Ontario Geological Survey, Open File Report 6340, 138p., 2018
Report of Activities 2017, Resident Geologist Program, Red Lake Regional Resident Geologist Report: Red Lake and Kenora Districts	A.F. Lichtblau, W. Paterson, C. Ravnaas, R.D. Tuomi, T.K. Pettigrew, S. Lewis and K. Wiebe	Ontario Geological Survey, Open File Report 6336, 100p., 2018
Report of Activities 2017, Resident Geologist Program, Southern Ontario Regional Resident Geologist Report: Southeastern Ontario and Southwestern Ontario Districts, and Petroleum Operations	A.C. Tessier, P.S. LeBaron, S.J. Charbonneau, D.A. Laidlaw, A.C. Wilson and L. Fortner	Ontario Geological Survey, Open File Report 6341, 93p., 2018
Report of Activities 2017, Resident Geologist Program, Thunder Bay North Regional Resident Geologist Report: Thunder Bay North District	R.M. Cundari, G.F. Paju, S.L.K. Hinz, R.D. Tuomi and T.K. Pettigrew	Ontario Geological Survey, Open File Report 6337, 79p., 2018
Report of Activities 2017, Resident Geologist Program, Thunder Bay South Regional Resident Geologist Report: Thunder Bay South District	M.A. Puumala, D.A. Campbell, R.D. Tuomi, T.K. Pettigrew and S.L.K. Hinz	Ontario Geological Survey, Open File Report 6338, 101p., 2018

Title	Author(s)	Type and Year of Publication
Report of Activities 2017, Resident Geologist Program, Timmins Regional Resident Geologist Report: Timmins and Sault Ste. Marie Districts	E.H. van Hees, A. Pace, A. Bustard, T.S. Gomwe, P. Bousquet, C.M. Daniels, A.C. Wilson, L. Streit, P. Sword, C. Patterson and S.P. Fudge	Ontario Geological Survey, Open File Report 6339, 117p., 2018
Summary of Field Work and Other Activities, 2018	Ontario Geological Survey	Ontario Geological Survey, Open File Report 6350, 426p., 2018
Wollastonite Skarn Mineralization and Associated Plutonic Rocks in the Grenvillian Central Metasedimentary Belt, SE Ontario	T.A.L. Grammatikopoulos	PhD thesis, 775p., Queen's University, 1999
Zinc Exploration in the Grenville Province of South-Eastern Ontario	H. Brearton, E. Wynands, K.N. Elliott and P. Marty	Fourth Year Engineering Design Project Report, 159p., Queen's University, 2018

MINERAL DEPOSITS NOT BEING MINED

Tables 13 through 21 list currently inactive mineral deposits with identified resources and past-producing mineral occurrences.

Table 13. Historical production of gold – Southeastern Ontario District.

Mine	Township	Operating Years	Tons Milled	Ounces of Gold Produced	Grade (ounces gold /ton)
Big Dipper	Barrie	1907–1909	52	17	0.33
Cook	Marmora	1901–1904	1483	289	0.26
Cordova	Belmont	1892	120 670	22 774	0.19
Craig	Tudor	1905–1906	1850	248	0.13
Deloro	Marmora	1897–1902	39 143	10 360	0.26
Gatling 5 Acre	Marmora	1900–1903	6114	2353	0.38
Gilmour	Grimsthorpe	1909–1910	550	172	0.31
Golden Fleece	Kaladar	1919–1922	unknown	480	unknown
Ledyard	Belmont	1893–1894	55	13	0.24
Pearce	Marmora	1893–1908	239	302	1.26
Richardson	Madoc	1866–1868	unknown	75 – 100	0.408
Sophia	Madoc	1896–1901	1800	110	0.06
Sovereign	Marmora	1878 1892–1900	unknown 1962	970 370	unknown 0.19
Star of the East	Barrie	1905–1907	976	134	0.14
		Total	**174 894**	**38 592**	

Table 14. Historical production of copper, lead, zinc – Southeastern Ontario District.

Mine	Township	Operating	Tons Milled	Production
Kingdon	Fitzroy	1884–1885, 1914–1931	905 000	76 821409 pounds Pb concentrate; 857 312 pounds Zn concentrate; 60 074 072 pounds Pb recovered
Long Lake	Olden	1897–1925, 1973–1974	3442, not available	$41 550 ore value, 9467 tons Zn valued at $1 227 000
Eldorado Copper	Madoc	1906	not available	234 000 pounds Cu matte containing 230 ounces Au, 182 ounces Ag, 109 000 pounds Cu
Hollandia Lead	Madoc	1903–1906	not available	2 653 365 pounds Pb

Table 15. Historical production of fluorite – Southeastern Ontario District.

Mine	MDI Number	Township	Operating Years	Total Production (Tons)
Bailey	31C06NW00003	Madoc	1907, 1916, 1917, 1944–1950	25 000
Blakely	31C06NW00019	Huntingdon	1918–1920, 1928, 1941–1947	5026
Coe	31C06NW00008	Huntingdon	1941–1942	114
Dwyer	31E01SE00091	Cardiff	1918–1920, 1943, 1944	97
Herrington South	31C05NE00009	Huntingdon	1917	13
Howard, Fred Hill	31C06NW00014	Huntingdon	1918, 1920, 1929, 1940–1942, 1944	2500
Johnston	31C06NW00013	Huntingdon	1943, 1944–1947, 1949	187
Keene	31C06NW00004	Huntingdon	1918–1919, 1943, 1944, 1950	5000
Kilpatrick	31C06NW00005	Huntingdon	1944, 1953–1959	11 566
Lee Junior	31C05NE00008	Madoc	1917, 1940, 1943–1945	2000
Lee Senior	31C05NE00006	Madoc	1916–1918, 1942, 1943	1600
McIlroy	31C05NE00003	Madoc	1917–1918, 1923, 1944	540
Miller	31C05NE00005	Madoc	1917–1919	460
Noyes	31C06NW00011	Huntingdon	1917–1920, 1941–1943	25 000
Palmateer	31C06NW00016	Huntingdon	1942	44
Perry	31C06NW00009	Huntingdon	1915–1920, 1941–1943	8000
Perry Lake	31C06NW00007	Huntingdon	1910, 1913, 1915, 1917, 1952, 1960	4000
Ponton	31C05NE00004	Madoc	1929–1942	1500
Rogers	31C06NW00018	Huntingdon	1909–1914, 1943–1951	45 000
Rooks	31C12SE00003	Madoc	1916–1918	100
South Reynolds	31C06NW00010	Huntingdon	1917–1918, 1943	100
Wallbridge and Herrington	31C05NE00007	Madoc	1920–1922, 1941–1943	6600
William Reynolds	31C12SE00002	Madoc	1941–1942	88

Fluorspar, a commercial fluorite product, is used as a flux in the making of steel and ceramics, as a constituent in the electrolytic process of making aluminum and in the production of hydrofluoric acid (HF). During World War II, a Canadian Government assistance program in the form of loans and drill hole explorations stimulated development of the Madoc deposits (Guillet 1964).

Table 16. Historical production of iron – Southeastern Ontario District.

Mine	Township	Operating Years	Tons Milled	Grade (% Fe)
Calabogie	Bagot	1883–1901	10 000	26
Martel	Bagot	pre-1890	2000	58.71
Williams (Black Bay)	Bagot	1880–1890	25 000	51.89
Black Lake	Bedford	1882–1884	4000	40
Glendower	Bedford	1873–1895	50 000	50 – 60
Belmont (Ledyard)	Belmont	1899–1900, 1911–1913	8433	51.2
Blairton	Belmont	1820–1875	300 000	51.8
Playfair (Dalhousie)	Dalhousie	1866–1871	11 100	57.6
Radnor	Grattan	1901–1907	18 824	47.5
Eagle Lake (Blessington)	Hinchinbrooke	1887–1891	700	65.55
Tomahawk (Mag-Iron)	Lake	1947, 1950–1957	2096	50.9
Wilbur	Lavant	pre-1900, 1907–1908	146 892	56.69
Magnetawan	Lount	1910–1912	6000	59.55
Paxton	Lutterworth	pre-1910	1000	not available
Miller	Madoc	1899	6823	not available
Wallbridge	Madoc	1900–1901, 1919, 1921	3421	not available
Marmoraton	Marmora	1952–1978	28 000 000	40
Bessemer	Mayo	1902–1913	99 613	42.18
Childs	Mayo	1913	9649	38.7
McNab	McNab	1873–1874	15 000	68
Robertsville and Mary	Palmerston	1895, 1900–1901, 1918–1909	13 477	70.5
Fournier	South Sherbrooke	1873	600	60
Howland	Snowdon	1880–1882	1500	58
Victoria	Snowdon	1882	unknown	58.35
Dog Lake	Storrington	1899	600	51.12
St. Charles	Tudor	1900–1902	5186	57 – 60
Coe Hill	Wollaston	1884–1914	100 000	51.4
		Total	**28 841 914**	

Table 17. Past-producing magnetite mines – Southeastern Ontario District.

Deposit / Township	Mineral Deposit Inventory Number / Status	Description	Reference*
Belmont (Ledyard) Belmont Tp.	MDI31C12SW00004 (Past Prod. w Reserves)	Drilling from 1906 indicated 200 000 tons of concentrating ore	MRC 11, p.287
Bessemer Mayo Tp.	MDI31F04SE00012 (Past Prod. w Reserves)	Reserves estimated at 2 480 819 tons averaging 28.62% recoverable Fe from 4 deposits	MRC 11, p.167
Black Lake Bedford Tp.	MDI31C10SE00026 (Past Prod. w/o Reserves)	Disseminations and massive magnetite in exposed widths from 10 to 50 feet	MRC 11, p.134
Blairton Belmont Tp.	MDI31C05NW00026 (Past Prod. w Reserves)	1914 reserves calculated at 1 800 000 tons of 51.8% Fe and 0.5 million tons of 54.9% Fe	MRC 11, p.288
Bluff Point Bagot Tp.	MDI31F07SE00011 (Past Prod. w/o Reserves)	Two main magnetite-bearing zones, each about 500 feet long and 40 feet wide	MRC 11, p.313
Calabogie Bagot Tp.	MDI31F07SE00009 (Past Prod. w Reserves)	The deposit contains 27 200 000 tons of ore grading 22.28% Fe proven by diamond drilling, recoverable by open pit	MDC 20, p.67
Chaffey South Crosby Tp.	MDI31C09NW00011 (Past Prod. w Reserves)	Reserves estimated to a depth of 500 feet are 11 110 000 gross tons averaging 29.76% Fe	MRC 11, p.258
Childs Mayo Tp.	MDI31F04SE00013 (Past Prod. w Reserves)	Reserves estimated at 6 193 330 tons averaging 19.25% recoverable Fe	MRC 11, p.169
Coe Hill Wollaston Tp.	MDI31C13SW00010 (Past Prod. w Reserves)	Reserves estimated in 1914 at 600 000 tons averaging 51.4% Fe	MRC 11, p.177-178
Glendower Bedford Tp.	MDI31C10SE00022 (Past Prod. w/o Reserves)	Early drilling indicated massive and disseminated ore at a depth of 500 feet	MRC 11, p.135
Grattan (Radnor) Grattan Tp.	MDI31F06NE00017 (Past Prod. w Reserves)	Proven reserves of 3 639 600 tons to a vein depth of 363 feet and indicated reserves of 9 099 000 tons to a vertical depth of 600 feet, averaging 27.74% Fe	MDC 20, p.98
Howland Snowdon Tp.	MDI31D15SE00096 (Past Prod. w/o Reserves)	Magnetite in a zone 25 feet in diameter at surface and larger with depth	MRC 11, p.149
Marmoraton Marmora Tp.	MDI31C05NE-00014 (Past Prod. w Reserves)	27 966 762 tons of ore averaging 42.8% Fe produced	OFR 5515, p.322
Martel Bagot Tp.	MDI31F07SE00013 (Past Prod. w/o Reserves)	Magnetite body 20 feet thick, dipping 60° southeast	MRC 11, p.317
Matthews North Crosby Tp.	MDI31C09NW00009 (Past Prod. w Reserves)	Estimated reserves to depth of 400 to 500 feet are 33 727 000 gross tons averaging 25.08% Fe, which includes 11 861 000 gross tons averaging 31.36% Fe	MRC 11, p.257
Radenhurst and Caldwell Lavant Tp.	MDI31F02NE00012 (Past Prod. w Reserves)	Main zone with indicated tonnage of 6500 tons of ore per slope foot averaging 32.77% Fe. Three additional zones totalling 1600 feet in length, averaging 17.08%, 16.71% and 25.50% Fe	MRC 11, p.251
Rankin Mayo Tp.	MDI31F04SE00016 (Past Prod. w Reserves)	Reserves estimated at 15 691 599 tons containing 15.3% recoverable Fe	MRC 11, p.170
Robertsville Palmerston Tp.	MDI31C15NE00005 (Past Prod. w/o Reserves)	Two zones, Robertsville Mine is 700 feet long and 50 feet wide and the Mary Mine 900 feet to northwest	MRC 11, p.141
St. Charles Tudor Tp.	MDI31C13SE00014 (Past Prod. w/o Reserves)	Three main deposits within an area of approximately 13 500 square feet	MRC 11, p.176
Summit Lake (Tomclid) South Canonto Tp.	MDI31F02SW00032 (Past Prod. w Reserves)	Published reserves in 1993 estimated at 3 Mt averaging 40% Fe; reserve estimate has not been adjusted to reflect production from the deposit in late 1990s	MP 161, p.377
Tomahawk Lake Tp.	MDI31C12NW00002 (Past Prod. w Reserves)	Lenses and patches of magnetite occur over a strike length of approximately 1000 feet	MRC 11, p.155
Victoria Snowdon Tp.	MDI31D15SE00098 (Past Prod. w/o Reserves)	Deposit was worked from a trench 240 feet long and 16 feet wide	MRC 11, p.150
Wilbur Lavant Tp.	MDI31F02SE00009 (Past Prod. w/o Reserves)	Nine workings reported	MRC 11, p.252
Williams Bagot Tp.	MDI31F07SW00027 (Past Prod. w/o Reserves)	Two zones of magnetite, approximately 800 and 240 feet long, 20 feet wide	MRC 11, p.318
Yuill Darling Tp.	MDI31F02NE00009 (Past Prod. w/o Reserves)	Lens of high-grade magnetite, 30 m long and 9 m wide, mined to a depth of 21 m	MDC 20, p.92

***Sources:** "MDC 20" = Carter, Colvine and Meyn (1980); "MP 161" = LeBaron et al. (1993); "MRC 11" = Shklanka (1968); "OFR "5515" = Carter (1984).*
(Publication series Mineral Resources Circular (MRC) [No.1-14], then renamed to Mineral Deposit Circular (MDC) [No.15–].)

***Note:** The resource estimates listed in this table are historical figures and do not follow the required disclosure for reserves and resources as outlined in National Instrument 43-101.*

Table 18. Titanium, tantalum and REE occurrences (compiled from MDI database: Ontario Geological Survey 2018a) – Southeastern Ontario District.

Name	Township	MDI File #	Commodity	Deposit Status
Harrington, Marsh Ore Bed	Marmora	MDI31C05NE00135	Au, Fe, Ti	Occurrence
Green Island Rutile	Huntingdon	MDI31C06NW00088	Ti	Occurrence
Matthews, Newboro Lake	North Crosby	MDI31C09NW00009	Fe, Ti	Past Producer with Reserves
Chaffey	South Crosby	MDI31C09NW00011	Fe, Ti	Past Producer with Reserves
Tommy Lake	North Crosby	MDI31C09NW00131	Ti	Occurrence
Ricketts	Lake	MDI31C12NE00109	Fe, Ti	Occurrence
Orton	Tudor	MDI31C12NE00122	Fe, Ti	Past Producer w/o Reserves
Hastings Road Magnetite	Tudor	MDI31C12NE00185	Fe, Ti	Occurrence
Harold White, Twin Lake	Methuen	MDI31C12NW00114	Fe, Ti	Occurrence
Horse Lake, Tripp	Methuen	MDI31C12NW00127	Fe, Ti	Occurrence
Maloney	Marmora	MDI31C12SW00002	Cr, Cu, Fe, Ni, Ti	Past Producer w/o Reserves
Canadian Nickel	Methuen	MDI31C12SW00121	Ti	Occurrence
Ridgway	Marmora	MDI31C12SW00122	Cu, Fe, Ti	Occurrence
Jocko Lake	Limerick	MDI31C13NE00107	Fe, Ti	Occurrence
Umfraville	Wollaston	MDI31C13NW00057	Co, Fe, phosphate, Ti	Occurrence
Canning Lake	Minden	MDI31D15NE00052	Fe, Ti	Occurrence
Pine Lake	Glamorgan	MDI31D16NW00215	Fe, Ni, Ti, V	Occurrence
Basin, Silver Crater (Basin)	Faraday	MDI31E01SE00054	Mica, Mo, Nb, Th, U, Ti	Past Producer w/o Reserves
Allen Lake	Harcourt	MDI31E01SE00306	Fe, Ti	Occurrence
Gal–Wood	Sabine	MDI31E08NE00010	Gd, Nb, Ta, Ti, U	Occurrence
Woodcox	Monteagle	MDI31F04NW00020	Ce, feldspar, Nb, U, Ta, Th, Ti, zircon	Past Producer w/o Reserves
Macdonald Mine	Monteagle	MDI31F04NW00023	Cu, feldspar, Mo, Nb, REE, Th, Ti, U, zircon	Past Producer w/o Reserves
Opeongo	Sebastopol	MDI31F06NE00093	Ag, Ce, Nb, Ta, Th, Ti, U, Y, zircon	Occurrence
East Rockingham	Brudenell	MDI31F06NW00085	Au, Ti	Occurrence
South Lamberts	Griffith	MDI31F06SE00161	Ti	Occurrence
Horton Tp., Ottawa River	Horton	MDI31F10SE00019	Fe, Ti	Occurrence
Mahoney and Morin	Sabine	MDI31E08SE00002	Feldspar, Nb, REE, Ta, U	Past Producer w/o Reserves
Genesee No.2 South	Monteagle	MDI31F04NW00018	Feldspar, Nb, Si, Ta, Th, U	Past Producer with Reserves
Plunkett, Plunkett South	Monteagle	MDI31F04NW00019	Ce, feldspar, amethyst, Mo, Nb, Th, Ta, U	Past Producer w/o Reserves
Dubblestein	Bangor	MDI31F05SW00010	Nb, Ta, Th, U	Occurrence
Tooeys Lake, Tooley Lake	Brougham	MDI31F06SE00090	Nb, Ta, Th, U	Occurrence
Renfrew Minerals, Wal–Gem West Quarry	Lyndoch	MDI31F06SW00013	Be, feldspar, fluorite, Mo, Nb, REE, Si, Ta, Th, U, zircon	Producing Mine
Barr Feldspar Quarry, Woermke	Fraser	MDI31F14SW00003	Ce, feldspar, Nb, Ta, Th, U	Past Producer w/o Reserves
Quinn	Olden	MDI31C10NW00366	Cu, Ni, REE	Occurrence
Orser–Kraft	South Sherbrooke	MDI31C15SE00027	Feldspar, Nb, REE, Th, U	Past Producer w/o Reserves
Nobles Bay, Rogers, J.	North Burgess	MDI31C16SE00004	Mica, REE	Past Producer w/o Reserves
Maclaren, W.L.	North Burgess	MDI31C16SW00017	Mica, phosphate, REE	Past Producer w/o Reserves
Christie Lake	South Sherbrooke	MDI31C16SW00142	Magnetite, Nb, REE	Occurrence
Drude South	Cavendish	MDI31D09NW00079	REE, Th, U	Occurrence
Copper Anomaly	Lutterworth	MDI31D15SE00151	Cu, REE, Sr, zircon	Occurrence
Rare Earth Anomaly	Lutterworth	MDI31D15SE00152	Cu, REE, Sr, zircon	Occurrence
North Rare Earth Anomaly	Lutterworth	MDI31D15SE00153	Cu, REE, Sr, zircon	Occurrence
Laurencin, M.	Cardiff	MDI31D16NE00160	Mo, REE, Th, U	Occurrence
McLennan, J.G.	Peck	MDI31E07NE00006	Nb, REE	Occurrence
Malcovitch, P.	Clyde	MDI31E08NW00003	Ce, REE, U	Occurrence

Name	Township	MDI File #	Commodity	Deposit Status
Gole, J.G.	Murchison	MDI31E09SE00004	Feldspar, Nb, REE, Si, U, zircon	Past Producer w/o Reserves
Cameron and Aleck	Murchison	MDI31E09SE00005	Feldspar, Nb, REE	Past Producer w/o Reserves
D'Eldona, Yankee Dam	Butt	MDI31E11NE00070	Nb, REE, U	Occurrence
Plunkett North	Monteagle	MDI31F04NW00185	Feldspar, REE, U	Occurrence
Lake Clear	Sebastopol	MDI31F06NE00092	REE, Th, U	Occurrence
Price, E.C., Quadeville	Lyndoch	MDI31F06SW00014	Be, feldspar, fluorite, Nb, phosphate, REE, Si, Th, U, zircon	Producing Mine
Universal Light Metals	Lyndoch	MDI31F06SW00065	Be, Ce, Nb, REE, Th, U	Occurrence
Lake Property, Lake Mine	Dickens	MDI31F12SW00006	Feldspar, REE	Past Producer w/o Reserves

Note: *MDI database was queried for Ti, Ta and REE occurrences. This listing indicates the presence of the commodities, not necessarily their order of abundance. This list should be used as a preliminary guide only. Hard copies of the complete MDI files are located at RGP office in Tweed.*

Table 19. Uranium deposits not currently being mined in the Southeastern Ontario District in 2018.

Deposit Township	MDI Number	Commodity	Reserve	Reserve Reference
Zenmac Burleigh, Anstruther Tps.	MDI31D09NE-00033 (Developed Prospect w Reserves)	U, Th	Indicated and inferred reserves are estimated at 406 000 tons grading 1.77 pounds U_3O_8 per ton	OFR 5311, p.461
Pole Star Burleigh, Anstruther Tps.	MDI31D09NE-00042 (Prospect)	U	Estimated size and grade from diamond drilling is 370 000 t averaging 0.8 kg U_3O_8 or double using a lower grade of 0.6 kg/tonne	OFR 5635, p.199-200
Canadian Dyno Cardiff Tp.	MDI31D16NE-00032 (Past Prod. w Reserves)	U, Th	Reserves of possible ore were estimated at 500 000 tons grading 0.065% U_3O_8	OFR 5311, p.71-72
Bicroft (Centre Lake) Cardiff Tp.	MDI31D16NE-00043 (Past Prod. w Reserves)	U, Th	Estimated reserves above 1200-foot level: 559 000 tons grading 2.0 pounds U_3O_8 per ton before dilution (1960)	OFR 5311, p.66-67
Blue Rock Occurrence Monmouth Tp.	MDI31D16NE-00143 (Developed Prospect w Reserves)	U, REE	Reserves estimated at 292 444 tons at 0.095% U_3O_8 within 500 feet of shaft and to a depth of 600 feet; 56 720 tons at 0.120% U_3O_8 to a depth of 200 feet in the Lake zone	OFR 5311, p.132, 133
Empire B Zone Monmouth Tp.	MDI31D16NE-00146 (Developed Prospect w Reserves)	U, Th, F	Drilling has indicated reserves of 2 179 166 tons grading 0.726 pounds U_3O_8 per ton	OFR 5311, p.135
Kenmac Chibougamau Cardiff Tp.	MDI31D16NE-00165 (Prospect)	U, Th	Estimated reserves: 200 000 tons averaging 0.20% U_3O_8 (1955)	OFR 5311, p.101
Rare Earth #1 Monmouth Tp.	MDI31D16NW-00195 (Developed Prospect w Reserves)	REE, U, Th	Official estimated reserves 541 821 tons indicated averaging 0.116% U_3O_8 (1957)	MRC 4, p.26
Farcroft Anstruther Tp.	MDI31D16SE-00059 (Developed Prospect w/o Reserves)	U	not known	
Garland Anstruther Tp.	MDI31D16SW-00093 (Prospect)	U, Th	not known	
Cavendish Cavendish Tp.	MDI31D16SW-00099 (Prospect)	U, Th	Estimated reserves: 435 624 tons grading 0.096% U_3O_8 (chemical)	OFR 5311, p.476
Bicroft (Croft) Cardiff Tp.	MDI31E01SE-00224 (Prospect)	U	Estimated reserves in 3 zones: 979 810 tons grading 1.20 pounds U_3O_8 per ton	OFR 5311, p.84-85
Fission Cardiff Tp.	MDI31E01SE-00235 (Prospect)	U, Th, F	not known	
Baumhour–Campbell Faraday Tp.	MDI31E01SE0-0248 (Prospect)	U, Th	not known	
Mell–Quirke Monteagle Tp.	MDI31F04NE-00067 (Prospect)	U, Th	not known	
Greyhawk Mine Faraday Tp.	MDI31F04SW-00036 (Past Prod. w Reserves)	U, Th	Estimated reserves of 0.2 million tons grading 0.065% U_3O_8	MDC 23, p.62
Faraday/Madawaska Mine Faraday Tp.	MDI31F04SW-00037 (Past Prod. w Reserves)	U, Th	Proven and probable reserves of 1 023 086 tons at 0.145% U_3O_8 (1976)	MDC 23, p.60

Sources: *"MDC 23" = Masson and Gordon (1981); "MRC 4" = Hewitt (1967); "OFR 5311" = Gordon, Rybak and Robertson (1981); "OFR 5635" = Menard (1987).*
(Publication series Mineral Resources Circular (MRC) [No.1-14], then renamed to Mineral Deposit Circular (MDC) [No.15–].)

Note: *The resource estimates listed in this table are historical figures and do not follow the required disclosure for reserves and resources as outlined in National Instrument 43-101.*

Table 20. Mineral deposits not currently being mined in the Southeastern Ontario District in 2018. (Note: table does not include nepheline syenite, trap rock, REE and dimension-stone deposits.)

Abbreviations

AF ..... Assessment Files
AR ..... Annual Report
CAMH ..... *Canadian and American Mines Handbook*
CMH ..... *Canadian Mines Handbook*
GR ..... Geological Report
MDC.....Mineral Deposit Circular [No.15–]
[*formerly* Mineral Resources Circular, No.1-14]
MDI ..... Mineral Deposit Inventory
MLS ..... Mining Lands, Sudbury
MP ..... Miscellaneous Paper
NM ..... *The Northern Miner*
OFR ..... Open File Report
PC ..... Personal Communication
Status: A; E; I; M ..... Active; Exploration; Inactive, Mining

Deposit Township	MDI File Number	Status	Commodity	Reserves	Reserve Reference
Ore Chimney prospect Barrie Township	MDI31C14SE-00142 (SO 1130)	AE	Ag, Au, Zn, Pb	11 000 tons above the 500-foot level Averages: 0.2 oz per ton Au, 5.64 oz per ton Ag, 2.0% Zn, 1.0% Pb	MRC 12, p.132; MDC 18, p.33
Macassa Nickel Limerick Township	MDI31C13SE-00099 (SO 0595)	AE	Ni, Cu	2 000 000 tons @ 1.0% Ni, 0.25% Cu	MRC 12, p.138
Renfrew Zinc (Renprior) Admaston Township	MDI31F07NE-00063 (SO 0286)	AE	Zn	16 000 tons @ 10.5% Zn to a depth of 30 m; Breakwater Resources optioned the property to Noranda Mining and Exploration in 1996	MRC 12, p.226; MDC 20, p.17
Harvey Simon prospect Lyndoch Township	MDI31F03NW-00044 (SO 0259)	AE	Cu, Fe, Zn	250 000 tons @ 1.1% Cu to 350 feet	MRC 12, p.226; MDC 20, p.45
Clyde Forks deposit Lavant Township	MDI31F02SE-00064 (SO 0351)	I	Cu, Sb, Ag, Hg	60 000 tons @ 0.67% Cu, 0.37% Sb, 0.03% Hg, 1.32 oz per ton Ag	MDC 20, p.36
Twin Lakes Diorite Methuen Township	MDI31C12NW-00114 (SO 3840)	AE	Ti	13.2 Mt of 21.7% TiO_2, recoverable from open pit to a depth of 165 m, with rock:ore ratio = 0:54. Diorite wall rock is currently being mined by MRT Aggregates for trap rock	Kingston, MacKinnon and Caley (1990, p.99)
Grattan deposit Grattan Township	MDI31F06NE-00017 (SO 0270)	AE	Fe	Proven: 3 639 600 tons to a vein depth of 363 feet. Indicated: 9 099 000 tons to a vertical depth of 600 feet @ average grade of 27.74% Fe	MDC 20, p.98
Radenhurst–Caldwell deposit Lavant Township	MDI31F02NE-00012 (SO 0349)	I	Fe	Main lens 2000 feet long by 31.3 feet wide; contains 6500 tons per slope foot at a grade of 32.77% Fe; 3 additional zones totalling 1600 feet in length average 17%, 16.7% and 25.5% Fe	MDC 20, p.104
Bessemer deposit Mayo Township	MDI31F04SE-00012 (SO 0235)	AE	Fe	No.4 deposit 2 480 819 tons @ 28.62% recoverable Fe. In 2007–2008, deposit was evaluated as source of iron	MDC 20, p.110
Childs deposit Mayo Township	MDI31F04SE-00013 (SO 0236)	AE	Fe	6 193 330 tons @ 19.25% recoverable Fe. In 2007–2008, deposit was evaluated as source of iron	MDC 20, p.114
Calabogie Magnetite property / Algoma Ore Prop. Ltd. Bagot Township	MDI31F07SE-00009 (SO 0353)	AE	Fe	Reserves of 45 million tons @ 25% Fe to 500 feet and 28% Fe to 1000 feet	MRC 11, p.314
Buckhorn deposit Bagot Township	MDI31F07NE-00069 (SO 0362)	I	Mo	Largest of numerous small lenses contains 1500 tons @ 1% MoS_2	MDC 20, p.132
Bannockburn (Madoc Mining Company Ltd.) Madoc Township	MDI31C12NE-00195 (SO 7274)	A	Au	225 000 tons grading 0.267 ounce per ton Au	MP 161, p.377
Cooper Spruce Ridge Resources Ltd. Elzevir Township	MDI31C11SW-00044 (SO 2679)	I	Au, talc	3 Mt @ 30–33% recoverable talc and 40 000 t @ 8.0 g/t Au	OFR 5945, p.92; OFR 5808, p.79
Dingman deposit Marmora Township	MDI31C12SE-00040 (SO 3590)	AE	Au	11.6 Mt @ 0.97 g/t Au	OFR 6296, p.50-51
Hawley Ram Petroleum Limited Olden Township	MDI31C10NW-00117 (SO 4057)	I	Wollastonite	2.5 Mt @ 32% wollastonite to a vertical depth of 75 m	OFR 5943, p.337

Deposit Township	MDI File Number	Status	Commodity	Reserves	Reserve Reference
Marmora Gitennes Exploration Inc. Marmora Township	MDI31C12SE-00096 (SO 3729)	I	Wollastonite	450 000 t (open pit) @ 47% wollastonite, plus 680 000 t @ 39% wollastonite in a separate zone	OFR 5715, p.50
Trudeau C. Roger Young Hungerford Township	MDI31C11SW-00049 (SO 1192)	A	Calcite, dolomite	4 Mt high-purity dolomite; no reserve estimate available for the calcite zone	OFR 5958, p.11-11
Verona–Kirkham Stewart Lake Resources Inc. Bedford Township	MDI31C10SE-00023 (SO 1244)	A	Graphite	1.6 Mt grading 9.5% graphite in 2 separate zones	MDC 33, p.16
Cal Graphite Corp. Butt Township	MDI31E11NE-00004 (NO 129)	AE	Graphite	Reserves of 60 Mt grading 3% graphitic carbon – Ontario Graphite Ltd. development project 2011	MDC 33, p.10
Globe Graphite Mine North Elmsley Township	MDI31C16SE-00016 (SO 1604)	I	Graphite	500 000 t of approximately 7% graphite below mined out portion to the 300-foot level	MDC 33, p.25
Cordova Mine Belmont Township	MDI31C12SW-00005 (SO 1670)	AE	Gold	115 982 tons grading 0.21 ounces per ton Au	OFR 5808, p.43
Newboro prospect North and South Crosby townships	MDI31C09NW-00009 (SO 1466) MDI31C09NW-00011 (SO 1469)	I	Iron, titanium	45 Mt proven and probable averaging 26.24% Fe, 6.60% TiO_2	OFR 5515, p.316
Madawaska Mine Faraday Township	MDI31F04SW-00037 (SO 0223)	I	Uranium	Measured reserve of 385 193 short tons grading 0.143% U_3O_8, 1 098 283 pounds U_3O_8; indicated reserve of 450 988 short tons grading 0.158% U_3O_8, 1 427 195 pounds U_3O_8, total reserves of 836 181 short tons grading 0.151% U_3O_8, 2 525 478 pounds U_3O_8	OFR 5515, p.393
Addington Mine Kaladar Township	MDI31C11NE-00010 (SO 0882)	I	Gold	Total geological reserve of 758 000 tons grading 0.14 ounces per ton Au	OFR 5808, p.71

***Sources:** "MRC 11" = Shklanka (1968); "MRC 12" = Shklanka (1969); "MDC 18" = Gordon et al (1979); "MDC 20" = Carter, Colvine and Meyn (1980); "MDC 33" = MacKinnon and LeBaron (1992); "MP 161" = LeBaron et al. (1993); "OFR 5515" = Carter (1984); "OFR 5715" = MacKinnon (1990); "OFR 5808" = LeBaron (1991); "OFR 5943" = Kingston, Papertzian and Sangster (1996); "OFR 5945" = Rogers (1996); "OFR 5958" = Kingston and Papertzian (1997); "OFR 6296" = Sangster et al. (2014).*
(Publication series Mineral Resources Circular (MRC) [No.1-14], then renamed to Mineral Deposit Circular (MDC) [No.15–].)

***Note:** The resource estimates listed in this table are historical figures and do not follow the required disclosure for reserves and resources as outlined in National Instrument 43-101.*

Table 21. Mineral deposits not currently being mined in the Southwestern Ontario District in 2018.

Abbreviations

AF ..... Assessment Files
AR ..... Annual Report
CAMH ..... *Canadian and American Mines Handbook*
CMH ..... *Canadian Mines Handbook*
GR ..... Geological Report
IMR ..... Industrial Mineral Report
MDC ..... Mineral Deposit Circular [No.15–]
[*formerly* Mineral Resources Circular, No.1-14]
MDI ..... Mineral Deposit Inventory
MLS ..... Mining Lands, Sudbury
MR ..... Mining Recorder
NM ..... *The Northern Miner*
OFR ..... Open File Report
PC ..... Personal Communication
PRW ..... Petroleum Resources Well No.

Deposit Name / NTS	Commodity	Tonnage-Grade Estimates and/or Dimensions	Ownership References	Reserve References*	Status
Amherstburg Quarry silica prospect (40J/03SE)	Silica	20 m thick over 66 ha (20–26 $\times 10^6$ t @ 94% SiO_2)	Amherst Quarries (1969) Ltd.	OFR 5861, p.32 IMR 9, p.29, 31	Inactive
Big Creek 1 (40J/03SE)	Silica	19.5 m thick @ 25 m (10×10^6 t of sandstone)	N/A	IMR 9, p.29	Inactive
Big Creek 1 (40J/03SE)	Silica	14.6 m thick @ 34.4 m (10×10^6 t of sandstone)	N/A	IMR 9, p.29	Inactive
Dow–Moore 2-20-12 (40J/16NW)	Salt	21 m thick @ 698 m 73 m thick @ 582 m 114 m thick @ 410 m	N/A	PRW Dow–Moore 2-20-XII	Inactive
Eastnor–Lindsay prospect (41H/03SW)	Dolomite	60 $\times 10^6$ t dolomite @ <0.10% impurities (SiO_2+Fe_2O_3+Al_2O_3)	N/A	PRW OGS Lindsay 7-III W	Inactive
Imperial Oil No.560, Sombra 2-12-H, Gormlay No. 1 (40J/090NW)	Salt	32.2 m thick @ 612.6 m 84.1 m thick @ 490.7 m 46.9 m thick @ 388.6 m	N/A	PRW Sombra 2-12-H	Inactive
Imperial Oil No.597, Logierait No.1-Y-R, R.C. Fleck No. 2B (40J/16NW)	Salt	29.6 m thick @ 680 m 87.8 m thick @ 544 m	N/A	PRW Imperial Oil No. 597B	Inactive
Lindsay prospect (41H/03SW)	Dolomite	>35 $\times 10^6$ t dolomite @ <0.10% impurities (SiO_2+Fe_2O_3+Al_2O_3)	N/A	PRW OGS Lindsay 31-VIII W	Inactive
Patton Farm (40J/03SE)	Silica	5.4 m thick @ 10.1 m	N/A	IMR 9, p.29	Inactive
Sunburst GB #7 McGillivray 41-NB (40P/04NE)	Salt	88.7 m thick @ 363.6 m 5.8 m thick @ 339.5 m	N/A	PRW Sunburst GB #7	Inactive
Tobermory prospect (41H/04NE)	Dolomite	60 $\times 10^6$ t dolomite @ <0.10% impurities (SiO_2+Fe_2O_3+Al_2O_3)	N/A	PRW OGS St. Edmunds 47-III W	Inactive
Union Gas–Enniskillen No. 29, D.V.L.A. No. 1 (40J/16SW)	Salt	25.6 m thick @ 610.8 m 78.6 m thick @ 485.5 m	N/A	PRW Union Gas–Enniskillen No. 29	Inactive
Union Gas–Moore No. 12 P&I Williams No. 1 (40J/16SW)	Salt	26.2 m thick @ 577.3 m 70.7 m thick @ 456.6 m	N/A	PRW Union Gas-Moore No. 12 P&I Williams No. 1	Inactive
Union–Moore No. 22 (40J/16SW)	Salt	36 m thick @ 580 m 32 m thick @ 437 m	N/A	PRW Union Moore No. 22	Inactive

***Sources:** "IMR 9" = Hewitt (1963); "OFR 5861" = Russell (1993).*

***Note:** The resource estimates listed in this table are historical figures and do not follow the required disclosure for reserves and resources as outlined in National Instrument 43-101.*

REGIONAL LAND USE GEOLOGIST ACTIVITIES—SOUTHERN REGION

Land-Use Planning Activities

The southern Regional Land Use Geologist, based in Tweed, co-ordinates input into land-use planning activities in the Southern Ontario Resident Geologist District (southeastern Ontario and southwestern Ontario districts) and the part of the Sudbury District south of the French River, including Manitoulin Island and St. Joseph Island. The southern Regional Land Use Geologist position was staffed throughout 2018 by Deborah A. Laidlaw, *P.Geo.*

The boundaries of the Regional Land Use Geologists' regions are indicated on Figure 20.

Figure 20. Extent of the Regional Land Use Geologists' ("RLUG") areas of responsibility (red lines indicate the regional boundaries; grey lines indicate the municipal boundaries).

The objective of the position is to ensure that geoscience information is considered in policy and land-use planning decisions. The geoscience information relates to

- mineral-related values and economic opportunities
- natural geological and mining-related hazards
- renewable and non-renewable energy sources
- groundwater resources

Program activities that support this objective include helping develop, deliver and administer provincial policies, practices and procedures; and providing advice and guidance to municipalities, agencies and others involved in or affected by land-use planning regarding geoscience-related matters.

In 2018, the southern Regional Land Use Geologist dealt with a variety of land-use planning issues throughout the southern region. The following sections summarize the work that was done.

CROWN LANDS

The Ministry of Energy, Northern Development and Mines (ENDM) engages with the Ministry of Natural Resources and Forestry (MNRF) when Crown land-use planning activities have the potential to impact provincial mineral interests, or to expose those using Crown lands to natural geological or mining-related hazards. These activities relate to forest management planning; energy and other major infrastructure projects; proposals to modify existing parks or create new ones; and various other initiatives related to Crown land use.

Forest Management Planning

The forest management planning process involves consideration of a wide range of values, including mineral values, in the context of forestry activities, and the relevance of legislation other than the *Crown Forest Sustainability Act*, such as the *Mining Act*. The southern Regional Land Use Geologist provided input into the development of the following Forest Management Plans:

- Bancroft–Minden Forest Management Plan 2021–2031
- Mazinaw–Lanark Forest Management Plan 2021–2031
- Ottawa Valley Forest Management Plan 2021–2031

Approved Forest Management Plans, with detailed information about annual operations, including plans for creating new access routes or decommissioning existing routes, and maps showing forest access roads are posted on the MNRF Web site (www.efmp.lrc.gov.on.ca/eFMP/home.do).

Provincial Parks and Conservation Reserves

In 2018, the southern Regional Land Use Geologist responded to 1 request for comment on the development of a provincial park management plan. The Egan Chutes Preliminary Park Management Plan will address the protection of the park's unique natural and geological features, including provincially significant mineral assemblages.

MUNICIPAL AND PRIVATE LANDS

The Ministry of Energy, Northern Development and Mines supports municipal and private land-use planning through the One Window Planning Service, led by the Ministry of Municipal Affairs and Housing (MMAH). When requested, the southern Regional Land Use Geologist provides input into, and

reviews, draft Official Plans, Official Plan Amendments, draft plans of subdivision and consent (severance) applications to ensure that provincial mineral interests, natural geological hazards and mining-related hazards are appropriately considered in the planning process.

Municipal Planning

The Provincial Policy Statement (PPS), which guides municipal planning in Ontario, is issued under the provisions of the *Planning Act*. The PPS was last modified in 2014. The revision includes enhanced provisions to help ensure that municipal Official Plans recognize mining operations and areas with significant mineral potential, so that they can be protected from incompatible land uses.

As a participant in MMAH's One Window Planning Service for Official Plans and their amendments, the southern Regional Land Use Geologist provided comments, mineral values mapping and other input as required for Official Plans and Official Plan Amendments, including

- 20 consent (severance) applications in 14 lower-tier municipalities
- 21 Official Plans and related planning initiatives (such as zoning by-laws and subdivision approvals) in 16 communities
- 3 new draft Official Plans or Official Plan updates

The municipalities involved in these planning initiatives are listed in Table 22; their locations are shown in Figures 21 and 22.

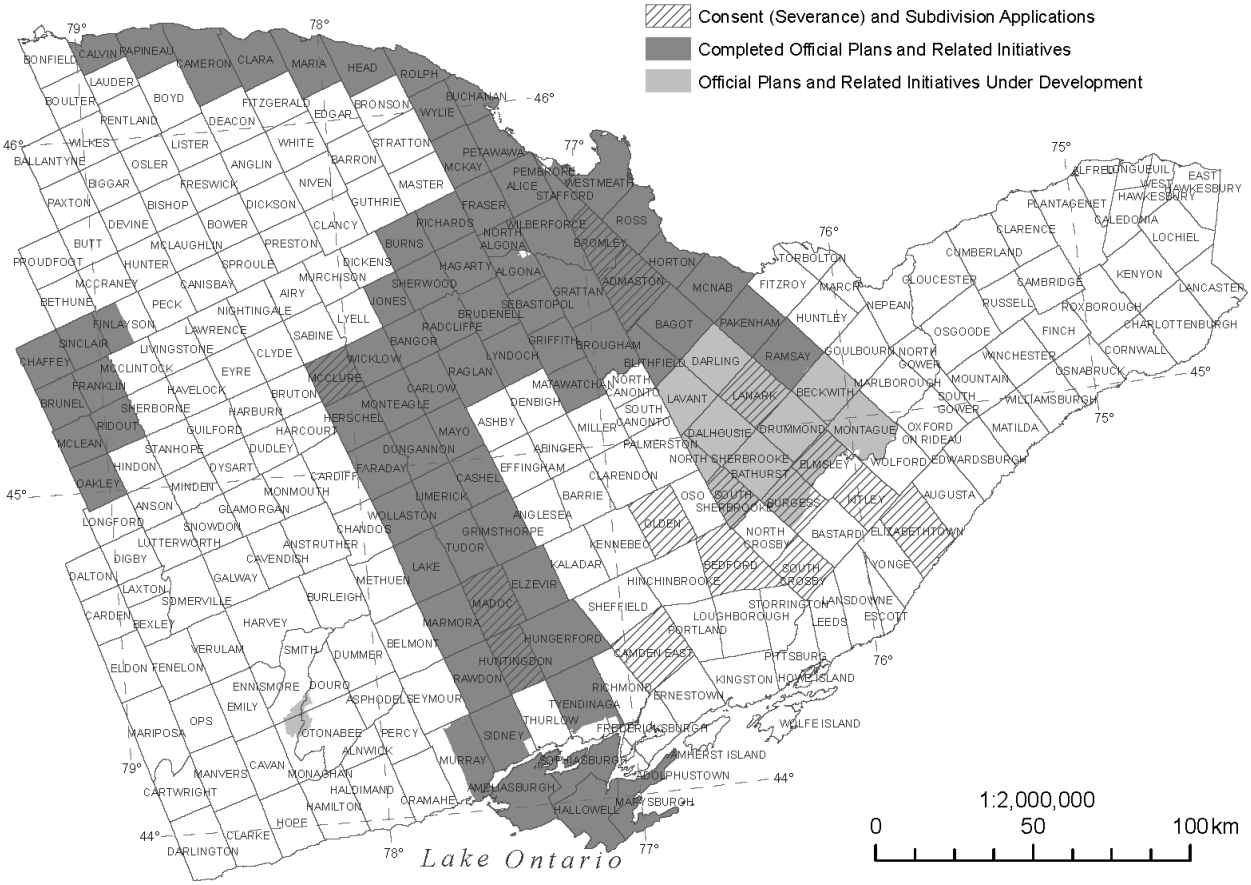

Figure 21. Planning initiatives with ENDM input, southeastern Ontario.

Table 22. Municipal planning initiatives with ENDM input, southern Ontario, 2018.

Consent (Severance) and Subdivision Applications
Consent, Admaston / Bromley, Township of
Consent, Bedford, Township of
Consent, Camden East, Township of (3)
Consent, Elizabethtown–Kitley, Township of
Consent, Huntingdon, Township of
Consent, Lanark, Township of
Consent, Madoc, Township of (2)
Consent, McClure, Township of
Consent, North Burgess, Township of (4)
Consent, North Elmsley, Township of
Consent, Olden, Township of
Consent, South Burgess, Township of
Consent, South Crosby, Township of
Consent, South Sherbrooke, Township of

Completed Official Plans and Related Initiatives
Armour, Township of
Carling, Township of
East Nipissing Planning Area
Grey, County of (3)
Hastings, County of (2)
King, Township of
Laurentian Valley, Township of
Middlesex, County of
Mississippi Mills, Municipality of
Muskoka, District Municipality of (2)
Norfolk, County of
Peel, Regional Municipality of (2)
Prince Edward, County of
Quinte West, City of
Renfrew, County of
South River, Village of

Official Plans and Related Initiatives Under Development
Barrie, City of
Lanark, County of
Peterborough, City of

Exemptions from Mining Tax

Section 189 (1) of the *Mining Act* allows owners of patented land to apply for exemption from paying mining tax. Key factors that are considered when applications are reviewed include whether or not the lands are being used for mining-related purposes, and whether or not there would be third-party interest in using the lands for mining-related purposes (e.g., the surrounding lands have registered mining claims and are being explored or the sites in question have provincially significant mineral potential).

During 2018, 5 such applications were reviewed for the southern region. Comments were provided to ENDM's Mining Lands Section to be consolidated with other information for the Ministry's consideration and decision.

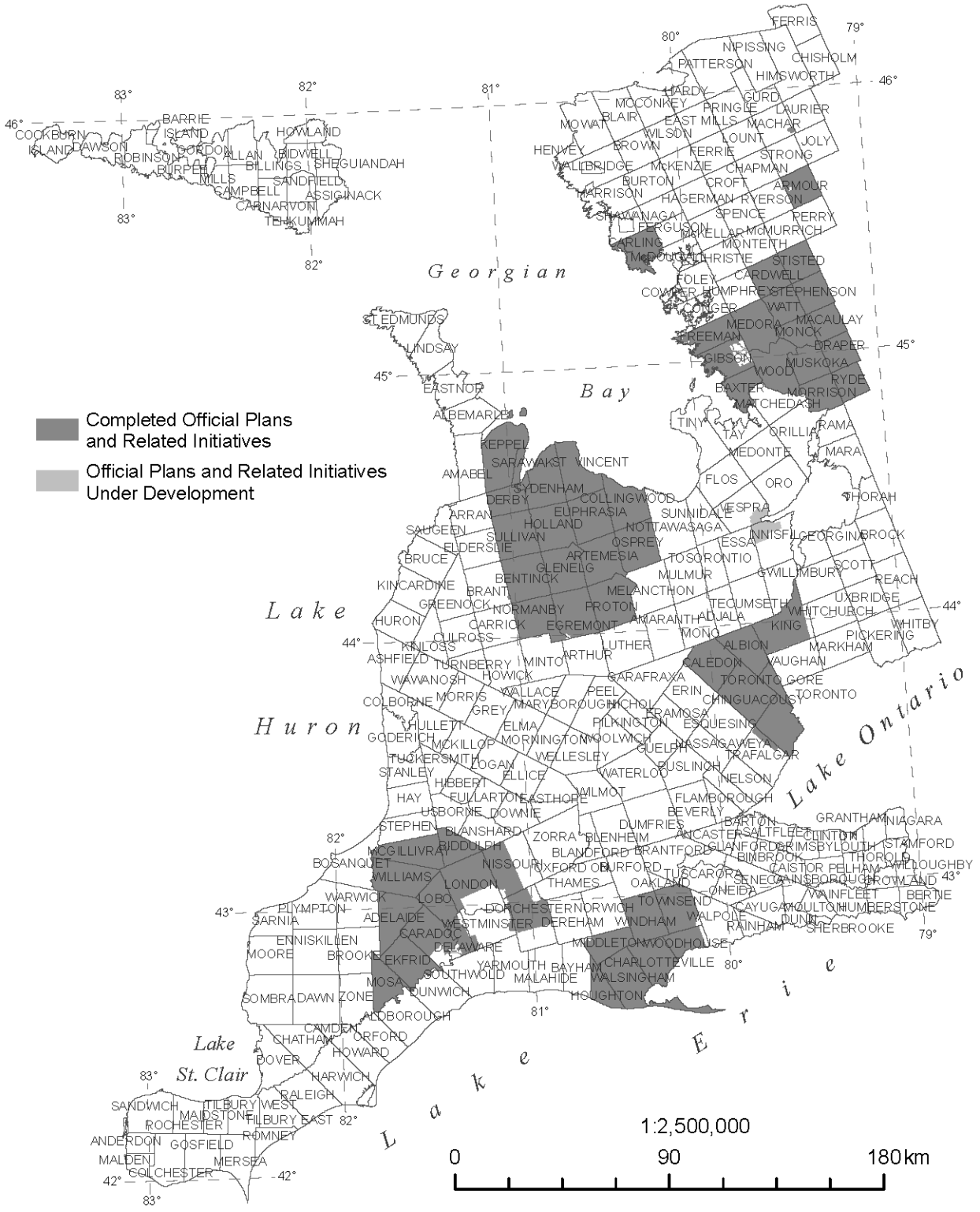

Figure 22. Planning initiatives with ENDM input, southwestern Ontario.

Other Activities

The southern Regional Land Use Geologist also undertook other related work in 2018, as outlined below.

GEOSCIENCE INTEGRATION PLAN

A goal of Ontario's Mineral Development Strategy (www.mndm.gov.on.ca/en/mines-and-minerals/mineral-development-strategy) is to develop geoscience policy options that would integrate geoscience information into government decision making and inform provincial land-use planning decisions related to the environment, ecology, climate change and public health and safety. A committee consisting of a core team with members from ENDM and an interministerial group with representatives from various provincial ministries was set up to help develop options, to consult with other Ontario Public Service (OPS) geoscientists and scientists for their input and perspective and to promote awareness that options for a geoscience integration plan are being prepared. Some options being considered are the development of a geoscience lens to promote and support the use of geoscience in decision-making processes and a Communities of Practice to improve communication and collaboration among geoscientists throughout government.

The southern Regional Land Use Geologist participated on the committee by attending teleconferences and providing input to geoscience-related initiatives.

INVESTMENT READY SITES

Ontario's "Investment Ready: Certified Site" program, operated by the Ministry of Economic Development, Job Creation and Trade promotes an inventory of sites that may be of interest to potential investors and purchasers. It prescreens the suitability of sites for development, and provides detailed information about the sites' access to utilities and transportation, and their environmental status. In 2018, the southern Regional Land Use Geologist provided information for 3 candidate sites for certification in southern Ontario.

CLASS ENVIRONMENTAL ASSESSMENTS

Class Environmental Assessments ("Class EAs") are documents that set out a standard environmental assessment process to evaluate the potential environmental effects of a project. There are currently 11 Class EAs in effect in Ontario (www.ontario.ca/page/class-environmental-assessments-approved-class-ea-information), relating to the development of new infrastructure, such as dams, transmission lines, pipelines, highway corridors, commuter rail stations and bus terminals, and sewer and water facilities; the establishment of new parks and conservation reserves; forest management plans; and Crown land dispositions.

The southern Regional Land Use Geologist worked with staff from MNRF and other ministries to ensure that relevant geoscience information and provincial mineral interests were identified and accommodated early in the planning process of projects subject to Class EAs. In 2018, feedback was provided for reviews of the following 4 Class EA projects within southern Ontario:

- 4-laning of a section of Highway 17 in Renfrew County and Nipissing District
- expansion of a landfill site in the Township of North Dundas
- construction of a natural gas pipeline to service the Georgian Sands planned subdivision in Simcoe County
- a proposal to acquire lands near Sarnia by Aamjiwnaang First Nation

CONFERENCES

The southern Regional Land Use Geologist engaged with clients at the Bancroft Gemboree. With approximately 5000 attendees each year, the Bancroft Gemboree is the largest gem and mineral show in Canada. It provides staff from the Resident Geologist Program with an opportunity to share information regarding the mineral sector with mineral collectors and the general public.

The southern Regional Land Use Geologist also attended the following workshops, presentations, field tours and symposia:

- Regional Scale Groundwater Geoscience Workshop in Guelph
- Ontario Stone Sand and Gravel Association Rehabilitation Presentation and Tour to the Niagara Region and
- Toronto Geological Discussion Group Mini-Symposium on New Technologies in Exploration.

MINERAL DEPOSIT COMPILATION GEOSCIENTIST—NORTHEASTERN ONTARIO

The Mineral Deposit Compilation Geoscientists (MDCG) investigate and document mineral deposits and occurrences across the province. Through field visits, comprehensive literature research and personal research, they work with regional and district Resident Geologist Program staff to ensure that the Mineral Deposit Inventory (MDI) database is regularly updated. Regular updates are required to ensure that the Ministry of Energy, Northern Development and Mines is using the most up-to-date information in making land-use planning and policy decisions. Records for certain areas are reviewed and updated in support of bedrock geology mapping and other field work conducted by the Earth Resources and Geoscience Mapping Section (ERGMS) of the Ontario Geological Survey. For 2018, A.C. Wilson was northeastern Ontario MDGC at the beginning of the year; P. Bousquet took on the acting position from September 17 to the end of year.

The MDI database is a dynamic compilation of over 19 100 records describing most of the known mineral occurrences in Ontario. It is an important reference tool for prospectors and geoscientists interested in exploring and acquiring mining properties in Ontario. When used in conjunction with other spatial databases generated by the Ontario Geological Survey, it provides an additional tool for making mineral discoveries in Ontario.

During 2018, complete township updates were compiled and entered for Raney, Dundonald, Lackner, Tedder, Johns, Strickland, Odlum, Hambleton, Matthews, Loveland and Byers townships. All townships are in the Timmins District. One record was updated in Lunkie Township, Sault Ste. Marie District.

The northeastern MDCG also provided MDI records compilation for land use planning decisions in the Timmins and Sault Ste. Marie Districts.

Total contributions to the MDI database, completed by the northeastern Ontario MDCG, in 2018, included 70 updates and 6 new records. A breakdown, by district, of the provincial records revised by the northeastern Ontario Mineral Deposit Compilation Geoscientist, is provided in Table 23.

Table 23. Mineral Deposit Inventory records revisions in northeastern Ontario in 2018.

Resident or District Office	Updates	Deletions	New
Kirkland Lake	0	0	0
Sault Ste. Marie	1	0	0
Southern Ontario	0	0	0
Sudbury	0	0	0
Timmins	69	0	6
Total	70	0	6

The publicly available version of the MDI database is updated monthly and is available from the OGS online data warehouse, GeologyOntario (www.ontario.ca/geology). The Mineral Deposit Inventory can also be viewed geographically using the OGSEarth application (www.ontario.ca/ogsearth), which helps users discover data through the Google Earth™ mapping service. The activity reports on mineral exploration, available using the OGSEarth application, includes monthly and year-to-date listings of the MDI records that have been updated.

ACKNOWLEDGMENTS

The authors would like to thank all producers, exploration companies, prospectors and developers who provided access to their operations or supplied information throughout 2018. Strong communication links between stakeholder groups and government ministries are essential for effective program delivery and, ultimately, to improve the delivery of government services.

ALLEN DUBBLESTEIN (1933–2018)

Allen Dubblestein of Maple Leaf, Ontario, was one of southern Ontario's most successful prospectors. Over a span of more than 40 years of prospecting, he discovered 2 marble properties that became producing quarries and staked several other prospects for marble, soapstone, rare earth elements and graphite, some of which were also optioned to mining companies for exploration and development. A millwright by trade, Allen installed and maintained machinery at many paper and rock processing mills, such as Domtar in Cornwall and the Omya calcium carbonate plant in Perth, where he was exposed to the utilization of minerals in various industrial applications and saw the value in prospecting for these important resources.

Allen regularly attended meetings of the Southern Ontario Prospectors Association with his wife, Doris, and frequently accompanied staff of the Southern Ontario Resident Geologist's Office on field visits to his properties, sharing his practical knowledge and experience. He was a valued member of the Ontario prospecting community.

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Ontario

Ontario Geological Survey
Resident Geologist Program

Petroleum Operations Section—2018

by

L. Fortner

2019

CONTENTS

Petroleum Operations Section—2018

Petroleum Operations Section—2018

L. Fortner[1]

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INTRODUCTION

In 2017, drilling frequency in Ontario licenced by the Petroleum Operations Section had achieved yet another historic low. In 2018, an uptick in the number of wells drilled included 3 oil and gas exploration wells.

Produced oil volumes in Ontario dropped 5.7% from 56 867 m^3 in 2016 to 53 623 m^3 in 2017. Audited and confirmed oil production volumes for 2018 were not available at the time this report was produced.

Produced natural gas volumes in Ontario dropped 11.9% from 155 310 374 m^3 in 2016 to 136 873 261 m^3 in 2017. Audited and confirmed gas production volumes for 2018 were not available at the time this report was produced.

The annual decline in oil and natural gas production in Ontario is directly related to reduced levels of drilling activity since 2004, such that there is insufficient new production to replace that from older existing wells. In turn, it is long-term pressure on oil and natural gas prices that has almost entirely eliminated new petroleum drilling in the province.

ACTIVITY

A total of 6 licences to drill new wells were issued by the Ministry of Natural Resources and Forestry in 2018. An additional 41 licences were issued in 2018 for plugging only, with 2 licences issued to operate or perform work on existing wells.

Drilling of new wells in Ontario had decreased to a low of 4 in 2017, but increased to 10 in 2018. This notable increase is primarily a result of a campaign to drill new natural gas storage wells, with 7 completions in 2018. However, included in the 10 new drills are 3 oil and gas exploration wells. There had only been 2 other exploration wells in total drilled from 2014 to 2017, inclusive. No new development wells were reported in 2018.

Cambrian Play

One of the exploration wells drilled in 2018 targeted Cambrian strata in the Municipality of Chatham–Kent. This was only the second well drilled to test the Cambrian in the province since 2013. Information on this new well remains confidential.

No development wells were drilled to the Cambrian again in 2018. There had been 1 development well drilled to this target in 2014, which had been the first since 2010.

Ordovician Play

There have been no exploration or development wells drilled to test the Ordovician interval since 2014.

Silurian Sandstone Play

No exploration wells have targeted Silurian sandstone units since 2011.

Unusually, there were no development wells drilled for Silurian sandstones in 2018. The 1 well in 2017 was completed as a private gas producer.

Silurian Carbonate Play

Until 2018, there had been no exploratory wells drilled for Silurian Guelph Formation reef and/or Salina Group targets since 2013. The one attempted in this past year occurred in Lambton County and has been plugged and abandoned.

There have still been no development wells drilled for this interval since 2013.

Devonian Play

One exploration well in 2018 was the first intended to test the Devonian play since 2013. It is located in Elgin County and was reported as plugged and abandoned.

No development wells were drilled for the Devonian interval in 2018, with the last occurring in 2014.

EXPLORATION TRENDS

The decade-long oversupply from the United States continues to weigh on North American natural gas prices and suppress interest in exploration and development activity in Ontario. The more recent oversupply of oil from United States shale development has also been contributing to pressure on prices and operator finances. However, it is possible that industry adjustments to moderate oil prices without recent extreme lows are providing some incentive to explore in the province again. It remains to be seen if the increase in activity in 2018 is the beginning of an upward trend.

Metric Conversion Table

Conversion from SI to Imperial			Conversion from Imperial to SI		
SI Unit	*Multiplied by*	*Gives*	*Imperial Unit*	*Multiplied by*	*Gives*
		LENGTH			
1 mm	0.039 37	inches	1 inch	**25.4**	mm
1 cm	0.393 70	inches	1 inch	**2.54**	cm
1 m	3.280 84	feet	1 foot	**0.304 8**	m
1 m	0.049 709	chains	1 chain	20.116 8	m
1 km	0.621 371	miles (statute)	1 mile (statute)	**1.609 344**	km
		AREA			
1 cm^2	0.155 0	square inches	1 square inch	**6.451 6**	cm^2
1 m^2	10.763 9	square feet	1 square foot	**0.092 903 04**	m^2
1 km^2	0.386 10	square miles	1 square mile	2.589 988	km^2
1 ha	2.471 054	acres	1 acre	0.404 685 6	ha
		VOLUME			
1 cm^3	0.061 023	cubic inches	1 cubic inch	**16.387 064**	cm^3
1 m^3	35.314 7	cubic feet	1 cubic foot	0.028 316 85	m^3
1 m^3	1.307 951	cubic yards	1 cubic yard	0.764 554 86	m^3
		CAPACITY			
1 L	1.759 755	pints	1 pint	0.568 261	L
1 L	0.879 877	quarts	1 quart	1.136 522	L
1 L	0.219 969	gallons	1 gallon	**4.546 090**	L
		MASS			
1 g	0.035 273 962	ounces (avdp)	1 ounce (avdp)	28.349 523	g
1 g	0.032 150 747	ounces (troy)	1 ounce (troy)	**31.103 476 8**	g
1 kg	2.204 622 6	pounds (avdp)	1 pound (avdp)	**0.453 592 37**	kg
1 kg	0.001 102 3	tons (short)	1 ton(short)	**907.184 74**	kg
1 t	1.102 311 3	tons (short)	1 ton (short)	**0.907 184 74**	t
1 kg	0.000 984 21	tons (long)	1 ton (long)	**1016.046 908 8**	kg
1 t	0.984 206 5	tons (long)	1 ton (long)	**1.016 046 9**	t
		CONCENTRATION			
1 g/t	0.029 166 6	ounce (troy) / ton (short)	1 ounce (troy) / ton (short)	34.285 714 2	g/t
1 g/t	0.583 333 33	pennyweights / ton (short)	1 pennyweight / ton (short)	1.714 285 7	g/t

OTHER USEFUL CONVERSION FACTORS

	Multiplied by	
1 ounce (troy) per ton (short)	31.103 477	grams per ton (short)
1 gram per ton (short)	0.032 151	ounces (troy) per ton (short)
1 ounce (troy) per ton (short)	20.0	pennyweights per ton (short)
1 pennyweight per ton (short)	0.05	ounces (troy) per ton (short)

*Note: Conversion factors in **bold** type are exact. The conversion factors have been taken from or have been derived from factors given in the* Metric Practice Guide for the Canadian Mining and Metallurgical Industries*, published by the Mining Association of Canada in co-operation with the Coal Association of Canada.*

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