

The Precambrian Basement of Eastern Ontario: Insights from a New Aeromagnetic Survey*

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Search and Discovery Article #30380 (2014)**

Posted November 10, 2014

*Adapted from oral presentation given at AAPG 43rd Eastern Section Meeting, London, Ontario, Canada, September 27-30, 2014

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Abstract

The Precambrian basement beneath the Paleozoic of eastern Ontario is poorly known due to low-resolution aeromagnetic coverage (800 m line spacing) and limited drilling. To improve our knowledge, in late 2013, 34,724 line km of aeromagnetic data were collected at 400 m line spacing over a 12,515 km² area of eastern Ontario east of longitude 76.51W to the Quebec border. These data were recently released as Ontario Geological Survey Geophysical Dataset 1075. This presentation summarizes both the results of the survey and the preliminary interpretation of the underlying basement geology, based on tracing known surface geology beneath the Paleozoic, which is assumed to be magnetically transparent. Eastern Ontario is underlain by Mesoproterozoic metasedimentary and metaplutonic rocks of the Grenville Province: the granulite facies Frontenac-Adirondack Belt (FAB) to the southeast and the lower amphibolite Sharbot Lake domain to the northwest, separated by the ca. 1160 Ma Maberly shear zone (MSZ). A 30 km wide zone of linear magnetic trends on the Frontenac side of the MSZ is interpreted as a high-strain zone parallel the boundary. The magnetic grain of FAB is characterized by magnetic lows (marbles, quartzites, some gneisses) and ovoid magnetic highs (ca. 1160 and 1080 Ma plutons), which can be reliably traced beneath thin (<400 m) Paleozoic cover as far east as the east-trending Gloucester fault, across which thickness of the Paleozoic increases abruptly (>800 m), resulting in a considerably subdued magnetic grain. East of the fault, interpretation of the basement geology is less reliable, although a possible Monteregean (Mesozoic) intrusion and a basement horst occur near the Quebec border north of Cornwall. Several large dikes, possibly related to the Grenville or Rideau dike swarms, are present beneath the Paleozoic north of Gananoque. Surprisingly, few faults and lineaments identified in the basement propagate into the overlying Paleozoic strata. Furthermore, many mapped faults in the Paleozoic are not obviously present in the basement magnetic pattern; for example west to northwest faults near Ottawa strike at a high-angle to ductile shear zones in the basement. In contrast, northeast-trending faults along the St. Lawrence River are subparallel to basement ductile shears zones, which may have been reactivated. The new survey should prove invaluable in exploration for both groundwater and other subsurface resources in eastern Ontario.

References Cited

Armstrong, D.K., and J.E.P. Dodge, 2007, Paleozoic Geology of Southern Ontario: Ontario Geological Survey Miscellaneous Release - Data 219, p. 28.

Legall, F.D., C.R. Barnes, and R.W. Macqueen, 1981, Thermal Maturation, Burial History and Hotspot Development, Paleozoic Strata of Southern Ontario - Quebec, from Conodont and Acritarch Colour Alteration Studies: Bulletin of Canadian Petroleum Geology, v. 29/4, p. 492-539.

Ontario Geological Survey, Map No. 2054 (coloured), Gananoque area, Ontario. Scale 1 inch to 2 miles.

Ontario Geological Survey, Map No. 2544 (coloured), Bedrock Geology of Ontario - Southern Sheet: Scale 1:1,000,000.

The Precambrian basement of Eastern Ontario: Insights from a new Aeromagnetic Survey

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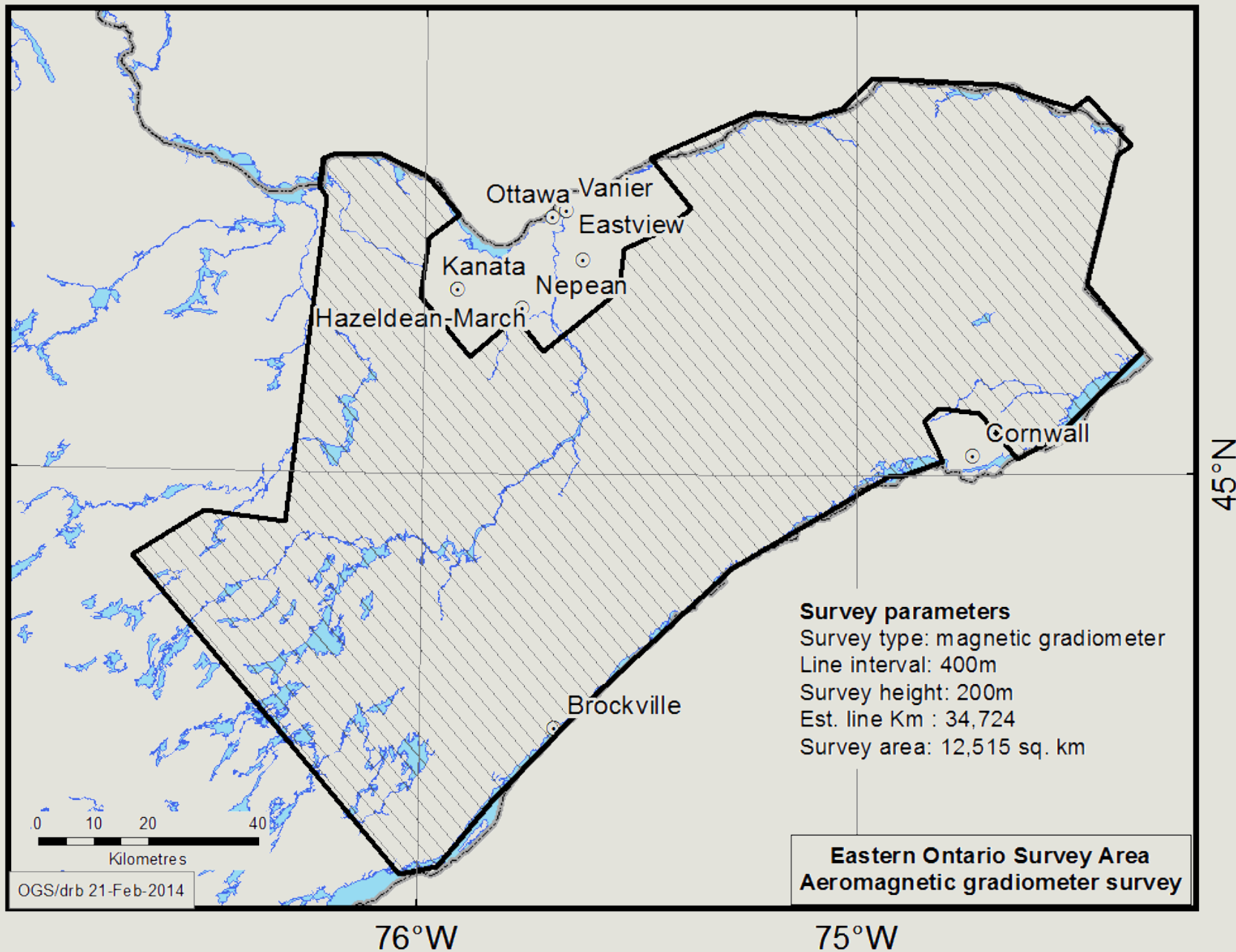
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This Talk

- brief overview of major units and tectonic divisions of the basement
- show some examples of the magnetic character of the major rock units in the basement
- show some examples of the magnetic character of some major structural features in the basement (previously known and newly recognized features)
- summarize what the survey tells us about the Paleozoic
- a few comments with respect to hydrocarbons
- summary and conclusions





GEOLOGICAL SETTING OF THE PRECAMBRIAN BASEMENT



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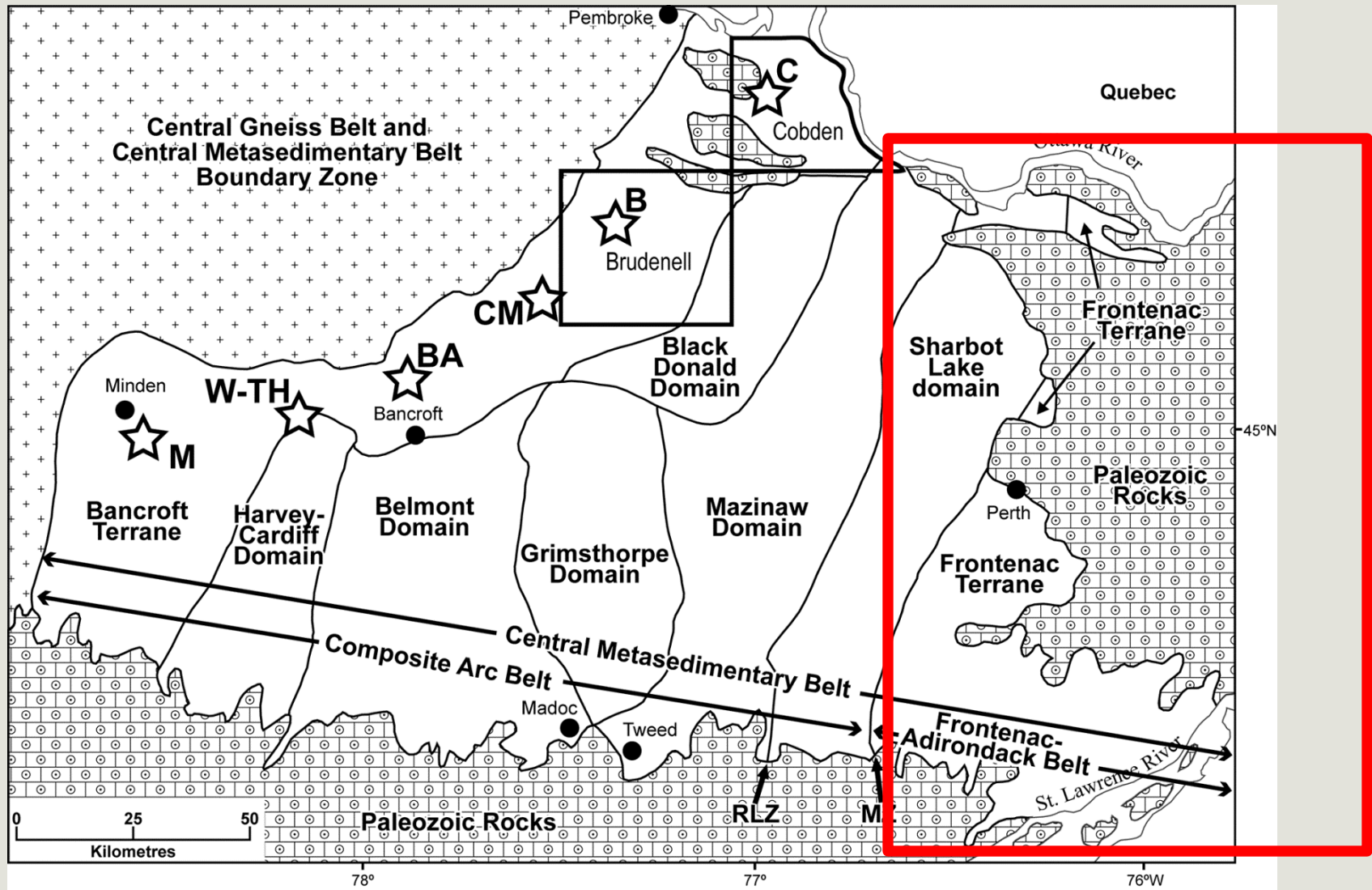
Sharbot Lake domain

- marble dominated (>1220 Ma)
- mafic volcanic rocks
- Lavant metagabbro (1224 Ma)
- Frontenac suite plutons (stitching *circa* 1160 Ma)
- Kensington-Skootamatta suite plutons (1090-1070 Ma)

Frontenac terrane

- quartzites (>1300 Ma)
- marbles & paragneiss (unknown-age)
- low-P granulite facies metamorphism at *circa* 1168 Ma
- Frontenac suite plutons (1175-1156, stitching SLD-FT boundary at *circa* 1160 Ma)
- Kensington-Skootamatta suite plutons (1090-1070 Ma)

Tectonic Divisions of the Grenville Orogen in Ontario



MAGNETIC CHARACTER OF MAJOR ROCK UNITS



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Survey Assumptions

- Paleozoic rocks are non-magnetic ,
i.e. “magnetically transparent”
- in contrast, basement rocks are variably magnetic
- geological contacts and faults can be identified by contrasting magnetic responses
- *basement faults continued to be active in Paleozoic and post-Paleozoic times*



SUPRACRUSTAL ROCKS

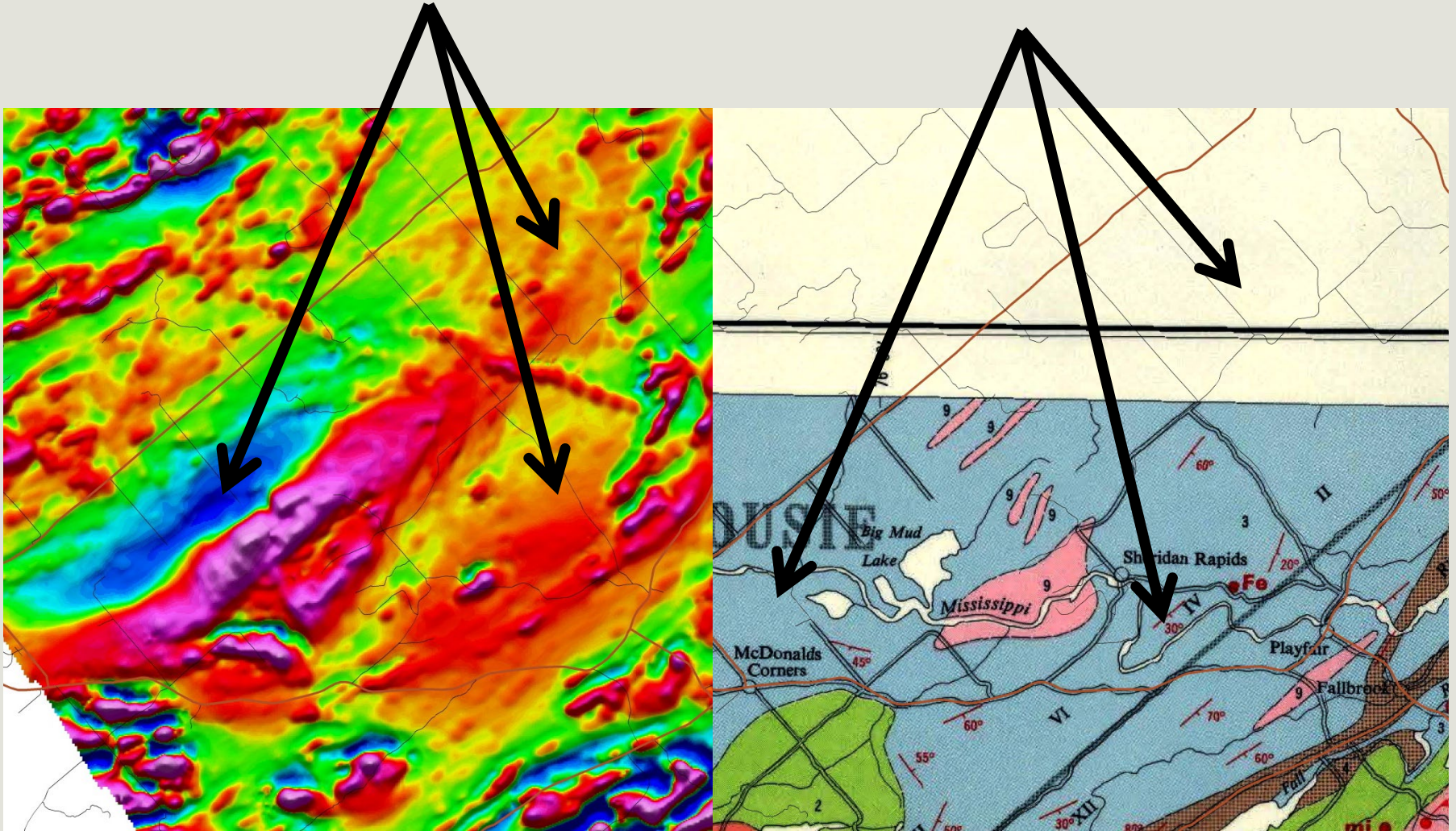


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Marbles

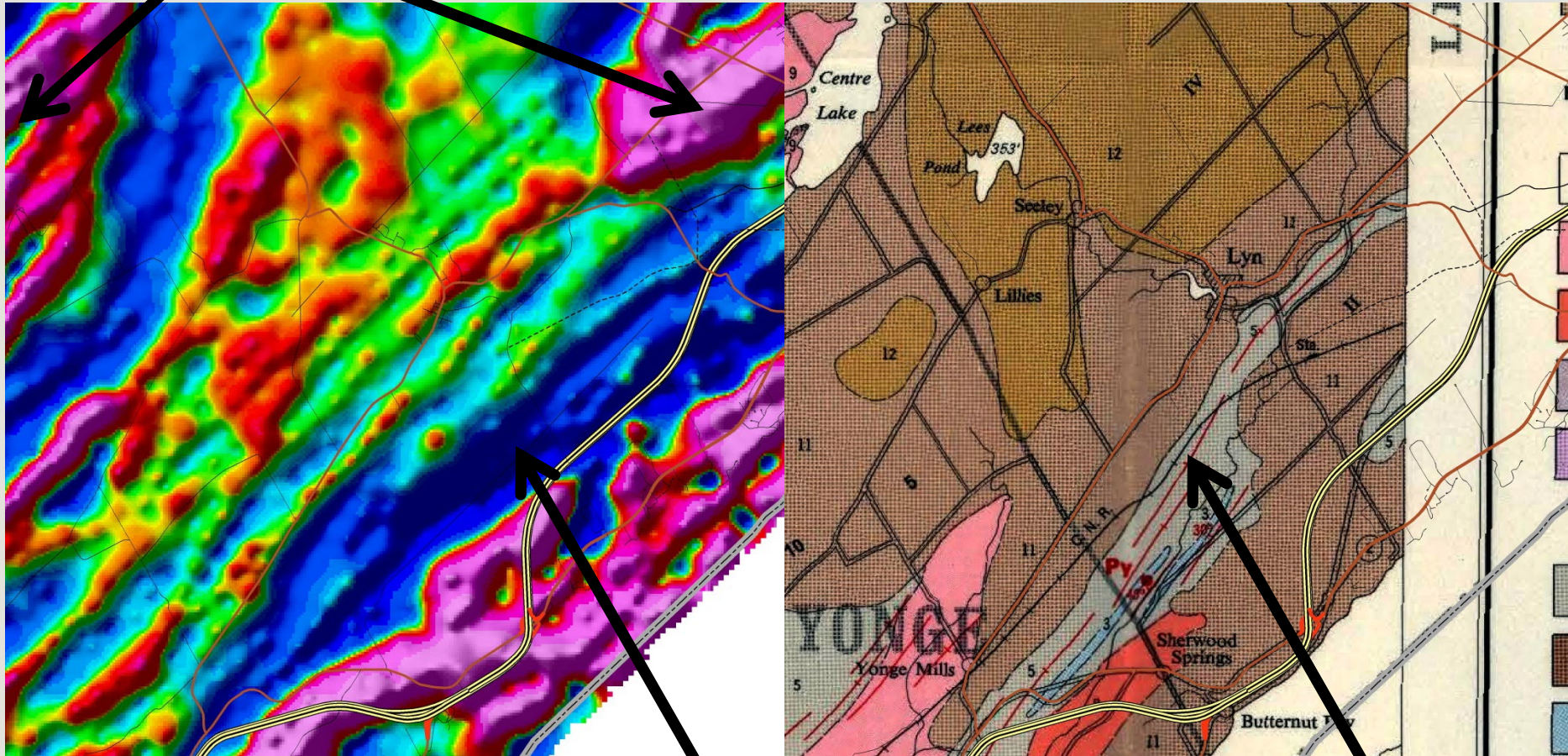


Geology from Ontario Geological Survey Map 2054

Quartzites

plutons

Geology from Ontario Geological Survey Map 2054

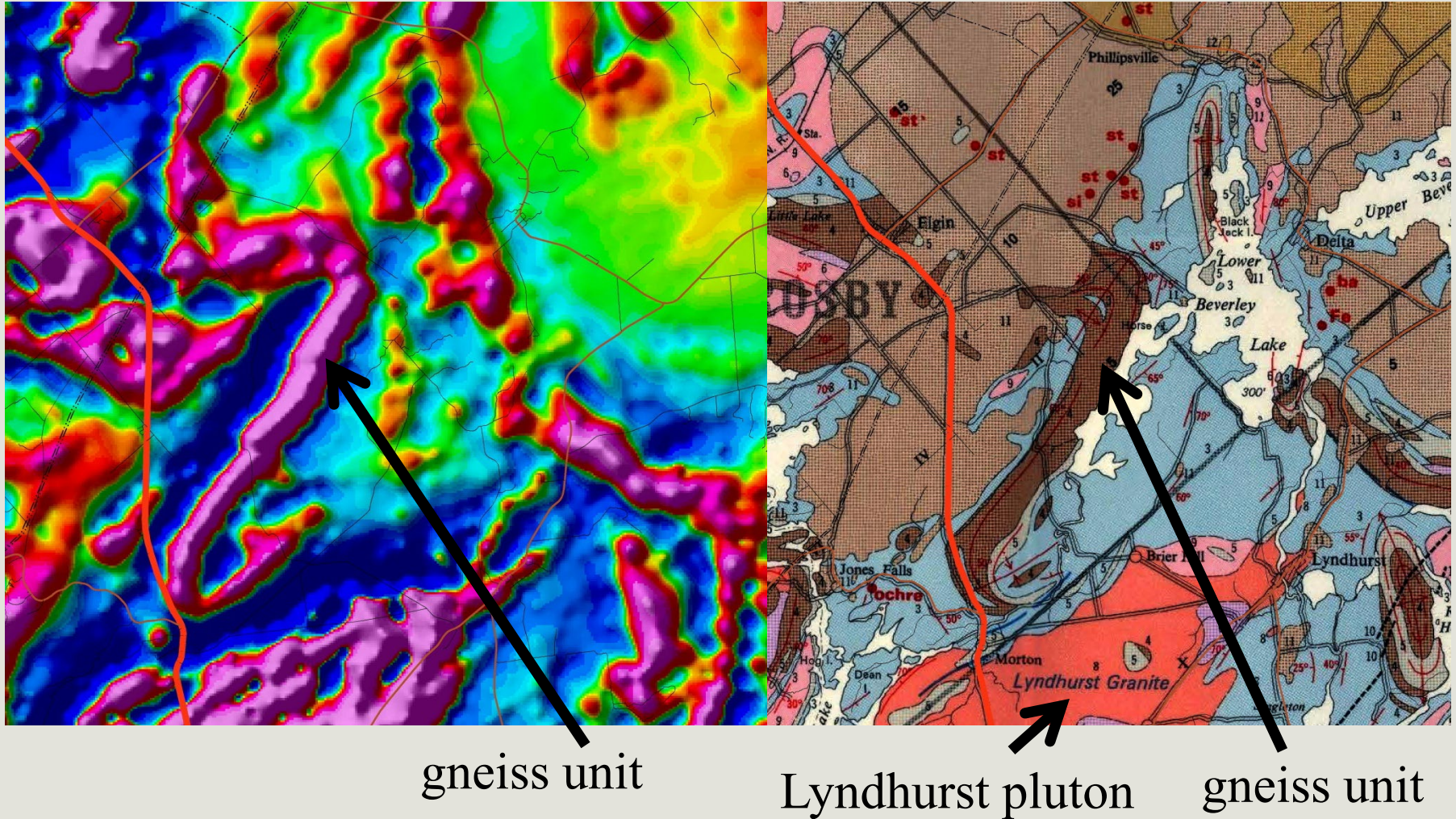


quartzite

quartzite

Granulite-facies Gneisses

Geology from Ontario Geological Survey Map 2054



PLUTONS

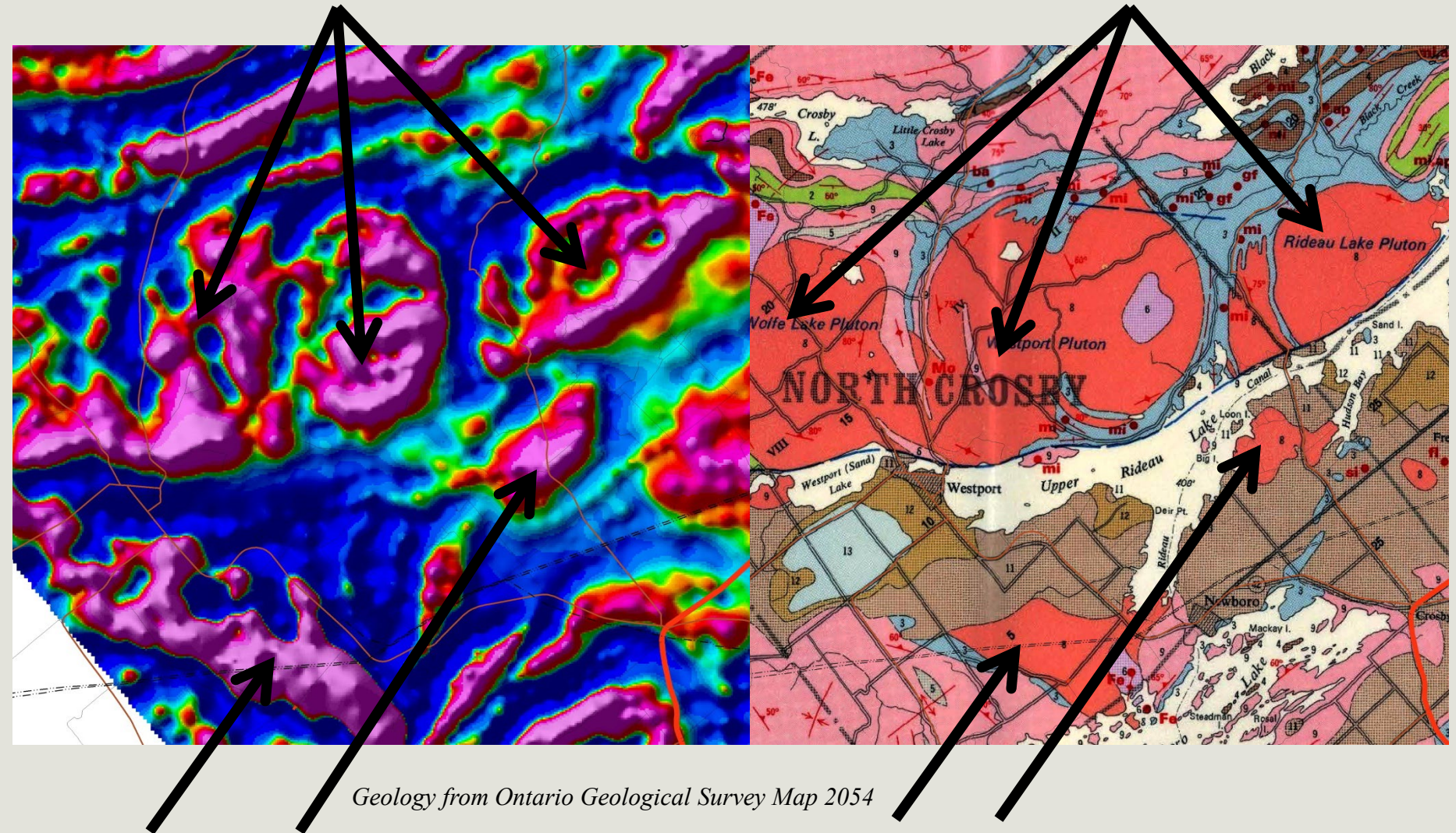


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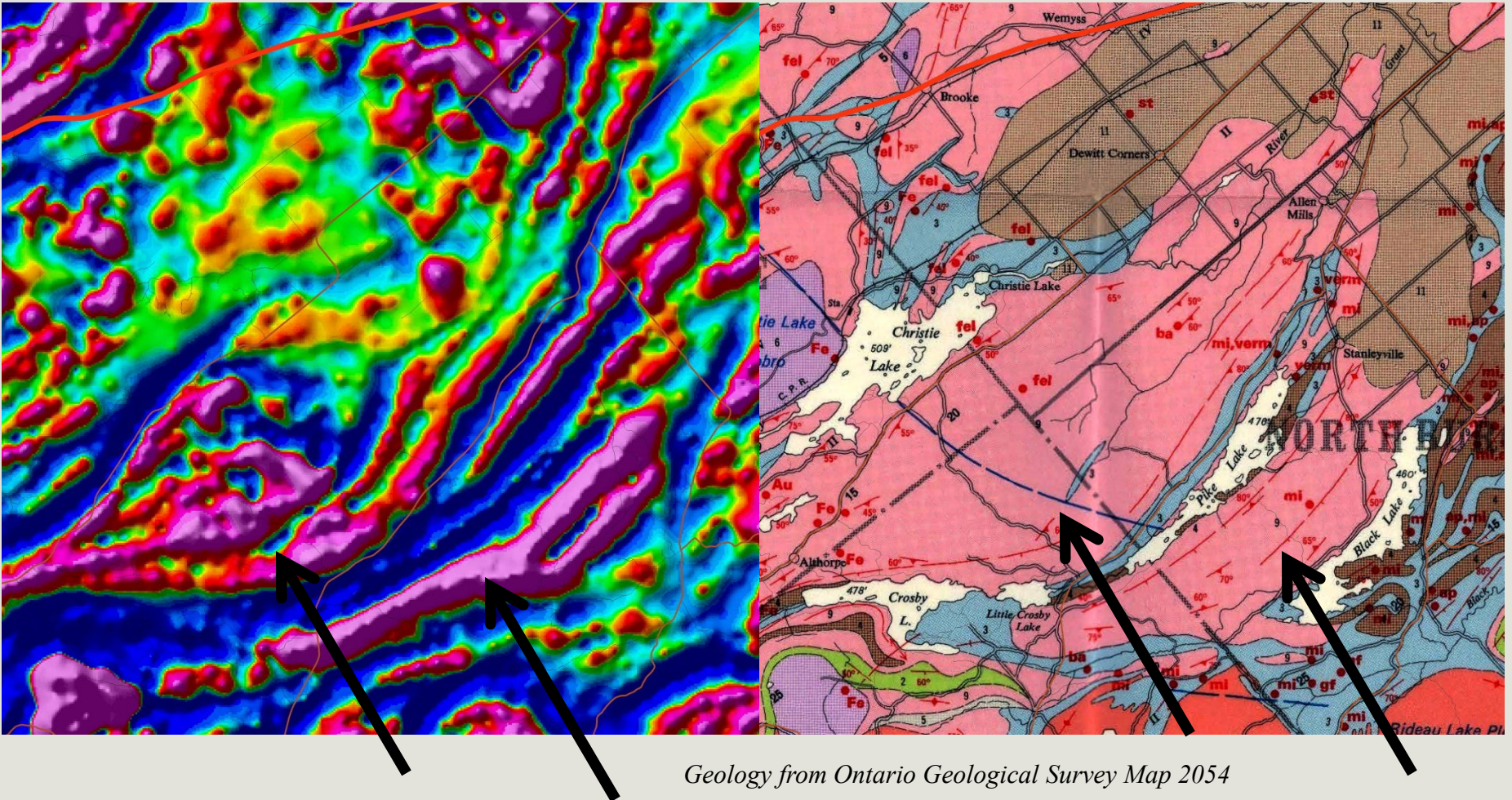
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Westport area plutons (circa 1075 Ma)

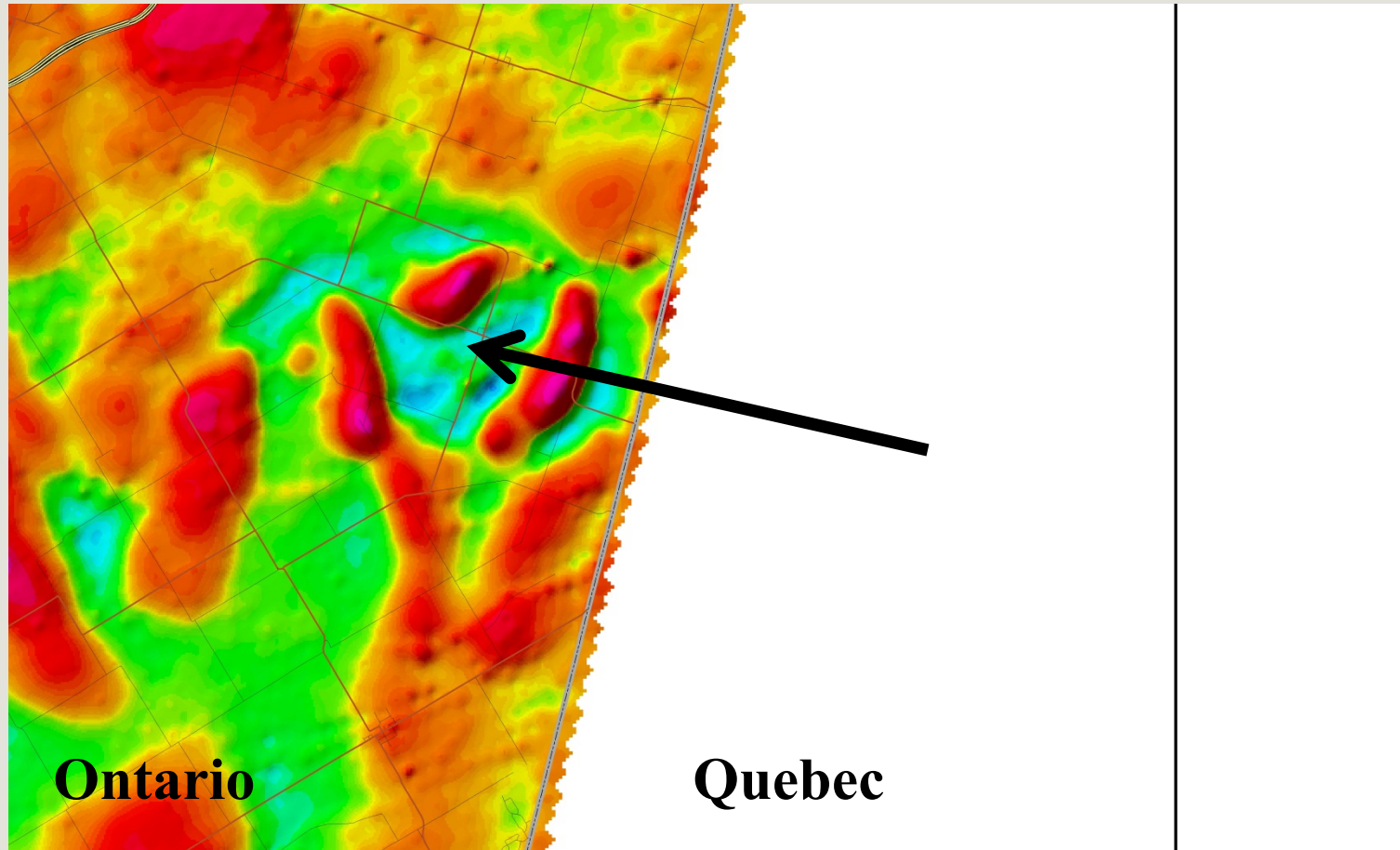


Christie Lake pluton (circa 1160 Ma)



Geology from Ontario Geological Survey Map 2054

Monteregian intrusion (Mesozoic)



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DIKES



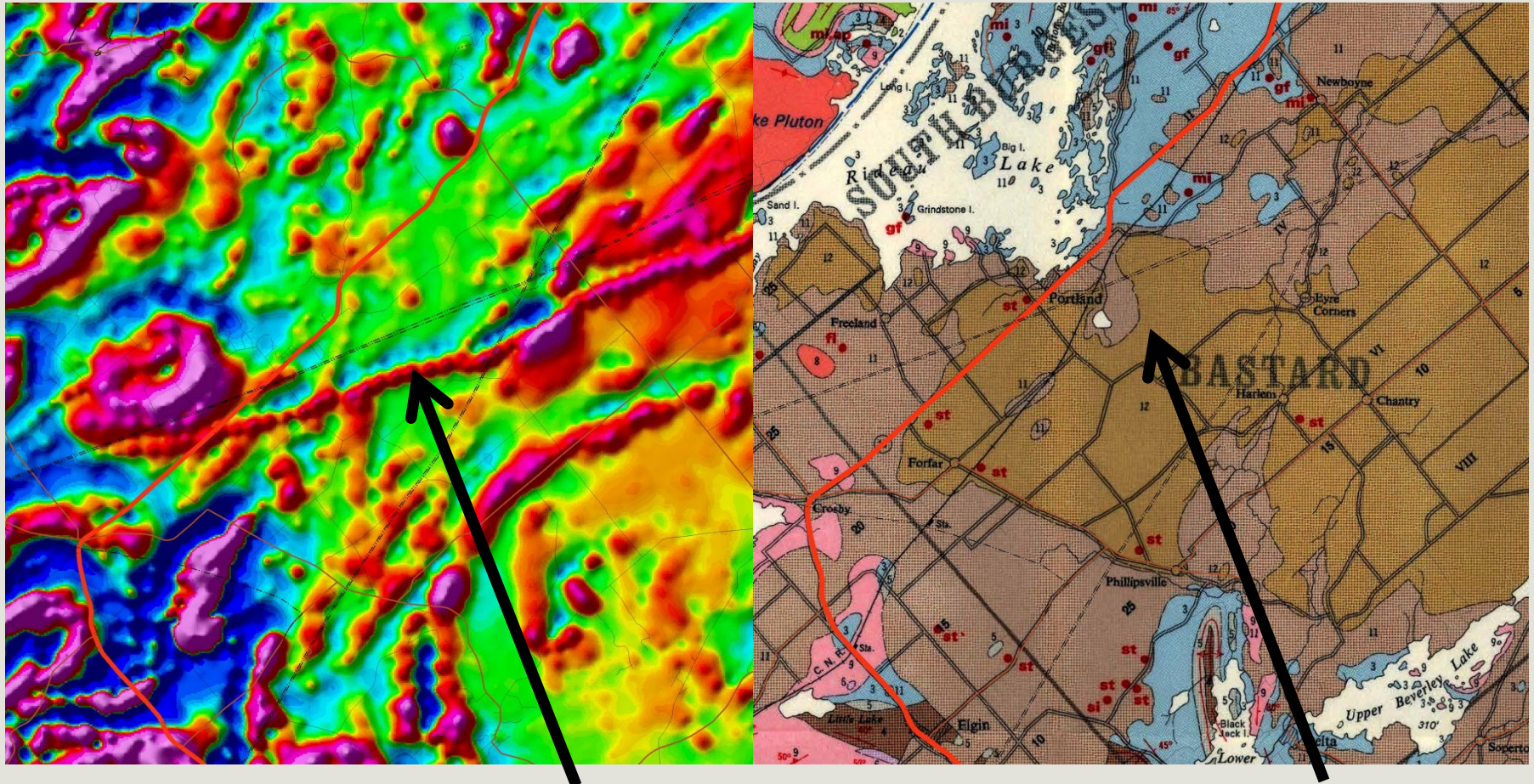
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Large dike beneath Paleozoic cover

Geology from Ontario Geological Survey Map 2054



dike

dike (beneath Paleozoic cover)

Dike Swarms in Region

- all are magnetic, different ages, possible assignment is based on trend alone
- Frontenac (Kingston), N to NW, *circa* 1160 Ma
- Grenville, W to NW, *circa* 590 Ma
- Rideau, NE, *circa* 590 Ma
- Brockville, NE, between 590 and 420 Ma?



MAGNETIC CHARACTER OF MAJOR STRUCTURAL FEATURES



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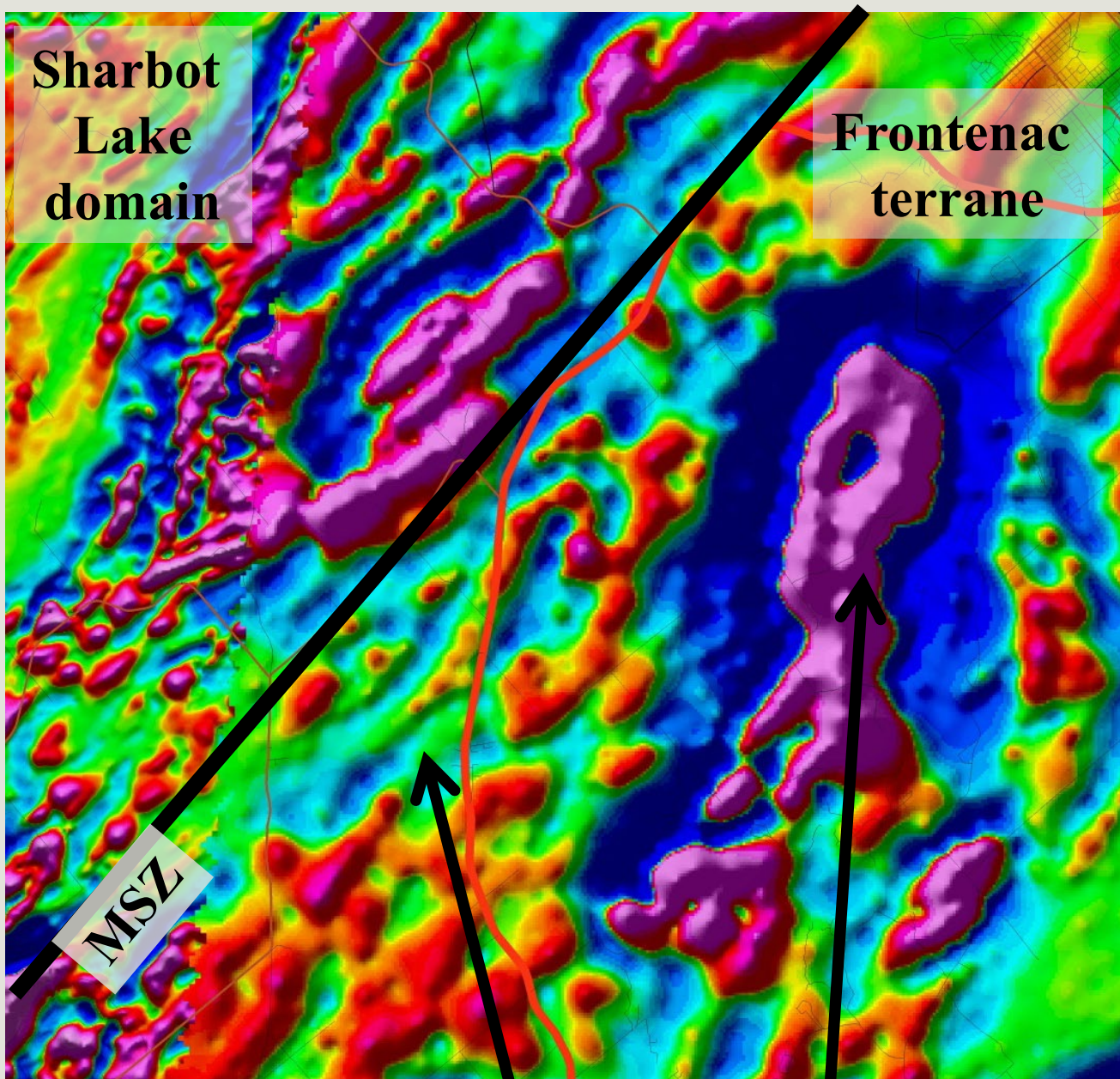
SHEAR ZONES and MAJOR STRUCTURES



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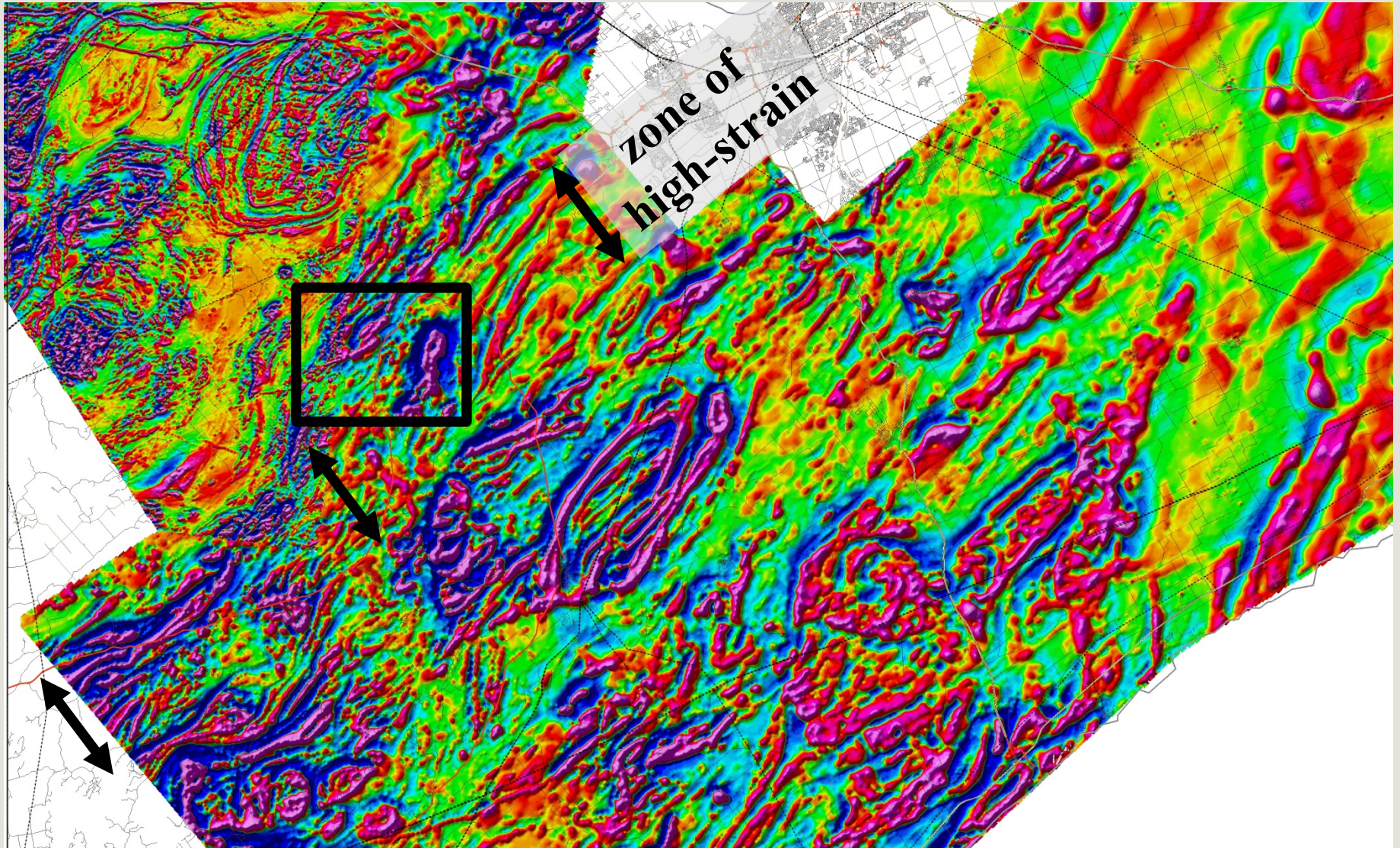


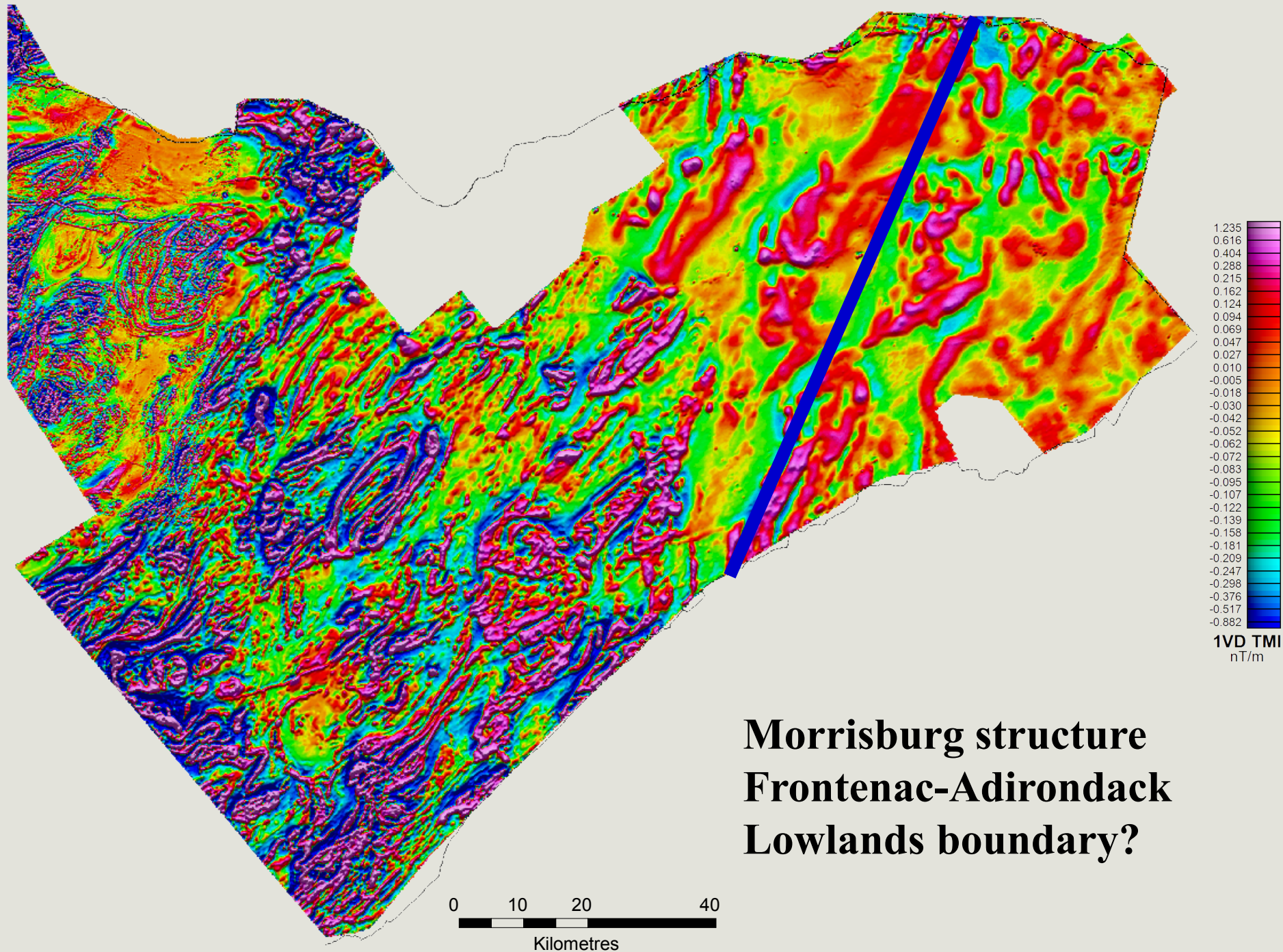
quartzite, migmatite

pluton

Sharbot
Lake-
Frontenac
boundary
(Maberly
shear
zone)

Sharbot Lake-Frontenac boundary (Maberly shear zone)





FAULTING and the BASEMENT

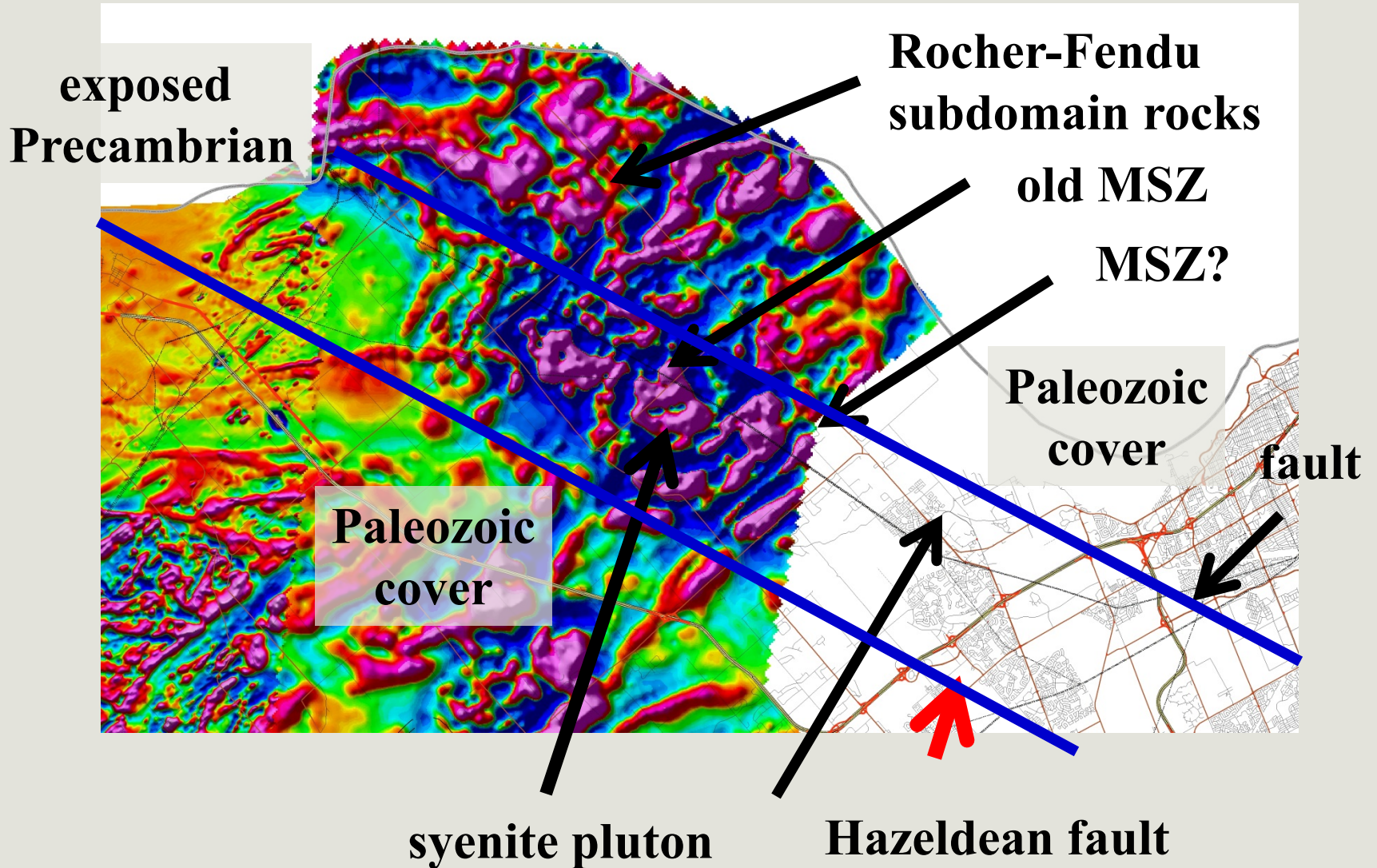


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Carp Ridge



THE PALEOZOIC



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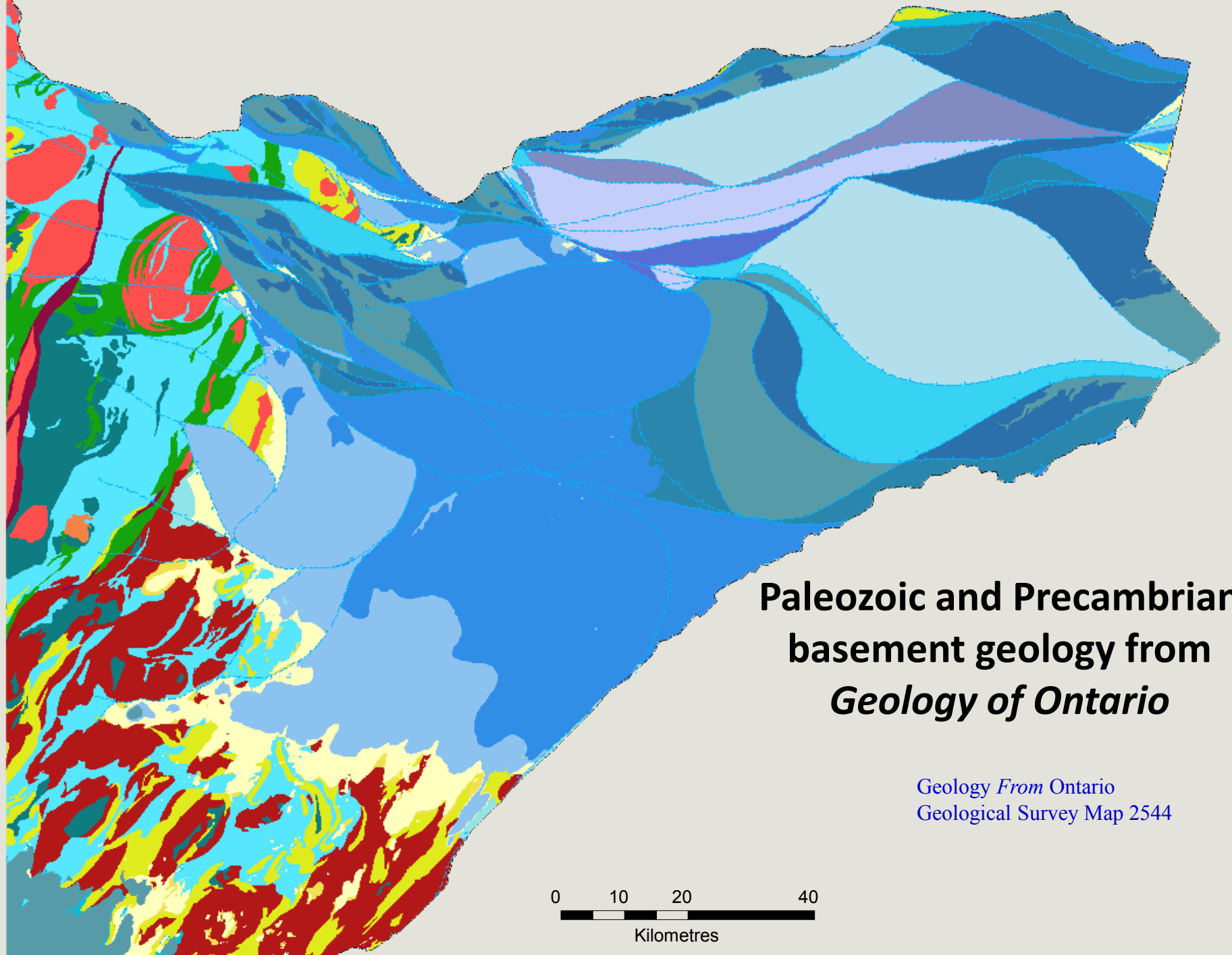
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Paleozoic Stratigraphy

| | | EASTERN ONTARIO OGS Nomenclature* | | EASTERN ONTARIO Nomenclature** | |
|---------------|----------------|--------------------------------------|----------------|-----------------------------------|-----------------|
| Mississippian | | | | | |
| ORDOVICIAN | U | Queenston Fm. | | Queenston Fm. | |
| | | Carlsbad Fm. | | Carlsbad Fm. | |
| | | Billings Fm. | | Billings Fm. | |
| | | Ottawa Gp. | Eastview Mbr. | Ottawa Gp. | Eastview Mbr. |
| | | | Lindsay Fm. | | Lindsay Fm. |
| | | | Verulam Fm. | | Verulam Fm. |
| | | | Bobcaygeon Fm. | | Hull Fm. |
| | | | | | Napanee Fm. |
| | | | Chaumont Fm. | | |
| | | | Lowville Fm. | | |
| | Pamelia Fm. | | | | |
| M | Rockcliffe Fm. | | Hog's Back Fm. | | |
| L | | | Rockcliffe Fm. | | |
| | | | Carillon Fm. | | |
| CAMBRIAN | | Beekman- town Gp. | Oxford Fm. | Beekman- town Gp. | Beauharnois Fm. |
| | | | March Fm. | | Theresa Fm. |
| | Potsdam Gp. | Nepean Fm. | Potsdam Gp. | Nepean Fm. | |
| | | Covey Hill Fm. | | Covey Hill Fm. | |

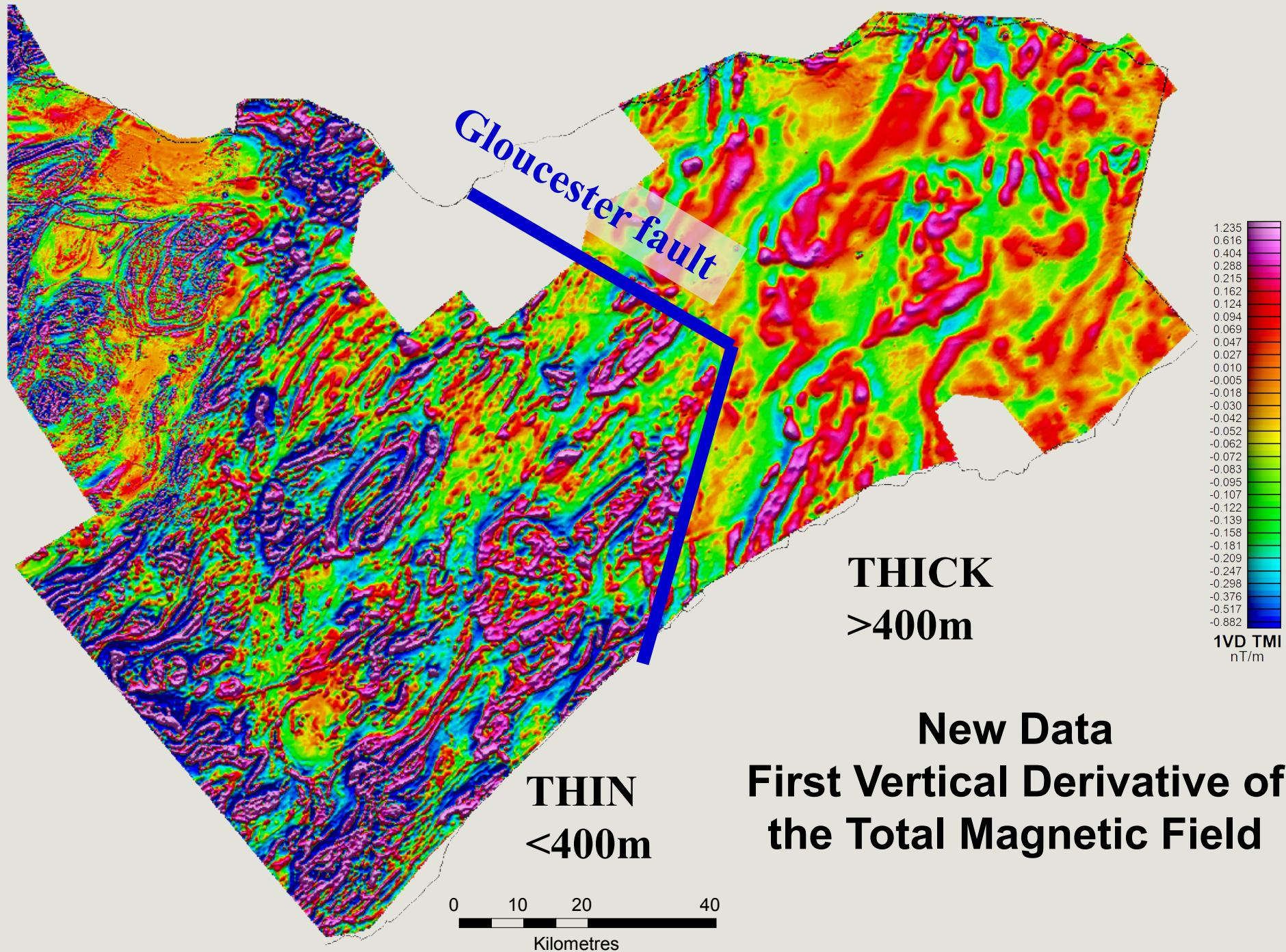
From Armstrong and Dodge,
2007, Ontario Geological
Survey Miscellaneous
Release—Data 219

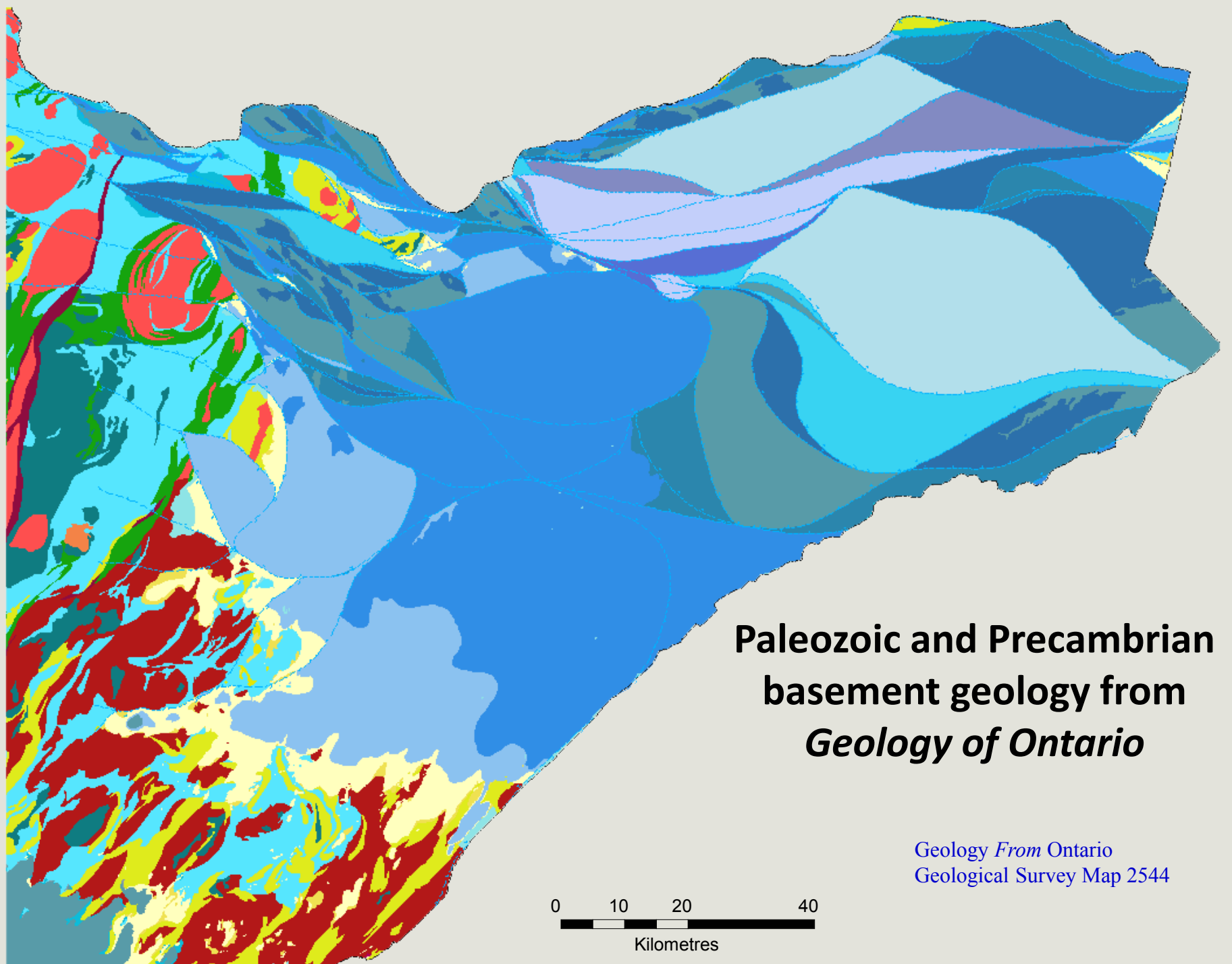


**Paleozoic and Precambrian
basement geology from
*Geology of Ontario***

Geology *From* Ontario
Geological Survey Map 2544

0 10 20 40
Kilometres

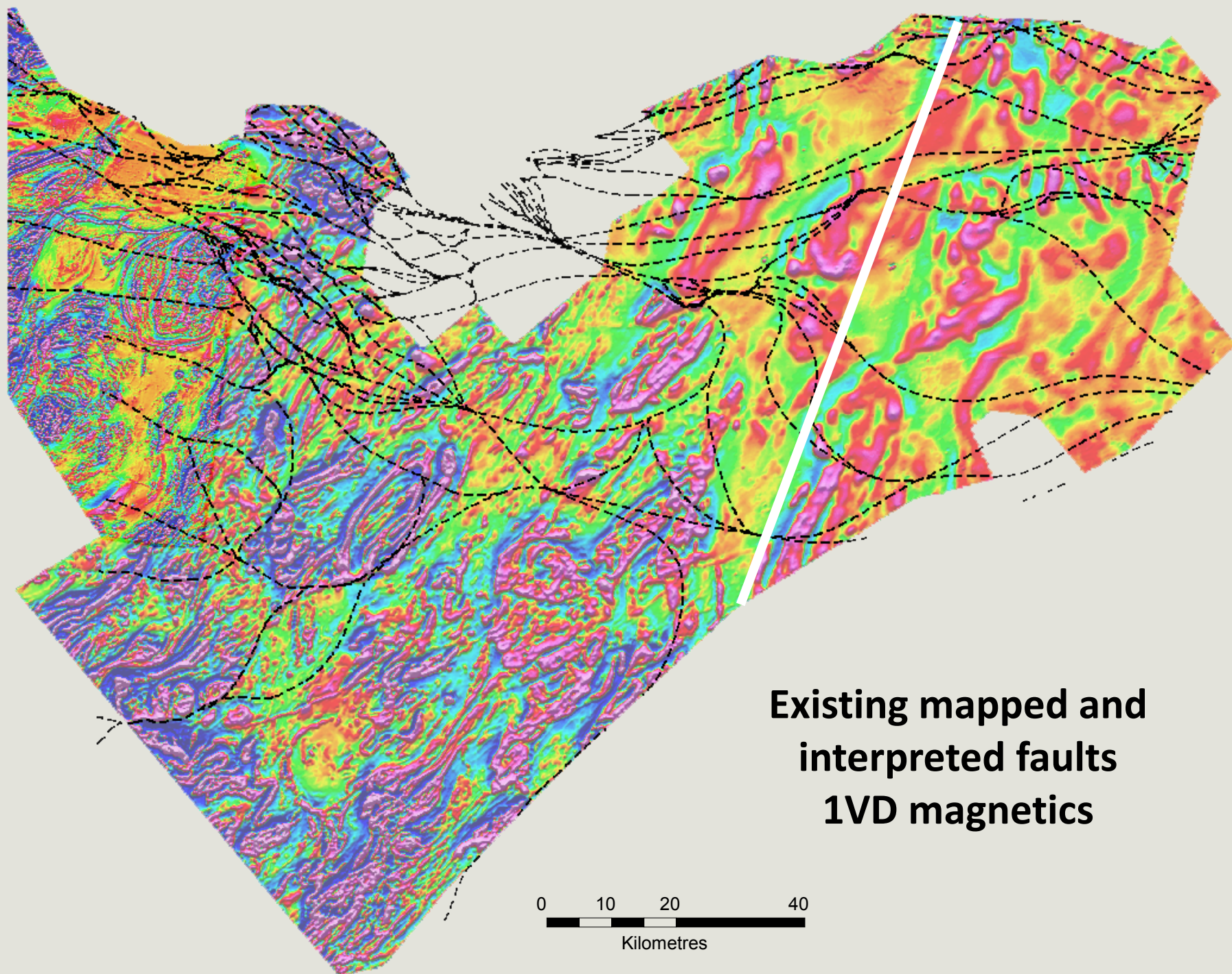




**Paleozoic and Precambrian
basement geology from
*Geology of Ontario***

Geology *From* Ontario
Geological Survey Map 2544

0 10 20 40
Kilometres



HYDROCARBON POTENTIAL



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Western part of survey area

- conodont alteration index of 3 in west of survey area (90°-120°C) is in liquid window
- *but strata are thin, mostly <400m*
- *no suitable cap rocks*

[for reference, most of southwestern Ontario is either <60°C (CAI 1) or in the 60-90°C range (CAI 2) — *data from Legall et al. 1981, CSPG Bulletin, v.29, p.492-539.]*



Eastern part of survey area

- area north and east of the Gloucester fault
- ~800 m thickness similar to that near Kincardine
- *conodont alteration index of 4-5 near Montreal is overmature (185°-300°C). This may be due to heat from the Great Meteor hotspot track (Jurassic)*
- *suitable source rocks?*
- *if Silurian cap rocks were present, they are gone now*
- *significantly more faulting with possible loss of hydrocarbons*



Summary

- Paleozoic cover thinner in the western part of the survey area than expected – allows tracing of units, especially plutons, beneath the Paleozoic
- faults affecting Paleozoic may not continue into basement, and/or may not significantly offset Precambrian units (thus not visible)
- possible Mesozoic pluton beneath thin Paleozoic cover



For More

See Article 15 in
*Ontario Geological Survey
Summary of Field Work and Other Activities 2014*
released December 2014

All geophysical data shown in this presentation are from
Ontario Geological Survey Geophysical Data Set 1075,
released in June 2014



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