ISSN 1916-6168 (online)
ISBN 978-1-4868-1665-1 (PDF)

ISSN 1484-9402 (print)
ISBN 978-1-4868-1664-4 (print)

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Tessier, A.C., LeBaron, P.S., Charbonneau, S.J., Laidlaw, D.A., Wilson, A.C. and Fortner, L. 2018. Report of Activities 2017, Resident Geologist Program, Southern Ontario Regional Resident Geologist Report: Southeastern Ontario and Southwestern Ontario Districts and Petroleum Operations; Ontario Geological Survey, Open File Report 6341, 93p.

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Ontario

Ontario Geological Survey
Open File Report 6341

Report of Activities, 2017
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2018

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ONTARIO GEOLOGICAL SURVEY

Open File Report 6341

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Southern Ontario Regional Resident Geologist Report:
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A.C. Tessier, P.S. LeBaron, S.J. Charbonneau, D.A. Laidlaw, A.C. Wilson
and L. Fortner

2018

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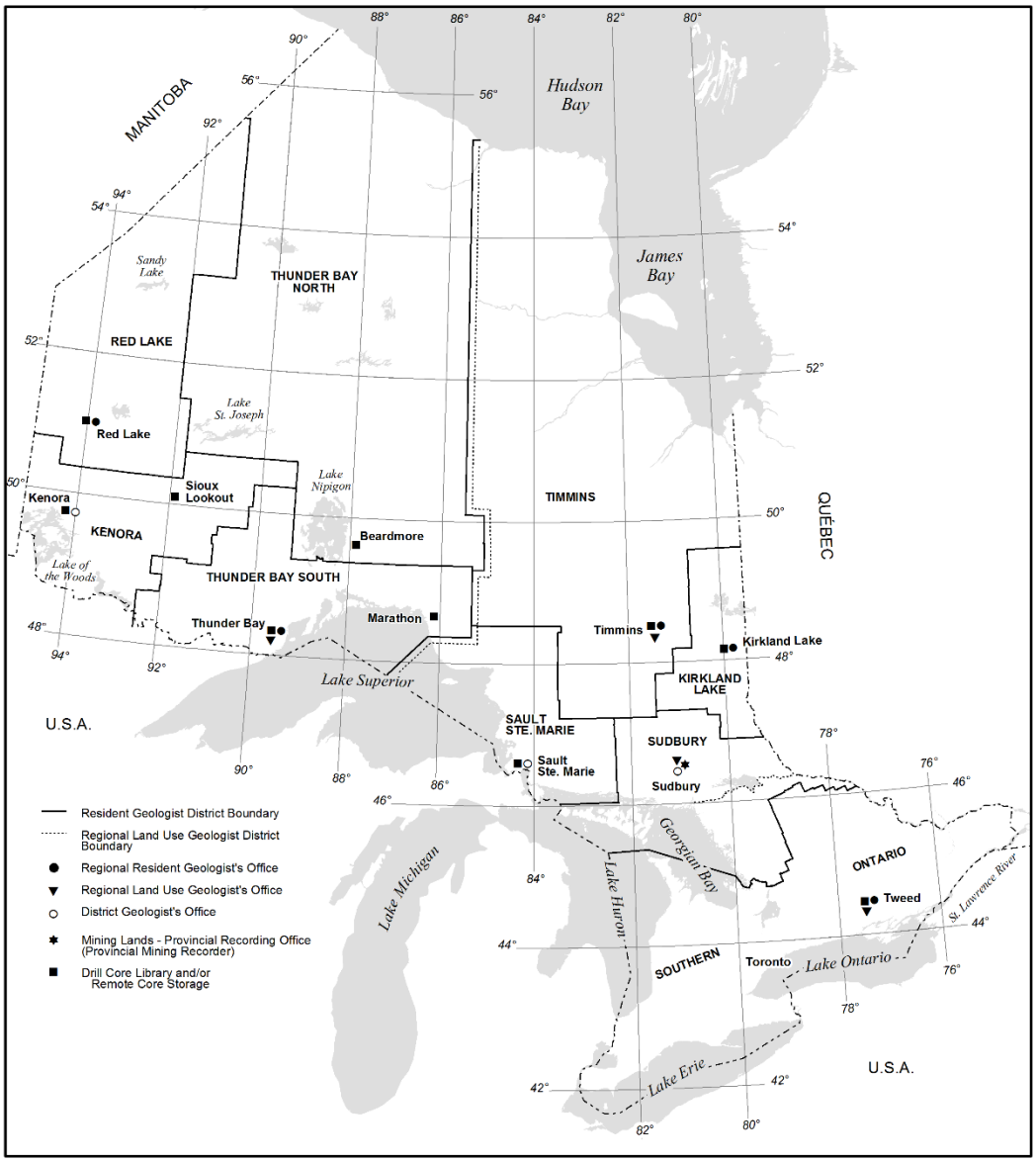
Parts of this report may be quoted if credit is given. It is recommended that reference be made in the following form:

Tessier, A.C., LeBaron, P.S., Charbonneau, S.J., Laidlaw, D.A., Wilson, A.C. and Fortner, L. 2018. Report of Activities 2017, Resident Geologist Program, Southern Ontario Regional Resident Geologist Report: Southeastern Ontario and Southwestern Ontario Districts and Petroleum Operations; Ontario Geological Survey, Open File Report 6341, 93p.



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ONTARIO GEOLOGICAL SURVEY

RESIDENT GEOLOGIST PROGRAM

REPORT OF ACTIVITIES—2017

SOUTHERN ONTARIO
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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, and includes both the provincial and national capitals. The region stretches over 800 km and is bordered by the Canada–US 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 striking 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 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.

In 2017, a total of 152 claims, covering approximately 12 614.54 ha, were recorded in Southern Ontario. Compared to the previous year, 3 fewer claims were recorded in 2017. The area covered by these 152 claims has decreased by 12% compared to the claims staked in 2016. Figure 3 shows the claim staking activity for southern Ontario in 2017. Claim staking in subdivided townships, in the Southern Ontario Mining Division followed a map-staking system introduced in 2011, whereas staking in unsurveyed townships was done by ground staking. Both map staking and ground staking ceased in Ontario on January 8, 2018 and are scheduled to be replaced by a province-wide online staking system on April 10, 2018, as part of Ontario's Mining Act Modernization.

Tables 9 through 17 provide details on currently inactive mineral deposits with identified resources and past-producing mineral occurrences. Please note that unless otherwise stated, the resources 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 2017, 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 2017, there were 104 mineral extraction operations in southern Ontario, including 9 industrial mineral operations, 3 trap rock producers (one of which also produces the raw material for mineral wool), 8 cement producer's quarries, 6 brick producer's quarries, 2 gemstone and mineral specimen sites, 66 dimension stone quarries and 10 specialty aggregate producers (for pavement, decorative and/or coloured, metallurgical flux, lime and high-density concrete). All of Ontario's production of salt, gypsum, natural gas and petroleum, shale (for brick), lime/dolime, cement, nepheline syenite, high-purity ground 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.

An estimated 5000 people were directly employed in mineral extraction and on-site processing plants in southern Ontario in 2017. These figures do not take into account the indirect jobs created by the mineral industry. In 2017, Ontario's non-metallic mineral production, excluding cement, 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 2017 were non-metallic minerals and most of this production came from southern Ontario mines and quarries. In 2017, approximately 25% of Ontario's total mineral wealth came from southern Ontario.

Wollastonite

CANADIAN WOLLASTONITE – ST. LAWRENCE DEPOSIT

Canadian Wollastonite (www.canadianwollastonite.com) is a privately held company incorporated in Ontario in 2001. The company owns just over 110 ha, 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.

To date, the wollastonite ore produced at the St. Lawrence Mine has been used in the metallurgical, agricultural and environmental sectors. As of 2017, wollastonite shipments destined for the metallurgical sector have increased by 30% every year and shipments of wollastonite and diopside product for the agricultural and horticultural sectors have increased 25% annually (B. Vasily, Canadian Wollastonite, personal communication, January 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 (Photo 1).
- In 2016, the mine's primary ancillary ore(orthogneiss) was approved for use as Class 1 and 2 railroad ballast.
- In 2016–2017, the company conducted research into the use of 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, 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, January 2018)

Canadian Wollastonite also plans to construct a beneficiation plant on its property to begin processing high-grade wollastonite and diopside products. A pilot plant is scheduled to start running at the end of the first quarter of 2018 to test the commercial scalability of the company's revised flow sheet. The revised process co-produces high-purity wollastonite and diopside products. (B. Vasily, Canadian Wollastonite, personal communication, January 2018).

Photo 1. Canadian Wollastonite soil amendment product. Photo by A.C. Tessier, July 2017 (Resident Geologist's Files, Southern Ontario Region, Tweed).

Nepheline Syenite

UNIMIN CANADA – NEPHTON AND BLUE MOUNTAIN MINES

Unimin Canada Ltd. (https://unimin.com and http://canadiannepheline.ca) is a subsidiary of privately owned, Belgium-based giant, Sibelco. Nepheline has been mined in the Havelock area for 80 years, with the Nephton Mine beginning in 1935 and Blue Mountain Mine in 1955. Unimin purchased the site in 1989 and has continued operations. 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, where 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).

On December 12, 2017, Unimin Corporation announced that it was merging with Fairmont Santrol, a company based in the United States, which is a leading provider of high-performance sand used by oil and gas exploration and production companies. The new company will be listed on the New York Stock Exchange. At the closing of the transaction, Fairmount Santrol's current shareholders will own 35% of the combined company, with Sibelco owning the remaining 65% (Unimin, news release, December 12, 2017, https://unimin.com/fairmount-santrol-merger).

At the end of 2017, Unimin received final approval for the expansion and modernization of the Blue Mountain operation (Photo 2). 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, https://unimin.com/modernization [accessed March 21, 2018]).

Photo 2. Panoramic view of Unimin's 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).

Construction is expected to start in January 2018 and 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, https://unimin.com/modernization/ [accessed March 21, 2018).

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 2017, the mine extracted approximately 1.3 million tons from the Nephton Mine, which translated into 624 618 t of nepheline syenite products. At current production rates, the mine reserves stand at 20 to 25 years, and the Inferred resources are estimated to last over 80 years (M. Clarkson, Unimin Canada Ltd., personal communication, January 2018).

The Blue Mountain Mine is the only nepheline syenite mine in North America. In fact, there are only 2 other nepheline syenite mines in the world, located in Russia and Norway.

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.

In 2017, Ontario produced an estimated 7.1 million tonnes (Mt) of salt valued at an estimated $276 million, down from $331 million in 2016. Salt remains one of the top 10 minerals produced in Ontario by value of production.

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 evaporation operations.

SIFTO CANADA CORP. – GODERICH MINE AND EVAPORATION PLANT

Sifto Canada Corporation (www.siftocanada.com) is a subsidiary of Compass Minerals International, Inc. (www.compassminerals.com), which trades on the New York Stock Exchange under the symbol CMP.

The Goderich 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 tons of salt per day. About 80% of production is used as road salt, shipped to hundreds of 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

softeners 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).

In 2017, the company was in its final year of a 3-year, $150 million project to re-line the mine shaft walls to the 600 m deep mine (*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. Sifto Canada employs 490 people at its Goderich facilities.

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 225 people; the brine evaporation plant employs another 95 people.

In July 2016, Windsor announced a $60 million expansion plan over the next 5 years, to deepen the mine another 400 feet and extend the mine life another 47 years to 2063 (K+S Windsor Salt, news release, July 25, 2016, www.windsorsalt.com/news).

In 2017, the Ojibway Mine produced approximately 2.5 Mt of salt. Another 200 000 to 250 000 t of salt were produced in 2017 at the Windsor evaporation plant, where reserves are estimated to last for over 20 years.

Gypsum

CGC INC. – HAGERSVILLE MINE

CGC Inc. is a subsidiary of United States–based USG Corporation, which trades on the New York Stock Exchange under the symbol USG. CGC Inc. is a leading marketer, manufacturer and distributor of gypsum wallboard products, interior finishing materials and suspended acoustical ceilings in Canada.

CGC Inc. (www.usg.com) is mining approximately 200 000 t of gypsum per year at their mine in Hagersville, where production started in the early 1930's 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 44 full-time workers.

Brick and Shale

In 2017, 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 2017 is estimated at $135 million, up from $128 million in 2016 (S. Jessome, MNDM, personal communication, 2018).

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. About 415 million units (approximately 16% of the company's total production) comes from the Ontario operations, which employ a total of 164 people.

The company extracts about 250 000 t of shale per year, the bulk of which is obtained from the Aldershot quarry. At current extraction rates, reserves are sufficient for another 25 to 30 years of production (Meridian Brick, http://aldershotquarry.ca/aboutus/meridian-brick/, "Aldershot Quarry Report, Issue 1, Spring 2017" [accessed January 18, 2018]).

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 2017 grew by 13% to $119.7 million, from $106.3 million for the same period in 2016. The increase represents strong demand in both the masonry products and landscape products business segments in Canada and the United States (Brampton Brick Limited, www.bramptonbrick.com, 2017 Third Quarter Report [accessed January 18, 2018]).

The increase in brick production required an increase in production from the company's shale quarry at Cheltenham (Photo 3). About 540 000 t of Queenston Formation shale were extracted in 2017.

Photo 3. The Cheltenham Quarry of Brampton Brick Ltd. 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).

In 2017, the company continued to appeal a decision by the City of Brampton to deny an application by Brampton Brick for re-zoning in order to open a shale quarry at Norval, about 10 km west of Brampton. 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 and proposed to create an excavation area of 9.35 ha. The proposed extraction rate was 200 000 t per year and total yield was projected to be 5.8 Mt. In addition to providing security of shale supply for the Brampton plant, the Norval shale contains lower amounts of chlorides and sulphates than the Cheltenham shale. The company proposes to blend the 2 shales to produce a new product line of buff-burning bricks. The Municipality of Brampton denied the re-zoning application in 2014 (City of Brampton, "Norval Quarry Re-Zoning Application", www.brampton.ca [accessed February 16, 2018]). 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, September 28, 2017, Minutes, www.peelregion.ca [accessed February 16, 2018]). The final hearing with the Ontario Municipal Board to determine whether the quarry will be approved is scheduled for September 28, 2018.

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 quarry near Georgetown (http://www.jazbrick.com).

Cement

There are 7 quarries and 6 modern processing plants in southern Ontario between Kingston in the southeast and St. Marys in the southwest. With the exception of Federal White Cement, which purchases its limestone from nearby quarries, all plants are also operating quarries on site. In 2016, the last year Natural Resources Canada compiled production statistics in Canada, cement production in southern Ontario was 5.4 Mt, valued at $645 million. Because demand continues to grow in Ontario and in the United States for construction materials, it is believed that production increased in 2017 and will continue to increase until at least 2020 (Petrus Group 2016).

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.

Cement demand in Ontario has grown at an annual average rate of 0.5% from 2000 to 2015 and is forecasted to grow at an annual rate of 3.4% to 2020. The growth is expected to be driven by an increase in non-residential construction spending and exports to the US (Petrus Group 2016).

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 2017, the company continued to evaluate the potential of underground mining of high-quality aggregates from beneath the Bowmanville quarry and the bed of Lake Ontario. The first stage of an environmental assessment has been completed and the company is continuing to test the quality of the aggregate resource at the proposed site. Construction of the new underground operation is not expected to begin for about 8 to 12 years (St. Marys Cement Inc., "Bowmanville Expansion Project", presentation at the Port Darlington Community Meeting, May 24, 2017, 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 LHN. 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 an increase in Canadian sales of cement, aggregates and ready-mix concrete in the first 3 months of 2017 and forecasts an additional 5% growth in earnings in 2018 (LafargeHolcim, www.lafargeholcim.com, Third Quarter 2017 Interim Report [accessed January 24, 2018]).

Lafarge and its 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 Canada Group Inc. 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 (Photo 4). 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).

Photo 4. Lehigh Cement Company port facility on the Bay of Quinte, Lake Ontario. Photo by A.C. Tessier, May 2017 (Resident Geologist's Files, Southern Ontario Region, Tweed).

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 purchased from local quarries. The plant employs about 50 people.

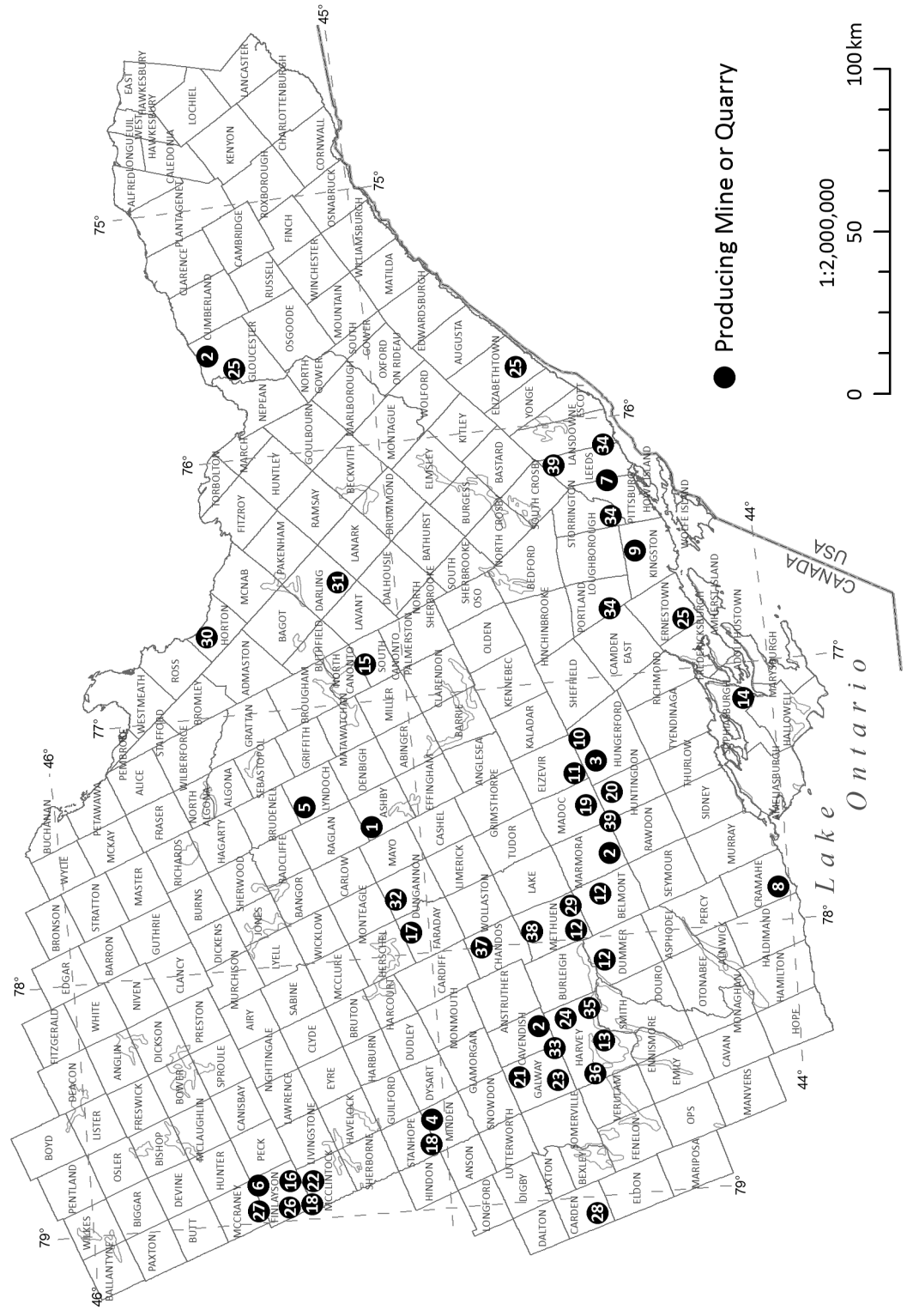

Figure 1. Mining activity in the Southeastern Ontario District in 2017 (keyed to Table 1).

Table 1. Mining activity in the Southeastern Ontario District in 2017 (keyed to Figure 1).

No.	Company/Individual (Mine or Quarry Name)	Township(s) (Main Commodity)	Mining Activity
1	2065342 Ontario Ltd. (Simpson Lake Quarry)	Ashby (Specialty aggregate)	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 (Specialty aggregate), Marmora, (Specialty aggregate), Cavendish (Dimension stone)	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	A. Marmaro and Terrazzo Olympic, LLC (Tweed Marble Quarry)	Hungerford (Dimension stone)	Tweed Marble Quarry was purchased in 2013. The quarry is currently under care and maintenance, but blocks are sold for sculpting.
4	Attia Quarries	Minden (Dimension stone)	Granite is quarried for use as landscaping, dimension, flag and masonry stone.
5	Aqua Rose Gems and Minerals (Beryl Pit / Rose Quartz Pit)	Lyndoch (Gemstones and 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.
6	Boothby Quarry	Finlayson (Dimension Stone)	Granite gneiss is quarried for flagstone and landscape stone.
7	Canadian Wollastonite (St. Lawrence Mine)	Pittsburgh, Leeds, Lansdowne (Industrial mineral - wollastonite)	Wollastonite skarn rock is produced and marketed as an agricultural soil additive, metallurgical purposes in steel and phosphate and heavy metal sequestration in tertiary water systems. Orthogneiss is also being quarried and used in Superpave™ aggregate and Class I and II railway ballast.
8	CRH Canada Group Inc. (Ogden Point Quarry)	Cramahe (Cement, limestone)	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.
9	Cruickshank Construction Limited	Kingston (12 quarries) (Dimension stone)	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.
10	Danford Construction Ltd. (Tweed Quarry)	Elzevir, Hungerford (Specialty Aggregate)	Granite-gneiss is extracted, crushed and approved for use in Superpave™ aggregates.
11	Danford Granite Ltd. (Bridgewater Trap Rock Mine)	Elzevir (Industrial mineral - mineral wool)	In 2017, 60 000 t of crushed basalt/gabbro were shipped and approved for mineral wool manufacturing by Roxul Inc., Milton. In 2017, Danford submitted plans to expand quarry production in 2018. Metabasalt is also quarried as trap rock for use as railway ballast.
12	Drain Bros. Excavating Ltd. (Havelock Quarry)	Belmont (Trap rock) Dummer (Specialty aggregate) Methuen (Specialty aggregate)	Basalt is extracted for use as trap rock from the Havelock Quarry in Belmont Township. The company also produces aggregate from limestone and granite in Dummer and Methuen townships, respectively. Some production also goes to the manufacturing of mineral wool. A dimension stone processing plant was constructed at the quarry site in 2017 and will be in full operation in 2018.
13	Dufferin Aggregates	Harvey (Dimension stone)	Grey limestone is extracted for use as armour stone, landscaping stone and crushed stone.
14	Lehigh Cement Company (Picton Quarry)	Sophiasburgh (Cement, limestone)	A cement plant and on-site limestone quarry with an annual production of slightly less than 1 000 000 tons. One of the largest cement plant in North America and employs 130 people. Subsidiary of Heidelberg Cement Group.
15	Ferromin Inc. (Tomclid Iron Mine)	South Canonto (Specialty aggregate - magnetite)	Magnetite is mined and crushed as high-density aggregate for use in heavy concrete applications, including radiation shielding.
16	Fraser Quarry	Finlayson (Dimension stone)	Predominantly pink gneiss is extracted for landscaping and other decorative applications.
17	Graf Quarry	Faraday (Dimension stone)	A variety of landscape and dimension stone is extracted from a quarry of calcitic marble breccia formerly held by Senator Stone and marketed as “Temagami Pink”.
18	Haliburton Stone Works	McClintock, Minden (Dimension stone)	A variety of granite, dolomite and limestone dimensional and landscape stones produced from 2 quarries.

No.	Company/Individual (Mine or Quarry Name)	Township(s) (Main Commodity)	Mining Activity
19	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.
20	JC Rock (Crookston Quarry)	Huntingdon (Dimension stone)	Historical producer, operates on demand; in 2010, limestone dimension stone was removed for restoration project, Belleville.
21	Jeff Parnell Contracting Limited	Galway (Dimension stone)	Limestone is sold as natural and dimension-cut armour stone, rockery stone, garden stone, natural surface steps and natural and dimensional flagstone.
22	John Bacher Construction Limited	McClintock (Dimension stone)	Granite and granitic gneiss is sold as building stone, flagging stone and landscaping stone.
23	Johnston Quarry	Galway (Dimension stone)	Gull River Formation limestone is removed for use as landscaping stone, flagstone and building stone.
24	Kawartha Rock Quarry Inc.	Harvey (Dimension stone)	Limestone is quarried to produce armour stone and flagstone.
25	Lafarge Canada Inc. (Bath, Brockville, Bearbrook and Hawthorne Quarries)	Ernestown (Cement, limestone) Pittsburgh (Cement, sandstone) Elizabethtown (Specialty aggregate) Gloucester (Specialty aggregate)	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. Four quarries in total.
26	McDonald Quarry	Finlayson (Dimension stone)	Gneiss is sold as flagstone, building stone and armour stone.
27	McFadyen's Stone Quarry	Finlayson (Dimension stone)	Gneiss is sold as flagstone, building stone, armour stone, guillotine cut ashlar, sawn thinstone veneer and custom guillotine, hearths and pier caps.
28	Miller Paving Ltd.	Carden (Dimension stone)	This quarry east of Brechin produces grey limestone for use as aggregate, architectural stone, landscaping/armour stone, asphalt limestone, crushed limestone and manufactured sand.
29	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.
30	Nesbitt Aggregates	Horton (Dimension stone)	Granite riverstone is quarried, sorted and split for use as flagstone, fieldstone, landscaping and masonry stone. The majority of production is exported to the United States.
31	OMYA (Canada) Inc. (Tatlock Quarry)	Darling (Industrial mineral - calcium carbonate)	Calcitic marble is mined to produce high-purity, fine-grind calcite for fillers with terrazzo chips and landscaping stone as secondary products. Annual production capacity is 250 000 tons and quarry reserves currently stand at over 5 000 000 tons.
32	Princess Sodalite Mine	Dungannon (Dimension stone)	Sodalite is sold as decorative stone, landscaping stone, mineral specimens, including fee for collecting.
33	Redstone Quarries	Galway, Harvey, Cavendish (Dimension stone)	Beige limestone and red sandstone are quarried for weathered landscaping stone and armour stone blocks.
34	Rideauview Contracts Ltd. (Ellisville, McCallum, Petworth, Rideauview, Sloan and Battersea quarries)	Rear of Leeds & Lansdowne, Storrington, Portland (Dimension stone)	Sandstone is produced for flagstone, granite blocks and masonry stone from the Ellisville Quarry in Rear of Leeds & 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. Six quarries in total.
35	Rigbe's Quarry	Harvey (Dimension stone)	Buff limestone is removed for use as weathered armoury and rockery, crushed aggregates and landscape stone.

No.	Company/Individual (Mine or Quarry Name)	Township(s) (Main Commodity)	Mining Activity
36	Stonescape Quarry	Harvey (Dimension stone)	Limestone flagstone and ledgerock are quarried north of Buckhorn.
37	T. Pluard (Elite Blue)	Chandos (Dimension stone)	A blue grey metasedimentary rock is extracted for a variety of uses, including armour stone, landscaping stone and dimension stone.
38	Unimin Canada Ltd. (Blue Mountain Quarry)	Methuen (Industrial mineral - nepheline syenite)	Nepheline syenite is mined from an open pit and processed in 2 mills at Nephton and Blue Mountain, respectively. In 2017, the company announced plans to close the Nephton plant and modernize the Blue Mountain facilities. Magnetite is produced as a by-product. Production rate is 2500 tons per day. The Nephton and Blue Mountain mines opened in 1935 and 1955, respectively. Unimin employs 200 people at the site.
39	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 & Lansdowne (Dimension stone)	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 & Lansdowne Township, red granite is produced for precast concrete panels, pavers, split block, spun concrete poles and landscaping. Eight quarries in total.

Table 2. Producing mines and quarries in the Southwestern Ontario District* in 2017 (keyed to Figure 2).

No.	Company/Individual (Mine or Quarry Name)	Township(s) (Main Commodity)	Mining Activity
1	A & A Natural Stone Ltd. (A & A Quarry)	Keppel (Dimension stone)	Grey dolostone is produced for use as flagstone, landscape stone and specialty aggregate.
2	Arriscraft International Inc. (Adair Marble Quarries)	Albemarle (Dimension stone)	Dolostone is produced for use as architectural stone.
3	Attia Quarries (Rama and Seabright quarries)	Rama (Dimension stone)	Stone is quarried for use as landscaping, dimension, flag and masonry stone.
4	Block and Stone Resource Group Inc.	Amabel (Dimension stone)	Dolostone is quarried for use as dimension stone.
5	Brampton Brick Ltd. (Cheltenham and Hungry Hollow North quarries)	Chinguacousy, Williams (Shale for brick)	Queenston Formation shale is extracted from the 2 quarries for use in the company's brick plant.
6	Bruce Peninsula Stone Ltd. (Lindsay, Wiarton and Mar quarries)	Lindsay, Amabel, Albemarle (Dimension stone)	Dolostone is produced from the 3 quarries for landscaping and building stone products.
7	Carmeuse Lime Canada Ltd. (Beachville Quarry)	Zorra (Cement, Lime)	Limestone is extracted, crushed and processed in on-site lime plant.
8	CGC Inc. (Hagersville Mine)	Oneida (Industrial mineral - gypsum)	An on-site wallboard plant utilizes gypsum from the mine. The mine produces approximately 200 000 t / year. CGC employs 44 people at the site.
9	Compass Minerals International, Inc. (Goderich Mine and brine fields)	Goderich (Industrial mineral - salt)	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 (Dimension stone)	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)	Toronto (Cement, 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. CRH employs 200 people at the site.
12	Cut Above Natural Stone (Cut Above Natural Stone Quarry)	Rama (Dimension stone)	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 (Dimension stone)	Dolostone is produced for use as armour, landscaping and crushed stone.
14	E.C. King Contracting Ltd. (Sydenham Quarry)	Sydenham (Specialty aggregate)	High-purity dolostone is crushed for construction aggregate and agricultural lime.

No.	Company/Individual (Mine or Quarry Name)	Township(s) (Main Commodity)	Mining Activity
15	Ebel Quarries Inc. (Ebel and Arnold Property quarries)	Amabel (Dimension stone)	Light and dark brown and black dolostone is produced for use as flagstone, landscaping stone, slabs, steps and wallstone.
16	Fowler Construction Company Ltd (Fleming Quarry)	Rama (Dimension stone)	Granitic gneiss is quarried for use as flagstone, building, landscaping, masonry and crushed stone.
17	Georgian Bay Marble and Stone (Cook Quarry)	Amabel (Dimension stone)	Dolostone is produced for use as landscaping stone, steps and building stone.
18	Hilltop Stone and Supply Inc. (Hilltop Quarry)	Esquesing (Dimension stone)	Grey and buff sandstone is quarried for use as flagstone, masonry stone and dimension stone.
19	Hope Bay Quarry Inc.	Albemarle (Dimension stone)	Dolostone is produced for use as flagstone, aggregate and armour stone.
20	Jazbrick (Georgetown Quarry)	Esquesing (Shale for brick)	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 (Specialty aggregate)	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 (Dimension Stone)	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 for brick)	Queenston Formation shale is extracted from the 3 quarries 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 (Dimension stone)	Dolostone is produced from the 3 quarries for use as custom-cut and architectural cut stone, masonry, ledgerock wallstone, marble tiles and slabs and landscape stone.
25	Rice & McHarg Ltd. (Rice and McHarg Quarry)	Esquesing (Dimension stone)	Grey and buff sandstone is produced for use as flagstone, masonry and landscaping stone.
26	Rockleith Quarry Ltd. (Rockleith Quarry)	Orillia (Dimension stone)	Beige, tan and blue-gold limestone and dolomitic limestone is produced for use as dimensional building stone.
27	Speiran Quarries Ltd. (Speiran Quarry)	Rama (Dimension stone)	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 (Cement, limestone)	Limestone is quarried and processed at cement plant complexes in Bowmanville and St. Marys.
29	The Canadian Salt Company Ltd. (Ojibway Mine and brinefields)	Sandwich (Industrial mineral - salt)	Underground workings are adjacent to international border. The company also produces salt from an adjacent brine field operation. In 2017, the company continued a multi-year, $60 million investment in the mine and brine fields, expected to extend the mine life to 2063.
30	Wiarton Stone Quarry Inc. (Wiarton Stone Quarry)	Amabel (Dimension stone)	Light brown, grey-beige and black dolostone is quarried for use as flagstone, steps, waterfall stone, 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 2017, please refer to the report of the Petroleum Operations Section (this volume).*

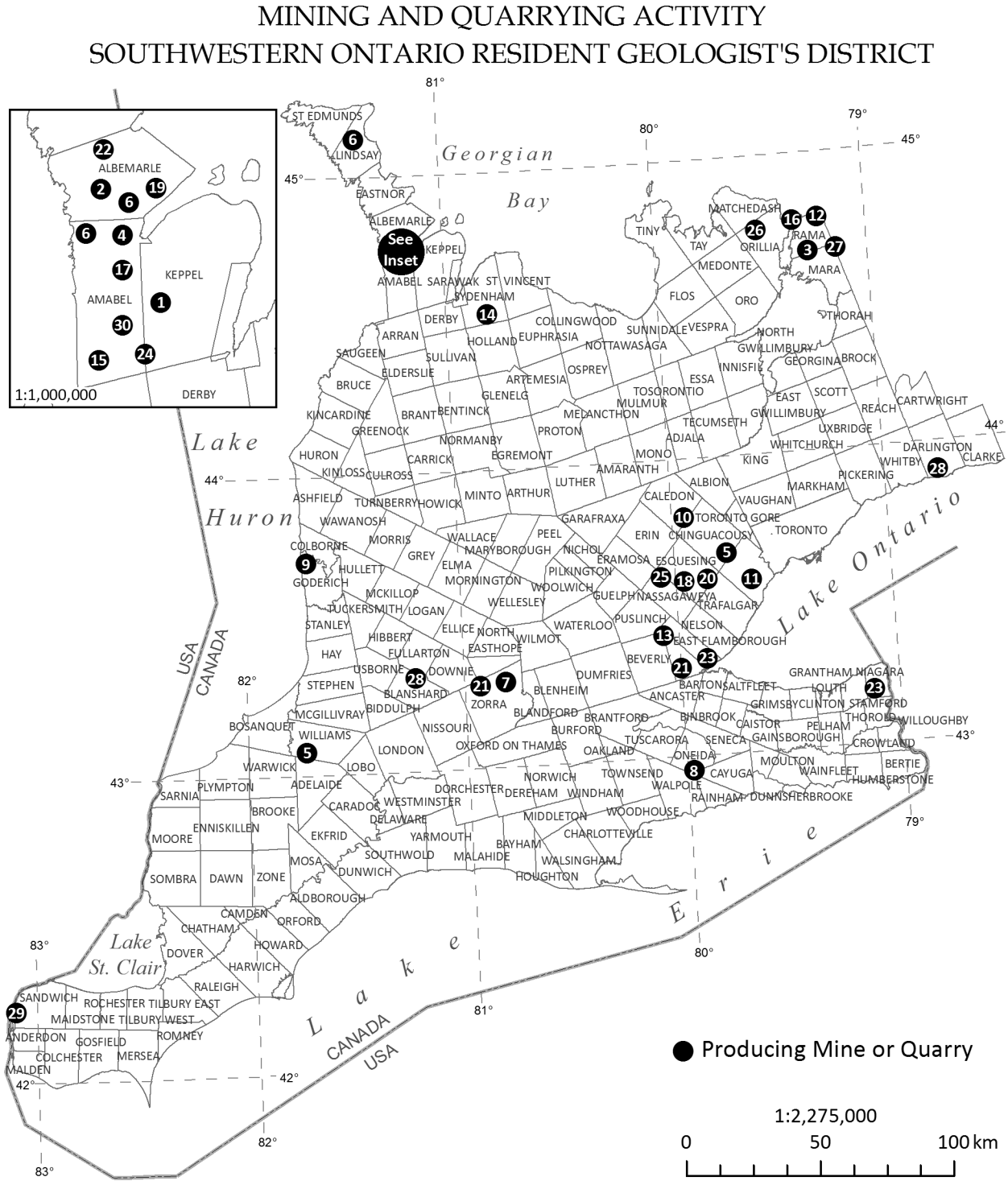

Figure 2. Producing mines and quarries in the Southwestern Ontario District in 2017 (keyed to Table 2).

Dimension and Building Stone

WIARTON AREA QUARRIES

The Wiarton area on the Bruce Peninsula in southwestern Ontario is the centre of the province's dimension stone industry. In 2017, 22 quarries in the County of Bruce were licenced under the *Aggregate Resources Act* to extract dimension stone for building, landscaping and flagstone markets. An additional 15 quarries were licenced to extract stone in the neighbouring County of Grey. Rowell (2012) identified, as provincially significant, bedrock resources in the County of Bruce and also provided details of National and Provincial Parks, physical, cultural and environmental constraints on development, including the Niagara Escarpment Plan, which limit development of resources within that area for dimension stone, as well as for crushed stone aggregate.

ORILLIA AREA QUARRIES

In Rama Township near Orillia, 5 companies operate a total of 7 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. All of these quarries are situated on lands where both mining and surface rights are privately owned. 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).

PETERBOROUGH AREA QUARRIES

There has been a long history of dimension-stone production in the Peterborough area. In 2017, 6 companies operated 6 dimension-stone quarries in the Peterborough area. Stone from these quarries is produced for export, as well as for local markets.

In 4 of the 6 quarries, Paleozoic limestone of the Gull River Formation is extracted for a variety of applications, including landscape, masonry and armour stone. Each of the companies has some form of on-site processing to split and/or cut stone to customer specifications. The Parnell quarry in Galway Township is located on a contact between the 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 interbedded marble and amphibolite unit is quarried to produce "Elite Blue" dimension stone.

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

In 2017, 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 facility contains a large, 118-inch (3 m) diameter diamond programmable saw, a smaller (36-inch) 5 axis-programmable saw, hydraulic guillotines and conveyor systems.

The plant was not officially open for business in early February 2018, but the company has started processing stone from the companies various Drain Bros. quarries in the area. Products will include armour stone, landscaping stone, steps and sills, paving stone, ashlar and veneer stone. 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 (Photo 5). An automated conveyor system moves the blocks between saws and guillotines with minimal handling. The plant will operate year round and will add up to 16 full-time jobs to the company's existing facilities and services, which include the supply, delivery and installation of asphalt products, aggregates and a variety of specialty stones. The company, established in 1971, also conducts large-scale land development projects and shoreline stabilization with over 300 employees at various locations within the Kawartha area.

Possible spin-off jobs and development opportunities may come in the areas of transportation, increases in landscaping business demand, and in local quarry development to provide a wider variety of stone products. The company will consider purchasing other types of southern Ontario stone for processing at the plant. (D. Corcoran, Drain Bros. Excavating Ltd., personal communication, 2018).

Photo 5. Slab saw, 118-inch diameter, Drain Bros. Excavating Ltd. stone processing facility, Havelock. Photo supplied by D. Corcoran (Drain Bros. Excavating Ltd., February 2018).

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. 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 in restoration of buildings at the Royal Military College in Kingston (T. Gillingwater, Architectural Consultant, personal communication, 2017).

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 a number of notable projects in Toronto including Old City Hall, the Ontario Legislature (Queen's Park), pillars at Union Station, and the Timothy Eaton Memorial Church.

Three companies continue to produce sandstone as dimension stone in the Brampton area: Rice & McHarg Ltd., Hilltop Stone and Supply Inc. and Credit Valley Quarries Co. Ltd. There is a perennial demand for Credit Valley sandstone for new projects, as well as a large demand for restoration of many historic sandstone buildings in the Greater Toronto Area.

In southeastern Ontario near Kingston, Nepean Formation (Cambrian) sandstone is quarried at the Sloan and Ellisville quarries of 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 recent and ongoing restoration of the Parliament Buildings in Ottawa, as well as for new building projects (www.rideauviewcontracts.com).

Trap Rock

There are 4 companies operating trap rock quarries in southeastern Ontario, all located near Highway 7 between Peterborough and Tweed. 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 the production of 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.

IKO 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 from a past talc exploration program on the property. The drill core from this program stored at the indoor storage facility of MNDM's Tweed Drill Core Library. The company shipped 30 000 t of gabbro to Roxul Inc. in Milton for rock wool manufacturing tests in 2015. The results were positive and the company increased shipments to 60 000 t in both 2016 and 2017 (A. Danford, Danford Granite Ltd., personal communication, February 2018). The company also operates several bedrock aggregate quarries in eastern Ontario and employs 25 permanent and 25 seasonal workers.

Calcium Carbonate (Marble)

OMYA CANADA INC. – TATLOCK QUARRY

OMYA Canada Inc. (www.omya.com) is a subsidiary of OMYA, a privately held global producer of industrial minerals headquartered in Switzerland. Worldwide, OMYA produces mainly fillers and pigments derived from calcium carbonate and dolomite. OMYA 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. In 2017, the quarry produced about 650 000 t of ore. Together, the Tatlock Quarry and Perth processing plant employ about 92 permanent workers (R. Hughes, Omya Canada Inc., personal communication, July 17, 2017).

EXPLORATION ACTIVITY

Assessment files received for the Southern Ontario Region are listed in Table 3. Exploration activity is listed in Table 4 and the location 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 2017, most of the exploration activity and expenditures in the Southern Ontario Region was focussed on gold, zinc and vermiculite, with smaller projects also focussed on graphite, industrial minerals and rare earth elements. The work consisted of limited to minor field exploration of gold prospects, re-logging and sampling of diamond-drill core stored at the outdoor Tweed Drill Core Library.

Use of the Tweed Drill Core Library as an exploration tool has increased in recent years, as funding has been lacking for major field exploration projects (*see* "Recommendations for Exploration" "Explore Southern Ontario with the Tweed Drill Core Library"). The following companies completed projects at the Tweed Drill Core Library facilities in 2017. Their projects will be discussed in this report with respect to the commodity being explored:

- Crown William Mining Corporation conducted a major program of core logging and sampling of drill core from the Bannockburn gold project in Madoc Township, at the former Mono gold prospect. From November 2016 to January 2017, approximately 4000 samples were collected.
- Skead Holdings Ltd. moved 1200 drill core boxes from 51 diamond-drill holes from the Salerno Lake zinc prospect in Snowdon Township in preparation for a major re-logging and sampling program. A small number of the holes were logged and sampled in November 2017 and the program will continue in the spring and summer of 2018.
- C. Bowdidge completed a resampling program of 3 diamond-drill holes from the Hawley wollastonite property in Olden Township as part of the data verification requirement for a new NI 43-101–compliant report on the project.
- California Gold Mining Inc. re-logged and photographed core from 20 diamond-drill holes from the Dingman gold prospect in Marmora Township. The company is reviewing their economic evaluation of the property.

Table 3. Assessment files received in the Southeastern Ontario District in 2017.

Abbreviations

Assay ..... Assays (standard metallics)
DD ..... Diamond drilling
Enviro ..... Environmental study
GC ..... Geochemical survey
GL ..... Geological survey
GM ..... Ground magnetic survey
PGM ..... Platinum group metals
Pr ..... Prospecting
REE ..... Rare earth elements
Samp ..... Sampling (other than bulk)
Str ..... Stripping
Tr ..... Trenching

No.	Township/Area (Commodity)	Company Name	Year	Type of Work	AFRO Number	Resident Geologist Office File Designation
1	Lyndoch (Graphite)	A. Dubblestein	2016	Pr, Str	2.57137	Lyndoch #59
2	Grimsthorpe (Au)	J. Chard, R. Dillman	2016	GM	2.57091	Grimsthorpe #96
3	Butt (Graphite)	M., M. and L. Gilchrist	2016	Pr	2.57267	Butt #70
4	Grimsthorpe (Au)	J. Chard, R. Dillman	2016	Assay, Samp	2.57281	Grimsthorpe #97
5	Methuen (Ilmenite)	Trigan Resources Inc.	2016	Assay, GC	2.57303	Methuen #64
6	Cardiff, Monmouth (U, Th, base metals)	Skead Holdings Ltd.	2016	GC	2.57364	Cardiff #273 Monmouth #186
7	Anglesea (Au)	R. Waring	2016	Assay, Pr, GL, Str	2.57350	Anglesea #48
8	Methuen (Trap rock))	Trigan Resources Inc.	2017	Enviro	2.57419	Methuen #65
9	Cardiff (U, Th, REE)	Skead Holdings Ltd.	2016	Assay	2.57492	Cardiff #274
10	Elzevir (Soapstone)	D. Milligan	2017	Pr	2.57555	Elzevir #36
11	Elzevir (Soapstone)	D. Milligan	2017	Assay	2.57559	Elzevir #37
12	Lyndoch (Au, PGM)	P. Bussierre	2016	Tr	2.57589	Lyndoch #60
13	Galway, Cavendish (Graphite)	J. Archibald	2016	GL, Pr, Str, Tr	2.57594	Galway #75 Cavendish #162
14	Sebastopol (Pegmatite)	D. Ross	2017	GL, Pr	2.57802	Sebastopol #8
15	Galway, Cavendish (Pegmatite)	D. Ross	2017	Pr	2.57759	Galway #76 Cavendish #163
16	Cardiff (Pegmatite)	Skead Holdings Ltd.	2017	GM	2.57687	Cardiff #275
17	Cardiff (Mineral specimens)	The Corp. of the Municipality of Highlands East	2017	Str	2.57864	Cardiff #276
18	Tudor (Au)	Union Glory Gold Ltd.	2017	DD, Assay	2.57879	Tudor #131
19	Cashel (Mineralization)	J. Laidlaw	2017	Pr	2.57880	Cashel #21
20	Cardiff (U, Th, REE)	Skead Holdings Ltd.	2017	Assay	2.57911	Cardiff #277
21	Snowdon (Zn)	Skead Holdings Ltd.	2017	Assay, Pr	2.57991	Snowdon #27
22	Monmouth (U, Th, REE)	Skead Holdings Ltd.	2017	Assay, Pr	2.57993	Monmouth #187
23	Butt (Graphite)	M., M. and L. Gilchrist	2016	Pr	2.58302	Butt #71
24	Matawatchan (Graphite)	J. Martin, J. Andreana	2017	Pr	2.58180	Matawatchan #3

Table 4. Exploration activity in the Southeastern Ontario District in 2017, keyed to Figure 3.

Abbreviations

Beep ..... Beep Mat survey
DD ..... Diamond drilling
GL ..... Geological survey
GM ..... Ground magnetic survey
Pr ..... Prospecting
REE ..... Rare earth elements
Samp ..... Sampling (other than bulk)

No.	Company/Individual	Township/Area (Commodity)	Exploration Activity
1	Dubblestein, A.	Lyndoch (Marble, diopside)	Samp
2	California Gold Mining Inc.	Madoc, Marmora (Au)	Re-logging of DD core
3	Crown William Mining Corp.	Madoc (Au)	Samp (DD core)
4	Ross, D.	Sebastopol (Pegmatite)	Pr, GL
5	Ross, D.	Galway, Cavendish (Pegmatite)	Pr
6	Drain Bros. Excavating Ltd.	Belmont (Dimension stone)	Plant construction
7	Martin, J.	Matawatchan (Graphite)	GM, Beep, Pr, Samp
8	Laidlaw, J.	Cashel	Pr
9	Waring, R.	Anglesea (Au)	Pr, Samp
10	Skead Holdings Ltd.	Monmouth (U, Th, REE, graphite)	Samp (DD core), Pr
11	Skead Holdings Ltd.	Snowdon (Zn)	Samp (DD core), Pr
12	Skead Holdings Ltd.	Cardiff (U, Th, REE)	Samp (DD core)
13	Union Glory Gold Ltd.	Tudor (Au)	DD
14	Union Glory Gold Ltd.	Kaladar (Au)	Pr
15	Bowdidge, C.	Olden (Wollastonite)	Samp (DD core)

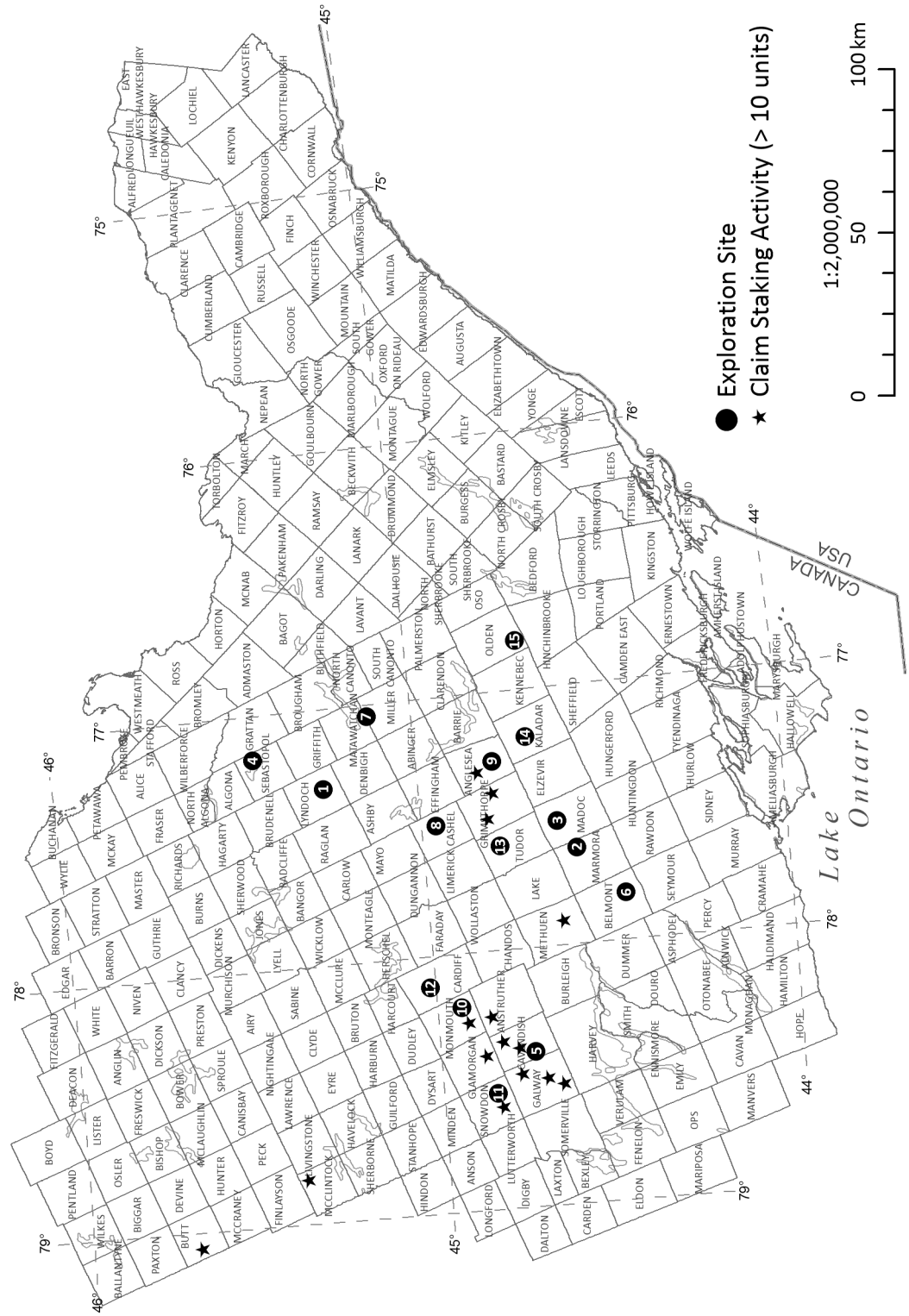

Figure 3. Exploration activity in the Southeastern Ontario District in 2017 (keyed to Table 4).

Gold

UNION GLORY GOLD LIMITED – TUDOR PROSPECT

The most significant exploration expenditure in southern Ontario was incurred by Union Glory Gold Ltd. on a diamond-drilling program on the company's wholly owned Tudor Township gold prospect. The program of 5 NQ drill holes (totalling 711 m) was completed in March 2017 and tested the Main mineralized zone (Smith 2017).

The Main mineralized zone, trending 180° and dipping steeply to the west, is a gold-bearing felsic metavolcanic unit with 10 to 45% quartz veins, 5 to 8% disseminated arsenopyrite and locally visible gold. Previous drilling results included 3.20 m at 5.69 g/t Au, 14.87 m at 0.9 g/t Au, 16.46 m at 1.28 g/t Au and 22.95 m at 2.38 g/t Au (Smith 2017). The 2017 drill program was designed to test the Main zone at vertical depths ranging from 70 to 100 m, below a 2011 drill-hole intersection of 1.55 g/t Au over 4.55 m.

Smith (2017) recommended follow-up drilling and geochemical work, based on significant results from the 2017 phase of drilling, which are provided as follows:

Drill Hole	From (m)	To (m)	Width (m)	Gold Grade (g/t Au)
17-1	100.00	103.00	3.00	2.40
17-1	110.36	112.36	2.00	1.75
17-2	113.25	119.25	6.00	3.33
17-2	125.28	128.28	3.00	1.93
17-3	84.00	86.00	2.00	2.27
17-3	92.00	93.00	1.00	2.14
17-3	96.00	99.00	3.00	2.35
17-3	107.69	109.17	1.48	3.02
17-4	116.50	118.50	2.00	3.00
17-4	123.50	125.50	2.00	1.96
17-4	127.50	133.80	6.30	2.31
17-5	Hole abandoned due to mechanical issues			

UNION GLORY GOLD LIMITED – ADDINGTON PROJECT

From 2013 to 2016, Union Glory Gold Ltd. conducted exploration work at the Addington gold project to confirm the historical model of the deposit and conduct an economic assessment of the gold resource. In addition, baseline environmental and preliminary metallurgical studies were also started.

- In 2013, Union Glory completed a program of sampling of archived diamond-drill core stored at MNDM's Tweed Drill Core Library.
- In June 2015, Union Glory completed 5 diamond-drill holes, totalling 305 m, on the Addington gold mine property to verify historical drill intercepts.
- From May to November 2016, Union Glory completed 48 diamond-drill holes, totalling 9553 m, at the Addington gold project. (G. Smith, Union Glory Gold Ltd., personal communication, 2016).
- In 2017, Union Glory carried out an internal resource estimate on the project. Although the results of the resource estimate are confidential, additional drilling work has been recommended for the future. A soil geochemical survey to cover the southern extension of the mineralized zone was also recommended (G. Smith, Union Glory Gold Ltd., personal communication, 2017).

CROWN WILLIAM MINING CORPORATION – BANNOCKBURN GOLD PROJECT

From November 2016 to January 2017, Crown William Mining Corporation conducted a major program of core logging and sampling of drill core from the Bannockburn gold project in Madoc Township, at the former Mono gold prospect. Approximately 4000 samples were collected and analyzed to verify the historical drill-core assay data and to add a significant number of new analyses to better estimate the gold resource of the deposit (Jeffs 2017).

Following this extensive program of sampling and re-logging historical diamond-drill core, Crown William carried out an internal NI 43-101–compliant resource estimate, the results of which remain confidential.

The deposit, formerly known as the Mono Gold Mines Inc. prospect, consists of a complex series of quartz veins at a folded contact between mafic metavolcanic and metasedimentary rocks. The deposit was previously estimated to contain an NI 43-101–non-compliant resource of 372 000 tons grading 0.395 ounce gold per ton (Schorn 1998). The bulk of the contained gold ounces is located within the "Conduit Zone", a zone of low-grade mineralization with potential for open pit mining, described by Tessier et al. (2017, p.19-20). The "Conduit Zone" is a northwest-striking structure dipping steeply to the east, and is postulated to have served as a conduit for gold-bearing veins in a halo of low-grade wall-rock mineralization (Jeffs 2017).

CALIFORNIA GOLD MINING INC. – DINGMAN GOLD PROSPECT

California Gold Mining Inc. re-logged and photographed core from 20 diamond-drill holes from the Dingman gold prospect in Marmora Township. The company is reviewing their economic evaluation of the property, which hosts a low-grade, high-tonnage deposit containing 11.6 Mt of NI 43-101–compliant Indicated mineral resource averaging 0.97 g/t Au in a highly altered, porphyritic granodiorite intrusion (Roscoe 2011).

R. WARING – KILLER CREEK GOLD PROJECT

Prospector R. Waring continued exploration of his gold prospect in in the vicinity of Killer Creek in Anglesea Township, concessions XII and XIII, lots 25 and 26. In 2017, an additional 33 claims (88 units) were added to the property, which now covers approximately 6700 ha in Anglesea, Grimsthorpe and Elzevir townships.

Gold mineralization occurs in rusty, smoky quartz veins within sheared metavolcanic rocks, possibly associated with east-trending cross structures in the vicinity of the Partridge Creek shear zone. The geology of the property was described in detail in a property examination report by Sangster et al. (2016, p.32-35: *see* "Waring Creek Gold Prospect, Anglesea Township").

Best results in 2017 included assays from 5 grab samples of quartz veins that ranged from 0.94 to 5.59 g/t Au. Future work will attempt to expose the quartz veins through mechanical trenching in 2018 (Mr. R. Waring, Prospector, personal communication, January 2018).

Zinc

In 2017, Skead Holdings Ltd. initiated an exploration program at the Salerno Lake zinc prospect in Snowdon Township. A total of 1200 drill-core boxes from 51 diamond-drill holes were moved from pallets to racks at the Tweed Drill Core Library in preparation for a major re-logging and sampling program. A small number of the cores were logged and sampled in November 2017 and the program will continue in the spring and summer of 2018 (R. MacGregor, personal communication, January 2018). 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).

Wollastonite

C. Bowdidge completed a resampling program, on diamond-drill core from 3 holes drilled at the Hawley wollastonite property in Olden Township in 1998, as part of the data verification requirement for a new NI 43-101–compliant report on the project, which is to be completed in 2018 (C. Bowdidge, personal communication, January 2018).

Graphite

Development of the Kearney and Bissett Creek deposits, which are 2 advanced-stage graphite projects in the Grenville Province, continued to be stalled in 2017 because of a lack of financing. The properties, briefly described below, were described in more detail by Sangster et al. (2014, p.15-17).

ONTARIO GRAPHITE LTD. – KEARNEY MINE

The Kearney Mine in Butt Township, near Huntsville, was first brought into production in 1989 and remained operational through 1994, during which time it achieved a peak production rate of 10 000 t per year of flake graphite product. The mine has been under new ownership and management since 2007. An NI 43-101–compliant report, completed in October 2013 for Ontario Graphite Ltd., confirmed 51.5 Mt of Measured and Indicated Resources (2.14% Cg[6] average) and 46.8 Mt of Inferred Resources (2.0% Cg average) (www.ontariographite.com, under Kearney Mine | Fact Sheet).

NORTHERN GRAPHITE CORPORATION – BISSETT CREEK DEPOSIT

The Bissett Creek deposit of Northern Graphite Corporation (www.northerngraphite.com) is located in Maria Township, northern Renfrew County, Southern Ontario Mining Division, but is approximately 2 km north of the boundary of the Southern Ontario Resident Geologist Region. A 2014 Preliminary Economic Assessment provided for an annual graphite production of 44 200 t of graphite annually for the first 10 years (Northern Graphite Corporation, news release, June 24, 2014). The deposit contains an NI 43-101–compliant resource of 69.8 Mt of Measured and Indicated Resources (1.74% Cg[6] average) and 24.0 Mt of Inferred Resources (1.65% Cg[6] average). In 2015, the company announced the successful production of coated spherical graphite for use as anode material in lithium ion batteries (Northern Graphite Corporation, news release, May 19, 2015).

[6] "Cg" is a calculated value: graphite as carbon = total carbon less the amount of carbon present as CO_2.

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*., Regional Resident Geologist; P.S. LeBaron, *P.Eng*., District Geologist; D.A. Laidlaw, *P.Geo.*, Regional Land Use Geologist; and S.J. Charbonneau, District Geological Assistant. A.C. Wilson, *P.Geo.*, Mineral Deposit Compilation Geologist—Northeastern Ontario, contributes to updates and review of the Mineral Deposit Inventory database for southern Ontario. A detailed description of the latter's activities is included in this report (*see* "Mineral Deposit Compilation Geologist—Northeastern Ontario").

Summer Experience Program (SEP) student, E. Mick, 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 MNDM Indigenous Relations and Reconciliation 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 2017, the District Geological Assistant and the SEP student continued a program of standardizing the collection and distribution of various unique RGP data holdings in all offices across the province. To date, all university theses, mine plans and drill-core logs have been scanned and a spatial index of the university theses catalogue has been distributed online via OGSEarth application (www.ontario.ca/ogsearth). Scanning of unique, hard-copy documents from the office's mineral deposit and assessment files, most of which represent donated files and reports that are not part of the assessment file database, is ongoing. Plans are to make this material available online in the future.

There are over 6000 mineral occurrences in southern Ontario documented in the Mineral Deposit Inventory (MDI) database (Ontario Geological Survey 2017a). Staff of the Southern Ontario Regional Resident Geologist's office work with A.C. Wilson, Mineral Deposit Compilation Geologist—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 2017 field season, visits were made to 53 MDI locations in southeastern Ontario and 3 sites in southwestern Ontario. Many of the field visits were done as part of a sampling program for carbonate- and phosphate-associated rare earth element mineralization that was undertaken by staff of the Southern Ontario Resident Geologist's Office, described in "Property Visits" in this report. New information, such

as analytical results for samples and verification of location based on global positioning system (GPS) measurements, will be added to the MDI database.

Since September 2017, the Regional Resident Geologist has been co-supervising a Queen's University fourth year Geological Engineering Design Project on exploration for zinc in the Grenville Province of southern Ontario.

First Nations Interactions

In March 2017, the Regional Resident Geologist and the District Geologist gave presentations to the Algonquins of Ontario on a summary of mineral exploration and development activities in southern Ontario and an outline of a prospecting course that was proposed for later in the year. The prospecting course has been tentatively rescheduled for the spring of 2018.

In May, the Regional Resident Geologist and the District Geologist attended a meeting of the Mineral and Aggregates Working Group of the Algonquins of Ontario for presentations of exploration projects by local prospectors with projects within the Algonquin Land Settlement Area. Staff of the Indigenous Relations and Reconciliation Branch and the Mineral Exploration and Development Section also attended the consultation meeting.

Mineral Shows, Presentations, Outreach and Field Trips

In January, the Regional Resident Geologist attended and assisted in staffing the Ontario booth at the Cambridge House Conference and the Association for Mineral Exploration (AME) Exploration Roundup conference in Vancouver. The District Geologist and the Regional Land Use Geologist gave presentations on the "Role of the Ontario Geological Survey" and "The Use of Geoscience in Land Use Planning" to a delegation from China at York University.

In February, the Regional Resident Geologist gave a presentation on the geology and mineral deposits of southern Ontario for third year students of the Queen's University Geological Engineering program.

In March, staff assisted in the development and presentation of 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 on "Critical Minerals – Ontario Potential".

In April, the District Geologist presented a poster and sample display at the Ontario Prospectors Exploration Showcase in Thunder Bay and gave a presentation on "Southern Ontario – Production, Exploration, Development and Recommendations for 2017 and Beyond". The same poster, sample display, and presentation were presented by the Regional Resident Geologist at the Northeastern Ontario Mines and Minerals Symposium in Timmins, also attended by the District Geologist.

In May, the Regional Resident Geologist and the District Geologist attended presentations at the Geological Association of Canada–Mineralogical Association of Canada annual meeting at Queen's University in Kingston. The District Geologist assisted as a driver for a 4-day post-meeting field trip on "Tectonic and Metamorphic Architecture of the Northeastern Composite Arc Belt and the Central Metasedimentary Belt Boundary Tectonic Zone, Grenville Orogen", led by Manuel Duguet and Michael Easton of the Earth Resources and Geoscience Mapping Section of the Ontario Geological Survey.

In June, 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. Staff of the Southern Ontario Resident

Geologist's Office gave a prospecting course to 19 registrants in co-operation with the Southern Ontario Prospectors Association. The course included Friday evening and Saturday classroom activities and field trips and outdoor exercises on Sunday over 2 consecutive weekends in June. The Regional Resident Geologist also gave presentations on the geology and mineral deposits of southern Ontario to students at Queen's University, Campbellford High School and at École St-Philippe in Grande Pointe (Chatham-Kent). The District Geological Assistant accompanied members of the Buffalo Geological Society on a field trip to the Tweed Marble Quarry.

In July, the District Geologist led a field trip for members of the Scarborough Gem and Mineral Club.

In August, staff of the Southern Ontario Resident Geologist's Office provided a booth at the 4-day Bancroft Gemboree with a poster and sample display and gave daily presentations on "The Mines of Southern Ontario".

In September, the Regional Resident Geologist and the District Geologist guided 2 field trips on the geology of the Madoc–Marmora area and the Cordova gold mine for faculty and students in the Environmental Geology program at Trent University. The District Geological Assistant accompanied members of the Ottawa Lapsmith and Mineral Club on a field trip to the Tweed Marble Quarry and staffed the Southern Ontario Resident Geologist Program booths at the Queensborough Historical Day event, the Scarborough Mineral Show, and the Ancaster Mineral Show. The District Geologist also attended the Ancaster show and gave presentations on "The Mines of Southern Ontario" to over 200 elementary students and their teachers.

In October, the Regional Resident Geologist attended the AEMQ (L'Association de l'exploration minière du Québec) Xplor Conference in Montreal. The District Geologist guided a field trip to the Bannockburn gold prospect for faculty and students in the Environmental Geology program at Trent University.

In November, the Regional Resident Geologist and the District Geologist guided a field trip to the former Canada Talc Mine property to examine geology and rehabilitation results with Trent University students and staff; provided a 2-day field trip to show the geology and gold deposits of southern Ontario, including examination of drill core from gold prospects stored at the Tweed Drill Core Library, for geologists from a junior exploration company based in Montreal; and attended a presentation on "Processing Considerations for Specialty Materials Project Development", with a focus on graphite, sponsored by the Toronto chapter of the Canadian Institute of Mining, Metallurgy and Petroleum.

Activities of the Senior Conservation Geologist, Ministry of Natural Resources and Forestry

D. Webster, the Senior Conservation Geologist of the Ministry of Natural Resources and Forestry (MNRF), is responsible for the evaluation and delineation of sites of geoscientific significance that may be designated for protection by land use planning or by the establishment of provincial parks, conservation reserves, or areas of natural and scientific interest (ANSIs). In some cases, staff of the Resident Geologist's Office may collaborate with, or provide information to, the Senior Conservation Geologist on sites that are currently protected or are being considered for protection. Recent activities of the Senior Conservation Geologist in southern Ontario include a review of the land status and geology of the Crotch Lake Conservation Area and Lake St. Peter Provincial Park to consider possible expansion of the park boundaries. No new ANSIs were created in southern Ontario in 2017. The Senior Conservation Geologist was responsible for compiling an updated (2017) version of the MNRF document, "A Framework for the Conservation of Ontario's Earth Science Features", first published in 1981. The report documents the various geological environments found in Ontario and explains the reasoning behind the protection of earth science features (D. Webster, MNRF, personal communication, January 2018).

Diamond-Drill Core Collection

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 2017, clients conducted 2 significant relogging and sampling programs on diamond-drill core stored at the Tweed Drill Core Library. The first sampling program involved sampling of previously unsampled sections of drill core from the Bannockburn gold project, in Madoc Township, of Crown William Mining Corp. at the former Mono gold prospect. From November 2016 to January 2017, approximately 4000 samples were collected. The second program, conducted by Skead Holdings Ltd., consisted of moving (and re-boxing, if necessary) about 1200 drill core boxes from 51 diamond-drill holes from the Salerno Lake zinc prospect in Snowdon Township from pallets to racks. Relogging and sampling of the core began in November 2017 and will continue in the spring and summer of 2018. These 2 major projects and other occasional users represent a total of 59 person-days of Drill Core Library use in 2016.

Other work completed at the Drill Core Library in 2017 includes the logging, labelling and cataloguing of 364 boxes (a total of approximately 1600 m) of drill core from the former Canada Talc Mine site in Madoc, brushing out and clearing debris from the site as part of an ongoing maintenance program, and installation of 4 new sets of metal core racks at the off-site storage area.

Table 5 provides a five-year summary of program activity and Table 6 lists new publications added to the Resident Geologist Program office (in Tweed) technical library during 2016.

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

Activity	2013	2014	2015	2016	2017
Field Investigations / Property Visits	45	39	36	27	57
Field Trips Given / Field Guides Written	3	3	6	7	10
MDI Records Revised	173	64	351	456	441
Presentations to Ministry of Municipal Affairs and Housing, Ministry of Natural Resources and Forestry, Ministry of Aboriginal Affairs	14	17	7	6	7
Clients Visits to RGP–Tweed Office	394	232	263	226	184
Drill Core Library Users	114	40	69	283	59
Client Communications / Interactions (Presentations/Poster Sessions)	>3000	>3000	>3000	>3000	>3000

Table 6. Library acquisitions in 2017 by the Southern Ontario Resident Geologist Program (publications of particular interest to the Southern Ontario District are shown in bold).

Title	Author(s)	Type and Year of Publication
Discrete, High-Quality Hydraulic Conductivity Estimates for the Early Silurian Carbonates of the Guelph Region	E.H. Priebe, C.J. Neville and F.R. Brunton	Ontario Geological Survey, Groundwater Resources Study 16, 2017
Geological, Geochemical, Geochronological and Geophysical Data from the Cobden Area, Grenville Province	R.M. Easton and B. Azar	Ontario Geological Survey, Miscellaneous Release—Data 323, 2017
Graphic Logs with Analytical and Geochronological Data from Hand Auger, Probe and Section Sites in the Niagara Peninsula	A.K. Burt	Ontario Geological Survey, Miscellaneous Release—Data 353, 2017
Ontario Airborne Geophysical Surveys, Magnetic Data, Grid Data (ASCII and Geosoft® Formats), Magnetic Supergrids	Ontario Geological Survey	Ontario Geological Survey, Geophysical Data Set 1037—Revised, 2017
Index to Maps, Bedrock Geology, 1991–2016	Ontario Geological Survey	Ontario Geological Survey, scale 1:1 000 000, 2017 (set of 4 maps)
Index to Maps, Surficial Geology, 1991–2016	Ontario Geological Survey	Ontario Geological Survey, scale 1:1 000 000, 2017 (set of 4 maps)
Index to Published Reports, Maps and Digital Data, 2011–2016	Ontario Geological Survey	Ontario Geological Survey, Miscellaneous Paper 177 (Supplement 2011–2016), 112p., 2017
Geographic Index to Published Reports, Maps and Digital Data, 2011–2016	Ontario Geological Survey	Ontario Geological Survey, Miscellaneous Paper 178 (Supplement 2011–2016), 327p., 2017
Precambrian Geology of the Black Donald Lake Area, Grenville Province	M. Duguet, S. Ma and K. Whitney	Ontario Geological Survey, Preliminary Map P.3808, scale 1:20 000, 2017
Paleozoic Geology of the Welland-Fort Erie Area	D.K. Armstrong	Ontario Geological Survey, Preliminary Map P.3811, scale 1:50 000, 2017
Quaternary Geology of the Collingwood Area	R.P.M. Mulligan	Ontario Geological Survey, Preliminary Map P.3815, scale 1:50 000, 2017
Quaternary Geology of the Western Half of Barrie and Elmvale Areas	R.P.M. Mulligan	Ontario Geological Survey, Preliminary Map P.3816, scale 1:50 000, 2017
Report of Activities 2016, Resident Geologist Program, Red Lake Regional Resident Geologist Report: Red Lake and Kenora Districts	A.F. Lichtblau, G.F. Paju, C. Ravnaas, R.D. Tuomi, A. Tims and K. Wiebe	Ontario Geological Survey, Open File Report 6324, 107p., 2017
Report of Activities 2016, Resident Geologist Program, Thunder Bay North Regional Resident Geologist Report: Thunder Bay North District	R.M. Cundari, M.R. Brunelle, G.D. White, R.D. Tuomi and A. Tims	Ontario Geological Survey, Open File Report 6325, 66p., 2017
Report of Activities 2016, Resident Geologist Program, Thunder Bay South Regional Resident Geologist Report: Thunder Bay South District	M.A. Puumala, D.A. Campbell, R.D. Tuomi, A. Tims and M.R. Brunelle	Ontario Geological Survey, Open File Report 6326, 96p., 2017
Report of Activities 2016, Resident Geologist Program, Timmins Regional Resident Geologist Report: Timmins and Sault Ste. Marie Districts	E.H. van Hees, P. Bousquet, A. Pace, C.M. Daniels, A.C. Wilson, A. Samuel and J. Walmsley	Ontario Geological Survey, Open File Report 6327, 109p., 2017
Report of Activities 2016, Resident Geologist Program, Kirkland Lake Regional Resident Geologist Report: Kirkland Lake and Sudbury Districts	P.J. Chadwick, D.L. Guindon, D.G. Farrow, A.S. Péloquin, J. Suma-Momoh, C.M. Daniels, A. Wilson, L.A. Bardeggia, F. Belley-Biswas, and N. Sabiri	Ontario Geological Survey, Open File Report 6328, 117p., 2017
Report of Activities 2016, 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 6329, 73p., 2017

Title	Author(s)	Type and Year of Publication
Insights into the Tectonic and Metamorphic Architecture of the Composite Arc Belt and the Frontenac-Adirondack Belt near Perth, Ontario, Grenville Orogen: A Geological Guidebook	R.M. Easton	Ontario Geological Survey, Open File Report 6330, 54p., 2017
Tectonic and Metamorphic Architecture of the Northeastern Composite Arc Belt and the Central Metasedimentary Belt Boundary Tectonic Zone, Grenville Orogen: A Geological Guidebook	M. Duguet and R.M. Easton	Ontario Geological Survey, Open File Report 6331, 115p., 2017
Summary of Field Work and Other Activities, 2017	Ontario Geological Survey	Ontario Geological Survey, Open File Report 6333, 408p., 2017
Southern Ontario Stream Sediment Project (SOSSP) Summary Report-Organic Contaminants	S.R. Chaudhuri, R.D. Dyer, R. Fletcher, P. Helm, M. Millar, E.J. Reiner and P.G. Welsh	Ontario Geological Survey, Open File Report 6335, 43p., 2017
Geology and Geochemistry of Grenville Marble in Southeastern Ontario	T.W. Grant, P.W. Kingston	Ontario Geological Survey, Open File Repot 5509, 1982
Occurrence and Distribution of Platinum-Group Elements in British Columbia	V.J. Rublee	British Columbia Ministry of Energy, Mines and Petroleum Resources, Open File 1986-07, 1986
A Mastodon in a Biscuit Box	P. Russell, J. Hoganson, P. Karrow and J. Motz	University of Waterloo, 2010
Elzevir Township Mineral Deposits Mapping Project	M. Berghout, G. Ludolph, J. French, R. Grindrod, S. Murphy	unpublished report 1986 (Southern Ontario Resident Geologist Office library)
Genesis of Stratiform Lead-Zinc-Barite-Fluorite Deposits (Mississippi Valley Type Deposits): A Symposium	Edited by J.S. Brown	The Economic Geology Publishing Company, Economic Geology Monograph 3, 1966
Peterborough and the Kawarthas	W.P. Adams and C.H. Taylor	Peterborough, 2009
The History of Mineral Collecting: 1530–1799	W.E. Wilson	The Mineralogical Record, 1994
Canada from Space	B. Banks	Camden House Publishing, 1989
Fossils, Rocks, and Time	L.E. Edwards and J. Pojeta, Jr.	United States Geological Survey, 1993
Glacial and Post-Glacial Lakes in Ontario	A.P. Coleman	University of Toronto, 1922
Mineral Collecting in Ontario: A Guide for Rockhounds	MNDM	MNDM, 2002
Rocks and Minerals	W.M. Tovell and J.A. Mandarino	Ontario Department of Tourism and Information, 1979
The Geology and Metallogeny of the Grenville Province	Edited by R. Theriault	Society of Economic Geologists–University of Western Ontario, short course, 2005

PROPERTY EXAMINATIONS

In 2017, a total of 56 properties in the Southern Ontario region were visited by Resident Geologist Program staff; these visits are listed in Table 7.

Table 7. Property visits conducted by the Southern Ontario Regional Resident Geologist and staff in 2017 (keyed to Figures 4 and 5).

Number	Property / Operation	Commodity
	Southeastern Ontario District	
1	Biederman marble quarry (abandoned), Wilberforce Township	Marble
2	Blue Mountain Quarry, Unimin Canada Ltd., Methuen Township	Nepheline syenite
3	Cadieux (Renprior) Zinc, Nyrstar Corporation, Admaston Township	Zinc
4	Chandos Elite Blue Quarry, T. Pluard, Chandos Township	Marble dimension stone
5	Christie Lake occurrence, Sherbrooke Township	Phosphate/REE?
6	Cordova gold mine, Belmont Township	Gold
7	Crow Lake occurrence, Oso Township	Phosphate/REE?
8	Davidson Quarry, H&H Construction Inc., Ross Township	Dolomitic marble aggregate
9	Dingman prospect, California Gold Mining Inc., Marmora Township	Gold
10	Eagle Lake occurrence, Hinchinbrooke Township	Phosphate/REE?
11	Gilmour gold mine (abandoned), Grimsthorpe Township	Gold
12	Gold Base (Veley) prospect, Kennebec Township	Gold
13	Havelock Quarry, Drain Bros. Excavating Ltd., Belmont Township	Dimension stone
14	Hollywood, Tom occurrence, Oso Township	Phosphate/REE?
15	Hwy 417–Libby's Road occurrence, McNab Township	Sulphides
16	John Stevens property, Huntingdon Township	Gold, Jade
17	Koizumi mica prospect, Kaladar Township	Muscovite
18	Little–Bryan property, Lyndoch Township	Graphite, diopside
19	MacLaren Mine (abandoned), Bedford Township	Phosphate/REE?
20	Madoc project, Crown William Mining Corp., Madoc Township	Gold
21	Madoc talc mine (closed), Sherritt International, Huntingdon Township	Talc, Nephrite
22	Methuen prospect, W. Brown, Methuen Township	Marble dimension stone
23	Ore Chimney Mine (abandoned), Barrie Township	Gold
24	Ore Mountain prospect, Barrie Township	Gold
25	Orser–Kraft occurrence, Sherbrooke Township	Phosphate/REE?
26	*Perth Area occurrences (22 sites), Burgess Township	Phosphate/REE?
27	Picton Cement Plant and Picton Quarry, Lehigh Cement, Sophiasburgh Township	Limestone, cement
28	St. Lawrence Mine, Canadian Wollastonite, Pittsburgh Township	Wollastonite
29	Tatlock Quarry, Omya Canada Inc., Darling Township	High-purity $CaCO_3$
30	Tatlock Road–Union Hall occurrence, Ramsay Township	Sulphides, REE
31	Tweed Marble Quarry, A. Marmaro & Terrazzo Olympic LLC, Hungerford Township	Marble
32	West gabbro property, Trigan Resources Inc., Methuen Township	Ilmenite
	Southwestern Ontario District	
33	Cheltenham Quarry, Brampton Brick Ltd., Chinguacousy Township	Shale
34	Ojibway Mine, The Canadian Salt Company, Sandwich Township	Salt
35	Rice and McHarg Quarry, Rice & McHarg Ltd., Esquesing Township	Sandstone

**Perth area sites visited and sampled for phosphate and/or rare earth elements include the following locations: Anglo-Canadian West, Anglo-Canadian, Baby, Byrne, Cantin, Cordick, E. Shultz Property, E. Shultz Mine, Hanlon West, Hanlon, M. Philips Mine, Mahon, Martha–Munslow, Matheson Bell, Noble and Watts, Nobles Bay, Old Adams, Old Anthony, Otter, roadcut CR21, Silver Queen, and Watts, Adams and Noble.*

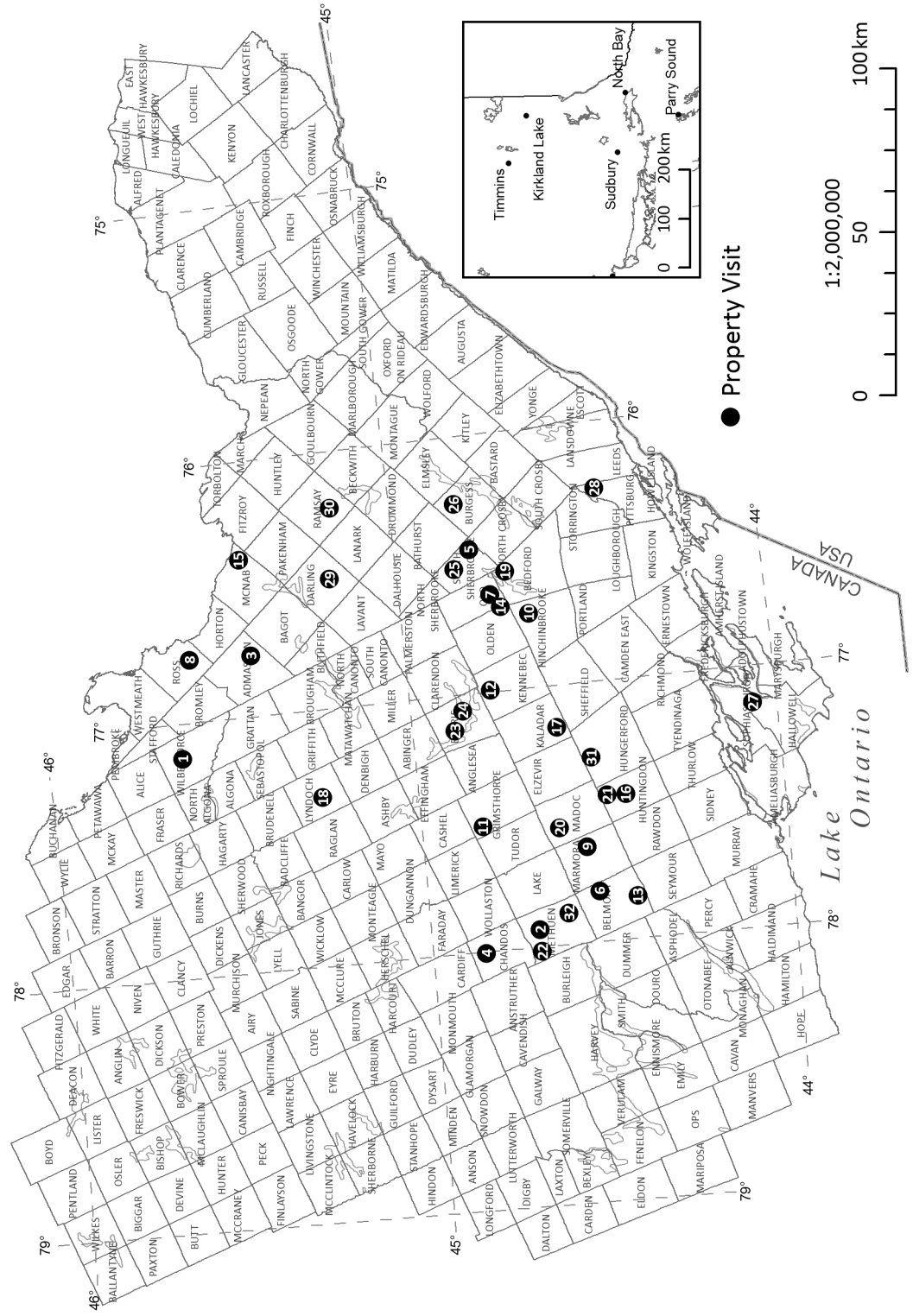

Figure 4. Property visits (keyed to Table 7) and claim staking activity in the Southeastern Ontario District in 2017.

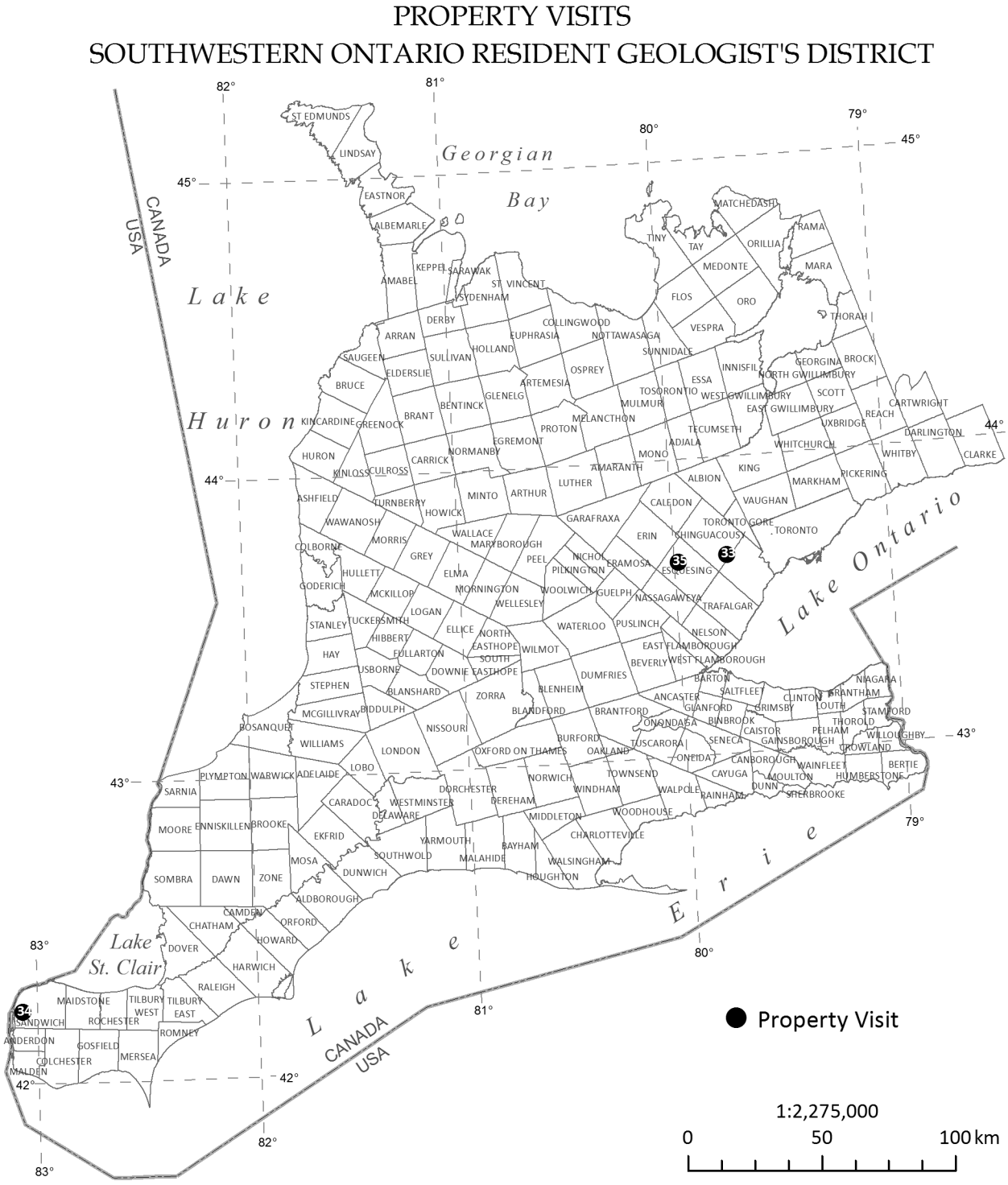

Figure 5. Property visits (keyed to Table 7) in the Southwestern Ontario District in 2017.

Cadieux Zinc Property, Admaston Township

On September 20, 2017, the Regional Resident Geologist and District Geologist visited the Cadieux property in Admaston Township, approximately 7 km south of the town of Renfrew (*see* inset in Figure 7). The visit focussed on historical trenches dating from 1983.

Nyrstar Corporation owns the property and acquired it on August 26, 2011, as part of their takeover of Breakwater Resources Inc. Nyrstar is a global producer of zinc, lead, copper, gold and silver with operations in Europe, the Americas and Australia, and listed on Euronext Brussels under the symbol NYR.

BACKGROUND

The Cadieux deposit (also known as the Renfrew or Renprior deposit) is one of several stratiform, marble-hosted zinc deposits known in the Central Metasedimentary Belt, Frontenac terrane and the New York Lowland of the Grenville Province of Ontario, Quebec and New York State (Figure 6). These deposits all show characteristics consistent with models of sedimentary exhalative (SEDEX) mineralization (i.e., submarine sediment-hosted) associated with basin–margin faults.

Other zinc deposit types of the Central Metasedimentary Belt are believed to be volcanogenic massive sulphide (VMS) deposits. There is also mounting evidence that non-sulphide and/or silicate zinc deposits may be present in the Central Metasedimentary Belt (Larivière and Gauthier 2007).

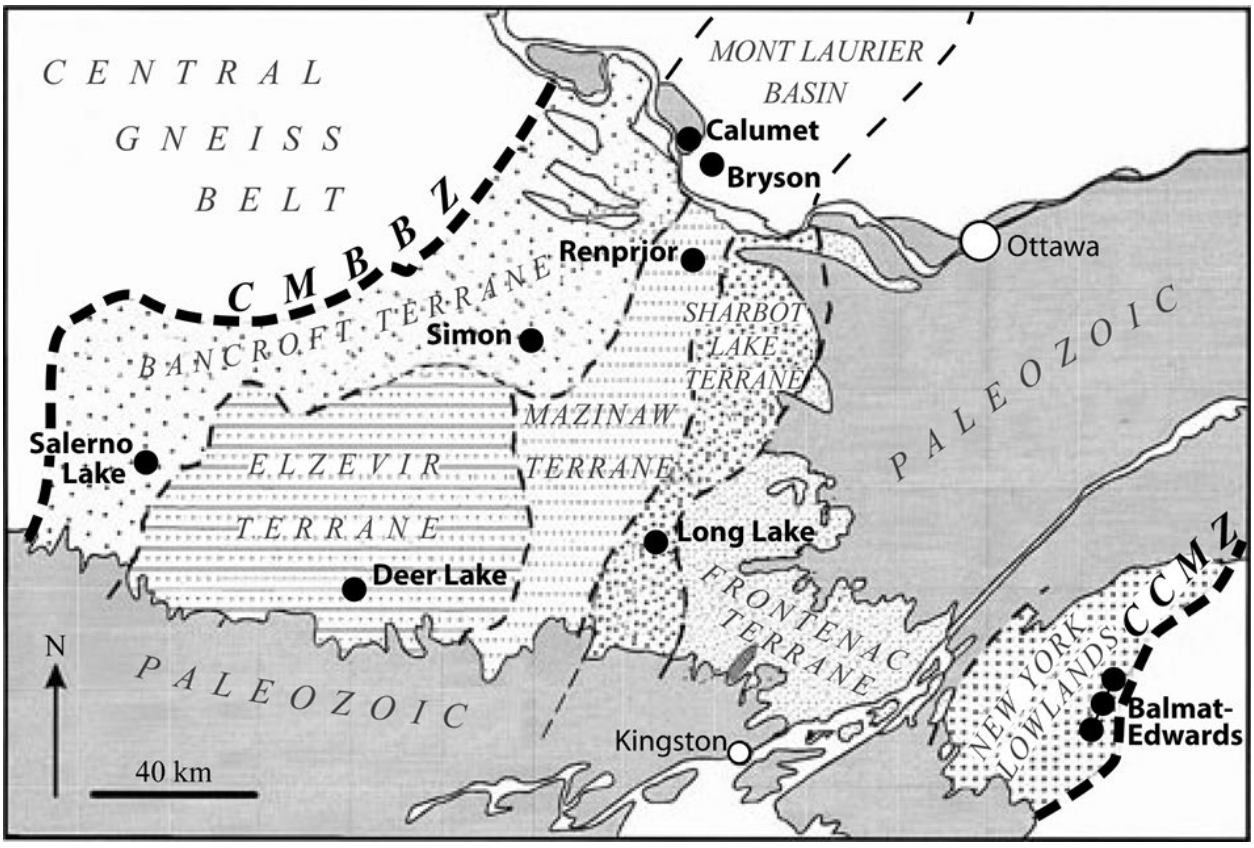

Figure 6. Locations of major zinc deposits and prospects within the Central Metasedimentary Belt of Ontario, Quebec and New York State (*modified from* Easton 1992). Abbreviations: CCMZ – Carthage-Colton mylonite zone; CMBBZ – Central Metasedimentary Belt Boundary Zone.

Sedimentary Exhalative (SEDEX) Zinc Deposits

The Balmat–Edwards zinc deposit in New York State is the most important zinc deposit in the Grenville Province, and has been mined for over a century. Through the course of its operating history, the mine has produced 43 million tons of ore at an average grade of 9.4% Zn. Now owned by Titan Mining Corporation, the deposit is reported as having an additional NI 43-101–compliant Measured and Indicated Mineral Resources of 2 158 000 tons with an average grade of 13.29% Zn and Inferred Mineral Resources of 2 276 000 tons with an average grade of 13.37% Zn (www.titanminingcorp.com).

Other significant zinc deposits in the Central Metasedimentary Belt, believed to be of SEDEX origin are the following:

- The Cadieux zinc deposit in Ontario with a non-NI 43-101–compliant resource of 1.45 Mt grading 8.8% Zn and 0.8% Pb (Roger and Turcotte 1997). This deposit is the subject of this property visit and described in further detail herein.
- The Salerno Lake zinc deposit in Ontario with non-NI 43-101–compliant resources totalling 1.1 Mt averaging 5.8% Zn in 2 separate zones (Soever 1980).
- The past-producing Long Lake Mine in Ontario, which produced about 100 000 tons of ore averaging 11.6% Zn in 1973–1974.
- The Leitch and Lafontaine zinc deposits in the Gatineau area of Quebec. Leitch has a non-NI 43-101–compliant resource of 75 000 t grading 8% Zn. Norzinc Mines produced 20 000 t at an average grade of 14% Zn at the Lafontaine deposit from a small open pit in 1953 (www.midlandexploration.com).

Volcanogenic Massive Sulphide Zinc Deposits

The Central Metasedimentary Belt is also host to several zinc deposits that are believed to be of volcanogenic origin. The most significant volcanogenic massive sulphide zinc deposits discovered to date include the following:

- The Montauban deposits, approximately 80 km west of Quebec City, which produced 2.66 Mt at grades of 4.53% Zn, 1.54% Pb, 2.50 ounces silver per ton and 0.02 ounce gold per ton between 1911 and 1955 (Prabhu 1981).
- The Calumet past-producing zinc mine in the Gatineau area of Quebec, which produced 3.8 Mt of ore averaging 5.8% Zn, 1.6% Pb, 65 g/t Ag and 0.4 g/t Au between 1942 and 1968 (Corriveau, Perreault and Davidson 2007).
- The Simon copper prospect in Ontario, which is believed to contain about 300 000 t, averaging 1.1% Cu, 4 to 5 % Zn and 15 g/t Ag (Taner 2008).
- The Deer Lake zinc-copper-silver prospect in Ontario, where a total of 8 diamond-drill holes all encountered mineralization throughout their entire length, with values ranging up to 0.1% Cu, 1.13% Zn and 0.5 ounce silver per ton [17 g/t Ag] between 1956 and 1968 (Carter 1984).

Non-Sulphide Zinc Deposits

The potential for non-sulphide zinc mineralization also exists in the Central Metasedimentary Belt, although no significant deposits of this type have been reported to date. Larivière and Gauthier (2007) reported 3 silicate zinc occurrences at Bryson, Quebec, where zincian serpentine and zincian magnetite are found. The occurrences are hosted by dolomitic marbles rich in diopside and forsterite, exhibiting retrograde metamorphism into zincian serpentine nodules. 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, a zinc-bearing equivalent of olivine. Microprobe analyses of the magnetite found a composition intermediate between magnetite (Fe_3O_4) and franklinite ($ZnFe_3O_4$) (Larivière and Gauthier 2007).

CADIEUX DEPOSIT – LOCATION AND ACCESS

The property consists of mineral rights to Admaston Township, concessions II, III and IV, Lot 1 and concessions III and IV, Lot 2, and the western half of Lot 2, Concession II. Nyrstar also holds the surface rights to Concession III, Lot 2, east half of Concession IV, lots 1 and 2, and part of the east half of Lot 1, Concession III (Figure 7). The property is easily accessible by County Road 2 going south from Renfrew, turning southwest onto Pucker Street, which is along the southern edge of the property.

CADIEUX DEPOSIT – EXPLORATION HISTORY

Since the first discovery of zinc at the Cadieux property in 1922, the property has been the site of several phases of exploration. Through time, the deposit has also been called the Renfrew, Renprior or Hisko deposit. Unfortunately, records are sporadic because, in southern Ontario, companies are not required to report their assessment work when it is carried out on private property. The following section is based on the information that could be gathered by the authors and from the summary reports of Soever and Jackson (1983), Soever and Henault (1985), Roger (1996), and Roger and Turcotte (1997).

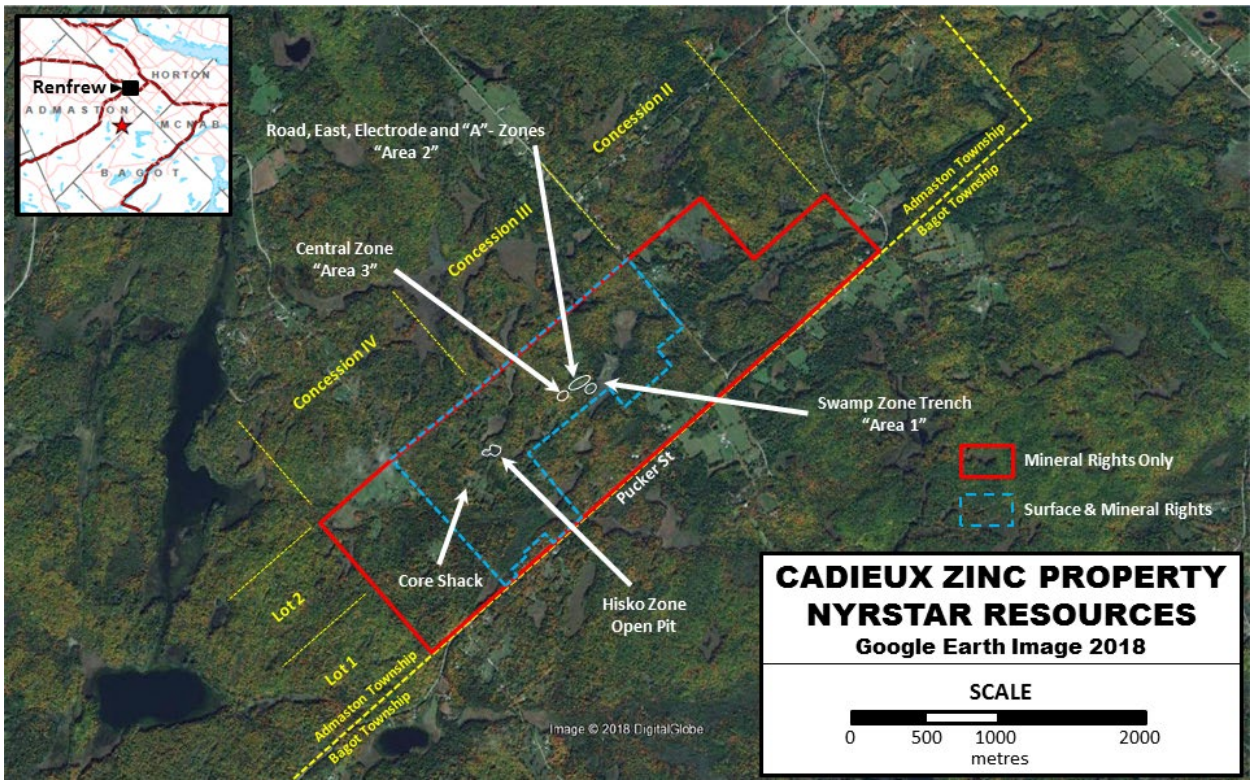

Figure 7. Location map of the Cadieux property claims and the different mineralized zones that outcrop at surface. Areas 1, 2 and 3 refer to mechanical stripping areas from Sulpetro Minerals' exploration work in 1983.

1922–1924: The first discovery of sphalerite on the property is reported to have been made during the summer of 1922 by Joseph Legree on Concession III, Lot 2 of Admaston Township. Legree and his partner William Dean proceeded to acquire mineral rights to the property and opened an exploration pit later that year. The showing was commonly referred to as the "Renfrew zinc prospect".

1925: Coniagas Mines Limited optioned the property and continued exploration with surface stripping and 5 diamond-drill holes (C-1 to C-5) for a total of 1483 feet [~452 m].

1926: Early in 1926, the property was optioned by Ottawa Valley Mines Limited, which completed 4 diamond-drill holes (S-1 to S-4) for a total of 1187 feet [~362 m]. In the same year, the British Metal Corporation Limited attained ownership, continued surface exploration and drilled 7 more diamond-drill holes (BMC-1 to BMC-7) for a total 1487 feet [~453 m].

1944: It is reported that the Canadian Department of Mines and Resources carried out a flotation test and metallurgical study on 2 ore specimens from the showing. Results are not published.

1947: New Calumet Mines Limited acquired control of Concession III, lots 1 and 2 and completed 13 diamond-drill holes (A-1 to A-13) for a total of 2287 feet [~697 m]

1948–1950: In 1948, the property covering Concession III, lots 1 and 2 was transferred to Cadieux Mines Limited. In 1948–1949, Cadieux Mines completed 11 diamond-drill holes (A-14 to A-24) for a total of 4216 feet [~1285 m]. In 1950, Cadieux Mines completed 7 X-ray holes (A-25 to A-31) for a total of 825 feet [~251.5 m].

Also in 1950, Lomega Gold Mines Limited took a lease on the eastern half of lots 1 and 2, Concession IV (referred to as the Hisko property) and, in September 1950, Lomega transferred control to Renprior Mines Limited.

1950–1951: Renprior built a mill on the property with a capacity of 35 to 50 tons per day. During June and July of 1951, the first mining operation on the property produced over 60 tons of concentrate, containing 55% Zn, 6% Pb and minor amounts of silver and gold. In September 1951, Renprior Zinc Mines Limited also acquired the Hisko property and began an exploration program that included trenching, geophysical surveys and 45 diamond-drill holes, for a total of 7000 feet [~2134 m]. Renprior Zinc Mines abandoned the property shortly thereafter and returned it to Cadieux Mines Limited.

1972: Kerr Addison Mines Limited optioned the property from Cadieux Mines Limited. Kerr Addison carried out detailed geochemical, geological and geophysical surveys, and completed 5 diamond-drill holes for a total of 1500 feet [~457 m]. Kerr Addison also completed a trenching program that failed to outline any new zinc-bearing horizons.

1978–1985: St. Joseph Exploration Limited (which later became Sulpetro Minerals Limited) acquired the property in 1978. Sulpetro carried out an extensive and systematic exploration program on the property, including detailed geologic mapping, soil and bedrock sampling, extensive stripping, trenching and blasting, channel sampling of mineralized zones and a total of 14 293 m of diamond drilling in 64 holes (SJ-1 to SJ-64). Eldor Resources became a joint-venture partner in the later years of Sulpetro's tenure on the property. Much of the geologic understanding of the Cadieux deposit came from the work by Sulpetro, which culminated in a non-NI 43-101–compliant resource estimate of 1.25 Mt grading 9.4% Zn and 0.7% Pb for the "Swamp zone" alone.

1985–1996: **Information gap**.
What is known is that, in 1985, Sulpetro Minerals amalgamated and became Novamin Resources Inc. Breakwater Resources Inc. acquired the property between 1985 and 1990. There is no record of work being carried out by Breakwater Resources, except for a 2-page metallurgical report dated 1990. Flotation tests were carried out at the Balmat laboratory in New York State, using the Balmat flotation process. The report concluded: "If this is representative of the orebody, this ore would be one of the best treating ores we presently mill" (Kemp 1990).

1996–1998: Noranda Mining and Exploration Inc. optioned the property from Breakwater Resources. Noranda carried out geophysical surveys (magnetometer, induced polarization), boulder mapping and soil geochemistry, and completed 13 diamond-drill holes (CA-96-1, CA-96-1A to CA-96-1G; CA-97-01, CA-97-01A, CA-97- 01B, CA-97-02 and CA-97-02A), for a total of 5457 m.

1998–2017: **Information gap**.
What is known is that Noranda returned the property to Breakwater during this period and, in 2011, Breakwater Resources Inc. was acquired by Nyrstar. Nyrstar has owned the property since and the property has been dormant.

REGIONAL GEOLOGY

The Cadieux property is located in the Mazinaw domain (1250–1300 Ma) of the Central Metasedimentary Belt of the Grenville Province. In the Admaston Township area, rocks of the Grenville Supergroup are characterized by marbles and dominantly clastic metasedimentary rocks with minor metavolcanic rocks. Plutonic rocks include granite, granodiorite, tonalite, gabbro and diorite. The supracrustal rocks have all been subjected to upper amphibolite-facies metamorphism and multiphase deformation (Soever and Jackson 1983). As part of a multi-year project, the Ontario Geological Survey conducted 1:20 000 scale mapping in the area; for further information, *see* Duguet, Magnus and Ratcliffe (2012, 2014), Duguet, Dubé-Bourgeois and Ma (2013) and Duguet (2014).

The Cadieux property is located at the northeastern end of a marble belt that trends southwesterly. The marble belt ranges in width from 1 to 2.5 km and is bounded to the northwest and the southeast by clastic metasedimentary rocks that locally may be of volcanic origin (Soever and Jackson 1983). In the immediate area of the Cadieux deposit, the marble belt is approximately 1.7 km wide. Approximately 500 m southwest of the property, the marble belt is cored by a felsic metavolcanic unit exposed over a strike length of approximately 2.7 km and 700 m in width. This felsic metavolcanic unit is believed to represent the axis of a doubly plunging antiform that plunges to the northeast, underneath the Cadieux property. A similar structure is interpreted to the northeast of the Cadieux property (Soever and Jackson 1983).

Locally, the Cadieux property is intruded by the Hurd's Lake granite, exposed just southeast of the property. A small syenitic to gabbroic intrusion is also located just northeast of the property.

Three phases of deformation exist on the property, but the second phase controls all the significant zinc-mineralized zone(s), which plunge moderately to the northeast (Roger and Turcotte 1997).

PROPERTY GEOLOGY

The authors have not been able to locate a geological map of the whole property. However, in 1983, Sulpetro Minerals Limited conducted an extensive program of mechanical stripping, trenching, detailed geologic mapping and bedrock sampling on the north-central part of the property (Figure 8). Three areas, covering 16 100 m², were stripped of vegetation and overburden, pressure-washed to expose a clean bedrock surface, mapped in detail and sampled. Trenches were then blasted to expose fresh surfaces of the mineralized zones and channel sampling was carried out. A total of 37 trenches were blasted for a total length of 301 m (Soever and Jackson 1983). Trenches varied in depth from 60 to 120 cm and ranged from 1 to 2 m wide. Only areas 1 and 2 were visited during the course of this property visit.

The property geology described below is largely based on descriptions from Soever and Jackson (1983) who supervised the work done by Sulpetro at the time and had the benefit of seeing the clean, stripped areas. Although most of the stripped areas and blasted trenches can still be relocated, 34 years of regrowth now hinders detailed mapping efforts.

All of the Cadieux property is underlain by a variety of marbles that host the zinc mineralization. The rocks are broadly subdivided as calcitic and dolomitic marbles, and "silicated-marbles", which are characterized by greater than 15% tremolite, diopside and/or serpentine (Soever and Jackson 1983). Local horizons of massive diopside and diopside-quartz were also reported, but were not observed by the authors. Other units consist of bands of dark grey, amphibole-rich paragneiss, often observed as large boudins and small, boudinaged, quartzo-feldspathic, pegmatitic dikes.

The marbles are typically pale grey to white with dark grey weathering, becoming rusty where adjacent to the mineralized zones (Photo 6B and 6C). Grain size varies, but acicular tremolite was observed to reach up to 15 cm in length (Photo 6A). Carbonate minerals are typically recrystallized, subhedral and coarse grained (up to a few millimetres in grain size).

Units strike generally 040° to 060° and dips vary from subvertical to 65° southeast. However, the units were reported by Soever and Jackson (1983) to be strongly folded. Maps show older, isoclinal folds that are refolded by a second generation of isoclinal folds with subvertical fold axial planes, trending 050°. Both generations of fold axes appear to be plunging to the northeast. Older, possibly pretectonic, structures were also reported to be folded by Soever and Jackson (1983). These structures were also described as preferred sites of hematitic alteration.

Mineralization

Five main zones of zinc mineralization were reported by Roger and Turcotte (1997). From the southwest to northeast, these are the Hisko, Central, Road, East and Swamp zones. The Swamp zone, the largest mineralized zone, is sometimes referred to as the "Main Zone". The zones generally plunge 40° along a 050° trend. The zones range from 1 to 10 m wide with down-plunge dimensions known to exceed 500 m. Roger (1996) estimated the total Probable and Possible geological resource on the property at 1.45 Mt grading 8.8% Zn and 0.8% Pb (not compliant with NI 43-101 standards).

The zinc mineralization observed at surface consists of coarse-grained, recrystallized, dark red to brown, disseminated to semi-massive sphalerite (*see* Photo 6B). Locally, minor amounts of galena and pyrite are observed. The zinc mineralization is often associated with the calc-silicate-bearing marbles, which may represent hydrothermally altered versions (now at upper amphibolite facies) of the calcitic and dolomitic marbles. Sphalerite is often observed as interstitial grains, between calc-silicate and carbonate minerals.

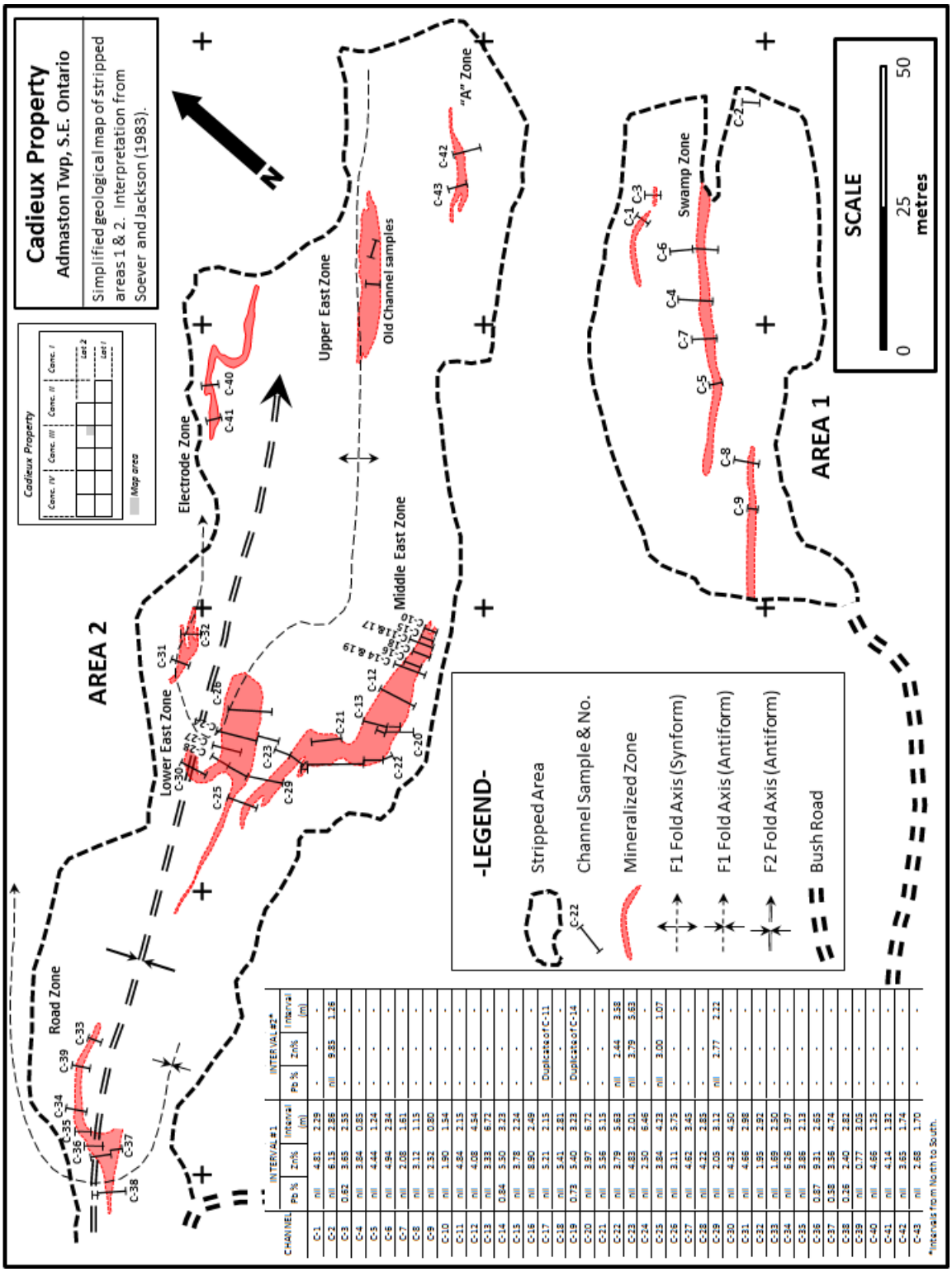

Figure 8. Surface mineralization and structural interpretation of stripped areas 1 and 2 with assay results from channel sampling (*see* Figure 7 for location at the property scale). *Modified from* Soever and Jackson (1983).

Figure 8 shows the distribution of the zinc mineralization at areas 1 and 2. Soever and Jackson (1983) reported that area 1 was dominantly underlain by dolomitic marbles which host the "Swamp Zone", whereas area 2 was dominantly underlain by the "silicate-marbles".

The authors visited areas 1 and 2 of the property and the on-site core storage facilities (Photo 6D). Multiple zones of mineralization were sampled from the blasted trenches of areas 1 and 2 (*see* Figure 8 for locations; Table 8 provides the assay results).

Table 8. Assay results of grab samples collected during the property visit. Locations are shown on Figure 8, using the trench area number, zone and channel number. (Resident Geologist's Files, Southern Ontario Region, Tweed)

Sample	Trench	Zone	Channel	Zn (%)	Pb (%)	Easting	Northing
REN-17-1	Area 1	Swamp	C-4	4.69	nil	366609	5030782
REN-17-2	Area 1	Swamp	C-7	8.19	0.03	366609	5030782
REN-17-3	Area 2	A	C-42	19.64	nil	366573	5030828
REN-17-4	Area 2	Electrode	C-41	13.05	nil	366549	5030840
REN-17-5	Area 2	Middle East	C-15	8.52	nil	366526	5030791
REN-17-6	Area 2	Road	C-37	6.90	0.04	366429	5030766
REN-17-7	Area 2	Road	C-38	12.67	1.37	366425	5030777

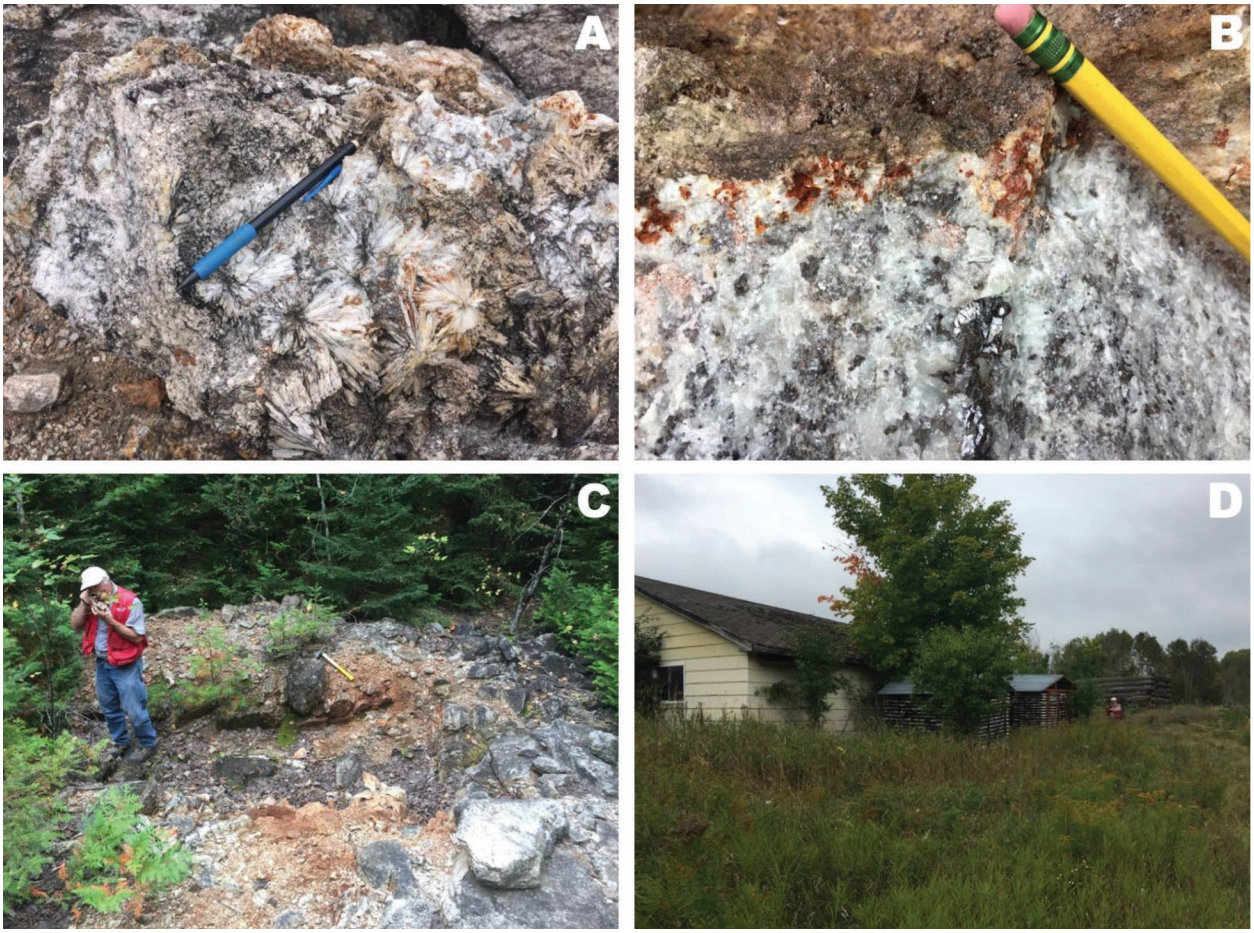

Photo 6. Photos of the Cadieux property. **A**) Mineralized horizon from the "A"-zone showing radiating tremolite aggregates (at channel sample C-42). **B**) Disseminated sphalerite in marble from the Middle East zone (adjacent to channel sample C-15). **C**) Surface exposure of the Road zone mineralized trench (at channel sample C-36, looking southwest along strike). **D**) Part of the core storage facilities on site (*see* Figure 8 for location on the property).

CONCLUSION

In the current economic context, with zinc prices at their highest since July 2007, zinc stockpiles declining and a steady high demand worldwide, the Cadieux deposit becomes a target of interest.

The following factors enhance the property's appeal:

- The property has been dormant since the late 1990s and Nyrstar has no immediate plans for future exploration.
- Proximity to infrastructure makes the deposit easy to access all year, thus significantly reducing exploration costs.
- The Balmat operations and the Valleyfield zinc refinery are nearby and may be amenable to custom processing.
- Zinc mineralization is coarse-grained and recrystallized, making metallurgical processes simple (Kemp 1990).
- The surface rights to most of the property are already acquired.

It is the right time for an exploration company to revisit the Cadieux deposit and investigate its potential. It is also a great time to explore southern Ontario's underexplored marble belts of the Central Metasedimentary Belt for SEDEX-type deposits, with all the modern exploration tools now available.

Brampton Brick Limited – Cheltenham Quarry, Chinguacousy Township

A.C. Tessier, P.S. LeBaron and K.E. Hahn (ERGMS-OGS) visited the Cheltenham Quarry site in June 2017. The property visit was guided by Dave Thompson for Brampton Bricks.

Brampton Brick Ltd. 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. Increased demand in both the masonry products and landscape products business segments in Canada and the United States has also prompted an increase in production from the company's shale quarry at Cheltenham (Brampton Brick Limited, www.bramptonbrick.com, 2017 Third Quarter Report [accessed January 18, 2018]).

Brick production at the current site of the Brampton Brick Plant is believed to have started in the late 1880s (Guillet 1967). The old brick plant at the site of the Cheltenham Quarry, however, was built by the Interprovincial Brick Company in 1912, bought by Domtar Construction Materials Ltd in 1928 and closed on January 1, 1965 (Guillet 1967). Quarrying at the Cheltenham Quarry is assumed to have started at that time.

CHELTENHAM QUARRY – LOCATION AND ACCESS

The Cheltenham Quarry is located in Chinguacousy Township, Concession V, lots 29 and 30. The quarry is off Mississauga Road, 1.4 km from Cheltenham and approximately 14 km west of Brampton (Figure 9).

Red shale from the Queenston Formation is extracted in the Cheltenham Quarry. The Queenston Formation is the uppermost Upper Ordovician unit in southern Ontario. In the Cheltenham area, it is underlain gradationally by the shaly and impure limestones of the Georgian Bay Formation, and overlain unconformably by the sandstones of the Lower Silurian Whirlpool Formation (Easton 1992).

At the Cheltenham Quarry, the Queenston Formation consists of thinly bedded, recessive-weathering "brick-red" shale, intercalated with a number of more competent "blue shale horizons", up to 1 m in thickness. The "Red Shale" is earthy, clay rich and massive in hand sample (Photo 7A); the "Blue Shale"

is typically a pale greenish-grey, calcareous siltstone locally showing ripple marks and cross bedding (Photo 7B). These intercalated horizons are observed on every wall of the pit (Photo 7C).

Excavation is typically done by backhoe, except for one particularly competent, 1 m thick bed of "Blue Shale" that typically needs to be blasted in order to excavate. The excavated material is transported onto stock piles for drying, mixing and weathering. The shale turns to rubble within a week of exposure under normal weathering conditions (*see* Photo 7A). The "Blue Shale" is mixed and incorporated with the "Red Shale" and the mix is shipped to the plant. The material that is shipped to the plant has to maintain a carbonate proportion of approximately 20% within the clay material to ensure proper firing of the bricks (D. Thompson, Brampton Brick Ltd., personal communication, June 19, 2017).

Occasionally, horizons (or pockets) rich in gypsum (Photo 7D) are encountered and piled away from the stockpile, as they are not conducive to brick production.

Hematized horizons within the "Blue Shale" and remnants of "Blue Shale" within the "Red Shale" (*see* Photos 7A and 7B) suggest early diagenetic alteration.

About 540 000 t of Queenston Formation shale were extracted in 2017 (1600 t per day) at what is referred to as phase 2 of the quarry operation (Photo 8). Phase 1, an earlier pit located north of the current extraction site, was rehabilitated approximately 5 years ago (Photo 7E; Figure 10) into a lake and surrounding wetland. Phase 3 will be located at the south end of the current pit (D. Thompson, Brampton Brick Ltd., personal communication, June 19, 2017). The quarry operation is run by 2 to 6 persons from Brampton Brick Ltd. and contractors.

The availability of red shale from the Queenston Formation as raw material for brick fabrication is threatened by urban encroachment. Municipalities are currently evaluating the red-shale resources within their respective municipal boundaries.

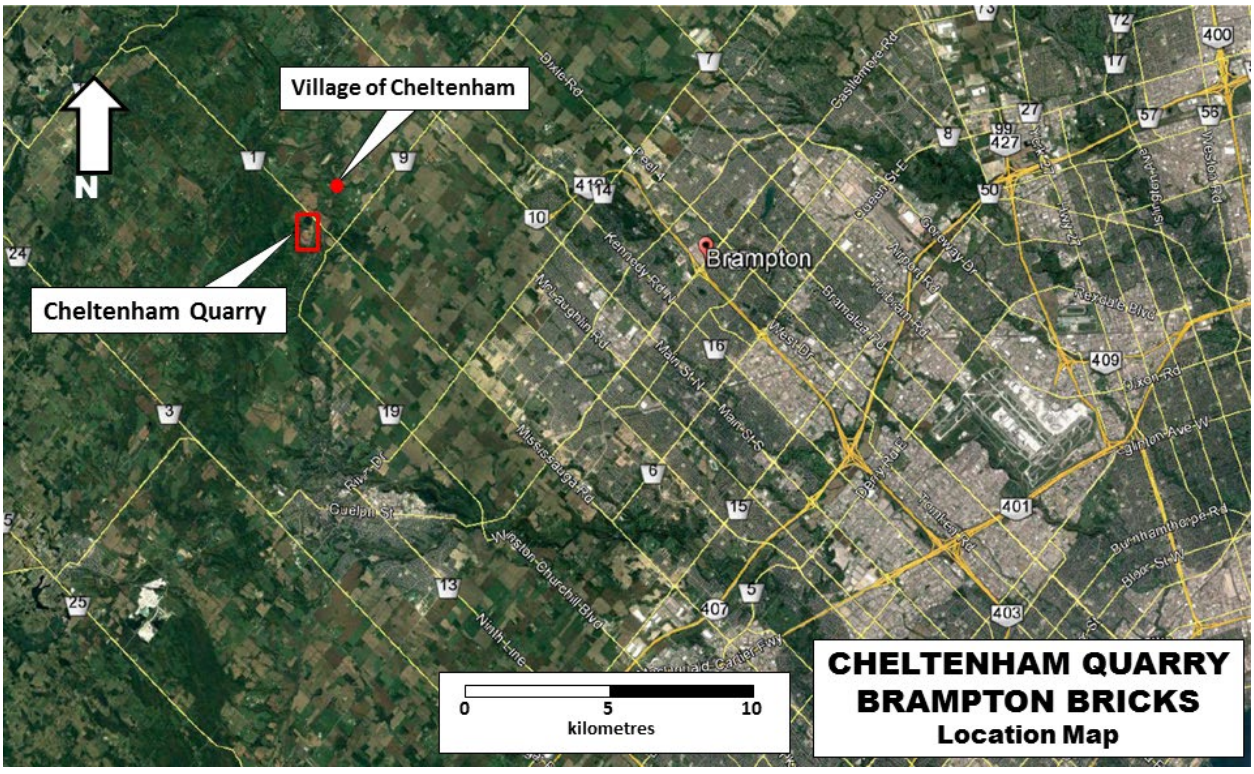

Figure 9. Location map of the Cheltenham Quarry (image *from* Google Earth™ mapping service).

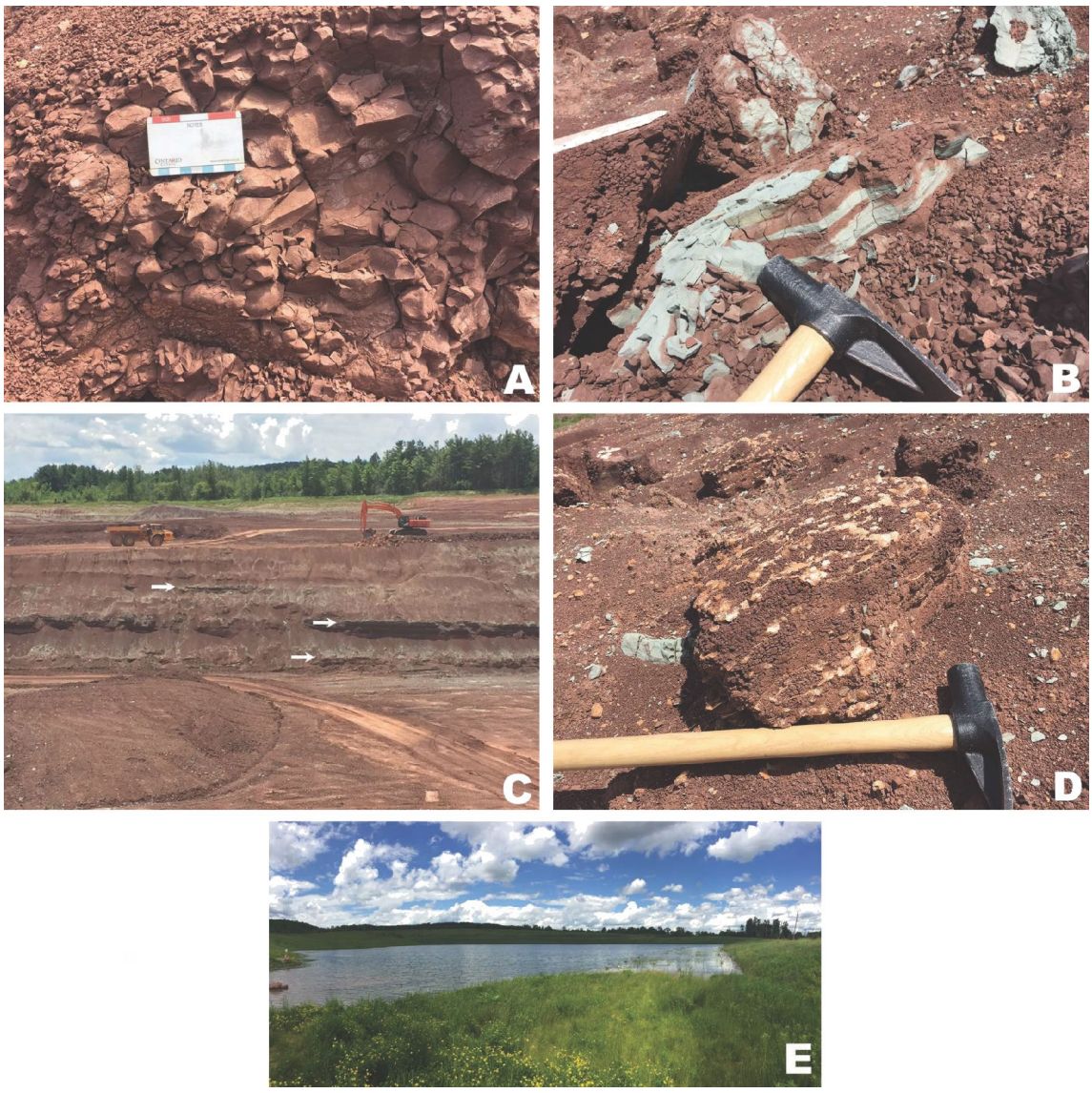

Photo 7. **A**) "Red Shale" from stock pile. The rock turns to rubble within a few weeks of being exposed to surface weathering conditions. **B**) "Blue Shale" partially hematized into "Red Shale" from the stockpile. Note the rubbly texture resulting from exposure to weathering. **C**) South wall of the quarry, showing intercalated "Red Shale" and "Blue Shale". Arrows point to the resistant "Blue Shale" beds. "Red Shale" is recessively weathered. **D**) "Red Shale" with gypsum "kernels". **E**) Rehabilitated phase 1 of the Cheltenham Quarry, looking northwest.

Photo 8. Panoramic photo showing phase 2 of the Cheltenham Quarry, looking south. Photo by A.C. Tessier, June 2017 (Resident Geologist's Files, Southern Ontario Region, Tweed).

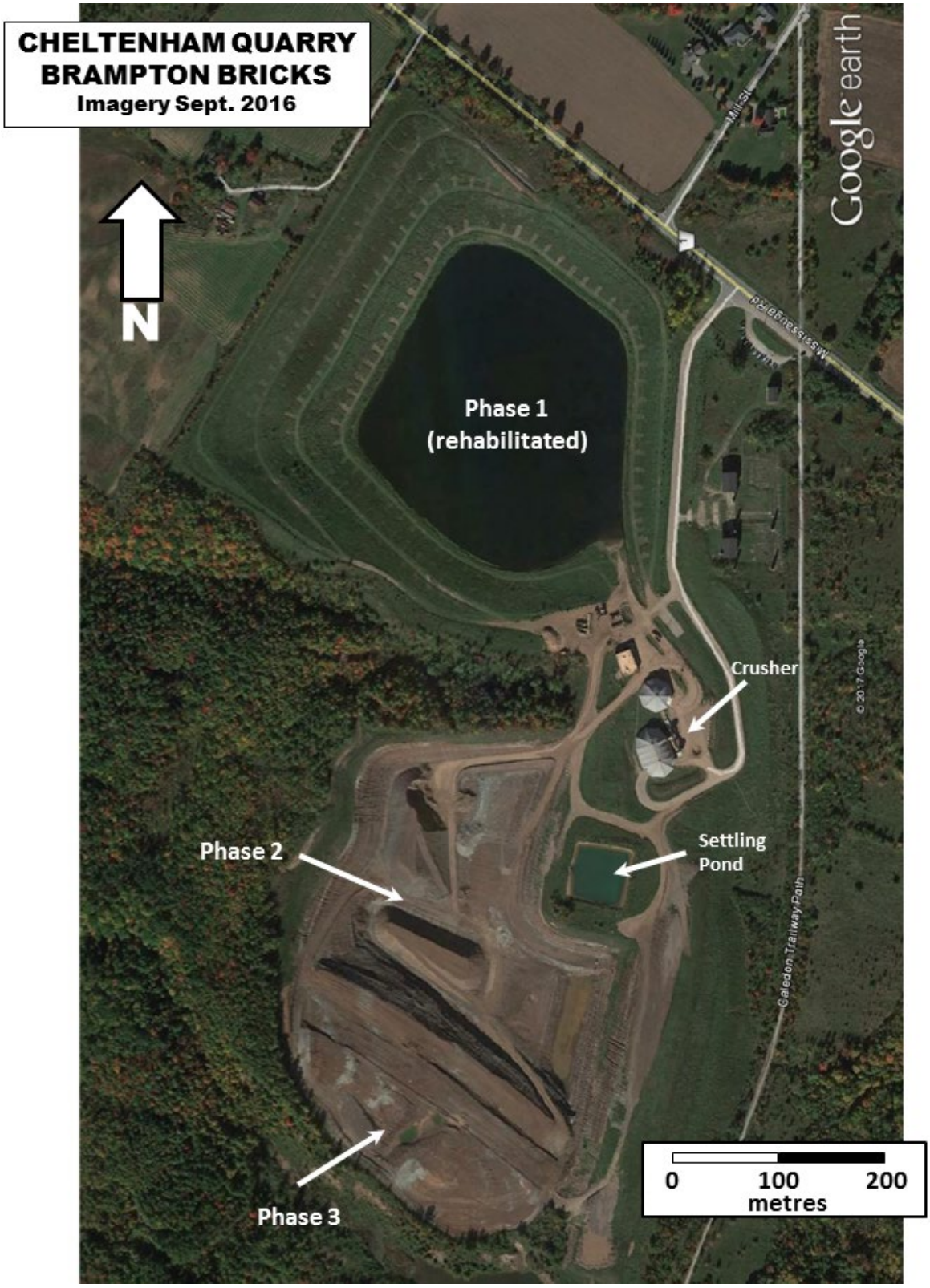

Figure 10. Areal view of the Cheltenham Quarry phases 1, 2 and 3. For other photos of phases 1 and 2, *also see* Photos 7 and 8. Image *from* Google Earth™ mapping service.

Rare Elements and Rare Earth Elements Project, Perth and Sharbot Lake Areas

In 2017, there was renewed interest in many rare earth elements (REE) and rare elements (also referred to as “rare metals”), such as niobium and tantalum, as both demand and prices increased, primarily because of increased production of permanent magnets and rechargeable batteries used in the electric vehicle industry (Roskill Information Services 2018).

Rare earth magnets are the world’s strongest permanent magnets. Neodymium and praseodymium are key components of magnets used in electric motors and regenerative braking systems in hybrid and electric vehicles, as well as in miniaturization of high-technology applications, such as hard-disc drives, DVDs, and cell phones. Nickel metal hydride (NiMH) rechargeable batteries, also used in hybrid and electric vehicles, contain cerium and lanthanum. A full hybrid electric vehicle with a lithium-ion battery contains approximately 1 kg of rare earth elements (Alonso et al. 2012).

Recent mapping in the Central Metasedimentary Belt by the Ontario Geological Survey has identified REE mineralization in calcite vein-dikes, in coarse-grained, pink, calcite-rich rocks, in diopsidites, in apatite-rich carbonates and in mica pyroxenites that were mined in the early to mid-1900s as sources of phosphate and mica. Total REE contents of up to 2280 ppm in apatite, 2095 ppm and 689 ppm in non-apatite-bearing, pink-orange calcite marble were obtained from samples in the Cobden area (Easton 2014). More recently, in the Perth area, total REE contents of 748 ppm (mainly light REE) and 1678 ppm Sr were obtained from a pink calcite rock from the Cantin Mine (a former mica-apatite producer; Easton 2016a). A preliminary model for the deposits was presented by Easton (2016b). An important feature of the mineralization is the presence of rare earth element–enriched carbonate phases that are more conducive to REE extraction than rare earth element–bearing silicates of the pegmatitic deposits, without the deleterious radioactive elements (i.e., U, Th).

To follow up on the REE potential of these metasomatic carbonate-phosphate occurrences, staff of the Southern Ontario Resident Geologist Office conducted a sampling program of past-producing, apatite (phosphate)-mica deposits in the Perth and Sharbot Lake areas. The objective of this sampling program was to determine if these deposits represent potential targets for REE exploration.

A total of 28 sites were visited and sampled during the months of July and August 2017. Most (23) of the sites are clustered in Burgess Township, south of the town of Perth. In the Sharbot Lake area, 2 sites are located in Oso Township, 2 more in South Sherbrooke Township and 1 in Hinchinbrooke Township. The small deposits were typically mined as small operations, ranging from trenches to small open pits, and some with development, albeit limited, underground.

The mineralization consists of complex arrays of vein-dikes and small irregular intrusive bodies, ranging in width from a few centimetres up to 6 m, discontinuously over strike lengths of up to 400 m (based on reported underground workings and surfaces trenches). Based on the old excavations, individual “lenses” do not appear to exceed 50 m in length. Irregular offshoots to the main intrusive bodies extend over several metres in all orientations.

The intrusive rock consists dominantly of coarse-grained, buff-pink calcite with euhedral crystals of biotite, apatite and diopside in various proportions and ranging in size from 5 mm to larger than 30 cm. The pink calcitic material appears to be crosscut locally by pale apple-green to black, fine-grained masses of diopside, apatite, biotite and calcite with euhedral phenocrysts of diopside and biotite, up to 30 cm in diameter (Photo 9).

Multiple samples of the calcite-biotite-diopside-apatite rocks were collected and sent to the Ontario Geological Survey Geoscience Laboratories in Sudbury for analyses. Preliminary results showed up to 4429.8 ppm Sr, up to 873 ppm Ce and up to 518 ppm La (Resident Geologist's Files, Southern Ontario Region, Tweed). The data are currently being processed for future analysis and publication by the Ontario Geological Survey.

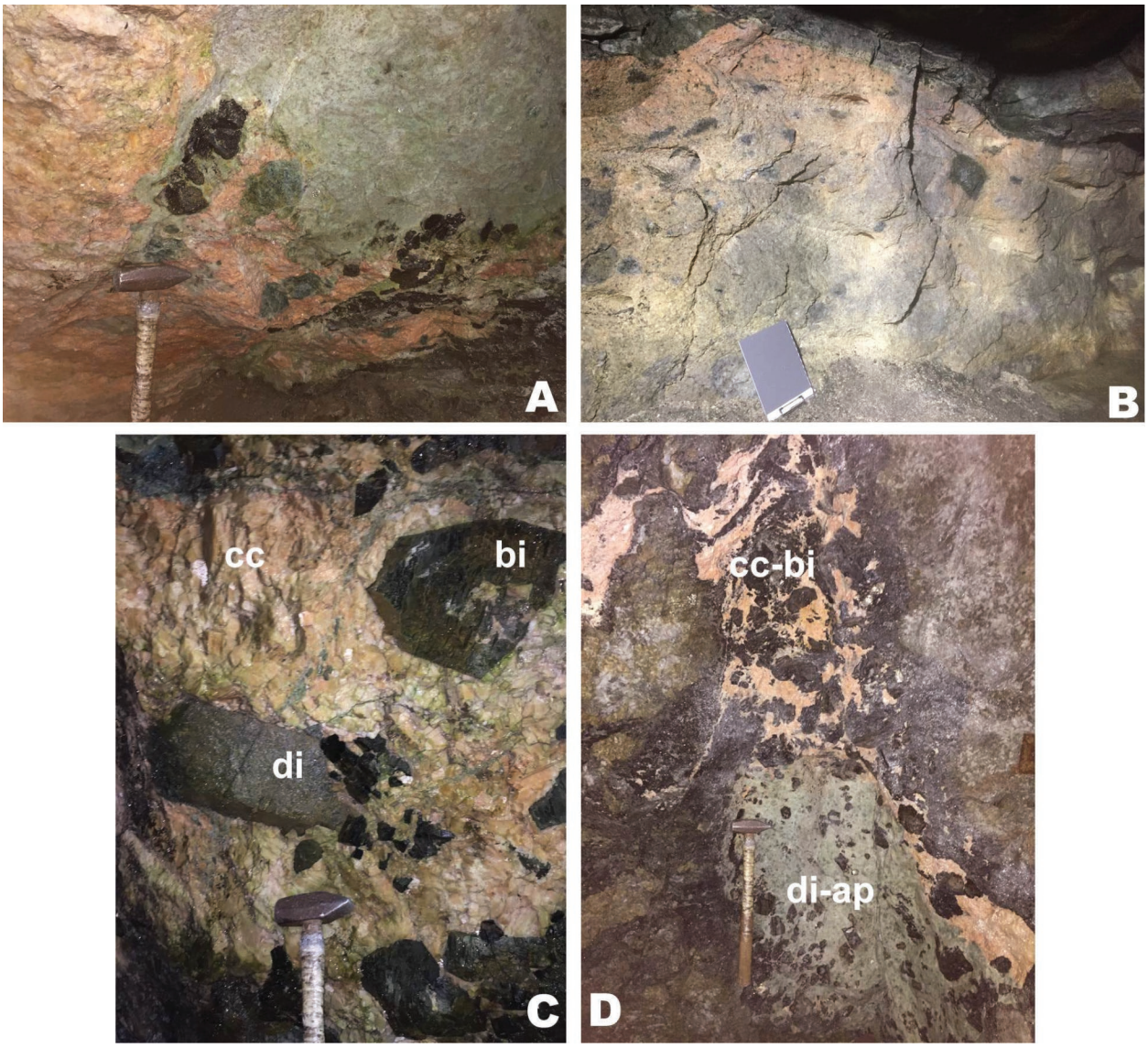

Photo 9. Underground photos from the Silver Queen Mine, Murphy's Point Provincial Park, 14 km south of Perth. **A**) Apple-green diopside-apatite rock cutting the pink calcite rock. **B**) Subhorizontal "pink" calcite vein particularly devoid of phenocrysts (for scale, note pad is 30 cm). **C**) Pink calcite material (cc) with phenocrysts of diopside (di) and biotite (bi). **D**) Subvertical "vein" with pink calcite-biotite material (cc-bi) and green apatite-diopside material (di-ap). Both show large phenocrysts of biotite. For scale on Photos 9A, 9C and 9D, hammer head is 11 cm. Photos by A.C. Tessier, July 2017 (Resident Geologist's Files, Southern Ontario Region, Tweed).

RECOMMENDATIONS FOR EXPLORATION

Talc and Mica: Industrial Mineral Fillers in Southeastern Ontario

Note: The following recommendation is modified from *LeBaron (2018).*

The use of reinforced polymers based on talc, mica and other industrial mineral fillers has increased in recent years, led by the automotive industry, as manufacturers attempt to produce lighter vehicles for improved fuel efficiency in gas-powered and hybrid automobiles and to improve the power-to-weight ratio in electric vehicles (Imerys 2016).

Roskill Information Services (2015) estimated that the world talc demand would increase by 2.3% annually from 2015 to 2020. Growth was projected to be led by the plastics industry, with demand also increasing in paint, food processing and technical ceramics markets. The largest market for talc has traditionally been in the paper sector. However, by 2019, plastics are expected to overtake paper as the largest talc-consuming application worldwide. In polypropylene, talc imparts the mechanical properties of strength and stiffness, among others, allowing plastic to replace heavier metal components in vehicles. The average talc content of a light European Union automobile more than doubled between 2006 and 2014 (Roskill Information Services 2015).

The global production and consumption of mica has also increased significantly in the past few years and is expected to continue to grow at a rate of 2.6% annually from 2016 to 2024, reflecting high demand from several industries, such as plastics, paints, construction, electronics and cosmetics. Mica can be delaminated into extremely thin sheets that are flexible, chemically inert and very durable—properties that improve the qualities of some plastics. In the electronics industry, sheet mica is used as a thermal and electrical insulator. Fine-grained flake mica is added to paint to extend the shelf life and enhance the intensity and brightness of coloured pigments. The highly reflective aspect of flake mica also makes it useful in the production of cosmetics and toothpastes (Transparency Market Research 2016).

Both talc and mica have been produced historically in southeastern Ontario since the late 1800s. The closure of the Canada Talc Mine in Madoc in 2010 leaves only 1 producing talc mine in Canada, the Imerys Talc Canada Inc. mine and micronizing plant near Timmins.

Past mica mining operations in Ontario produced sheet mica for electrical applications. There are currently no mica mining operations in Ontario and only one in Canada—a phlogopite mine in Quebec operated by Imerys. The phlogopite is used to provide dimensional stability, increased stiffness and improved heat distortion temperature of plastic composites used in automotive applications (Imerys, “performance minerals - Mica”, www.imerys-perfmins.com [accessed November 1, 2017]).

The geology of Ontario’s talc and mica deposits and areas with potential for additional discoveries are described below.

TALC

Talc deposits in the Grenville Province of southeastern Ontario can be separated into 2 types: those derived from alteration of carbonate rock and those derived from alteration of ultramafic rock. Many occurrences of both types within the Central Metasedimentary Belt are described in detail by LeBaron and van Haaften (1989).

Carbonate-Hosted Talc

Southeastern Ontario's largest talc mine, the Canada Talc Mine at Madoc, operated from 1896 to 2010 and produced about 1.5 Mt of talc from a high-purity deposit hosted by dolomitic marble (Resident Geologist's Files, Southern Ontario Region, Tweed). Talc is the first mineral to form during progressive metamorphism of siliceous dolomitic limestone, according to the following reaction (Winkler 1979):

$$3 \text{ dolomite} + 4 \text{ quartz} + 1 \ H_2O = 1 \text{ talc} + 3 \text{ calcite} + 3 \ CO_2$$

With increasing temperature, tremolite is formed from the talc± calcite assemblage, followed by diopside ± tremolite ± quartz at higher grades of metamorphism. These reactions indicate that talc should be present near the tremolite isograd in areas underlain by siliceous dolomitic marble, a model that can be applied to the Canada Talc deposit at Madoc and to the definition of new areas with potential for talc deposits.

The Canada Talc deposit occurs within marble of the Belmont domain, an area of middle to upper greenschist-facies metamorphism in which quartz and dolomite coexist in carbonate rocks, except in zones of higher metamorphic grade within thermal aureoles of intrusive bodies (Figure 11). The deposit occurs in a zone of tremolitic marble, approximately 800 m northwest of the Moira [Lake] Granite. The host rock dolomitic sequence includes thin quartzite beds and stromatolitic marble consisting of alternating quartz and dolomite laminae: evidence of a pre-metamorphic environment with the ingredients necessary for the formation of talc.

Previous explanations of the origin of the talc zone (Hewitt 1972) involve siliceous hydrothermal fluids originating from the Moira Granite intrusion being introduced into the dolomite sequence along structural channels. However, although structural control may have been involved in the circulation of fluids, it is not necessary to assume an external source of silica and water. The contribution of the Moira Granite to the formation of the talc deposit may have been only heat, in which case, talc and tremolite alteration zones should be expected near the margin of the thermal aureole of any igneous intrusions, whether mafic or felsic, in areas of siliceous dolomitic marble of low regional metamorphic grade.

Based upon the deposit model described above, the Belmont domain hosts geological conditions favourable for the formation of talc deposits. Figure 11 shows several talc occurrences within areas of marble intruded by mafic to felsic plutons, such as the Moira Granite, Deloro Granite, Cordova Gabbro, Tudor Gabbro and Gawley Creek Syenite. This part of the Belmont domain is characterized by middle to upper greenschist-facies metamorphic assemblages, with higher grade assemblages noted at contacts with intrusive rocks (Easton 1992). Structural features, such as fold hinges and faults, within the favourable host rocks should also be investigated for talc mineralization. Topographic lows within areas of relatively resistant tremolitic marble may represent areas of shearing or faulting that may host softer, more talc-rich zones.

Ultramafic Intrusion-hosted Talc

A belt of talcose ultramafic rocks is intermittently exposed within a zone, up to 2 km wide, within the metavolcanic belt along the western margins of the Elzevir and Weslemkoon tonalitic batholiths, through Elzevir, Madoc, Grimsthorpe and Cashel townships (*see* Figure 11). These rocks are considered to be ultramafic intrusive phases of gabbroic rocks of the Canniff Complex, and possibly may be a partially preserved ophiolite fragment (Easton and Ford 1994). They have been altered to various assemblages of talc, chlorite, serpentine, carbonate, hematite, magnetite and anthophyllite.

Between 1883 and 1929, small quantities of talc-rich rock were quarried in Elzevir Township, near Actinolite, for use in roofing material and, in 1938, there was minor underground development on a talc occurrence in Cashel Township. Both occurrences, along with 14 others in the Elzevir–Cashel ultramafic

belt, are described by LeBaron and van Haaften (1989); the general characteristics of the talcose zones are provided as follows:

> "The talcose zones vary in width from 5 to 40 m, averaging 20 to 40% talc. Associated minerals include dolomite, serpentine, anthophyllite, chlorite, and magnetite. Less common are calcite, tremolite, and actinolite. Dimensions are difficult to determine because of poor exposure, but exposed widths of 15 m and lengths of 50 to 75 m are common. Both the McMurray occurrence (CL3) and the Cooper occurrence (MC6) are at least 40 m wide and over 300 m long." (LeBaron and van Haaften 1989, p.37-38)

LeBaron and van Haaften (1989, p.147) also reported that diamond drilling in 1985 on the Cooper occurrence, Madoc Township indicated "a possible 2 million-ton talc deposit to a depth of 30 m", grading 30 to 33% recoverable talc.

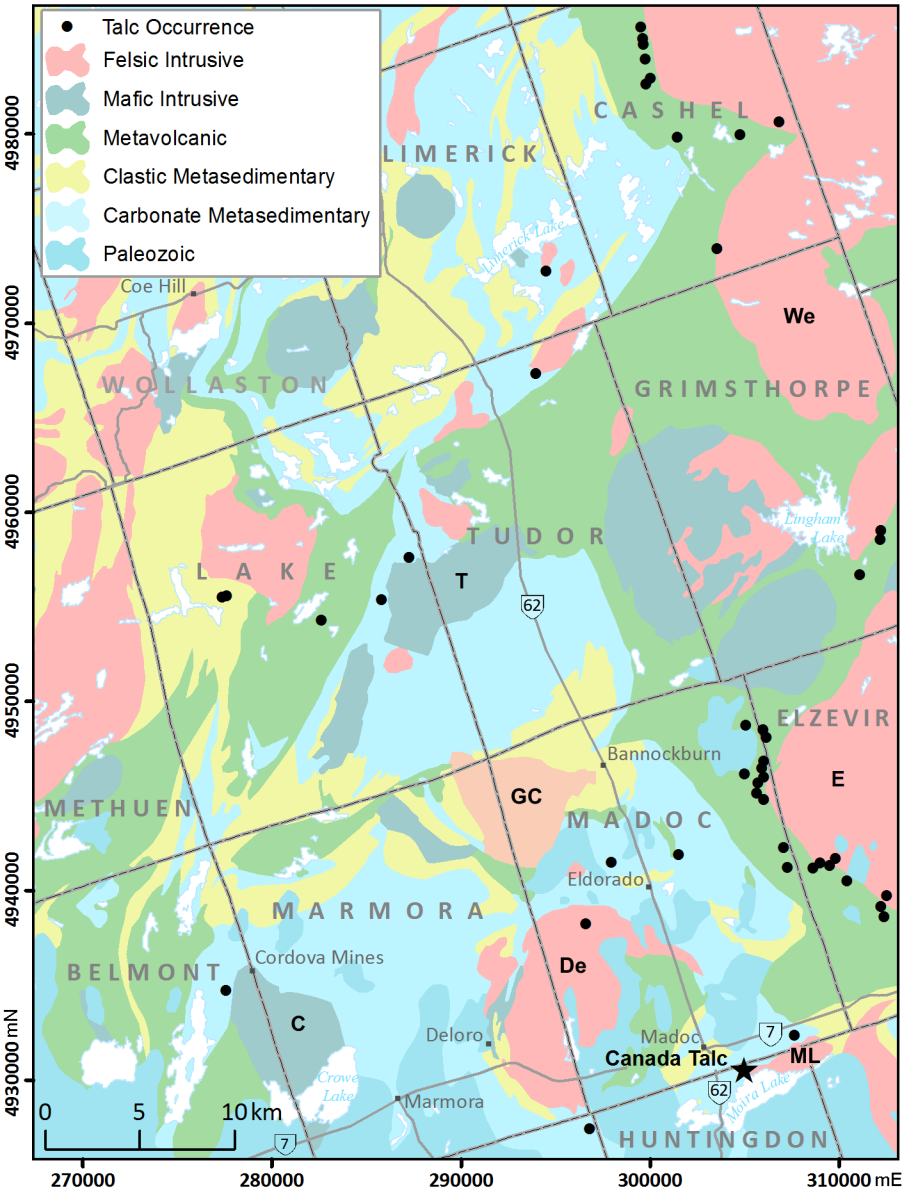

Figure 11. Geology and talc occurrences, Belmont domain, southeastern Ontario. Abbreviations: C, Cordova Gabbro; De, Deloro Granite; E, Elzevir Tonalite; GC, Gawley Creek Syenite; ML, Moira [Lake] Granite; T, Tudor Gabbro; We, Weslemkoon granite. Talc locations *from* Mineral Deposits Inventory database (Ontario Geological Survey 2017a); geology *from* Ontario Geological Survey (2011).

Beneficiation tests done on composite samples from the Cooper occurrence and from 2 occurrences in Cashel Township were described by LeBaron and van Haaften (1989, p.42-45, p.221-240). Feed grades ranged from 30 to 47% talc, recoveries ranged from 75 to 90%, and dry brightness was close to values for high-quality commercial talc. It was determined that talc products from all 3 properties have potential for use in the paint, plastics and paper industries.

The Elzevir–Cashel townships belt of ultramafic rocks is well-situated for the production of talc with respect to access, infrastructure and proximity to markets in Ontario, Quebec and the northeastern United States.

MICA

All mica historically mined in southeastern Ontario has come from carbonatite-pyroxenite and pegmatite dikes that produced coarse sheet mica. This recommendation for exploration focusses on metasedimentary rock–hosted, flake muscovite deposits, because white mica is the preferred variety for most mineral filler applications and the grade and tonnage potential for stratabound, flake muscovite deposits is much greater than that of pegmatite-hosted deposits: in the order of millions of tonnes of 30 to 60% mica in the former and thousands of tonnes of less than 5% in the latter (Watts, Griffis and McOuat and Ontario Geological Survey 2002).

The most significant, known flake muscovite deposit in southeastern Ontario is located in Kaladar Township (the Kaladar mica prospect: Figure 12). It consists of a muscovite schist up to 50 m thick, with a strike length of 2.5 km and containing up to 60% muscovite, with a possible resource of about 10 Mt to a shallow depth (non-NI 43-101–compliant; Watts, Griffis and McOuat and Ontario Geological Survey 2002). Accessory minerals include quartz, biotite, hematite and minor amounts of andalusite, sillimanite and tourmaline. The muscovite schist occurs within a belt of metapelitic gneisses and schists within the Clare River synform, a narrow northeasterly trending structure within the Mazinaw terrane of the Central Metasedimentary Belt (*see* Figure 12). The metapelitic rocks form part of the Flinton Group of metasedimentary rocks, which were deposited unconformably upon older rocks of the Grenville Supergroup between 1020 and 1155 Ma (Easton 2001).

The Kaladar mica prospect has been investigated by several companies since its discovery in 1978, including Omya Inc., Lacana Mining Corporation and Koizumi Group Canada Ltd. In 1982, Koizumi extracted a 5000 t bulk sample from a test quarry in Kaladar Township, Concession V, Lot 4 (UTM co-ordinates: 329490E 4940800N, Zone 18). The area of the test pit is currently designated by the Ministry of Natural Resources and Forestry as a Forest Conservation Reserve; however, strike extensions of the zone have potential for additional zones of muscovite concentration. In the area of the test pit and along strike to the southwest, creeks and beaver ponds follow the trend of the strata; therefore, it is possible that much of the muscovite schist is not exposed at surface, particularly in the nose of the Clare River synform.

Metapelitic gneisses and schists of the Flinton Group also occur in a narrow belt trending northeastward through Kaladar Township and into Barrie Township, and in the Fernleigh syncline through the central parts of Barrie and Clarendon townships (*see* Figure 12).

Within the Kaladar–Barrie townships belt, Verschuren (1983) noted that there is a lower potential for high-grade muscovite of significant tonnage, but that a few high-grade zones (40–50% muscovite) occur. This area may warrant further investigation, based on the observation that the muscovite zones may occupy topographic lows, as in the Clare River area.

In the Fernleigh syncline, muscovite occurs in a quartz-muscovite-staurolite schist that can be traced from Mississagagon Lake in Barrie Township to Ardoch near the eastern boundary of Clarendon Township. In this area, the flake size and abundance of muscovite increase and zones up to 20 m wide of potentially economic resources have been observed (Tibble and Ardoch properties: Watts, Griffis and McOuat and Ontario Geological Survey 2002, p.75).

CONCLUSION

An ideal mineral filler is inert, is non-hazardous, has a low specific gravity, is non-abrasive, has consistent properties and can be produced at a relatively low cost. Talc and mica meet these requirements and many occurrences of each are known within the Central Metasedimentary Belt of southeastern Ontario. The industrial applications of both minerals, particularly in the plastics industry, is increasing.

Exploration for talc is recommended within marble belts and ultramafic intrusive rocks of the Belmont domain. Exploration for mica is recommended in metapelitic rocks of the Flinton Group in the Mazinaw terrane.

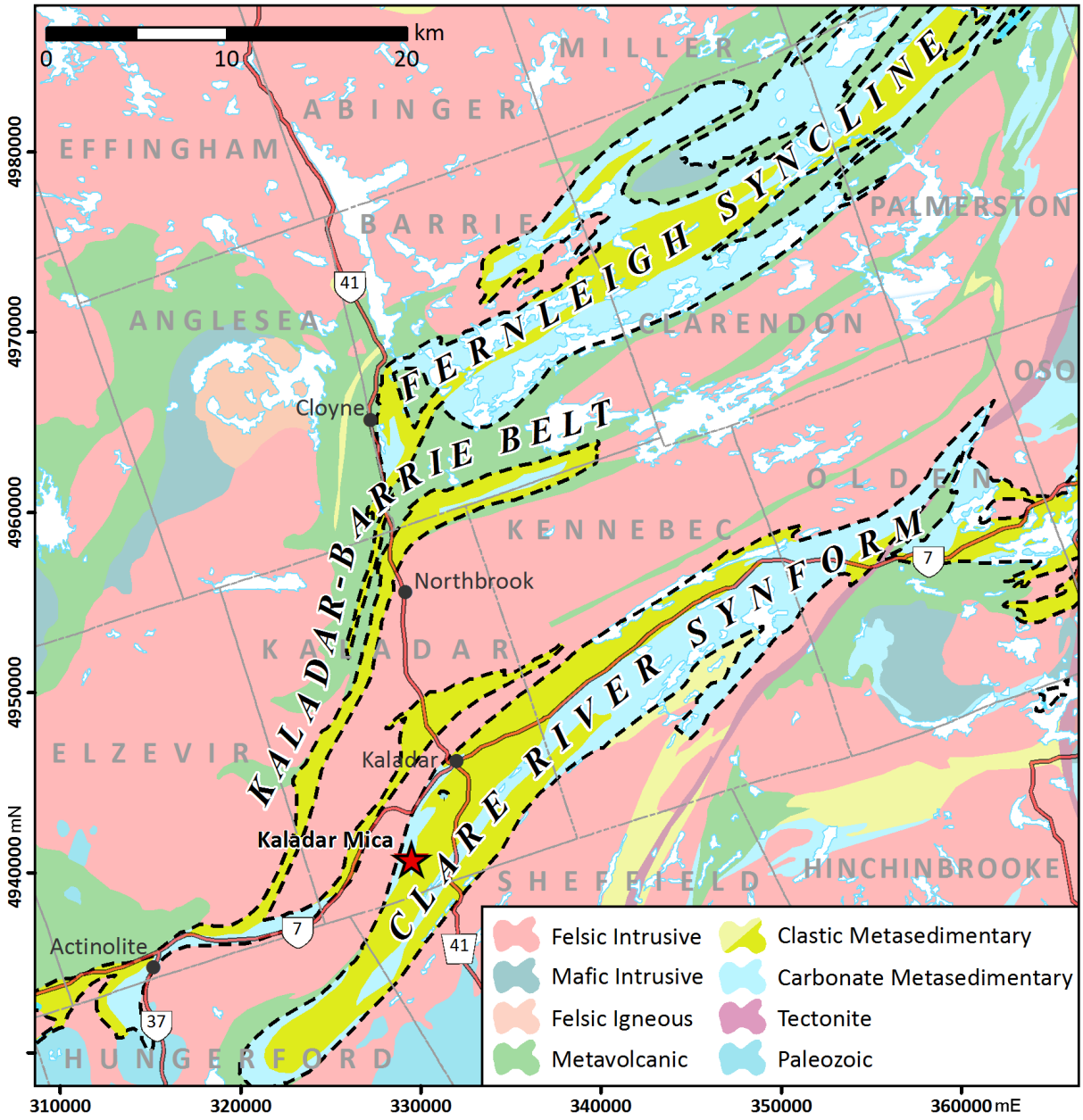

Figure 12. Location of predominantly Flinton Group clastic metasedimentary rocks (lime green) hosting pelitic metasedimentary rocks with potential for muscovite concentrations; geology *from* Ontario Geological Survey (2011).

Recommendation for Gold Exploration in Southern Ontario Using GeologyOntario and OGSEarth

Note: The following recommendation is modified from *Tessier and Charbonneau (2018).*

INTRODUCTION

An office-based study of southern Ontario's "gold camp" was undertaken by the authors, using information readily available to the public through OGSEarth, an online application that draws on information stored in the Mines and Minerals Division's online data warehouse, GeologyOntario. Data provided by OGSEarth are available in Keyhole Markup Language (KML) format and can be viewed using such applications as Google Earth™ mapping service. OGSEarth can be accessed at https://www.mndm.gov.on.ca/en/mines-and-minerals/applications/ogsearth).

Taking a predominantly structural approach, Mineral Deposit Inventory (MDI) records were reviewed for past gold producers, prospects and occurrences, and geological, magnetic (total field and first vertical derivative of the total magnetic field), gravity and digital elevation maps were interpreted in an effort to outline new target areas for exploration.

Previously unrecognized structures and other geological features are interpreted below, and areas of high potential for gold mineralization are recommended for further exploration.

GEOLOGY OF GOLD MINERALIZATION IN SOUTHERN ONTARIO'S GOLD CAMP

Figure 13 shows the geology and gold occurrences of the study area, an area loosely referred to as southern Ontario's "gold camp".

Regional Geology

The area of interest is centred on the Grimsthorpe domain and includes the eastern part of the Belmont domain (Elzevir terrane) and the southwestern part of the Mazinaw terrane, in the Central Metasedimentary Belt of the Grenville Province. The geology is dominated by mafic metavolcanic and clastic metasedimentary rocks of the Grimsthorpe Group (>1280 Ma), carbonate-dominated metasedimentary rocks of the Belmont domain and clastic metasedimentary rocks of the Flinton Group (*circa* 1155 Ma: Easton 2008).

The base of the stratigraphic sequence in the area consists of tholeiitic mafic to intermediate metavolcanic and volcaniclastic rocks of the Canniff Complex and the Tudor Formation. In the Madoc and Tudor townships area, the Tudor Formation is unconformably overlain by the carbonate-dominated metasedimentary rocks of the Belmont domain, whereas in the Elzevir and Kaladar townships area, the Tudor Formation is unconformably overlain by quartz arenites, "Timiskaming-style" conglomerates and pelitic schists of the Flinton Group (*circa* 1155 Ma: Easton 1992). In the southern portion of the study area, Grenvillian rocks are unconformably overlain by subhorizontal Paleozoic limestones. Grenvillian supracrustal rocks are crosscut by several suites of intrusive rocks (Easton 1992, 2008).

In the area, greenschist- and lower amphibolite-facies metamorphism took place from 1130 to 1070 Ma (Easton 1992, 2000).

Controls for Gold Mineralization in Southern Ontario

In the past, the following controls for gold mineralization in southern Ontario have been suggested, as summarized by Sangster et al. (2014) (refer to Figure 13 for locations of deposits):

1. Intrusive margins: The Cordova and Deloro mines are quartz vein-type deposits that formed within intrusions, near the margins of the Cordova Gabbro and the Deloro Granite. The veins include pyrite, chalcopyrite, arsenopyrite, tourmaline and iron-bearing carbonates.
2. Metavolcanic–metasedimentary contact at the top of the Tudor Formation: The Sophia, Mono and Gilmour gold deposits occur in metavolcanic and metasedimentary rocks near the top of the Tudor Formation where it is in contact with the carbonate-dominated metasedimentary rocks of the Belmont domain. Deposits consist of quartz and quartz-ankerite veins containing pyrite, pyrrhotite, arsenopyrite and traces of native gold. All are structurally controlled and occur within zones with pervasive iron carbonate and/or biotite-sericite alteration (Fingas 2013, 2015).
3. Flinton Group unconformity at the top of the Tudor Formation: The Addington and Ore Chimney mines and the Harlowe area occurrences represent concentrations of gold in metavolcanic and metasedimentary rocks at the top of the Tudor Formation, immediately beneath the unconformity with the Flinton Group sedimentary rocks (which include Timiskaming-type conglomerates), along the northern margin of the Northbrook granodioritic pluton (Moore and Morton 1986). Gold mineralization consists of quartz veins with tourmaline, pyrite, chalcopyrite, galena, sphalerite and tetrahedrite.

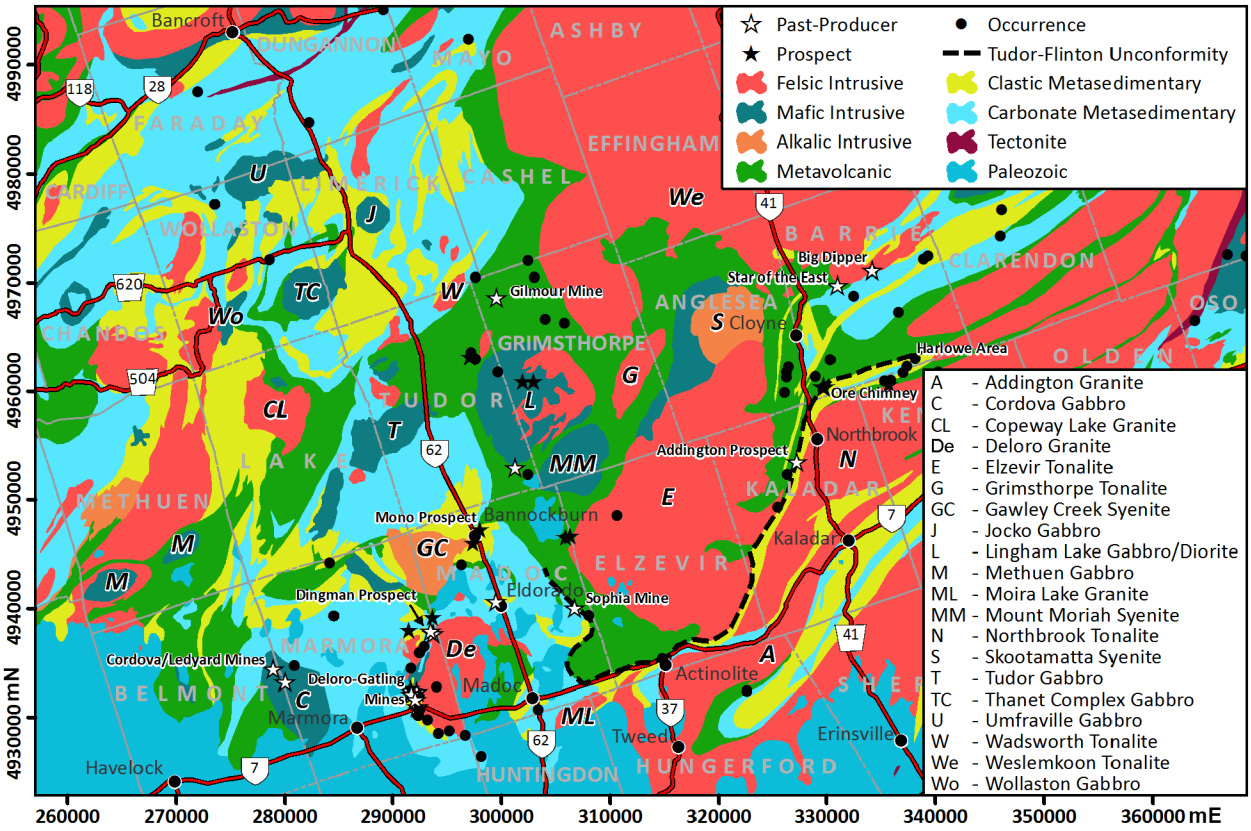

Figure 13. Regional geology of the study area with locations of past producers, prospects and gold occurrences. Figure created using bedrock geology from Ontario Geological Survey (2011) and data *from* Ontario Geological Survey (2017a), both of which are available through OGSEarth. The UTM co-ordinates are provided using NAD83 in Zone 18.

It should be noted that the Dingman deposit stands alone as a structurally controlled stockwork deposit with disseminated gold, confined to a small intrusive body. The Dingman deposit (11.6 Mt at a grade of 0.97 g/t Au) has potential for a low-grade, high-tonnage operation (Sangster et al. 2014, p.50-51).

METHOD

For this compilation, geological, geophysical and digital topographic elevation maps were downloaded "as is" from OGSEarth without any data manipulation. The geophysical maps were interpreted for linear and circular features and geological maps were used as lithological controls.

Records for past producers, prospects and occurrences where gold is the primary commodity were downloaded from the Mineral Deposit Inventory (MDI). Discretionary occurrences were not included. Occurrence criteria are from MNDM (2012) and Wilson et al. (2008). For additional details on certain occurrences, references listed in the MDI records were consulted.

The MDI records for past producers and prospects were reviewed and the general orientations of veins were recorded and compiled. Although much of the data is based on historical documents and must be refined, a number of broad orientation clusters of veins are observed in all parts of the study area (Figure 14).

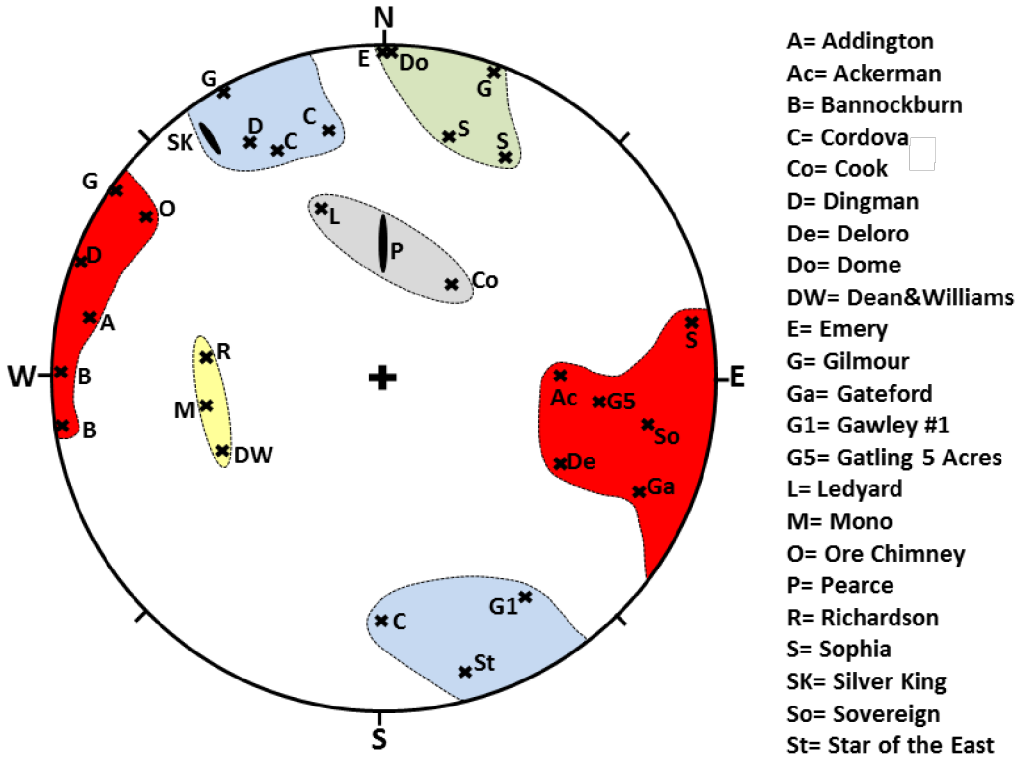

Figure 14. Stereographic representation (Wulff net) of groupings of poles to gold-bearing quartz veins from the past producers and prospects in southern Ontario. Broad groupings occur at N-030°, shown in red; 065°, in blue; 100°/80°S, in green; 350°/45°E, in yellow; and 090°/30°S, in grey. Data *from* LeBaron (1991), Carter (1984) and Malczak, Carter and Springer (1985).

INTERPRETATION

Figures 15 to 18 show derived maps of the study area, with interpretation.

Gravity Map

Figure 15 shows the gravity map of the study area with the outline of positive gravity anomalies. With the exception of the Deloro Granite and its associated gold occurrences, there is a clear association of a positive gravity anomaly with the southern Ontario gold camp. The positive gravity anomaly appears to be associated with mafic volcanic rocks of the Canniff Complex and the Tudor Formation, with a negative gravity anomaly at its core, associated with the Elzevir Tonalite (*see also* Real and Thomas 1987).

Other positive gravity anomalies occur over the Cordova Gabbro area just west of the town of Marmora; associated with the Umfraville gabbro, south of the town of Bancroft; and in the northeast portion of the study area. A weak positive gravity anomaly (not outlined on Figure 15) extends northeastward from gold occurrences near the towns of Cloyne and Northbrook to the positive gravity anomaly in the northeast portion of the study area.

Magnetic and Digital Elevation Maps

Vertical gradient magnetic (Figure 16), first vertical derivative of the total magnetic field (Figure 17) and digital elevation maps (Figure 18) are excellent tools to outline linear structures, large-scale fabrics and circular features.

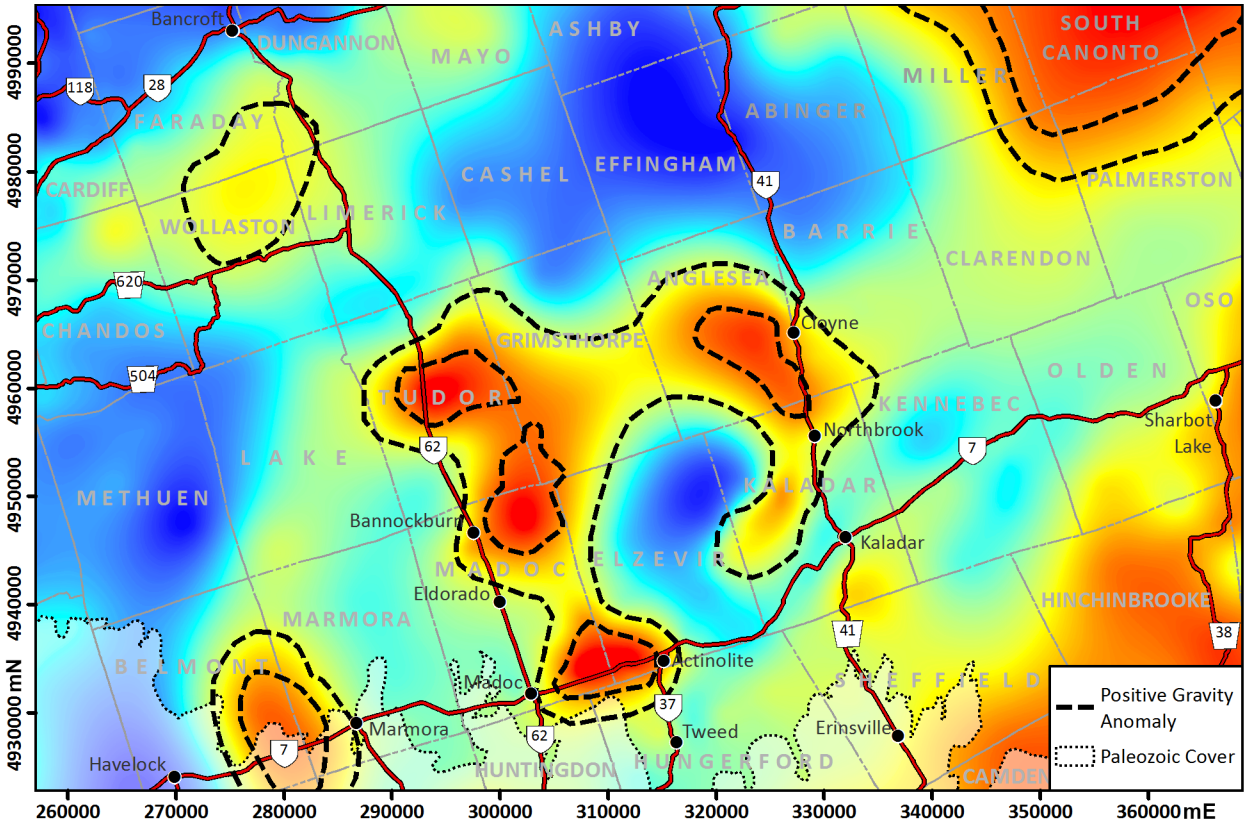

Figure 15. Image of gravity data covering the study area overlain with general outlines of positive gravity anomalies (interpreted using data *from* OGSEarth). Gravity data *from* Ontario Geological Survey (2003a). The UTM co-ordinates are provided using NAD83 in Zone 18.

CIRCULAR FEATURES AND INTRUSIONS

The vertical gradient magnetic map is particularly useful for distinguishing intrusive rocks, which are generally identified by their circular or crosscutting features. Intrusive rock signatures are grouped into 3 main groups, listed below, and are shown on Figure 16:

- **magnetic "high"** includes the Skootamatta, Mount Moriah, Gawley Creek, Tudor, Umfraville, Wollaston Lake and Methuen intrusions and another intrusion in the central part of Chandos Township.
- **magnetic "low"** includes the Cordova, Lingham Lake (although the northernmost part of Lingham Lake shows a semi-circular magnetic high), Weslemkoon, Wadsworth, Northbrook, Addington, Grimsthorpe and Elzevir intrusions.
- **complex** includes the Thanet, Deloro, Moira [Lake], Jocko Lake and the Copeway [Lake] intrusions, as well as another intrusion that, from the magnetic data, appears to be straddling the southern portion of the Madoc–Elzevir township boundary, but was not observed at surface by Di Prisco, Hammar and Easton (2001).

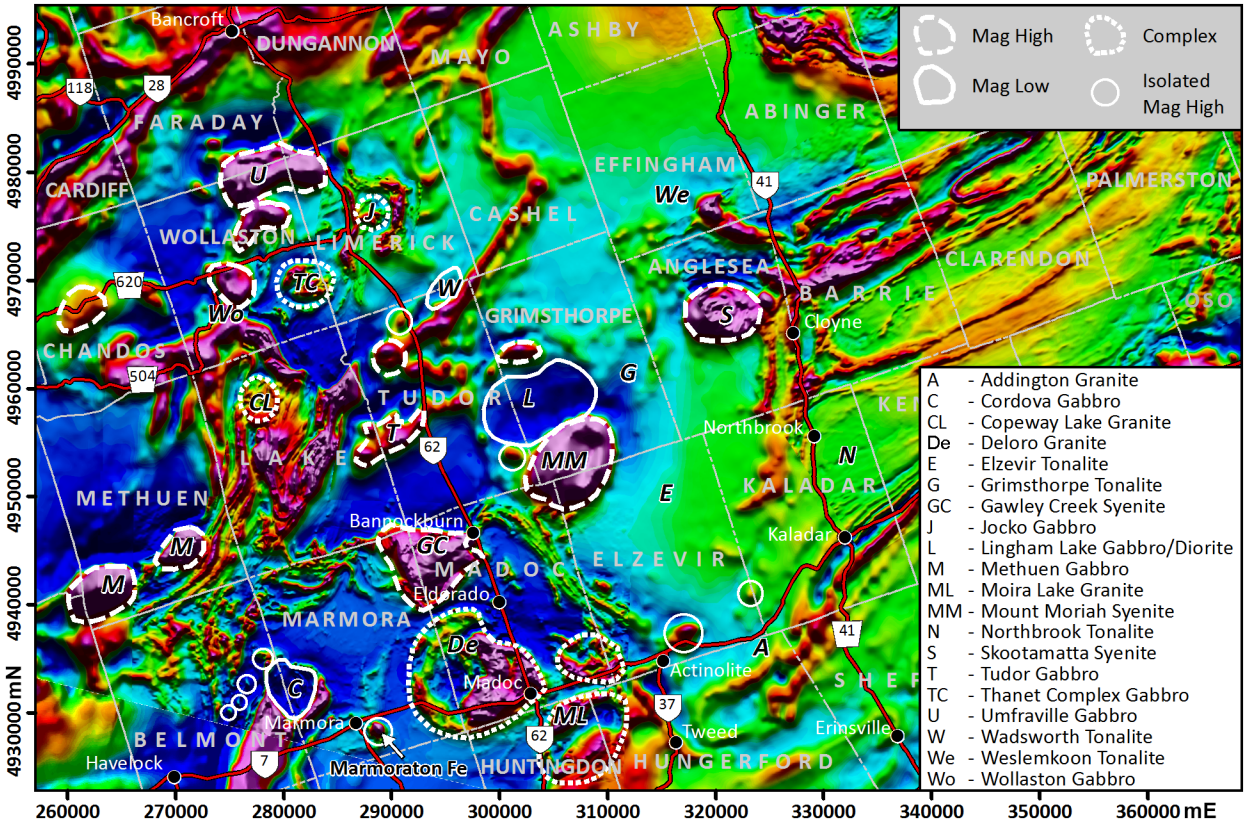

Figure 16. Image of the total magnetic field overlain with interpreted intrusions outlined in white (interpreted using data *from* OGSEarth). Intrusion outlines are based on magnetic "high" and "low", circular features (*see* text). Total magnetic field image is a composite of geophysical data *from* Ontario Geological Survey (2003a, 2003b, 2010). The UTM co-ordinates are provided using NAD83 in Zone 18.

LINEAR FEATURES AND STRUCTURAL FABRICS

Total magnetic field, first vertical derivative of the total magnetic field and digital elevation maps are also very effective for picking out structural fabrics and lineaments. Figures 17 and 18, respectively, show interpretations of structural fabrics and lineaments on the first vertical derivative of the total magnetic field and digital elevation maps. The following observations are made:

- Two dominant orientations of structures are evident: one trending 060°–070° and the other trends north. Based on the data derived through this office-based study, the age relationship between the 2 families of structures is unclear, but the structures appear to be mutually crosscutting and, therefore, possibly synchronous.
- These dominant structures are shown on Figure 19, grouped as "corridors", with the Marmora–Northbrook, Coe Hill and Huntingdon Township structures oriented at 060°–070° and the Havelock–Gilmour and Actinolite–Cloyne structures oriented northward.

Perhaps not surprisingly, these orientations correspond with the dominant orientations of mineralized gold-quartz veins from past producers and prospects of the area (*see* Figure 14).

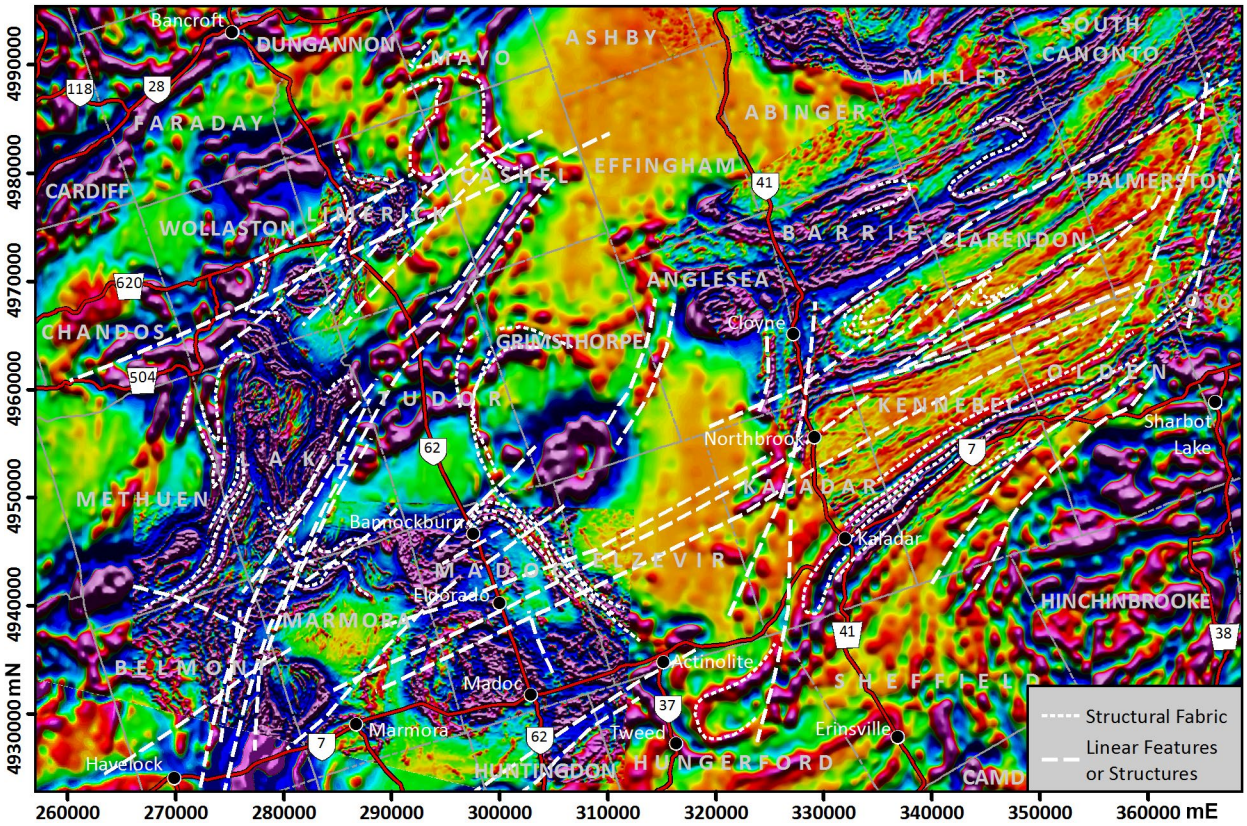

Figure 17. Image of the first vertical derivative of the total magnetic field overlain with interpreted structures and structural fabrics indicated in white (interpreted using data from OGSEarth). First vertical derivative of the total magnetic field image is a composite of geophysical data *from* Ontario Geological Survey (2003a, 2003b, 2010). The UTM co-ordinates are provided using NAD83 in Zone 18.

OTHER STRUCTURES

Several structures are interpreted, trending at 120° to 300°, one of which is observed immediately north of the past-producing Sophia mine, where many mineralized veins coincide with that orientation. Another structure with the same orientation is interpreted within the Elzevir Tonalite.

Only 1 structure is observed with an easterly trend, cutting the Thanet and Wollaston Lake intrusions in Limerick Township.

CONCLUSIONS

Historically, guides for gold exploration in southern Ontario included

- lithological contacts, including contacts with intrusions that provide a competency contrast with surrounding rocks (especially where they are crosscut by structures)
- proximity to the upper contact of the Tudor Formation mafic volcanic rocks where they are unconformably overlain by the Flinton Group clastic sedimentary rocks (including Timiskaming-type conglomerates) or the carbonate-dominated metasedimentary rocks of the Belmont domain
- low metamorphic grade (greenschist to lower amphibolite) rocks
- small, deformed intrusions, such as the granitoid that is host to the Dingman prospect

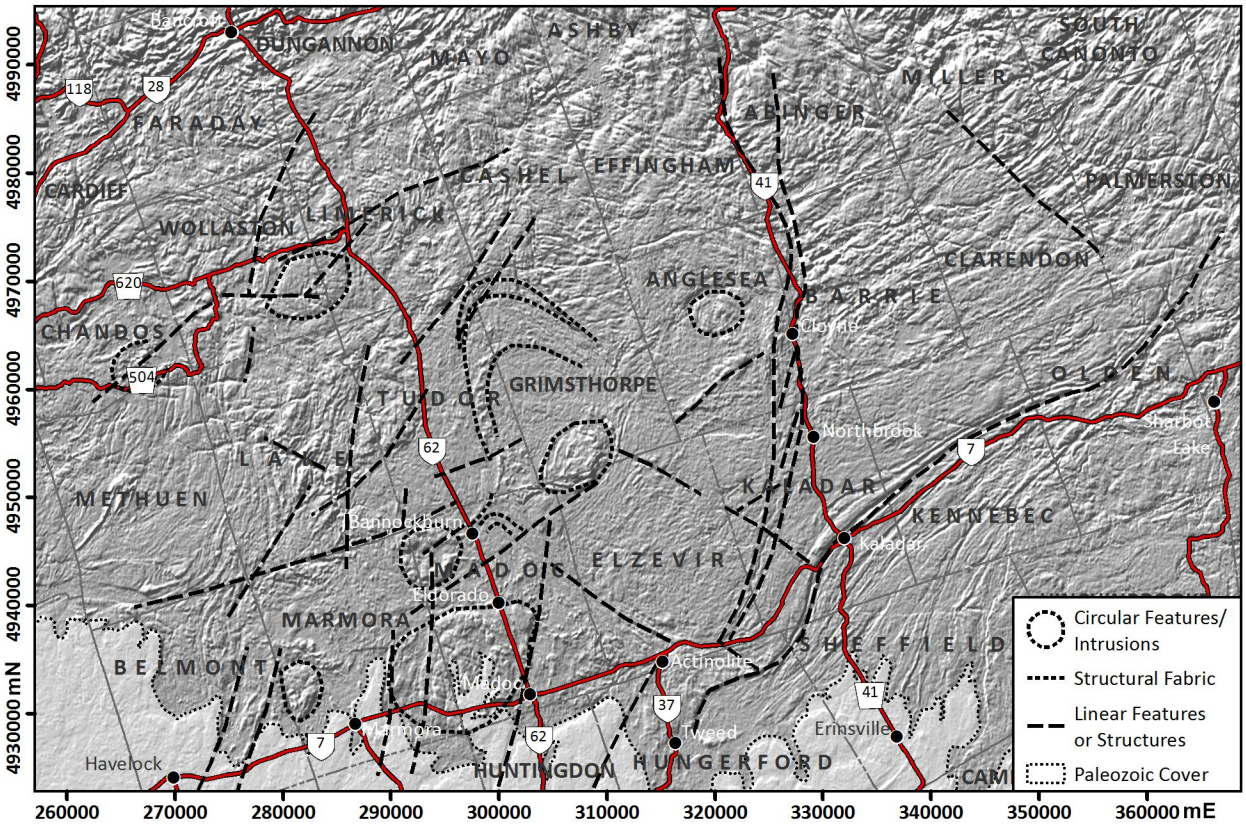

Figure 18. Digital elevation map overlain with interpreted geological features indicated in black (interpreted using data *from* OGSEarth). Digital elevation data *from* Shirota and Barnett (2004). The UTM co-ordinates are provided using NAD83 in Zone 18.

This study suggests the following additional parameters should be considered for gold exploration in southern Ontario:

- association with positive gravity anomalies
- association with north-trending structures (ranging from 350° to 035°)
- association with northeast-trending structures (ranging from 060° to 070°)
- isolated magnetic anomalies, such as the one associated with the Cordova Mine

RECOMMENDED TARGETS

By overlapping interpretations from all 3 maps (*see* Figure 19), the following observations were made and a number of targets emerged. Six preliminary target areas are recommended for exploration, in order of decreasing priority:

1. The area located at the upper contact of the Tudor Formation mafic volcanic rocks along the Havelock–Gilmour corridor. The area is also located at the northern edge of, and within the positive gravity anomaly associated with, the gold camp. In the same area, 3 small intrusions (the Wadsworth tonalite and 2 unnamed circular intrusions southwest of the Wadsworth tonalite) may provide potential for Dingman-style gold mineralization, as well as rheological contrasts favourable to provide sinks for gold mineralization.

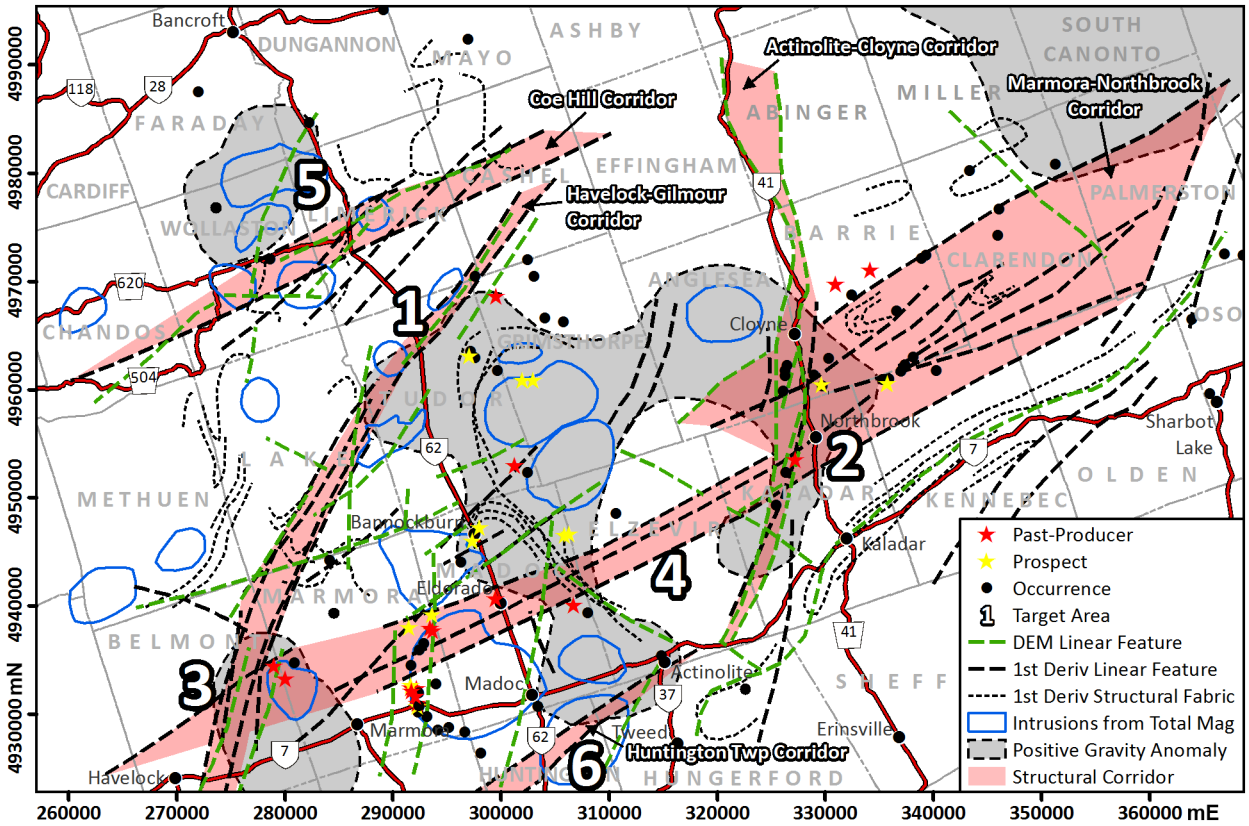

Figure 19. Map showing preliminary recommended targets (*see* text for numbers), overlain with compiled interpretations of structures from magnetic and digital elevation maps, positive gravity anomaly contours and gold occurrences. The UTM co-ordinates are provided using NAD83 in Zone 18.

2. The Cloyne–Northbrook area, where the Marmora–Northbrook corridor intersects the Actinolite–Cloyne corridor within the positive gravity anomaly of the gold camp. Targets include the Marmora–Northbrook and Actinolite–Cloyne lineaments, the upper contact of the Tudor Formation and the eastern contact of the Elzevir Tonalite.
3. The Havelock–Gilmour corridor, in the area west of the Cordova Gabbro, where it is located in the western part of a positive gravity anomaly. A number of prospective isolated magnetic "highs" are also observed within the corridor.
4. The Elzevir Tonalite, where it is intersected by the Marmora–Northbrook corridor. These intrusions have not typically been targeted in southern Ontario and the interpretation of these favourable structures cutting through them may present opportunities. The Silver King occurrence (northeast-trending veins) is an example within the Elzevir Tonalite.
5. The Coe Hill corridor, where previously unrecognized structures, trending 065° and 090°, are interpreted to cut through the Thanet, Jocko Lake and Wollaston Lake intrusions. In the same area, 3 structures, parallel to the northern portion of the Havelock–Gilmour corridor, are also interpreted to be along the flank of the positive gravity anomaly over the Umfraville gabbro.
6. The Huntingdon Township corridor, where it is interpreted to cut the Moira [Lake] Granite. The target is, however, located underneath Paleozoic sedimentary cover.

Explore Southern Ontario with the Tweed Drill Core Library

Note: The following recommendation is modified from *Charbonneau and LeBaron (2018).*

INTRODUCTION

The Southern Ontario Resident Geologist's Office maintains a diamond-drill core library storage facility in Tweed, one of 7 drill-core libraries (DCL) administered by the Resident Geologist Program across the province. The Tweed DCL is an off-site facility housing over 250 000 m of core from 3420 drill holes in southern Ontario, with approximately 75% stacked on pallets and 25% 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. The Tweed DCL is the only public repository of drill core intersecting the Precambrian rocks of southern Ontario, and a very large proportion of the core is deemed irreplaceable. Fifty-seven of these drill holes start in Paleozoic sedimentary rocks and continue into the Precambrian basement rocks. The majority of core in the library was donated over the past 30 years by mineral exploration companies and mines.

Drill core can be used as an effective tool to identify potential mineral exploration targets. The Tweed DCL contains core from many areas of the Grenville Province's Central Metasedimentary Belt, considered favourable for gold, base metal, rare earth and industrial mineral mineralization (Figure 20). By visiting the Tweed DCL and viewing core from these areas, one could essentially "explore" large areas of southern Ontario quickly and inexpensively using primary data. Exploration projects that include the sampling and/or relogging of core from the Tweed DCL can submit the work completed for assessment credit.

VIEWING AND SAMPLING OUR CORE

Viewing and sampling core from previous drilling projects provides an opportunity to reassess the mineral potential of an area, including looking for commodities different from what may have been the original intent of the exploration. For example, diamond-drill core that targeted the deep parts of the talc orebody at the Canada Talc Mine in Madoc in 1987 intersected a marble unit hundreds of metres thick. Some of the marble is unfractured over substantial lengths of core and displays interesting textures and colours. This marble should be examined as a source of dimension stone, landscaping stone and/or decorative aggregate (Photos 10 and 11).

Other examples demonstrating this concept and the potential exploration opportunity that is present when revisiting drill core include 1) many uranium prospects, which have potential for rare earth elements (REE), and 2) some magnetite skarns drilled for iron, which also have potential for light REEs (Sangster et al. 2012). The Tweed DCL stores core from hundreds of drill holes in the historic Bancroft uranium camp and many former magnetite mines and exploration projects. Very little of this core has been analyzed for REE content.

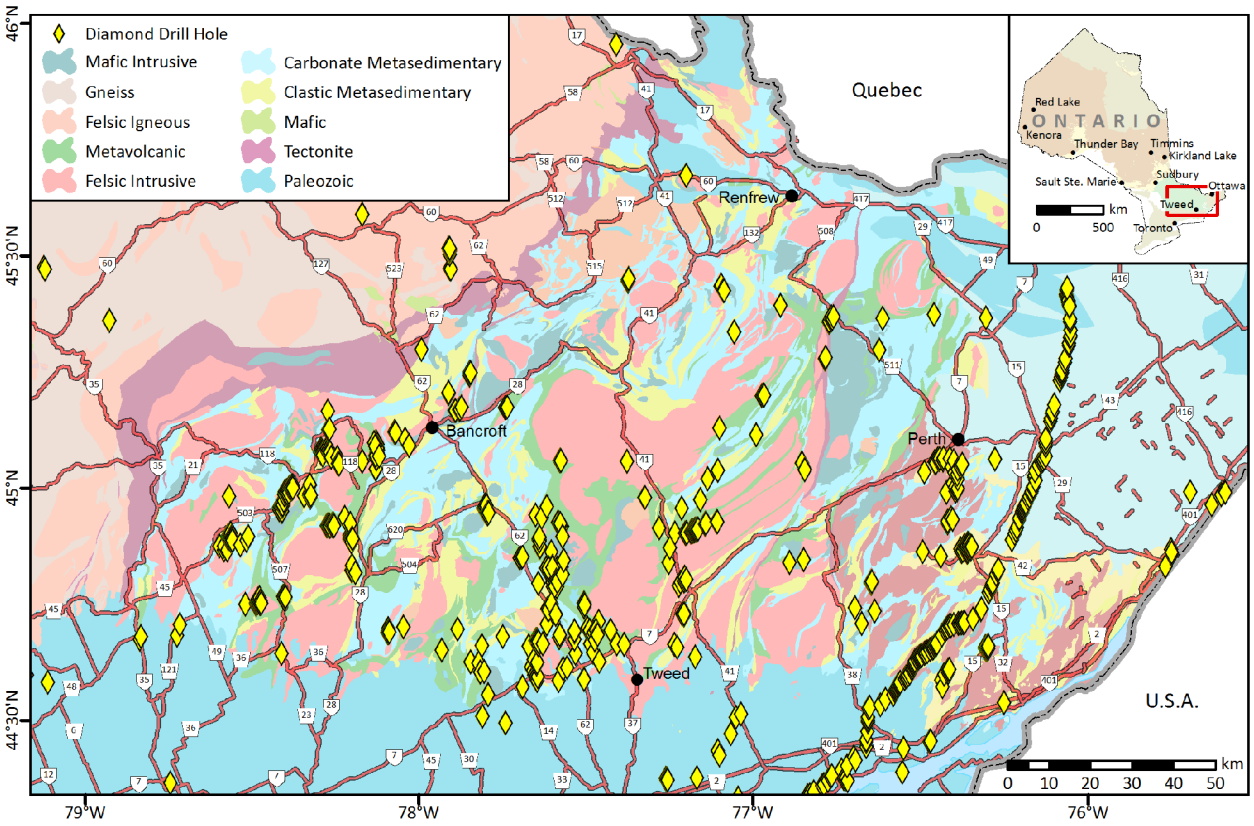

Figure 20. A generalized map of the Central Metasedimentary Belt of the Grenville Province, showing the locations of drill holes for which core is stored at the Tweed Drill Core Library. Regional geology *from* Ontario Geological Survey (2011).

SUCCESS STORIES

The Tweed DCL played an important role in the development of several recent exploration projects in southern Ontario.

For example, in 2013, Union Glory Gold Limited relogged and resampled drill core from 4 historical drilling programs completed at the Addington gold mine in the 1980s. The company collected a total of 267 samples from 39 drill holes held in the Tweed DCL in order to confirm previous estimates of tonnage and grade and to upgrade the existing database to NI 43-101 compliancy (McBride 2013).

Also in 2013, as part of their Bannockburn project, Crown William Mining Corp. collected 446 samples from 22 drill holes with the purpose of identifying low- or moderate-grade vein and wall-rock mineralization that may have been missed during historical drilling campaigns. This was done to assess the potential for a high-tonnage, lower grade deposit amenable to bulk-mining methods. The resampling program was successful in identifying a zone of increased vein density and coincident wall-rock mineralization, which is reported to be amenable to open pit mining (Fingas 2013).

Both resampling programs were successful in advancing the projects at a very low cost, relative to the expense of new diamond drilling.

Photo 10. White marble breccia fragments with dark green serpentine matrix and veining, Canada Talc Mine.

SUMMARY

Diamond-drill core stored in the Tweed DCL (and in other MNDM facilities) is a useful resource for conducting mineral exploration. This is especially the case in southern Ontario, where assembling a land position may be more time consuming. Large areas may be explored quickly and inexpensively using primary data (i.e., the core). New exploration concepts and the potential for alternative commodities may be tested through the re-examination of historical drill core originally drilled for another purpose. Expenses related to the sampling and/or relogging of historical drill core may be submitted for assessment credit. There is no cost to use the library and the Southern Ontario Resident Geologist's Office is able to provide additional equipment for use, such as magnetic susceptibility meters, microscopes and core saws. Please contact the Southern Ontario Resident Geologist Office for more information or to obtain a copy of the drill core library catalogue and a detailed map.

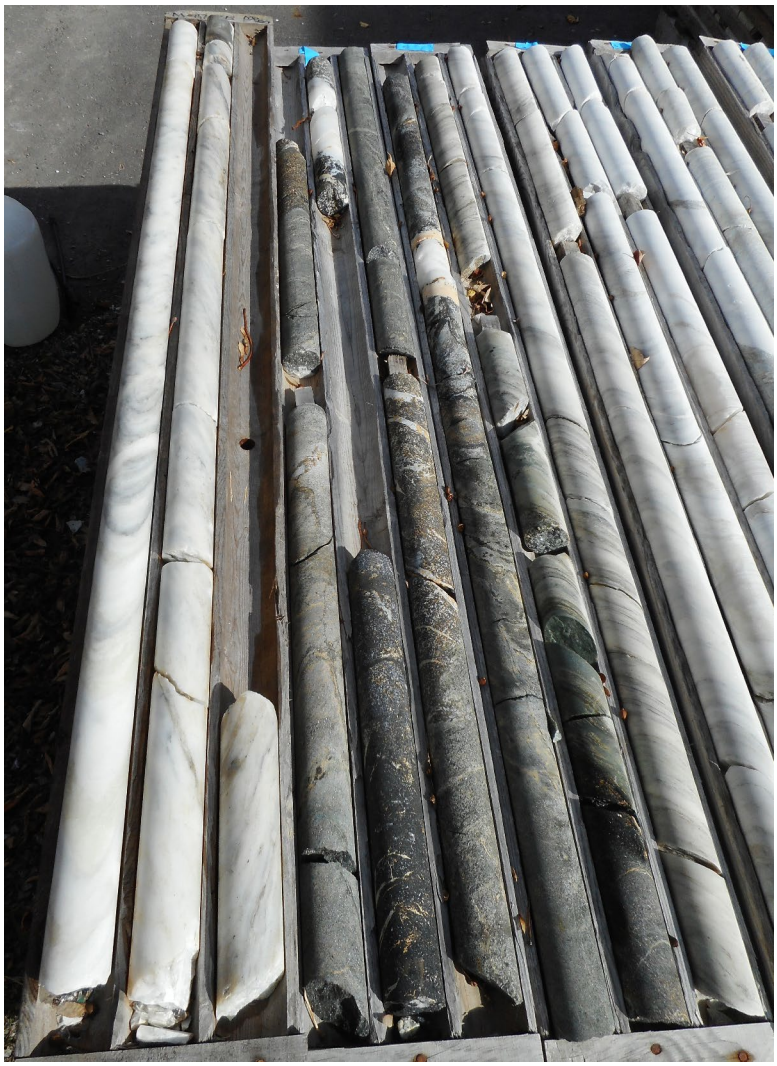

Photo 11. Banded white and pale green marble (and mafic dike), Canada Talc Mine; the piece of drill core on the extreme left of the photo is unbroken for a length of 1.5 m.

OGS ACTIVITIES AND RESEARCH BY OTHERS

Multi-year mapping and related projects in southern Ontario by staff of the Earth Resources and Geoscience Mapping Section, Ontario Geological Survey, continued during the 2017 field season.

In the eastern part of the Central Metasedimentary Belt, Grenville Province, the first phase of a two-year, 1:50 000 scale bedrock mapping project in the Carleton Place area was completed. Details of the project are presented in the following article, published in *Summary of Field Work and Other Activities, 2017* (Ontario Geological Survey 2017b):

- Precambrian and Paleozoic Geology of the Carleton Place Area, Grenville Province; by R.M. Easton

Other OGS studies related to Paleozoic geology and energy studies, Quaternary geology, aggregate resources and groundwater resources in southern Ontario were in progress in 2017. Detailed descriptions of the following projects are included several articles published in *Summary of Field Work and Other Activities, 2017* (Ontario Geological Survey 2017b):

Paleozoic Geology and Energy Studies

- Paleozoic Geology of Eastern Ontario; by C. Béland Otis
- Lithofacies and Stratigraphy of the Devonian Onondaga Formation, Southwestern Ontario; by S. Sun, F.R. Brunton and J. Jin

Groundwater Studies

- Digging Deep on the Niagara Peninsula: A Drilling Update; by A.K. Burt
- An Update on Subsurface Data Collection for Three-Dimensional Sediment Mapping in the Central Part of the County of Simcoe, Southern Ontario; by R.P.M. Mulligan
- The Ambient Groundwater Geochemistry Program: Manitoulin Island and North Shore Areas; by K.M. Dell, M.A. Francis and S.M. Hamilton
- East Ottawa–Champlain Township Groundwater Study; by T. Di Iorio, M. Melaney, S. Foubister and S.M. Hamilton
- Status Report on Three-Dimensional Geological and Hydrogeological Modelling of the Paleozoic Bedrock of Southern Ontario; by T.R. Carter, F.R. Brunton, J. Clark, L. Fortner, C.N. Freckelton, C.E. Logan, H.A.J. Russell, M. Somers, L. Sutherland and K.H. Yeung
- Building a Geological Framework to Support Regional Groundwater Management: Data Capture, Consolidation and Reclassification in Southern Ontario; by H.A.J. Russell, N. Baranova, H.L. Crow, D.I. Cummings, C.E. Logan, A. McBride, A.J-M. Pugin and D.R. Sharpe
- A Surficial Sediment Chemostratigraphic Framework for Southern Ontario; by H.A.J. Russell, A.F. Bajc, R.D. Knight and D.A.J. Stepner

Several other OGS publications related to geoscience projects in southern Ontario were released in 2017 and are listed in Table 6.

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 2017 and in early 2018. 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. T.A. Al and Dr. I. Clark (University of Ottawa) led a program studying Paleozoic strata at the Bruce Nuclear site on the eastern margin of the Michigan Basin for the purpose of developing nuclear waste disposal strategies for Ontario Power Generation. Research into the transport properties of the shales and argillaceous limestones that represent the repository and barrier aquitard horizons at the site focusses on quantifying the diffusion properties of these materials, on characterizing porewaters and organics in these formations, and on determining the age and origin of fluids and gases in the section. Current publications related to this research include Petts et al. (2017) and Celejewski, Barton and Al (in press).
- Dr. D.A. Schneider (University of Ottawa) supervised 3 MSc thesis projects, listed below, in the Ottawa–Bonnechere graben and the St. Lawrence Platform. Two have been completed: Hardie, Schneider and Garver (2017) and Emberley and Schneider (2017), respectively, both used low-temperature thermochronology to understand the cooler than 200°C thermal history of the region, which has implications for the age of the landscape and the hydrocarbon potential. For a third MSc thesis project, to be completed in 2018, D.A. Schneider, J. Spalding, C. Gautheron, P. Sarda, D.W. Davis and D.C. Petts plan to report on the examination of calcite-filled joints in the St. Lawrence Platform in Prince Edward County to determine the low-temperature (brittle) history of the region, in which several fault zones are exposed. Geochronological analyses (U/Pb using laser ablation inductively coupled plasma mass spectrometry) on the calcite in the veins yielded an age of *circa* 100 Ma (Cretaceous).
- Dr. W.M. Schwerdtner (University of Toronto) and Dr. T. Rivers (Memorial University of Newfoundland) continued their studies of Grenvillian structures in the western Ottawa River gneiss complex, Algonquin Park, Lake of Bays and French River regions in 2017. Presentations in 2017 included Rivers and Schwerdtner (2017) and Schwerdtner, Rivers and Waddington (2017).
- Dr. G.R. Dix (Carleton University) is conducting ongoing research of Turinian-Chatfieldian fossil assemblages in the Ottawa–Bonnechere graben, including re-examination of classic sites along the Ottawa River, north to Mattawa, to resolve long-standing issues of mixed Blackriveran–Trentonian assemblages. He is also supervising the following thesis projects in eastern Ontario:
    - PhD thesis research by N. Oruche on Blackriveran–Trentonian–equivalent stratigraphy in the Ottawa Embayment. Papers in progress include the following:
        - "Lithostratigraphy of the Blackriveran-Rocklandian (Upper Ordovician) foreland succession, and a U-Pb ID-TIMS date for the Millbrig volcanic ash bed, in the Ottawa Embayment: Relevance for extrabasinal correlation in eastern North America"; by N. Oruche, G.R. Dix and S. Kamo (submitted to Canadian Journal of Earth Sciences in January 2018)
        - "Chemostratigraphy of the equivalent Blackriveran-Trentonian succession, Ottawa Embayment"; by N. Oruche and G.R. Dix
    - a BSc Honours thesis by S. Gadzewich:
      "Chemostratigraphic correlation of two Ordovician outliers (Pembroke and Eganville Areas), Ottawa–Bonnechere Graben"
    - a BSc Honours thesis by Gaoxiang Li:
      "Organic carbon and geophysical (gamma-ray, density) log response (GSC Russell core, eastern Ontario): using PetroMod to characterize Cambro-Ordovician basin maturation".

- Dr. B. Sherwood Lollar (University of Toronto) is supervising an MSc thesis by J. West, entitled “Geochemical analysis of groundwater-fed streams on the Niagara Escarpment”. The study will examine several geochemical properties (pH, conductivity, dissolved inorganic carbon, anions, cations, isotopic composition (O and D), dissolved gases, and temperature of the river waters at different points across the various underlying Paleozoic formations (Amabel, Queenston, Georgian Bay and Blue Mountain). Field samples collected in 2017 will be analyzed to determine whether the groundwater geochemical signature is preserved, then compared to the OGS ambient groundwater survey data, and studied to determine whether properties change over the various rock units.
- A Queen’s University, fourth year Geological Engineering Design Project, entitled “Zinc Exploration in Southern Ontario”, is being supervised by Dr. G. Olivo (Queen’s University) and A.C. Tessier (Regional Resident Geologist, Southern Ontario, MNDM). The project consists of an office-based study compiling all regional geological, geophysical and geochemical data that are available within the Central Metasedimentary Belt and Frontenac Terrane. The data will be assigned a weight and converted into a raster analysis of the study area to generate target areas for possible sedimentary exhalative (SEDEX), volcanogenic massive sulphide (VMS), skarn, Mississippi Valley-type (MVT) and silicate zinc deposits. The students are H. Brearton, N. Elliot, P. Marty and E. Wynands. The study began in September 2017 and will be completed in April 2018.

MINERAL DEPOSITS NOT BEING MINED

Tables 9 through 17 list currently inactive mineral deposits with identified resources and past-producing mineral occurrences.

Table 9. Historical production of gold – Southeastern Ontario District.

Mine	Township	Operating Years	Tons Milled	Ounces 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	1893–1994	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	unknown	970	unknown
		1892–1900	1962	370	0.19
Star of the East	Barrie	1905–1907	976	134	0.14
		Total	**174 894**	**38 592**	

Table 10. Historical production of copper, lead, zinc – Southeastern Ontario District.

Mine	Township	Operating	Tons Milled	Production
Kingdon	Fitzroy	1884–1885, 1914–1931	905 000	76 821 409 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 11. 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 12. 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 13. 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 14. Titanium, tantalum and REE occurrences (compiled *from* MDI database: Ontario Geological Survey 2017a) – 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 these complete MDI files are located at RGP office in Tweed.*

Table 15. Uranium deposits not currently being mined in the Southeastern Ontario District in 2017.

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 tonnes 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 & 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 16. Mineral deposits not currently being mined in the Southeastern Ontario District in 2017. (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 and LeBaron (1992); "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 17. Mineral deposits not currently being mined in the Southwestern Ontario District in 2017.

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 2017 by Deborah A. Laidlaw, *P.Geo.*

The boundaries of the Regional Land Use Geologists' regions are indicated on Figure 21.

Figure 21. 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 hazard;
- 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 2017, 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 Northern Development and Mines (MNDM) 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; Far North land use planning; 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 Algonquin Park Forest Management Plan 2020–2030.

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).

Aggregates

The southern Regional Land Use Geologist ensured that mineral potential, mineral sector activity and mining-related hazards were identified and considered before decisions were made regarding 1 aggregate quarry application received from MNRF.

MUNICIPAL AND PRIVATE LANDS

The Ministry of Northern Development and Mines supports municipal and private land use planning through the One Window Planning Service, led by the Ministry of Municipal Affairs (MMA). 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 MMA'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 1 upper-tier and 13 lower-tier municipalities
- 14 Official Plans and related planning initiatives (such as zoning by-laws and subdivision approvals) in 14 communities
- 3 new draft Official Plans or Official Plan updates

The municipalities involved in these planning initiatives are listed in Table 18; their locations are shown in Figures 22 and 23.

The southern Regional Land Use Geologist attended the Ontario West Planning Workshop in London to network with clients and service providers engaged in municipal planning. This event dealt with planning issues that cover parts of the southern Regional Land Use Geologist's region.

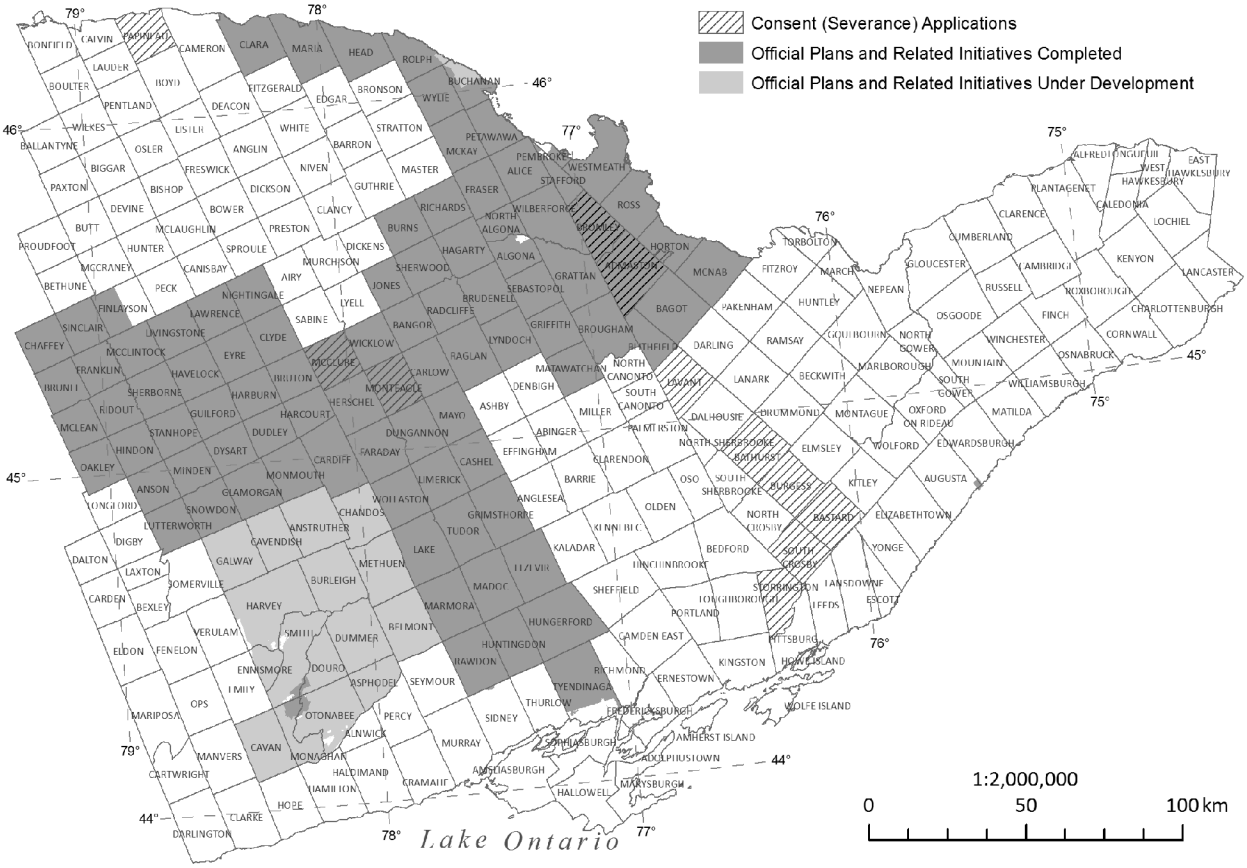

Figure 22. Planning initiatives with MNDM input, southeastern Ontario.

Table 18. Municipal planning initiatives with MNDM input, southern Ontario, 2017.

Consent (Severance) and Subdivision Applications
Consent, Admaston/Bromley, Township of (3)
Consent, Bastard, Township of (2)
Consent, Bathurst, Township
Consent, Foley, Township of
Consent, Haldimand, County of
Consent, Lavant, Township of
Consent, McClure, Township of
Consent, Monteagle, Township of (2)
Consent, North Burgess, Township of
Consent, Papineau, Township of
Consent, Renfrew, Town of
Consent, South Burgess, Township of (2)
Consent, South Crosby, Township of (2)
Consent, Storrington, Township of

Completed Official Plans and Related Initiatives
Burlington, City of
Goderich, Town of
Haliburton, County of
Hastings, County of
Hamilton, City of
Lambton, County of
Muskoka, District Municipality of
Niagara-on-the-Lake, Town of
Norfolk, County of
Peterborough, City of
Prescott, Town of
Renfrew, County of
Renfrew, Town of
Strong, Township of

Official Plans and Related Initiatives Under Development
Carling, Township of
Deep River, Town of
Peterborough, County 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 are staked and being explored or the sites in question have provincially significant mineral potential).

During 2017, 6 such applications were reviewed for the southern region. Comments were provided to MNDM's Mining Lands Section to be consolidated with other information for the Ministry's consideration and decision.

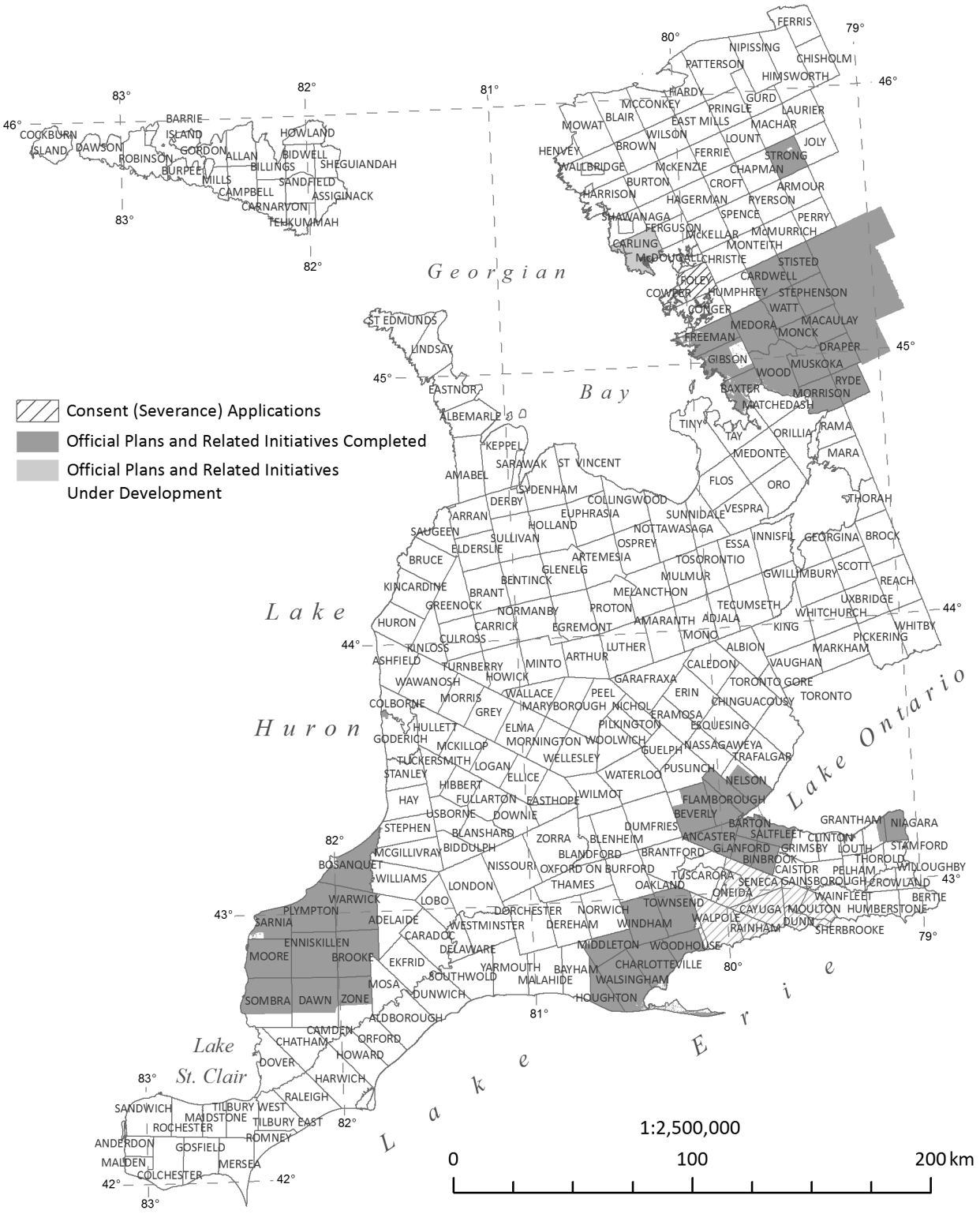

Figure 23. Planning initiatives with MNDM input, southwestern Ontario.

Other Activities

The southern Regional Land Use Geologist also undertook other related work in 2017, as outlined below.

GEOSCIENCE POLICY OPTIONS

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 MNDM and an inter-ministerial 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 geoscience policy options are being prepared. The southern Regional Land Use Geologist participated on the committee by attending teleconferences and providing input to geoscience policy-related initiatives.

INVESTMENT READY SITES

Ontario's "Investment Ready: Certified Site" program, operated by the Ministry of Economic Development and Growth promotes an inventory of sites that may be of interest to potential investors and purchasers. It pre-screens the suitability of sites for development, and provides detailed information about the sites' access to utilities and transportation, and their environmental status. In 2017, the southern Regional Land Use Geologist provided information for 12 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, 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 2017, feedback was provided for reviews of the following 9 Class EA projects within southern Ontario:

- expansion of a landfill in the City of London
- widening of a section of Highway 404 in York Region by Ministry of Transportation
- expansion of a sewage treatment plant in Winchester
- renewal of a sewage pump station in the City of Kingston
- construction of a natural gas pipeline to service the Community of Bobcaygeon
- project to assess alternative potable water storage solutions in the Town of Smiths Falls
- construction of a transmission line to deliver electricity generated from the Henvey Inlet Wind Energy Centre, located on the Henvey Inlet First Nation Reserve, to the Ontario electricity grid
- proposal to construct a municipal transformer station and rebuild an existing transmission line in south Nepean
- a project on 2 parcels of land along Highway 400 on Wahta Mohawks First Nation lands

GUIDANCE MATERIALS

In 2017, the southern Regional Land Use Geologist was called upon by partner ministries to review and provide input on proposed new or updated policies, and/or supporting guidance materials. Comments were prepared and submitted for the following

- Ministry of Municipal Affairs–Ministry of Housing Capacity and Constraints on Water and Wastewater Systems in the Greater Golden Horseshoe
- MNDM Regional Land Use Geologist Handbook
- Ministry of Municipal Affairs–Ministry of Housing Coordinated Plan Review

ONTARIO BIODIVERSITY STRATEGY

The Ontario Public Service (OPS) Biodiversity Network is an inter-ministry forum led by MNRF's Biodiversity Branch. It allows members to exchange information and plan for biodiversity-related policies, processes, projects and activities across the province to help implement the Ontario Biodiversity Strategy. The strategy itself was developed by the Ontario Biodiversity Council (http://ontariobiodiversitycouncil.ca/), a non-governmental organization.

The southern Regional Land Use Geologist along with S. DeVos, Land Use Planning and Policy Co-ordinator and S. McLean, Policy Advisor, represented MNDM on the OPS Biodiversity Network by attending teleconferences and providing input to biodiversity-related initiatives.

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 conferences and workshops:

- Policy Innovation Hub Conference in Toronto
- Geological Association of Canada–Mineralogical Association of Canada Joint Annual Meeting in Kingston
- Climate Change Communications Workshop in Toronto

MINERAL DEPOSIT COMPILATION GEOLOGISTS—NORTHEASTERN ONTARIO

The Mineral Deposit Compilation Geologists (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 Northern Development and Mines is using the most up-to-date information in making land-use planning and policy decisions and that mineral industry clients have access to comprehensive and up-to-date records. Records for certain areas are reviewed and updated in support of bedrock mapping and other field work conducted by the Earth Resources and Geoscience Mapping Section (ERGMS) of the Ontario Geological Survey. A.C. Wilson is the northeastern Ontario MDCG.

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 explorationists 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.

In 2017, work focussed on updating MDI records for the Cobalt mining camp, located in the Kirkland Lake District.

Township updates were compiled and entered for the following districts:

District	Townships	Status
Timmins	West of Marberg	complete
Sault Ste. Marie	Copenace, Johnson, Tarbutt	complete
Kirkland Lake	Banting, Best, Brigstocke, Cassels, Coleman, Gillies Limit, Lorrain, South Lorrain	complete
Sudbury	Afton, Blezard Valley, Creelman, Fraleck, Lindsay, McConnell, Roberts, Scholes, Telfer	complete
Southeastern Ontario	Albemarle, Golbourne, Huntley, Lanark, Monmouth, Ramsay	complete
Southwestern Ontario	Bentinck, Collingwood, Derby, Eastnor, Egremont, Glenelg, Holland, Keppel, Osprey, Sarawak, Saltfleet, St. Edmunds, St. Vincent, Sullivan, Sydenham	complete

The northeastern Ontario MDCG also worked on changes and updates to MDI records for a variety of land-use planning decisions in the Kirkland Lake District and the Sault Ste. Marie District.

Total changes to the provincial MDI database, completed by the northeastern Ontario MDCG, in 2017 included 476 updated records, 26 records deleted and 1 new record. Deletion of an MDI record occurs when there is a duplication of data or similar occurrences are within 400 m of each other. A breakdown, by district, of the provincial records revised by the northeastern Ontario Mineral Deposit Compilation Geologist is provided in Table 19.

Table 19. Mineral Deposit Inventory records revisions in northeastern and southern Ontario in 2017.

District	Updates	Deletions	New
Timmins	1	0	0
Sault Ste. Marie	16	0	1
Kirkland Lake	233	0	0
Sudbury	45	3	0
Southeastern Ontario	133	13	0
Southwestern Ontario	48	10	0
Total	476	26	1

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.

ACKNOWLEDGMENTS

The authors would like to thank all producers, exploration companies, prospectors and developers who provided access to their operations or supplied information throughout 2017. Strong communication links between stakeholder groups and government ministries are essential for effective program delivery and, ultimately, to improve the delivery of government services.

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Ontario

Ontario Geological Survey
Resident Geologist Program

Petroleum Operations Section—2017

by

L. Fortner

2018

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Petroleum Operations Section—2017

Petroleum Operations Section—2017

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INTRODUCTION

Through 2017, drilling frequency in Ontario licenced by the Petroleum Operations Section has maintained the historic low realized in 2014. Exploration and development activity has been nearly non-existent during the past 4 years.

The average price of oil sold in Ontario during the year was approximately $67 per barrel: a notable increase from $56 per barrel in 2016. The price of natural gas in Ontario averaged $4.57 per MMBtu in 2017, significantly higher than the average $3.08 in 2016, but still relatively low in comparison to historic highs of 2004–2008.

Produced oil volumes likely fell to a new low again in 2017. However, no audited and confirmed oil production volumes for 2017 were available from Petroleum Operations Section at the time this report was produced. Verified production reports from 2016 indicate that annual oil production dropped approximately 17% in that year to 52 648 m^3 from a revised 63 504 m^3 in 2015. Total sales value of oil in 2016 was approximately $22.5 million, but the higher average unit price in 2017 may result in a higher total value of oil for that year even if production volumes have continued to decrease.

The continuing decline in oil production 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. Suppression of the price of oil, which began in 2014 after historic highs, combined with the longer term pressure on the price of natural gas, has almost entirely eliminated new petroleum drilling in the province.

Natural gas production has likely continued its long-term downward trend in 2017. However, no audited and confirmed gas production volumes for 2017 were available from Petroleum Operations Section at the time this report was produced. Natural gas production had previously fallen 7.7% in 2016 to a revised figure of 149 190 $\times 10^3$ m^3 from a total of 161 662 $\times 10^3$ m^3 in 2015. Estimated total value of gas production in 2016 fell to $15.4 million, as compared to $17.3 million in 2015.

ACTIVITY

A total of 11 licences to drill and operate new wells were issued by the Ministry of Natural Resources and Forestry in 2017. An additional 13 licences were issued in 2017 for plugging only, with 15 licences issued to operate or perform work on existing wells.

Drilling of new wells in Ontario continues to decrease, achieving a new low of 4 in 2017. The numbers for new drills reported from recent years, slightly revised from previous reports, are 6 in 2016, 6 in 2015, and 8 in 2014. The new drills in 2017 consisted of 1 development well and 3 natural gas storage wells. Of note is the return to 0 exploration wells, as occurred in 2015, after the 1 exploration well reported in 2016.

As in 2016, commercial exploration and development experienced no success in 2017, with the single development effort being a private gas well. The 1 exploration well that had been drilled in 2016 was immediately plugged and abandoned.

Cambrian Play

In 2017, no exploration wells were drilled to Cambrian rocks. One exploration well tested the Cambrian interval in 2016, but was plugged and abandoned. Previous to this, no exploratory wells had been drilled to test the Cambrian since 2013.

No development wells were drilled to the Cambrian again in 2017. 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 an Ordovician target since 2014.

Silurian Sandstone Play

No exploration wells have been drilled to test Silurian sandstone since 2011.

As in 2016, the only development well drilled in 2017 in any play was a Silurian sandstone private gas producer. It was located in Haldimand County.

Silurian Carbonate Play

There have been no exploratory or development wells drilled for Silurian Guelph Formation reef and/or Salina Group targets since 2013.

Devonian Play

No exploration wells have intended to test the Devonian play since 2013.

The last development well targeting the Devonian interval was drilled in 2014.

EXPLORATION TRENDS

The now roughly 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 now contributes to the pressure on prices and operator finances. Therefore, there is currently no incentive for a significant resumption of hydrocarbon exploration or development activity in Ontario.

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.*

ISSN 1484-9402 (print)
ISBN 978-1-4868-1664-4 (print)

ISSN 1916-6168 (online)
ISBN 978-1-4868-1665-1 (PDF)