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Easton, R.M. 2014. Proterozoic and Phanerozoic geologic history of the Cobden area, Grenville Orogen, Ontario, based on new geological and geophysical data; poster, Geological Society of America 2014 Annual Meeting, Vancouver, British Columbia, Canada, October 19–22.

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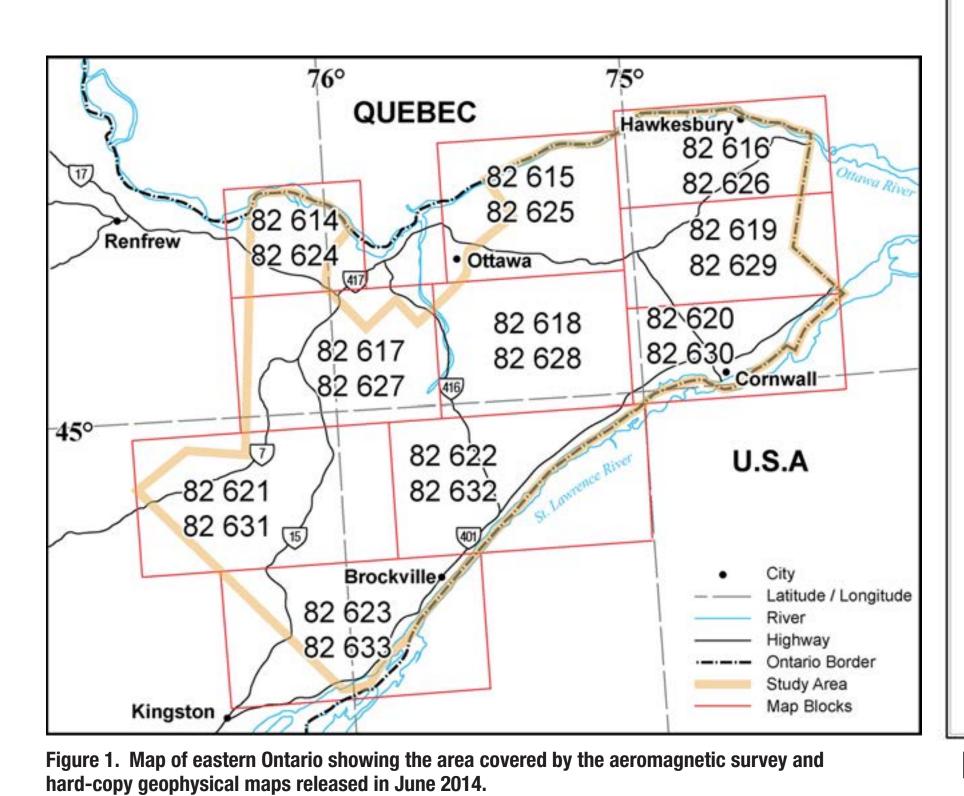
PRECAMBRIAN GEOLOGY OF THE GRENVILLE OROGEN IN EASTERN ONTARIO FROM AEROMAGNETIC AND COMPILED GEOLOGICAL DATA R.M. Easton and S.J. Magnus, Earth Resources and Geoscience Mapping Section, Ontario Geological Survey, Sudbury, Ontario P3E 6B5, mike.easton@ontario.ca, 705-670-5995.

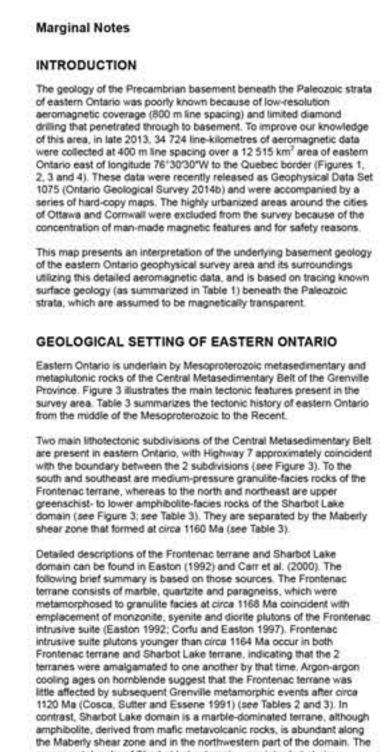
Abstract

The Grenville Orogen in eastern Ontario is almost entirely overlain by Paleozoic strata, consequently its geology was poorly known because of low-resolution aeromagnetic coverage (800 m line spacing) and limited diamond drilling that penetrated to basement. To improve our knowledge of this area, in late 2013, 34 724 linekilometres of aeromagnetic data were collected at 400 m line spacing over a 12 515 km² area from east of longitude 76°30'30"W to the Quebec border. These data were released in June 2014 as Ontario Geological Survey Geophysical Data Set 1075 and a series of hard-copy aeromagnetic maps.

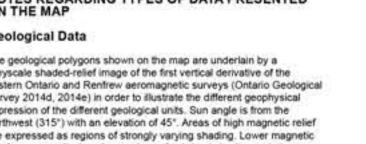
We present an example of one of 3 new 100 000 scale geological compilation maps for the Precambrian geology of eastern Ontario utilizing the detailed aeromagnetic data and existing geological data. This is possible as the Paleozoic strata are magnetically transparent, especially where thin (<400m thick). The geology polygons on the map are underlain by a greyscale shaded-relief image of the first vertical derivative of the aeromagnetic survey in order to illustrate the geophysical expression of the geological units. Sun angle is from the northwest (315°) with an elevation of 45°. Paleozoic rock units are not indicated directly on the map, although the Precambrian–Paleozoic unconformity is shown. Marginal notes and a table summarizing the tectonic history of the area are also provided. Two main lithotectonic subdivisions of the Central Metasedimentary Belt are present, with Highway 7 approximately coincident with the boundary between the 2 subdivisions. To the south and southeast are medium-pressure granulite-facies rocks of the Frontenac terrane, whereas to the north and northeast are upper greenschist- to lower amphibolite-facies rocks of the Sharbot Lake domain. They are separated by the Maberly shear zone that formed at circa 1160 Ma.

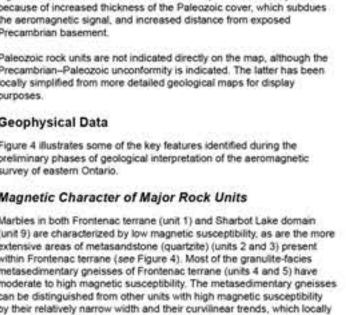
Highlights include 1) the Maberly shear zone is not readily evident, but a 10 to 20 km zone in Frontenac terrane immediately to the south characterized by strong linear magnetic trends likely a high strain zone in the hanging wall of the Maberly shear zone: 2) few faults and lineament asement propagate into the t beneath the Paleozoic: and 4 possible Monteregian (Mesozoic) intrusions occur near the Ontario-Quebec border.

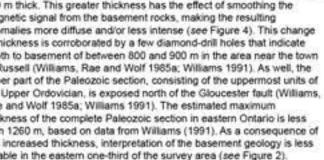


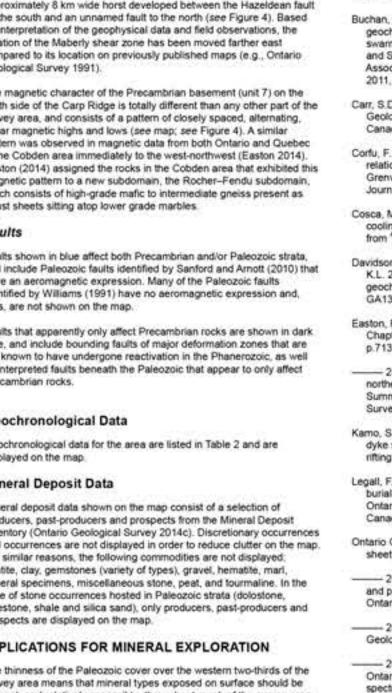


iveral mafic dike swarms are present within the survey area, mostly



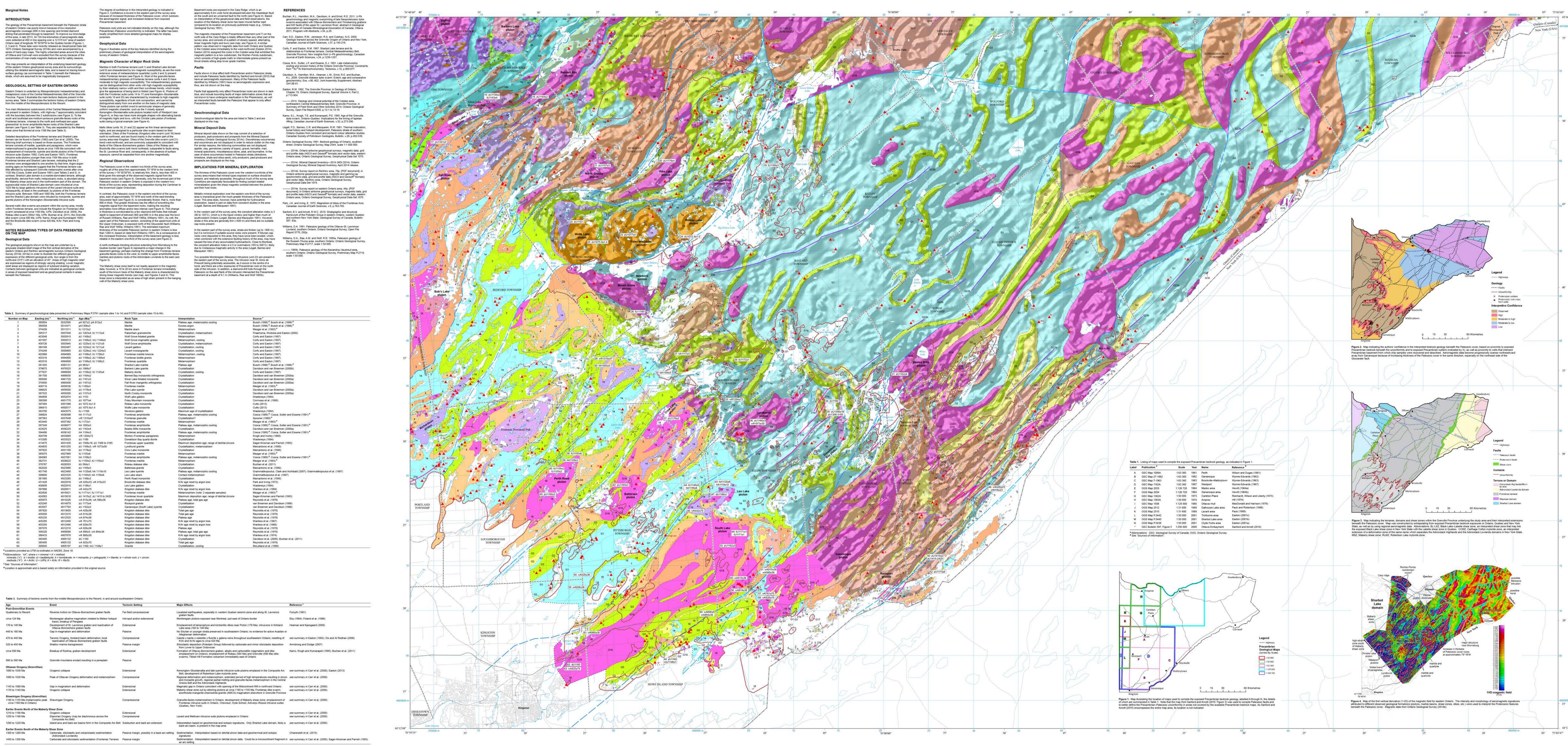






ation given the sharp magnetic contrast between

Two possible Monteregian (Mesozoic) intrusions (unit 23) are present the eastern part of the survey area. The intrusion near St. Anne de



Age	Event	Tectonic Setting	Major Effects	Reference
Post-Grenvillian Events	tra tra an			
Quaternary to Recent	Reverse motion on Ottawa-Bonnechere graben faults	Far-field compressional	Localized earthquakes, especially in western Quebec seismic zone and along St. Lawrence graben faults	Forsyth (1
circa 124 Ma	Monteregian alkaline magmatism (related to Meteor hotspot trace), breakup of Pangaea	Hot-spot and/or extensional	Monteregian plutons exposed near Montreal, just east of Ontario border	Eby (1984
176 to 148 Ma	Development of St. Lawrence graben and reactivation of Ottawa–Bonnechere graben faults	Extensional	Emplacement of lamprophyre and kimberlitic dikes near Picton (176 Ma); intrusions in Kirkland Lake area (160 to 148 Ma)	Heaman
440 to 180 Ma	Gap in magmatism and deformation	Passive	No Silurian or younger strata preserved in southeastern Ontario; no evidence for active Acadian or Alleghenian deformation	
470 to 440 Ma	Taconic Orogeny, foreland basin deformation; local reactivation of Ottawa–Bonnechere graben faults	Compressional	Calcite ± barite ± celestite ± fluorite ± galena veins throughout southeastern Ontario; resetting of K/Ar and Ar/Ar ages to circa 420 Ma	see summ
520 to 450 Ma	Shallow marine transgression	Passive margin	Siliciclastic deposition (Potsdam Group) followed by carbonate and minor siliciclastic deposition from Lower to Upper Ordovician	Armstrong
circa 590 Ma	Breakup of Rodinia, graben development	Extensional	Formation of Ottawa–Bonnechere graben, alkalic and carbonatitic magmatism and dike emplacement (in Ontario); emplacement of Rideau (584 Ma) and Grenville (590 Ma) dike swarms; Tibbet Hill Formation volcanism immediately east of Ontario	Kamo, Kro
990 to 590 Ma	Grenville mountains eroded resulting in a peneplain	Passive		
Ottawan Orogeny (Grenvillian)				
1060 to 1030 Ma	Orogenic collapse	Extensional	Kensington-Skootamatta and late syerilte intrusive suite plutons emplaced in the Composite Arc Belt, development of Robertson Lake mylonite zone	see summ
1080 to 1030 Ma	Peak of Ottawan Orogeny deformation and metamorphism	Compressional	Regional deformation and metamorphism, extended period of high temperatures resulting in zircon and monazite growth, regional partial meting and granulite-facies metamorphism in the Central Gneiss Belt and the Adirondack Highlands	see summ
1145 to 1080 Ma	Gap in magmatism and deformation	Extensional	Magmatic gap in Ontario coincident with opening of the Midcontinent Rift in northwest Ontario	see summ
1170 to 1145 Ma	Orogenic collapse	Extensional	Maberly shear zone cut by stitching plutons at circa 1160 to 1155 Ma; Frontenac dike swarm; anorthosite-mangerite-charnockite-granite (AMCG) magmatism elsewhere in Grenville Province	see summ
Shawinigan Orogeny (Grenvillian)				
1190 to 1155 Ma (metamorphic peak circa 1168 Ma in Ontario)	Shawinigan Orogeny	Compressional	Granulite-facies metamorphism in Ontario, development of Maberly shear zone, emplacement of Frontenac intrusive suite in Ontario, Chevreuil, Hyde School, Antwerp-Rossie intrusive suites (Quebec, New York)	see summ
Earlier Events North of the Maberly	Shear Zone			
1210 to 1190 Ma	Orogenic collapse	Extensional		see summ
1250 to 1190 Ma	Elzevirian Orogeny (may be diachronous across the Composite Arc Bett)	Compressional	Lavant and Methuen intrusive suite plutons emplaced in Ontario	see summ
1290 to 1220 Ma	Island arcs and back-arc basins form in the Composite Arc Belt	Subduction and back-arc extension	Interpretation based on geochemical and isotopic signatures. Only Sharbot Lake domain, likely a back-arc basin, is present in the map area	see summ
Earlier Events South of the Maberly	Shear Zone			
1300 to 1260 Ma	Carbonate, siliciclastic and volcaniclastic sedimentation (Adirondack Lowlands)	Passive margin, possibly in a back-arc setting	Sedimentation. Interpretation based on detrital zircon data and geochemical and isotopic signatures	Chiarenze
1450 to 1300 Ma	Carbonate and siliciclastic sedimentation (Frontenac Terrane)	Passive margin	Sedimentation. Interpretation based on detrital zircon data. Could be a microcontinent fragment in an arc setting	see summ

Example: Map P3793 is one of 3 compilation maps. Not to scale on poster.



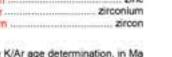
abed	
LEGEND ^{abed} PHANEROZOIC	Geop
CENOZOIC QUATERNARY	Ontar for Or Geop
PLEISTOCENE AND RECENT	Ontar magn Geos
UNCONFORMITY MESOZOIC	Geop Ontar magn
CRETACEOUS Alkalic Intrusive Rocks (Monteregian Alkaline Igneous Province) (124 Ma) ^{ef}	data, Data
INTRUSIVE CONTACT	Geolo Figun
PALEOZOIC UPPER ORDOVICIAN (Ottawa Group), MIDDLE ORDOVICIAN (Rockcliffe Formation), LOWER ORDOVICIAN	Ontar Easto Ontar
(Beekmantown Group) and CAMBRIAN (Potsdam Group) ^g Limestone, dolomite, calcareous limestone, calcareous dolomite, green mudstone and calcareous sandstone, sandstone, minor conglomerate	Easto Geok
UNCONFORMITY	Easto Geok
NEOPROTEROZOIC 22 Mafic Intrusive Rocks (Unknown Affinity)	Easto Geok Hewit
22a Mafic dike, mapped, unknown age or swarm 22b Mafic dike, geophysically defined, unknown age or swarm	scale Hewit Map 2
21 Mafic Intrusive Rocks (Grenville and Rideau Diabase Dike Swarms) (590 Ma) ^h	Hill, F scale
 21a Gabbro, fine to medium grained; dikes 21b Gabbro to diorite, fine to medium grained; porphyritic and amygdaloidal dikes* 	Lumb and t Belt,
INTRUSIVE CONTACT MESOPROTEROZOIC	of Ca MacD Ottaw
Kensington–Skootamatta Intrusive Suite ⁷ (1080 to 1065 Ma) Granitic Intrusive Rocks: Granite, alkali feldspar granite, minor	Scale Ontar Ontar
granodiorite, pink to grey, magnetic	Pauk Surve
19 Syenitic Intrusive Rocks: Syenite, monzonite, quartz monzonite, minor syenodiorite, massive, leucocratic, pink to red, typically magnetic	Pauk count
18 Mafic Intrusive Rocks (Kingston Diabase Dike Swarm) (1159 Ma) ^h : Gabbro, fine to medium grained; dikes, Frontenac	Reint Geok Sanfo
dike swarm INTRUSIVE CONTACT	of the New '
Frontenac Intrusive Suite ¹ (1180 to 1150 Ma) Granitic Intrusive Rocks: Monzogranite, syenogranite, minor	Map Wynr
	of Ca Wynn Geole
massive, leucocratic, pink to red; typically magnetic Dioritic Intrusive Rocks: Diorite, quartz diorite; foliated to massive	Wynn of Ca
14 Gabbroic Intrusive Rocks: Gabbro, leucogabbro, anorthosite gabbro, minor anorthosite; foliated to gneissic	Geoc
Lavant Intrusive Suite ⁴ (1240 to 1220 Ma)	Buch geocl assoc of the
13 Granitic Intrusive Rocks: Monzogranite, granodiorite, minor tonalite, pink to grey	Cana Abstr Busd
12 Mafic Intrusive Rocks 12a Gabbro, leucogabbro, minor anorthositic gabbro, pyroxenite, locally preserving igneous layering 12b Gabbro, fine- to medium-grained, sills and dikes intruded	Lake of Mic Busc
Elzevir Intrusive Suite ² (1270 to 1240 Ma)	faultir near v.15,
11 Granitic Intrusive Rocks: Granodiorite, tonalite, minor monzogranite, typically grey to pink-grey; variably magnetic	Carr, transe Earth
GRENVILLE SUPERGROUP	Chiar prove by de
Regional Low- to Moderate-Pressure Upper Greenschist- to Amphibolite-Facies Metamorphism in the Sharbot Lake Domain at circa 1070 Ma	Corfu Front from
10 Siliciclastic Metasedimentary Rocks 10 Impure sandstone, minor mudstone and siltstone.	Corriv K-rich timing
 locally thin to medium layered, locally rusty weathering* Gneiss, quartzofeidspathic, exhibiting gneissic to migmatitic textures, derived from metamorphosed siltstone, impure sandstone and mudstone, typically magnetic. Porphyroblastic minerals include gamet, siltimanite, cordierite, hypersthene 	v.105 Cosc Orog Unive
and amphibole. May be equivalent of unit 5 Carbonate Metasedimentary Rocks: Calcite, dolomite and siliceous dolomite marbles, typically thin to medium layered, locally containing minerals such as philogopite, tremolite and diopside	Cosc erosic therr Cutts the G
8 Metavolcanic Rocks Sa Predominantly mafic metavolcanic rocks, fine to medium grained, locally pillowed; intercalated with minor intermediate metavolcanic rocks and minor mudstone and siltstone 8b Amphibolite, fine to medium grained*	Ottav doma David Gren
TECTONIC CONTACT Regional Moderate- to High-Pressure Granulite-Facies	v.90, David plutor
Metamorphism in the Rocher-Fendu Subdomain at circa 1168 Ma ROCHER-FENDU SUBDOMAIN	south Geok [avail
7 Gneiss*: Gneiss of mafic to intermediate composition derived from a variety of protoiths. A geophysically defined unit not exposed on surface in the map area, although equivalents	David Centr Radio
are exposed in the Cobden area. Magnetic pattern is characterized by wormy, alternating, magnetic highs and lows TECTONIC CONTACT	Curre Dix, C Ordo
Regional Low- to Moderate-Pressure Granulite-Facies Metamorphism in the Frontenac Terrane at circa 1168 Ma	Emba Laure Easto
FRONTENAC TERRANE	(1080 zone, Ontar
6 Tectonites: Gneiss, mafic, intermediate and felsic, typically thin layered, highly deformed, derived in part from units 1 to 5. May locally contain layers, lenses and pods of intrusive rocks, including metagabbro and meta-anorthosite	Easto to the and g
5 Migmatitic Rocks 5a Gneiss, quartzofeldspathic, typically derived from units 3 and/or 4, which are variably intruded by syenite and/or	Eby, I Queb
granite of units 8 and 9 to form <i>it-par-it</i> gneisses* 5b Gneiss, quartzofeldspathic, containing 5 to 15% leucosome likely formed during partial melting*	Folan for pl Creta
 Granulite: Gnelss, quartzofeldspathic, equigranular (granulite-texture), fine to medium grained, pyroxene bearing (granulite facies) 	Forsy Cana Gram
3 Siliciclastic Metasedimentary Rocks: Gneiss, quartzofeldspathic, exhibiting gneissic to migmatitic textures, derived from metamorphosed siltstone, impure sandstone and mudstone.	Leo L south
ypically magnetic. Porphyroblastic minerals include garnet, silimanite, cordierite, hypersthene and amphibole Quartz-Rich Siliciclastic Metasedimentary Rocks;	Gram and v U-Pb terrar
Metamorphosed sandstone (quartzite), fine to medium grained, white to buff, locally intercalated with calcareous metasedimentary rocks (unit 1) and/or other metasedimentary rocks (unit 3). Typically display low magnetic susceptibility, except where intercalated with magnetic metasedimentary	abstri Ottav Hean kimbe Earth
Carbonate Metasedimentary Rocks Ta Calcite and dolomite marble, minor calc-silicate and	Kamo swarr Journ
 quartz-plagioclase pegmatite dikes and veins, all typically non-magnetic. The marbles typically contain minerals such as biotite, diopside, titanite, tremolite and wollastonite 1b Rocks of unit 1 interlayered with rocks of unit 2, minor 	Krogh
calc-silicate and quartz-plagioclase pegmatite dikes and veins, all typically non-magnetic ^e 1c Marble tectonic breccia, calcite matrix, with fragments	v.73, Marci evide
of amphibolite, guartzofeldspathic gneiss, metaguartz- arenite and rich in minerals such as biotite, phiogopite, tremolite, diopside	of On McLe geocl
* The Precambrian legend is a lithotectonic one, and stratigraphic order is only in part implied by numerical order. All Precambrian rocks have been subjected to regional metamorphism; many non-metamorphic terms are used for the sake of brevity.	evolu Mezg
^b Codes, unless otherwise indicated, refer to data compiled from geological maps listed under "Sources of Information". ^c The letter "G" preceding a code refers to data interpreted from	geocl ancie Park,
aeromagnetic geophysical maps listed under "Sources of Information", ^d This legend also applies to Preliminary Maps P.3791 (northwest sheet) and P.3792 (northeast sheet). Not all rock types may be present on each of the 3 maps.	Cana Pehra Ragia
 Unit absent on this map (south sheet). I Age from Eby (1984) and from Foland et al. (1986). 	ensia v.33, Praar
Paleozoic stratigraphy after Armstrong and Dodge (2007). ^h Age from Kamo, Krogh and Kumarapeli (1995) and from Buchan et al. (2011). (2011).	Elzev Provi Geok
¹ Igneous rock suites and their age ranges are adapted from Lumbers et al. (1990) and from Easton (1992), based on additional geochronological data found in Easton and Kamo (2011), Mezger et al. (1993) and Pehrsson, Hanmer and van Breemen (1996).	[avail Reyn dikes
	Cana Sage from
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ADDITIONAL SOURCES Geophysical data derived from: Ontario Geological Survey 1999. Single master gravity and aeromagnetic data	Di Ontario
for Ontario Geological Survey 1955, single master granty and according tele data for Ontario, ASCII, Excel [®] and Access [®] formats; Ontario Geological Survey, Geophysical Data Set 1035. Ontario Geological Survey 2014a. Ontario airborne geophysical surveys, magnetic and gamma-ray spectrometric data, grid and profile data (ASCII and	Ontario Geological Survey
Geosoft [®] formats) and vector data, Renfrew area; Ontario Geological Survey, Geophysical Data Set 1074. Ontario Geological Survey 2014b. Ontario airborne geophysical surveys,	MAP P.3793
magnetic data, grid and profile data (ASCII and Geosoft® formats) and vector data, eastern Ontario area; Ontario Geological Survey, Geophysical Data Set 1075. Geology (exposed Precambrian bedrock geology, as indicated in Table 1 and Figure 1) derived from: Armstrong, D.K. and Dodge, J.E.P. 2007. Paleozoic geology of southern Ontario; Ontario Geological Survey, Miscellaneous Release—Data 219. Easton, R.M. 1992. The Grenville Province; in Geology of Ontario, Chapter 19,	PRECAMBRIAN GEOLOGY PRECAMBRIAN GEOLOGY OF EASTERN ONTARIO INTERPRETE FROM AEROMAGNETIC AND COMPILED GEOLOGICAL DATA
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Davidson, A. and van Breemen, O. 2000a. Age and extent of the Frontenac plutonic suite in the Central Metasedimentary Belt, Grenville Province, southeastern Ontario; in Radiogenic Age and Isotopic Studies: Report 13, Geological Survey of Canada, Current Research, Paper 2000-F, #4, 15p. [available in electronic form only]	Ag silver Ni nickel Ar argon Pb lead Au gold py pyrite brt barite Rb rubidium cal calcite sh shale (stone) cdm corundum silica (stone)
 Davidson, A. and van Breemen, O. 2000b. Late Grenvillian granite plutons in the Central Metasedimentary Belt, Grenville Province, southeastern Ontario; in Radiogenic Age and Isotopic Studies: Report 13, Geological Survey of Canada, Current Research, Paper 2000-F, #5, 9p. [available in electronic form only] Dix, G.R. and Al Rodhan, Z. 2006. A new geological framework for the Middle Ordovician Carillon Formation (uppermost Beekmantown Group, Ottawa Embayment): Onset of Taconic foreland deposition and tectonism within the Laurentian platform interior; Canadian Journal of Earth Sciences, v.43, p. 1367-1387. Easton, R.M. 2013. Geology and mineral potential of Late Syenite (1080–1030 Ma) and associated rocks. Central Metasedimentary Belt boundary zone, Grenville Province; in Summary of Field Work and Other Activities 2013, Ontario Geological Survey, Open File Report 6290, p. 12-1 to 12-12. 	Cu copper Sb antimony dol dolomite soapstone ds dolostone (stone) Sr strontium Fe iron srp serpentinite fel feldspar tc talc g granite (stone) tr tremolite gr graphite trp trap rock (stone) grt garnet V uranium K potassium vm vermiculite mb marble (stone) Zr zinconium Mo molybdenum Zr zinconium bK biotite K/Ar age determination, in Ma Ma
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2000 CO. 10	potassium	vrm vermiculite
	limestone	wo wollastonite
	marble (stone)	Zn
	mica	Zr
	molybdenum	zm
к		biotite K/Ar age determination, in Ma
U		eyite U/Pb age determination, in Ma
Α		ende Ar/Ar age determination, in Ma
		azite U/Pb age determination, in Ma
		opite Ar/Ar age determination, in Ma
1		anite U/Pb age determination, in Ma
A		rock Ar/Ar age determination, in Ma
		-rock K/Ar age determination, in Ma
R		rock Rb/Sr age determination, in Ma
		ircon U/Pb age determination, in Ma
	ions shown in black are o onological methods.	nly used in conjunction with
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re of map area, approximately 13°02'20" W = 0.3048 m.