125 Years of Attempting to Understand the Origin and Tectonic Setting of Late Alkalic Suite intrusions present along the Laurentian Margin-Composite Arc Belt boundary zone, Grenville Orogen, Ontario: A Status Report

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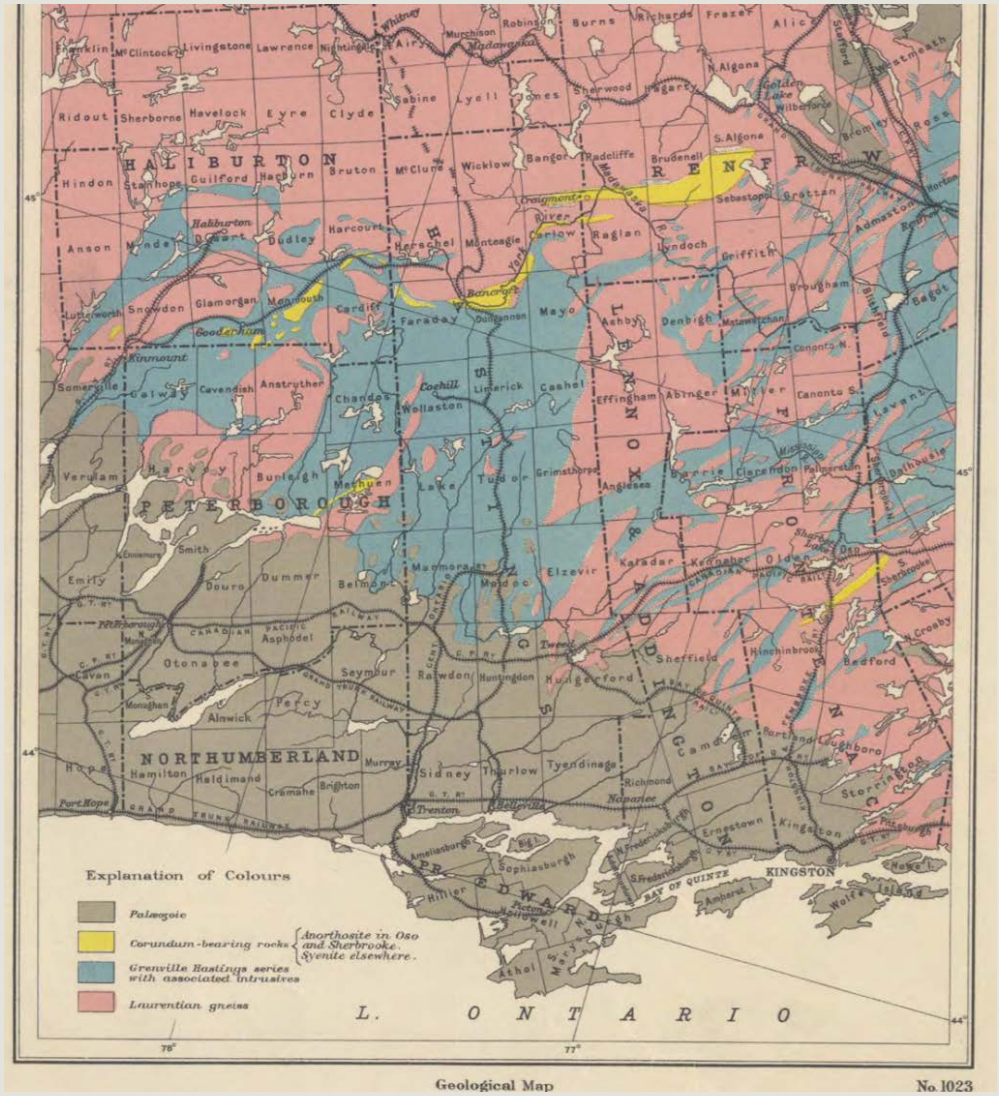
Grenville Late Alkalic Suite Intrusions

Left. Calcite veinlet in vari-textured and vari-grained pyroxene syenite. **Right.** Large calcite grains and veinlets in syenite



"Corundum-bearing rocks" - *in yellow*

Adams & Barlow 1908

Geological Survey of Canada Map 1023

Background - 1

- syenitic rocks along the CMBBTZ have been long-studied but are still not well-understood; for example
  1908 – Adams & Barlow;
  1940s – Gummer& Burr,
  1950s – Baragar, Carlson, Hewitt
  1960s & early **1970s** – Appleyard, Gittins
  1970s-1980s – Lumbers, Miller, Gittins)

Background - 2

- various origins suggested
  - magmatitic *or* metasomatic *or* metamorphosed evaporites *or* a combination of these
  - rift-environment (margin of Laurentia?)
- are carbonatites present with the syenites?
  - Yes? *or* No? *or* pseudo-carbonatites (Mitchell 2005)
- associated mineralization
  - Mo ± U ± Th - rare earth element (REE)
  - nepheline, corundum, gemstones, mineral collecting

Background - 3

- different lithostratigraphic assignments:
  - Kensington-Skootamatta suite
  - Nepheline syenite suite
  - Late alkalic and/or fenite-carbonatite suite
- emplacement ages not well constrained, with various ages assigned to these rocks ranging from circa 1290 to 1030 Ma
  - Nephton/Blue Mountain is only reliable older age, Rb-Sr 1258±41 Ma

This Talk - 1

- present new data from on ongoing 1:50 000 scale mapping by the OGS east of Bancroft (*NTS 31F/6 – Brudenell and 31F/10 - Coden)*
  - age relationships (relative and absolute [U-Pb])
  - geochemistry
  - mineralogy (SEM studies)
- discuss how they may have formed
- discuss briefly their mineral potential

This Talk - 2

- Location
- Regional geology
- Geology and types of syenite and related rocks
- New U-Pb geochronology results
- Tectonic Setting and Emplacement
- Summary and Conclusions

LOCATION and REGIONAL GEOLOGY

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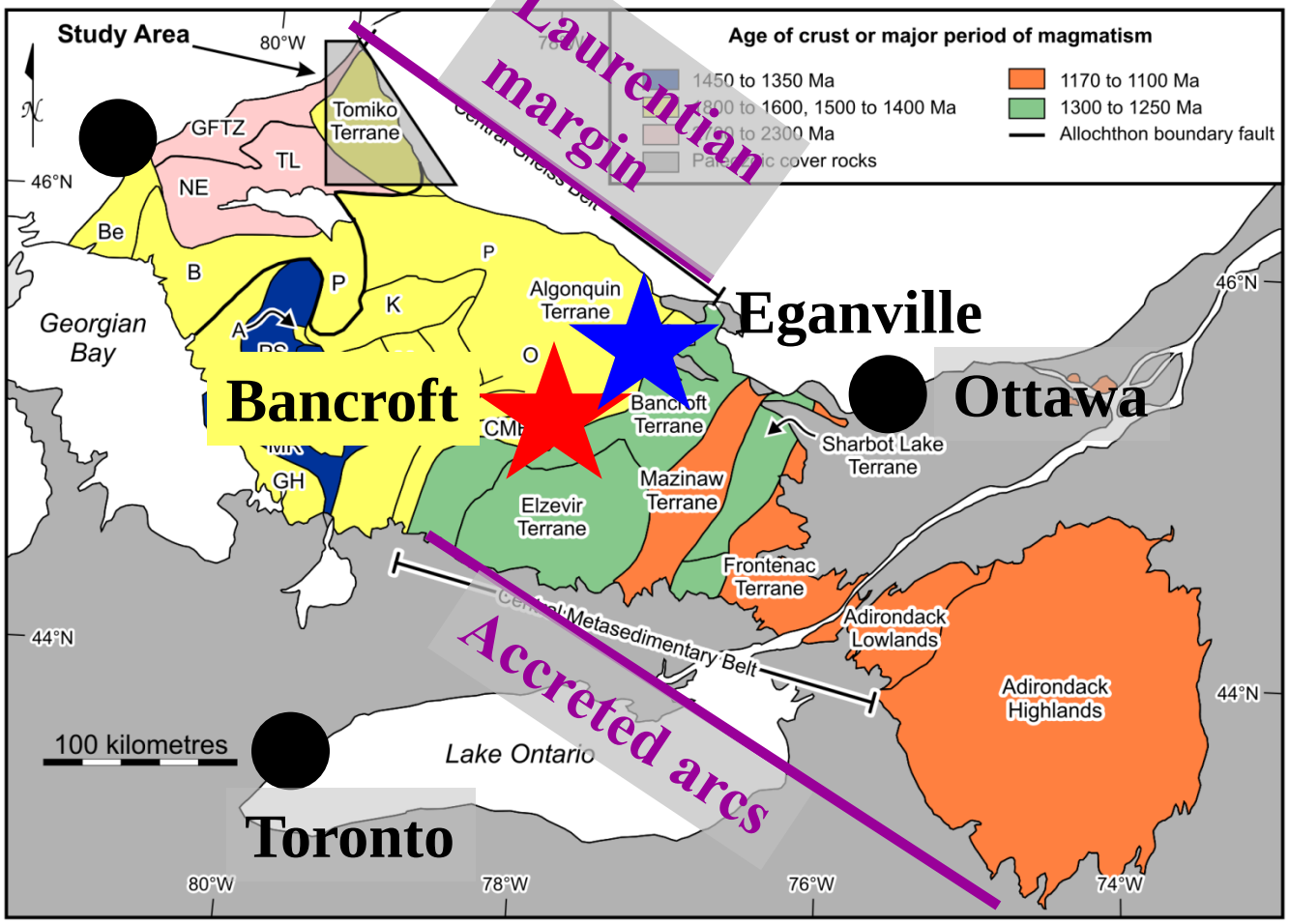
Where in North America

East-central Ontario

Where in Ontario



Abbreviations

A	Ahmic Domain	GH	Go Home Domain	NE	Nepewassi Domain
B	Britt Domain	H	Huntsville Domain	O	Openongo Domain
Be	Beaverstone Domain (part of Killarney magmatic belt)	K	Kiosk Domain	P	Powassan Domain
CMBbtz	Central Metasedimentary Belt boundary thrust zone	M	Muskoka	PS	Parry Sound Domain
GFTZ	Grenville Front Tectonic Zone	Mc	McCraney Domain	R	Rosseau Domain
		McL	McClintock Domain	S	Seguin Domain
		MR	Moon River Domain	SD	Shawanaga Domain
		N	Novar Domain	TL	Tilden Lake Domain

REGIONAL GEOLOGY

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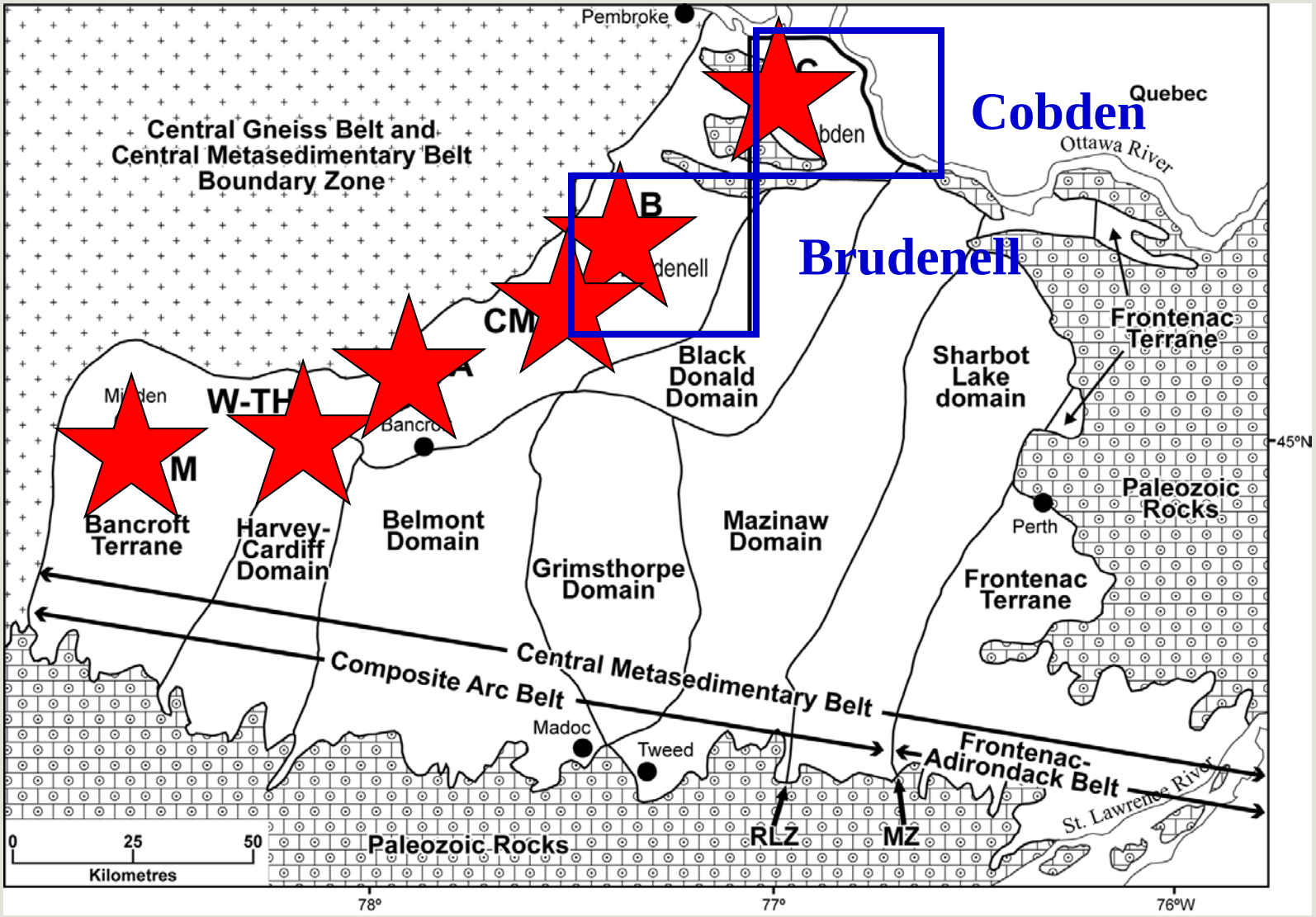
Regional Geological Setting

- near major tectonic boundary
  - **Central Gneiss Belt (CGB)** – Laurentian Margin
    - gneisses – high grade metamorphism (>1320 Ma)
  - **Central Metasedimentary Belt** (CMB) – Bancroft terrane - Composite Arc Belt (CAB)
    - ***mainly carbonate metasedimentary rocks*** *(typical host rocks)*
    - many types of intrusive rocks (1240-1030 Ma)
    - medium to high grade metamorphism (multiple?)
  - in boundary thrust zone between CGB and CMB

Geochemistry Summary

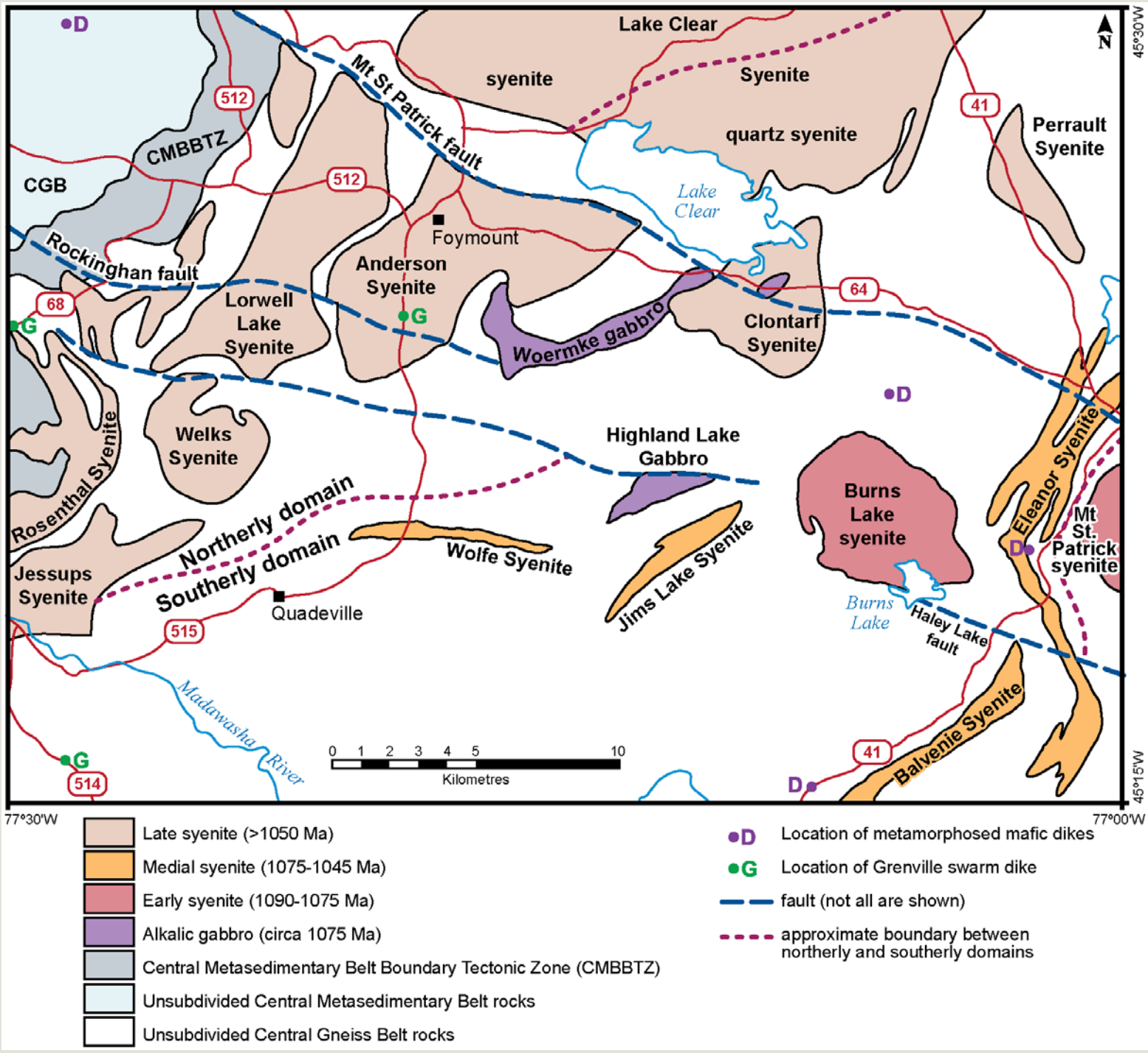
- trachyte to trachyandesite, minor phonolite, phonotephrite compositions
- miaskitic, pyroxene main mafic mineral
- mainly metaluminous (few peraluminous)
- mainly ferroan and alkalic on Frost et al. classifications, ultrapotassic
- volcanic-arc to within plate-granites
- REE and Zr contents vary based on mineralogy, up to 1300 ppm REE and 1300 ppm Zr

Geology


Pembroke
Central Gneiss Belt and
Central Metasedimentary Belt
Boundary Zone
Cobden
Quebec
Ottawa River
Brudenell
C
B
A
CM
W-TH
M
Black
Donald
Domain
Sharbot
Lake
domain
Frontenac
Terrane
Bancroft
Terrane
Harvey-
Cardiff
Domain
Belmont
Domain
Grimsthorpe
Domain
Mazinaw
Domain
Paleozoic
Rocks
Perth
Frontenac
Terrane
Central Metasedimentary Belt
Composite Arc Belt
Frontenac-
Adirondack Belt
Madoc
Tweed
St. Lawrence River
RLZ
MZ
Paleozoic Rocks
0
25
50
Kilometres
45°N
78°
77°
76°W

Three Syenite Types

- Older (1090 to 1070 Ma) [*Kensington-Skootamatta suite*]
  - roundish intrusions, potassium-rich, U and Th poor, associated alkalic mafic rocks
  - throughout CMB/CAB, not just in CMBBTZ
- Middle [*Late Alkalic, Fenite, Nepheline Syenite suites*]
  - linear, potassium-rich, some nepheline syenite
  - some Mo, locally some Th + U
- Late (1045 to 1030 Ma) [*Late Alkalic, Fenite suites*]
  - irregular REE, locally Th rich
  - extensive reaction with country rocks (metasomatism)

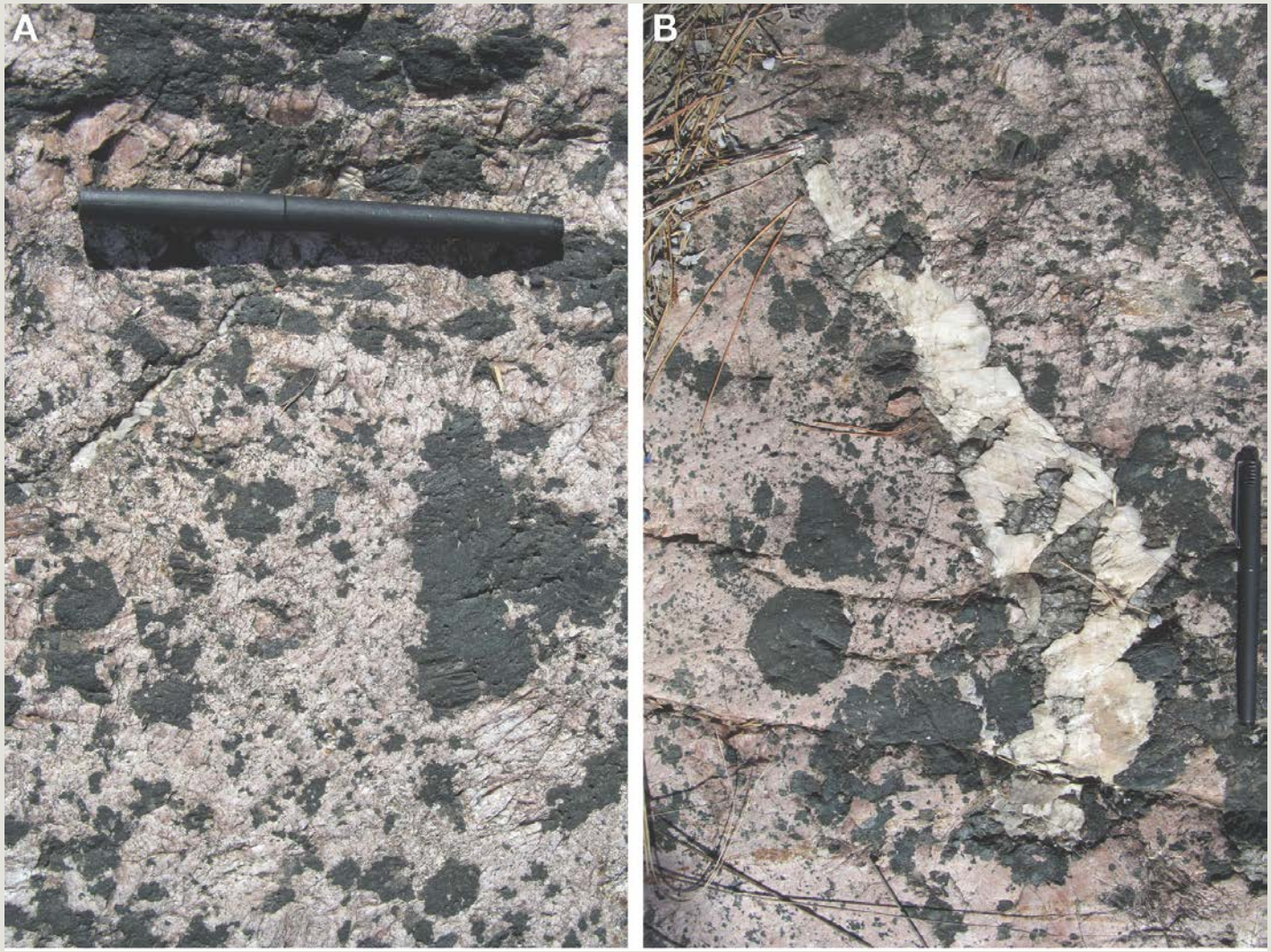

Lake Clear
syenite
Syenite
quartz syenite
Perrault Syenite
Mt St Patrick fault
512
CMBBTZ
CGB
Lake Clear
Foymount
Rockinghan fault
Anderson Syenite
Lorwell Lake Syenite
68
64
Woermke gabbro
Clontarf Syenite
Welks Syenite
Highland Lake Gabbro
Rosenthal Syenite
Northerly domain
Southerly domain
Jessups Syenite
Wolfe Syenite
Jims Lake Syenite
Burns Lake syenite
Eleanor Syenite
Mt St. Patrick syenite
Quadeville
515
Burns Lake
Haley Lake fault
Madawasha River
514
41
Balvenie Syenite
0 1 2 3 4 5 10
Kilometres
N
45°30'W
45°15'W
77°30'W
77°00'W
Late syenite (>1050 Ma)
Medial syenite (1075-1045 Ma)
Early syenite (1090-1075 Ma)
Alkalic gabbro (circa 1075 Ma)
Central Metasedimentary Belt Boundary Tectonic Zone (CMBBTZ)
Unsubdivided Central Metasedimentary Belt rocks
Unsubdivided Central Gneiss Belt rocks
Location of metamorphosed mafic dikes
Location of Grenville swarm dike
fault (not all are shown)
approximate boundary between northerly and southerly domains

Middle Syenites

Nepheline syenite

Syenite vein in melanocratic syenite

Late syenite – typical texture (diopside-K-feldspar-albite ± calcite)



Late syenite – typical texture (diopside-K-feldspar-albite)

Late syenite effects on host rocks

Typical Carbonate Rocks - Marbles

Typical Carbonates - Marble Breccia

Carbonate Rocks associated with Late Syenite – 1

Metasomatized Marble Breccias

Carbonate rocks associated with Late syenite - 2

Calcite + fluorite + apatite veins

Carbonate rocks associated with Late syenite - 3

Orange-pink calcite veins

Carbonate rocks associated with Late syenite - 4

Orange-pink calcite veins fragmenting host rock

U-Pb GEOCHRONOLOGY

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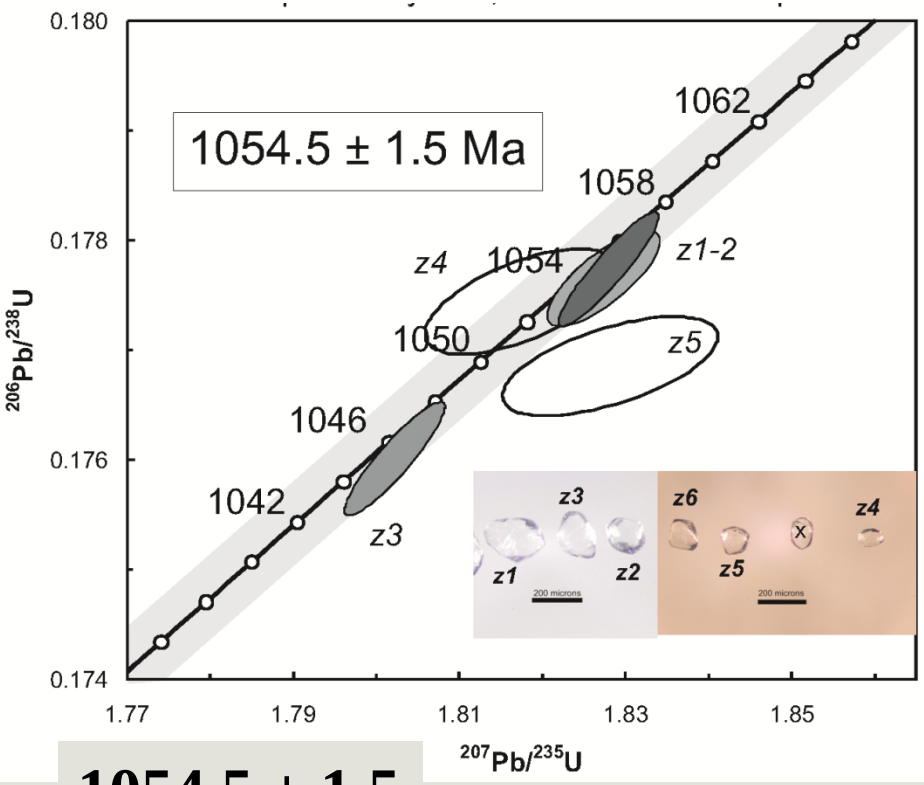
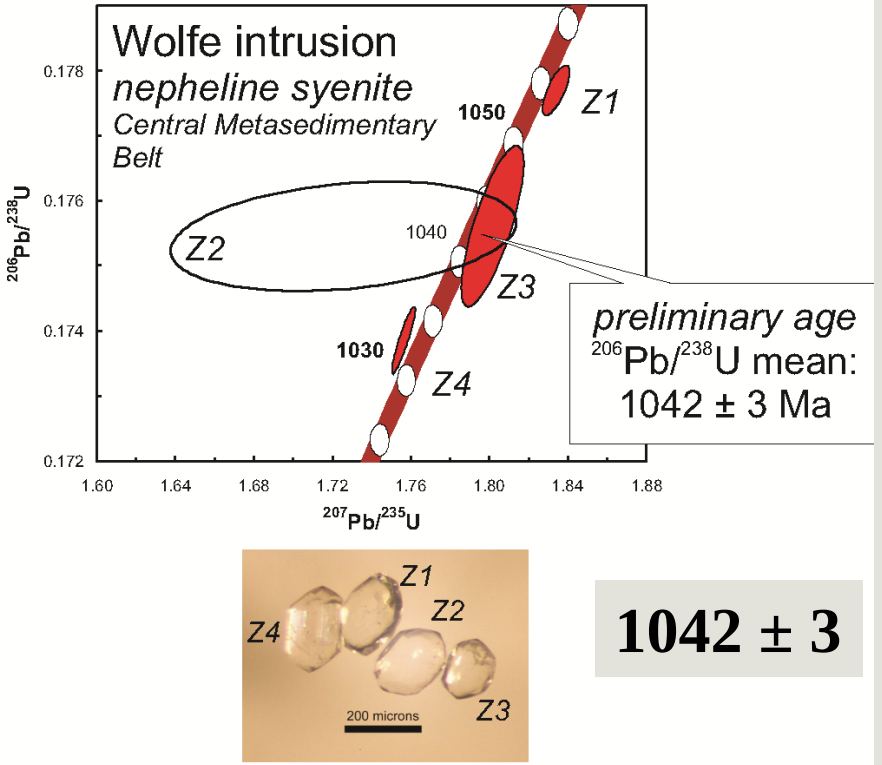
Medial syenites
Igneous-textured nepheline syenites

Tory Hill nepheline syenite



1054.5 ± 1.5

Wolfe nepheline syenite

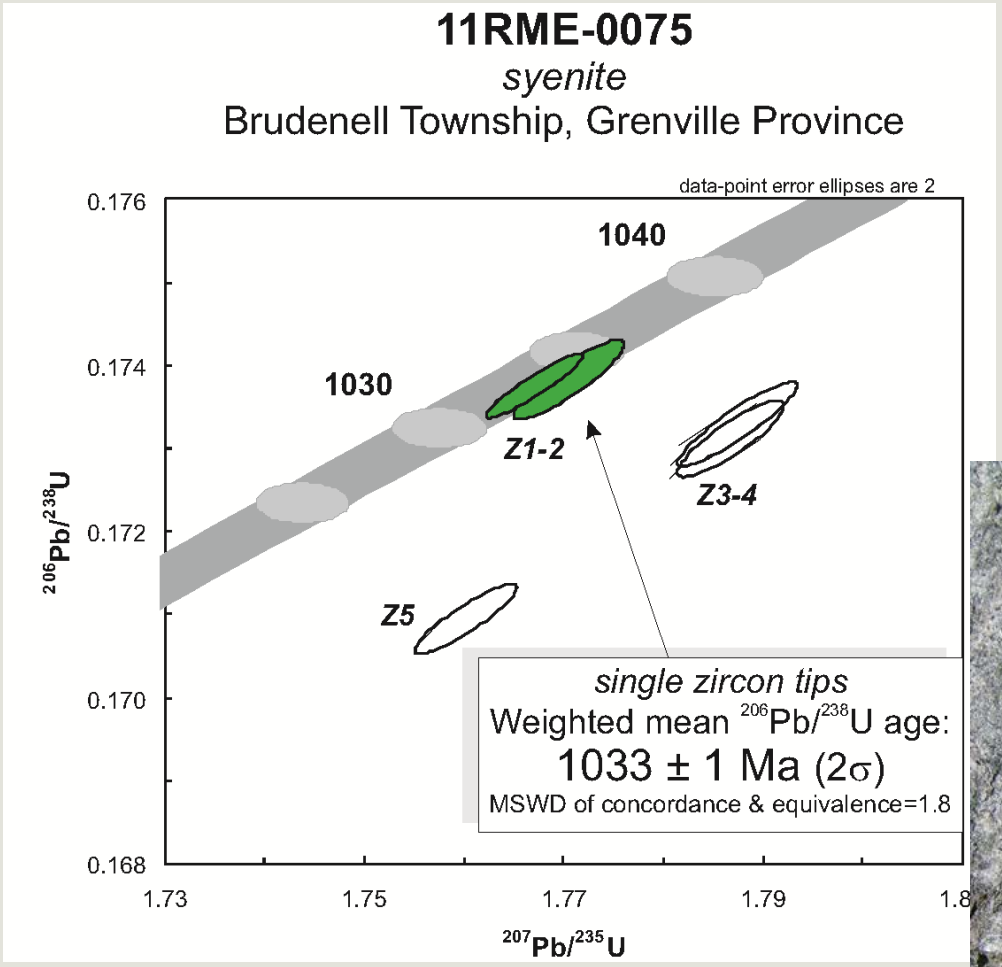


1042 ± 3

data from S.L. Kamo, Jack Satterly Laboratory, U Toronto

Late syenite, buff

- 1033 ± 1 Ma
- 1060 to 1064 inheritance
- Childe et al (2000)
  7 single grain ages, 1062 to 1033, the older ages likely reflect inheritance



data from S.L. Kamo, Jack Satterly Laboratory, U Toronto

Geochronology Summary

- Older (1090 to 1070 Ma) [*Kensington-Skootamatta*]
  - previous Ontario ages on syenites of 1089 ± 4, 1088 ± 2; ~1088, ~1088, 1083 ± 2, 1077 ± 4
  - associated mafic rocks 1073 ± 3 (this study)
- Middle (1055 to 1040)

  [*Late Alkalic, Fenite, Nepheline Syenite suites*]
  - 1054.5 ± 1.5 (this study) and 1042 ± 3 (this study)
  - not circa 1290 Ma as previously suggested by some workers
- Late (1040 to 1033) [*Late Alkalic, Fenite suites*]
  - 1033 ± 1 (this study) but with circa 1060 inheritance
  - 1033, 1036, 1044, 1049, 1056, 1056, 1062 (Childe et al 2000 GAC-MAC meeting) – likely varied degrees of inheritance

Geochronology

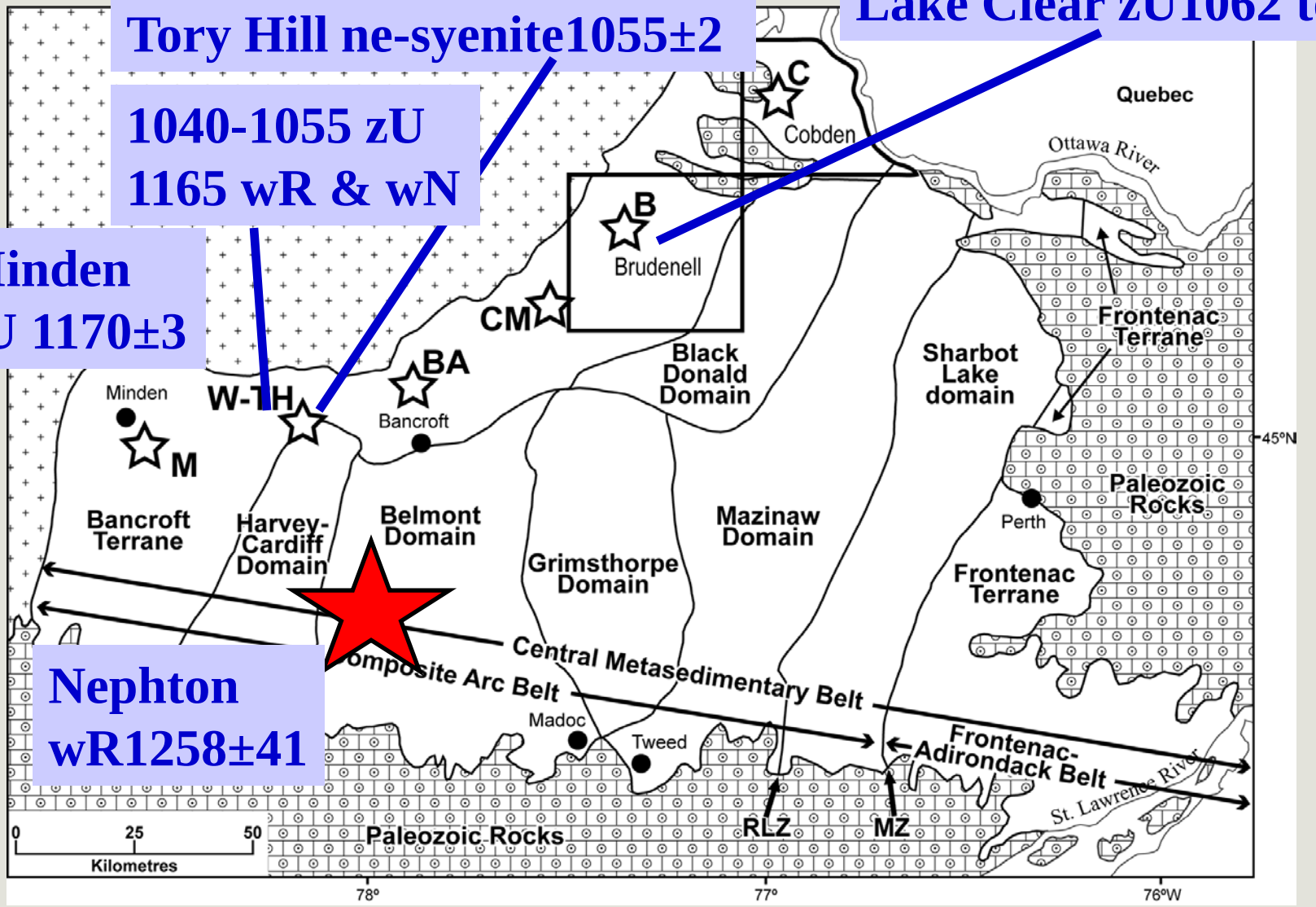
Wolfe ne-syenite zU1042±3
Lorwell syenite zU1033±3
Lake Clear zU1062 to 1033

Tory Hill ne-syenite1055±2

1040-1055 zU
1165 wR & wN

Minden
zU 1170±3

Nephton
wR1258±41



TECTONIC SETTING, ALONG STRIKE VARIATIONS and EMPLACEMENT

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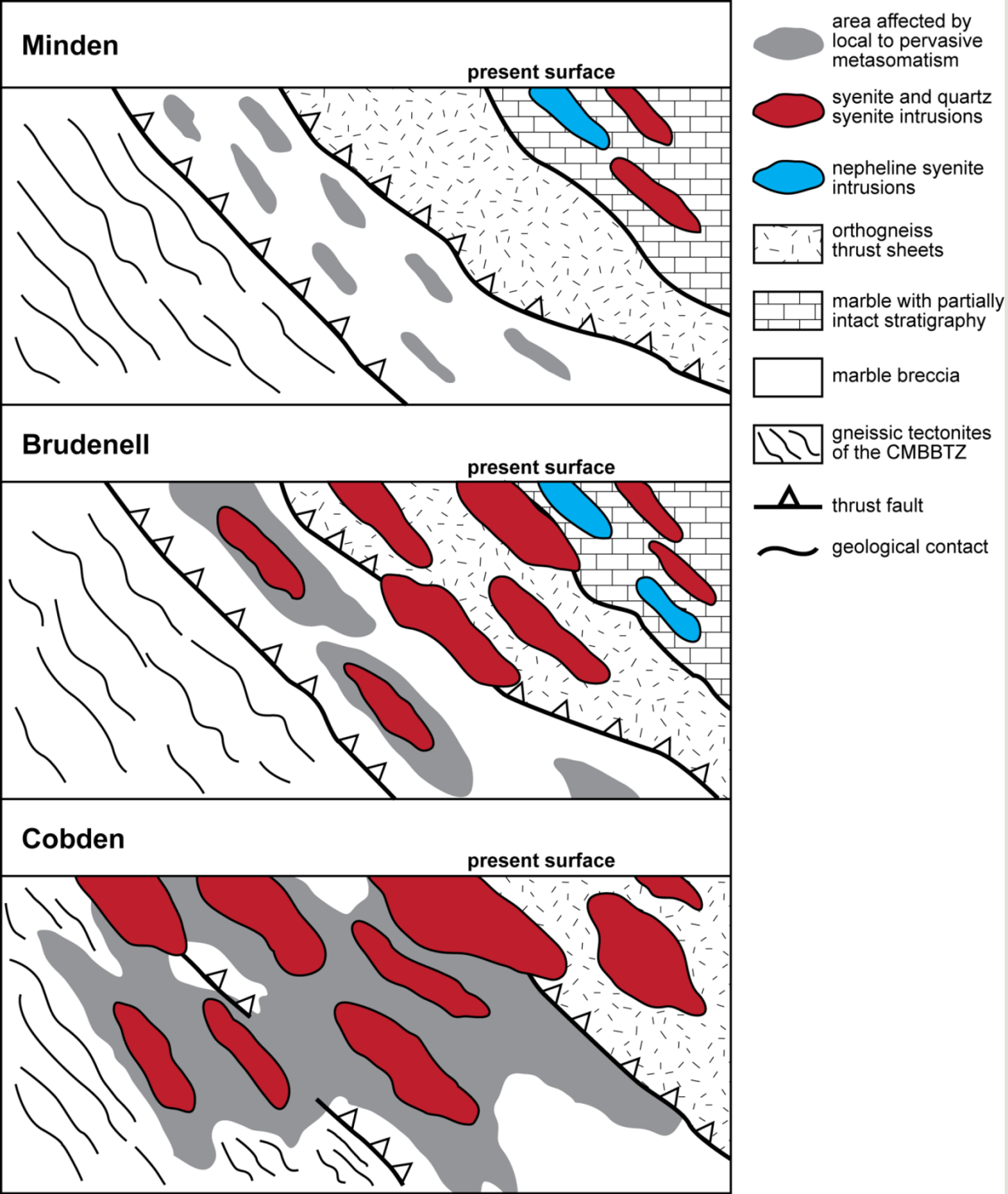
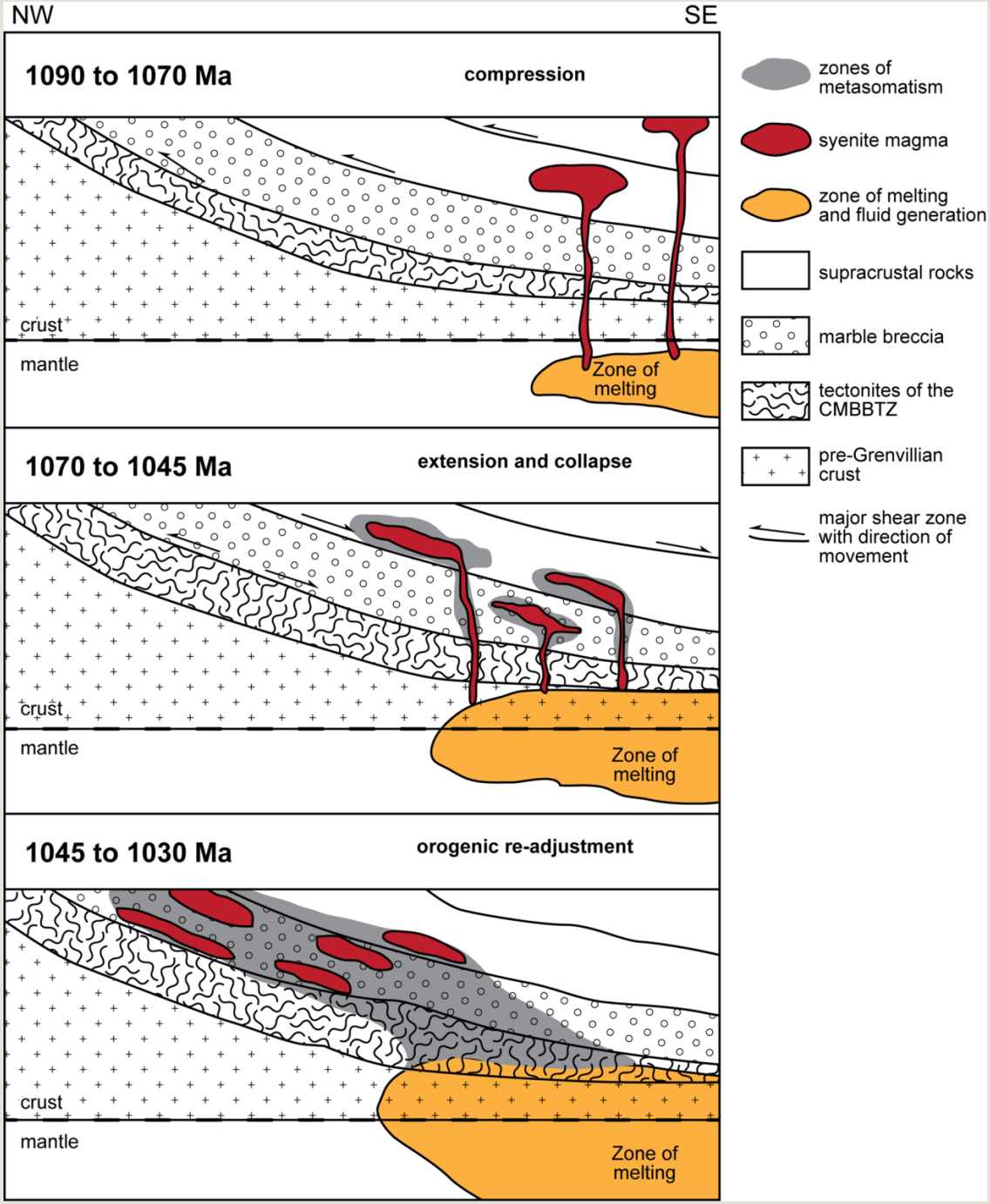


Along Strike Variations

- *for example:*
- different degrees of metasomatism of host rocks
- emplacement at different structural levels
- differences n mineralogy – e.g. red versus green apatite, presence of corundum, fluorite, etc.



Syenite Magmatic Evolution

1090-1070 – discrete, mantle-sourced plutons

1070-1045 – discrete mixed-source plutons (crust + mantle, minor metasomatism)

1045-1030 – irregular mixed-source plutons and reactive fluids

SUMMARY and CONCLUSIONS

Summary and Conclusions - 1

- current suite classification of syenite needs adjustment, especially ne- and late- syenite
  - 3 groups – early, middle, late
  - each has distinct form, lithology, chemistry, age
  - 1090 to 1070, 1055 to 1040, 1040 to 1033 Ma
- early syenite grouping has associated alkalic mafic magmatism
  - plutons and dikes

Summary and Conclusions - 2

- REE mineralization in metasomatised marbles adjacent to Late syenites
- REE minerals found along grain boundaries
  - likely emplaced by metasomatic fluids
  - allanite, parasite, hellandite main phases found
  - REE may be missed or underestimated during routine chemical analysis
- not likely any true carbonatites, but the metasomatized marbles may have flowed

Stay Tuned

for more information see
Ontario Geological Survey,
Summary of Field Work 2013
Open File Report 6290

Article 12

http://www.mndm.gov.on.ca/mines/geologyontario/default_e.asp