

Hands across the border: a preliminary tectonostratigraphic framework for the Western Churchill Province in Saskatchewan, Nunavut and Northwest Territories

Sally Pehrsson, Ken Ashton, Colin Card, Charlie Harper
Janet Campbell and the Western Churchill Metallogeny
Project team



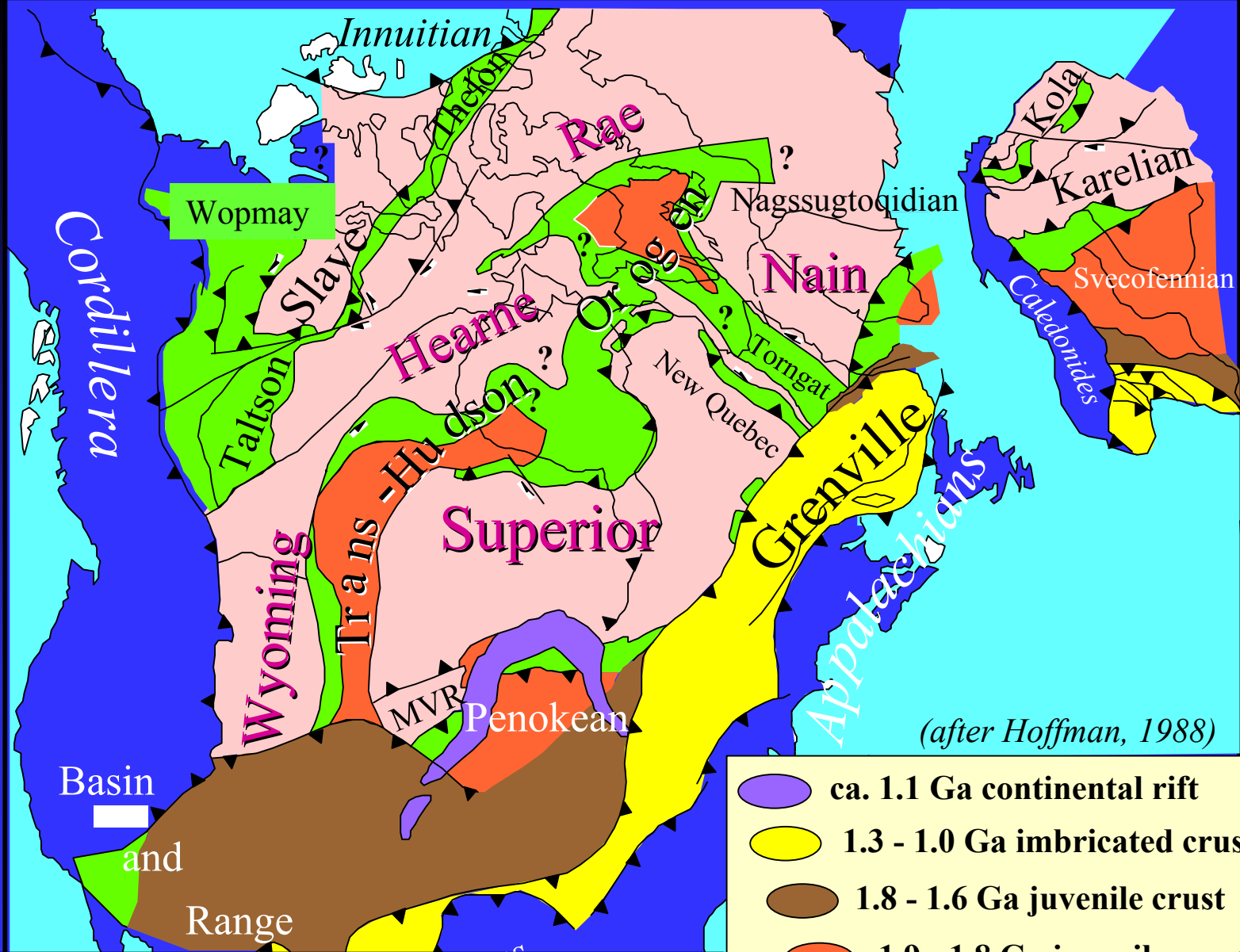
Natural Resources
Canada

Ressources naturelles
Canada



Saskatchewan
Industry and
Resources





(after Hoffman, 1988)

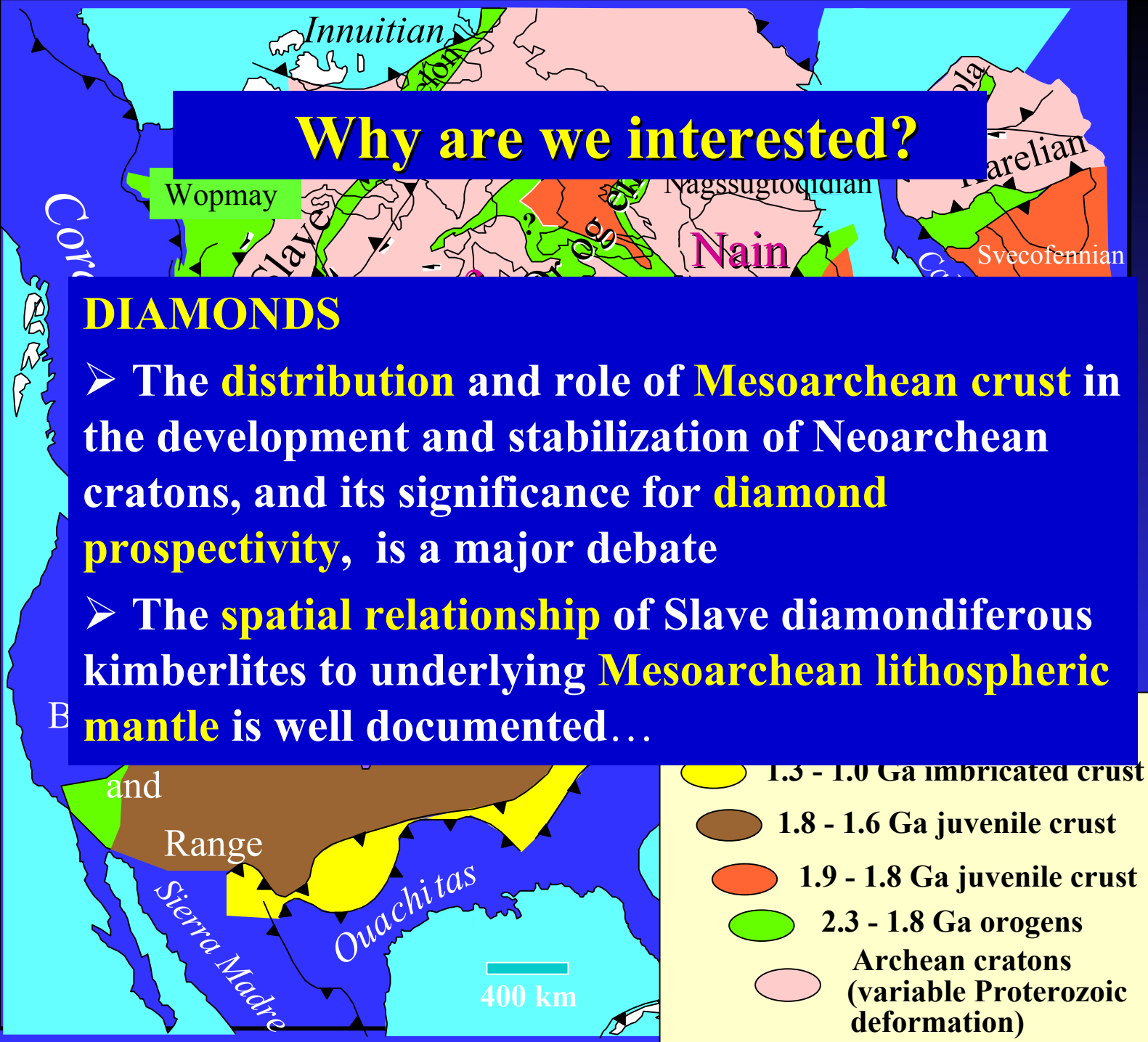
- ca. 1.1 Ga continental rift
- 1.3 - 1.0 Ga imbricated crust
- 1.8 - 1.6 Ga juvenile crust
- 1.9 - 1.8 Ga juvenile crust
- 2.3 - 1.8 Ga orogens
- Archean cratons (variable Proterozoic deformation)

Western Churchill; one of the largest Provinces Canadian Precambrian Shield; also the most poorly known. Made up of Meso-NeoArchean cratons substantially reworked during Paleoproterozoic 2.5-1.8 Ga. We are focused on understanding the regional tectonostratigraphic subdivisions as these have a fundamental impact on how exploration is geared towards different commodities.

Why are we interested?

DIAMONDS

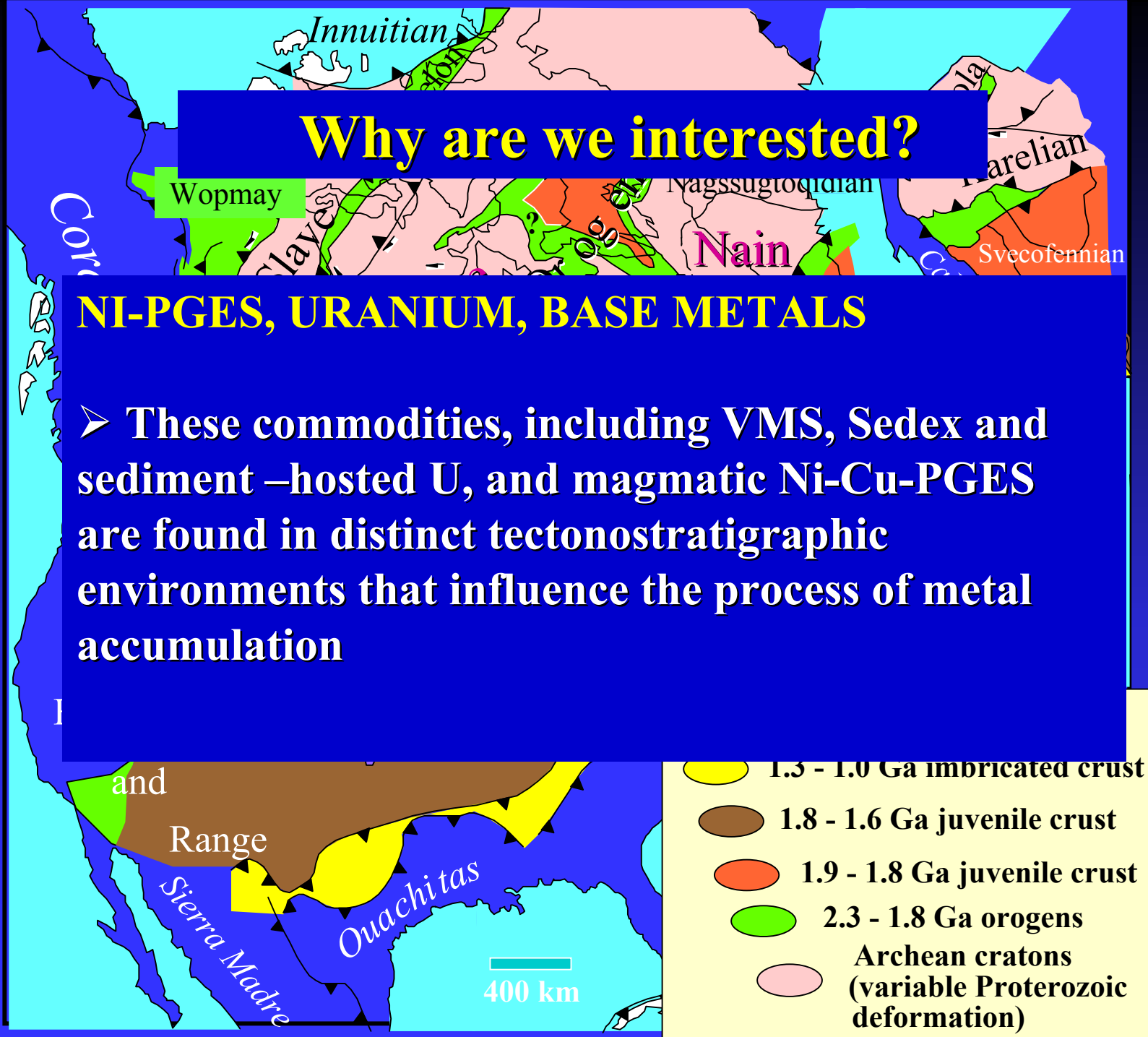
- The **distribution** and role of **Mesoarchean crust** in the development and stabilization of Neoproterozoic cratons, and its significance for **diamond prospectivity**, is a major debate
- The **spatial relationship** of Slave diamondiferous kimberlites to underlying **Mesoarchean lithospheric mantle** is well documented...



Why are we interested?

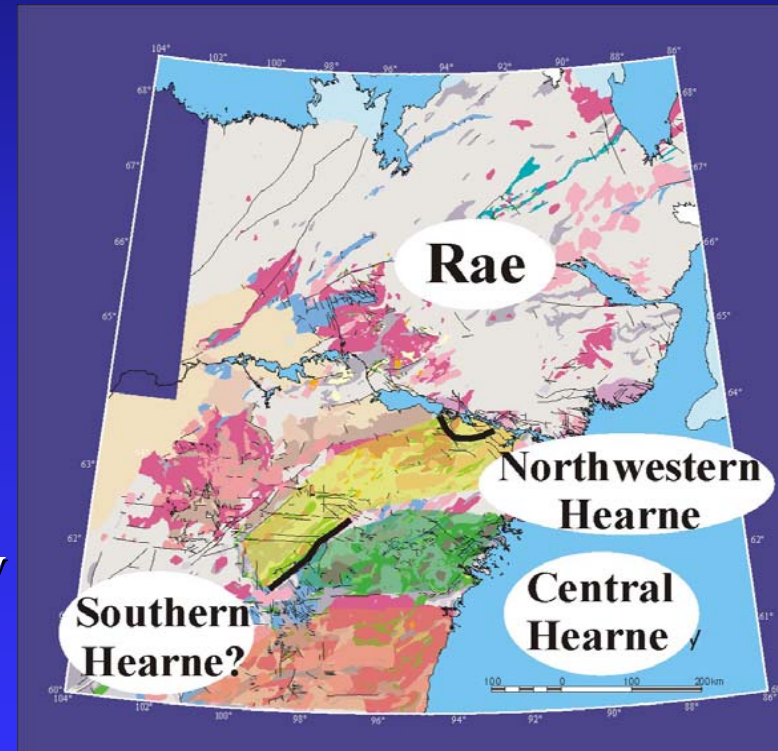
NI-PGES, URANIUM, BASE METALS

➤ These commodities, including VMS, Sedex and sediment –hosted U, and magmatic Ni-Cu-PGES are found in distinct tectonostratigraphic environments that influence the process of metal accumulation



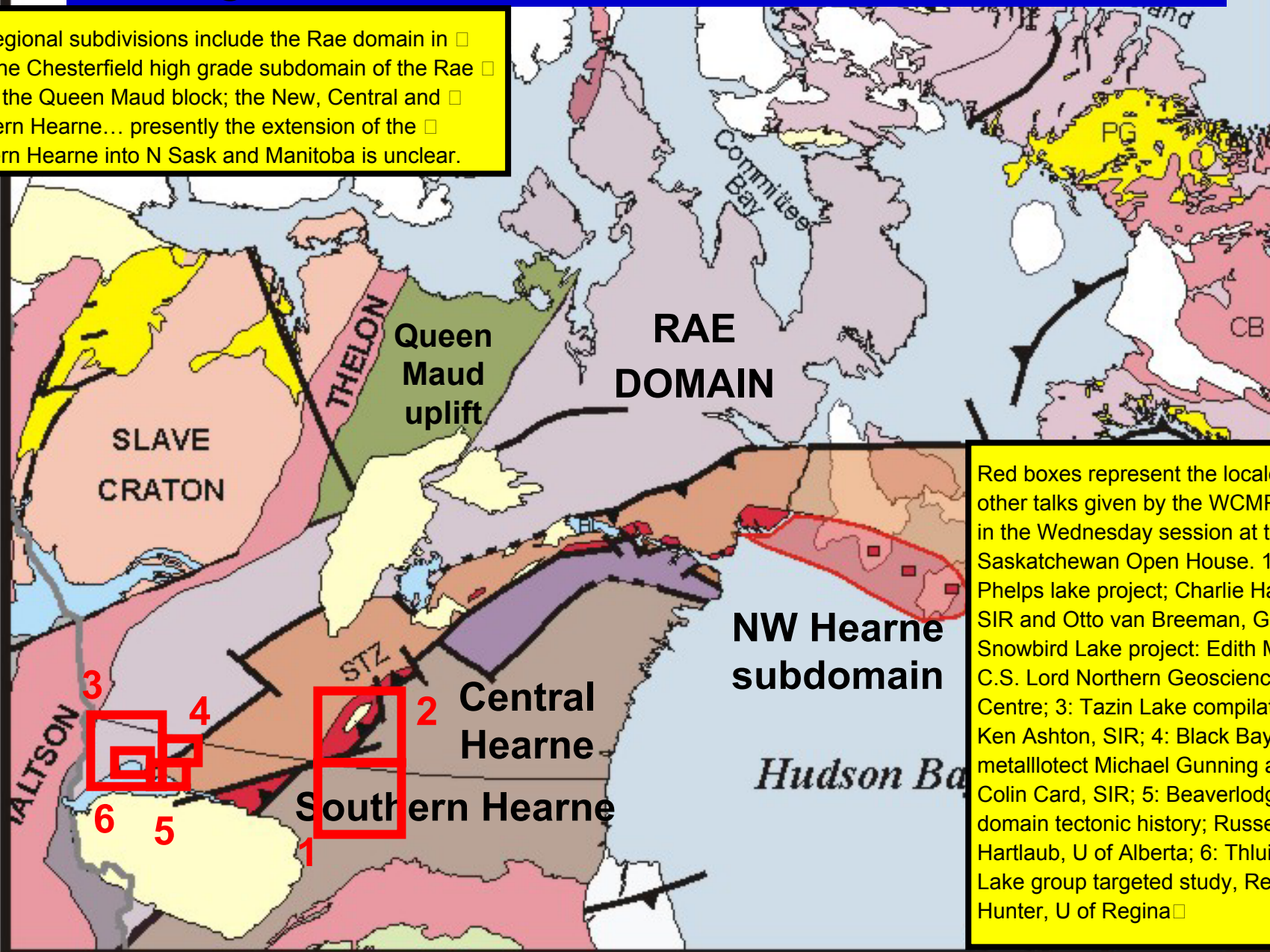
Overview

- Discuss proposed new Archean tectonostratigraphic subdivisions of the Western Churchill Province
- Review the regional metallogeny of the Archean domains and implications for cross border correlations
- Summarize the revised Proterozoic sequence stratigraphy, its distribution and implications for metallogeny



Regional subdivisions of the Western Churchill

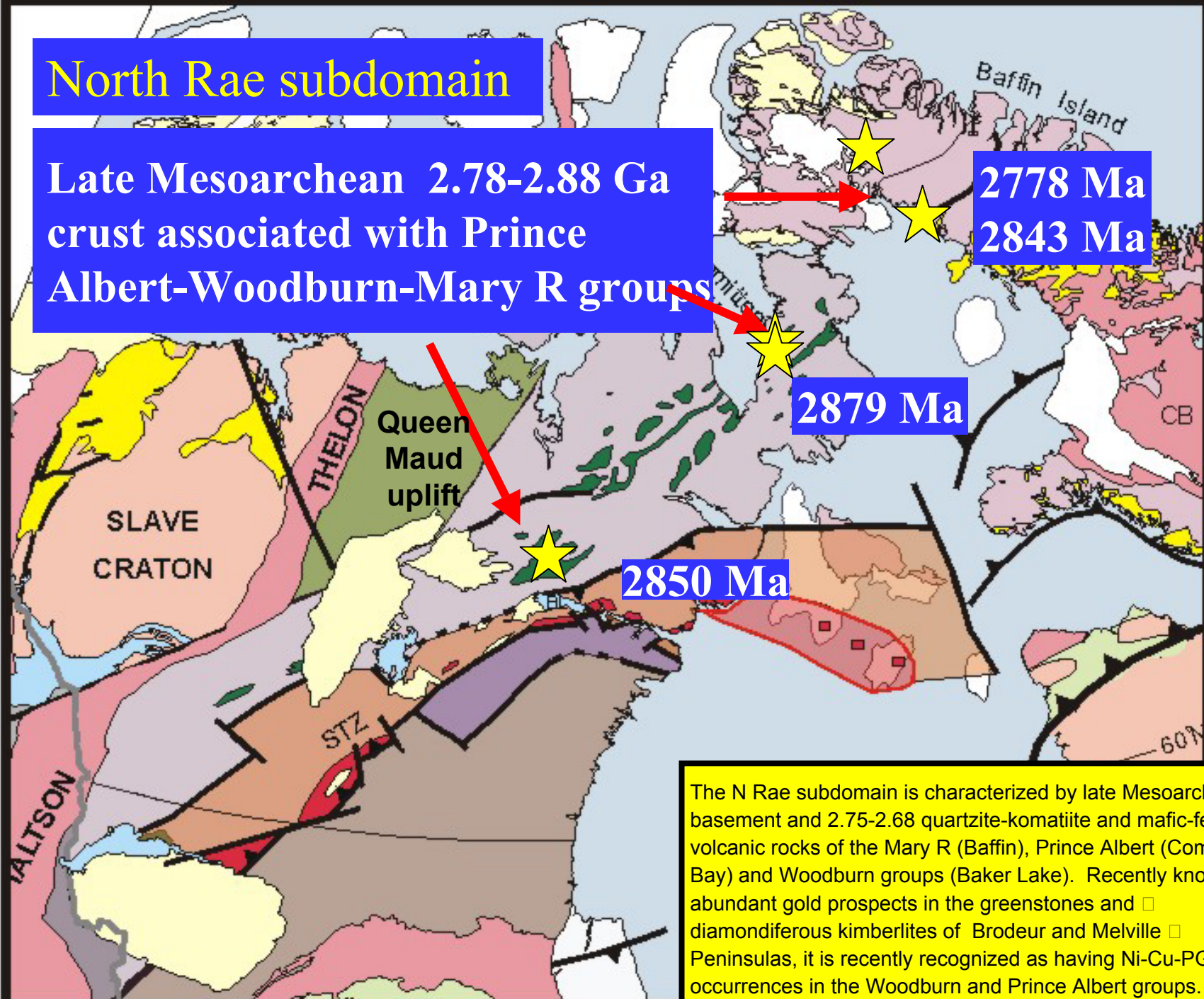
New regional subdivisions include the Rae domain in grey, the Chesterfield high grade subdomain of the Rae in red; the Queen Maud block; the New, Central and Southern Hearne... presently the extension of the southern Hearne into N Sask and Manitoba is unclear.



Red boxes represent the locales of other talks given by the WCMP team in the Wednesday session at the Saskatchewan Open House. 1: Phelps lake project; Charlie Harper, SIR and Otto van Breeman, GSC; 2: Snowbird Lake project. Edith Martel: C.S. Lord Northern Geoscience Centre; 3: Tazin Lake compilation; Ken Ashton, SIR; 4: Black Bay fault metallotect Michael Gunning and Colin Card, SIR; 5: Beaverlodge domain tectonic history; Russell Hartlaub, U of Alberta; 6: Thluicho Lake group targeted study, Rebecca Hunter, U of Regina

North Rae subdomain

Late Mesoarchean 2.78-2.88 Ga
crust associated with Prince
Albert-Woodburn-Mary R groups



The N Rae subdomain is characterized by late Mesoarchean □ basement and 2.75-2.68 quartzite-komatiite and mafic-felsic □ volcanic rocks of the Mary R (Baffin), Prince Albert (Committee □ Bay) and Woodburn groups (Baker Lake). Recently known for □ abundant gold prospects in the greenstones and □ diamondiferous kimberlites of Brodeur and Melville □ Peninsulas, it is recently recognized as having Ni-Cu-PGE □ occurrences in the Woodburn and Prince Albert groups. □

North Rae subdomain

Late Mesoarchean 2.78-2.88 Ga
crust associated with Prince
Albert-Woodburn-Mary R groups

2778 Ma
2843 Ma

2879 Ma

2850 Ma

Queen
Maud
uplift

SLAVE
CRATON

THELON




Baffin Island

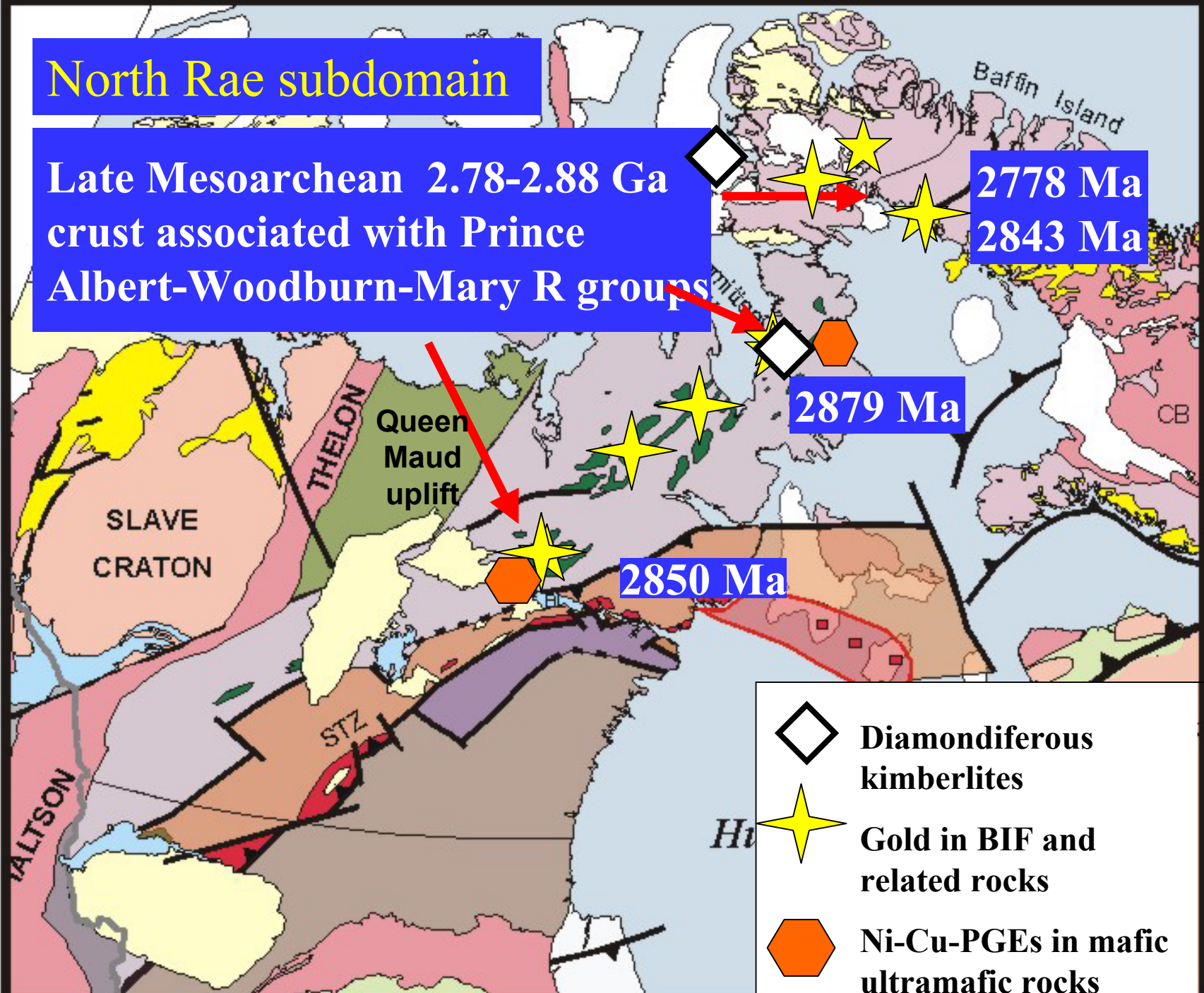
CB

STZ

WALTSON

Ht

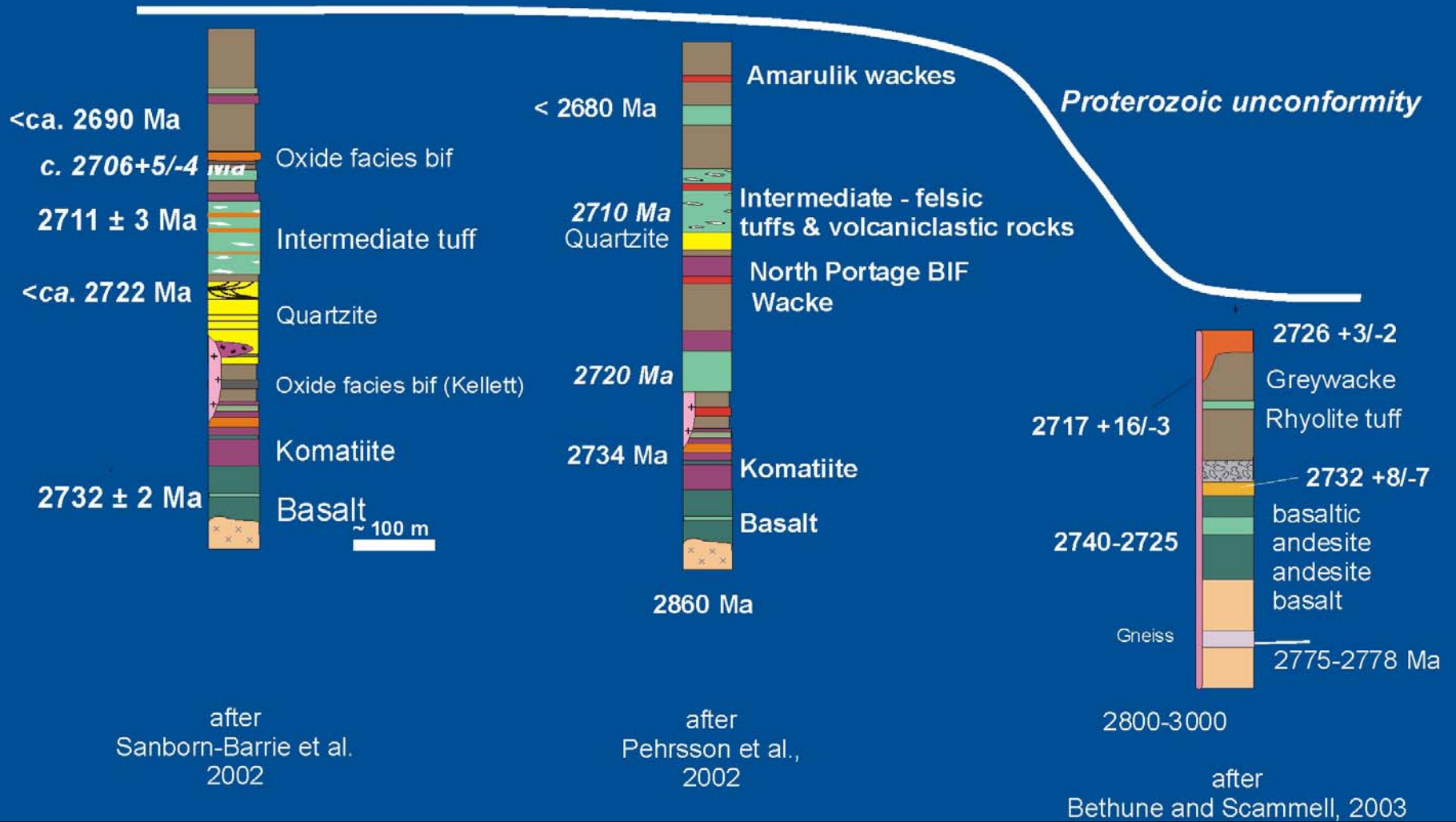
-  Diamondiferous kimberlites
-  Gold in BIF and related rocks
-  Ni-Cu-PGEs in mafic ultramafic rocks



Prince Albert group

Lower Woodburn group

Mary River group

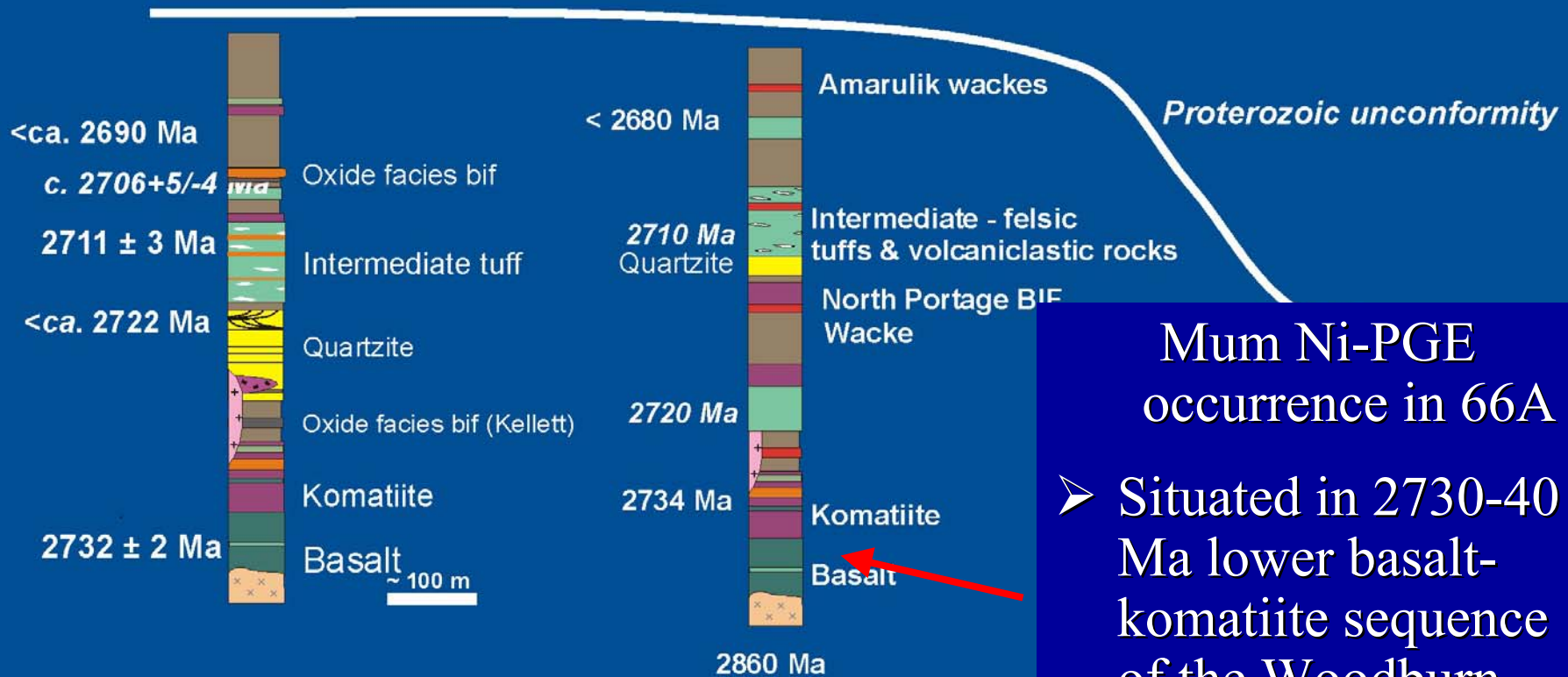


Characteristic of Rae is the classical Prince Albert group greenstone belt association...well established with lower Woodburn group and temporal correlation Mary River group. The Mum Ni prospect is situated in the Judge Sissons belt, the interpreted SW extension of the lower basalt komatiite 2735 Ma sequence of the Whitehills belt. In this region the basalt komatiite sequence was eroded through 2860 Ma basement.

Prince Albert group

Lower Woodburn group

Mary River group

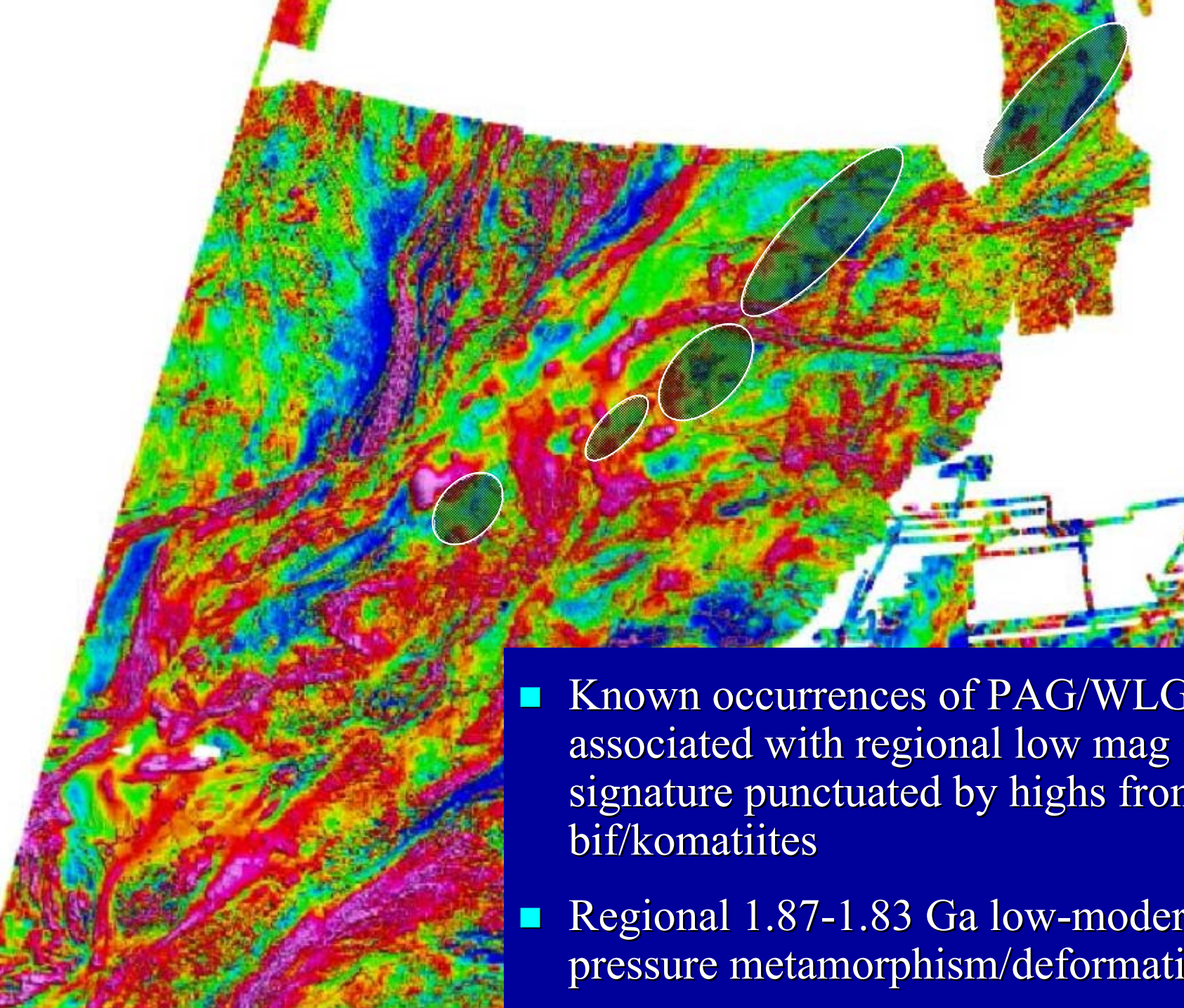


after Sanborn-Barrie et al. 2002

after Pehrsson et al., 2002

Mum Ni-PGE occurrence in 66A

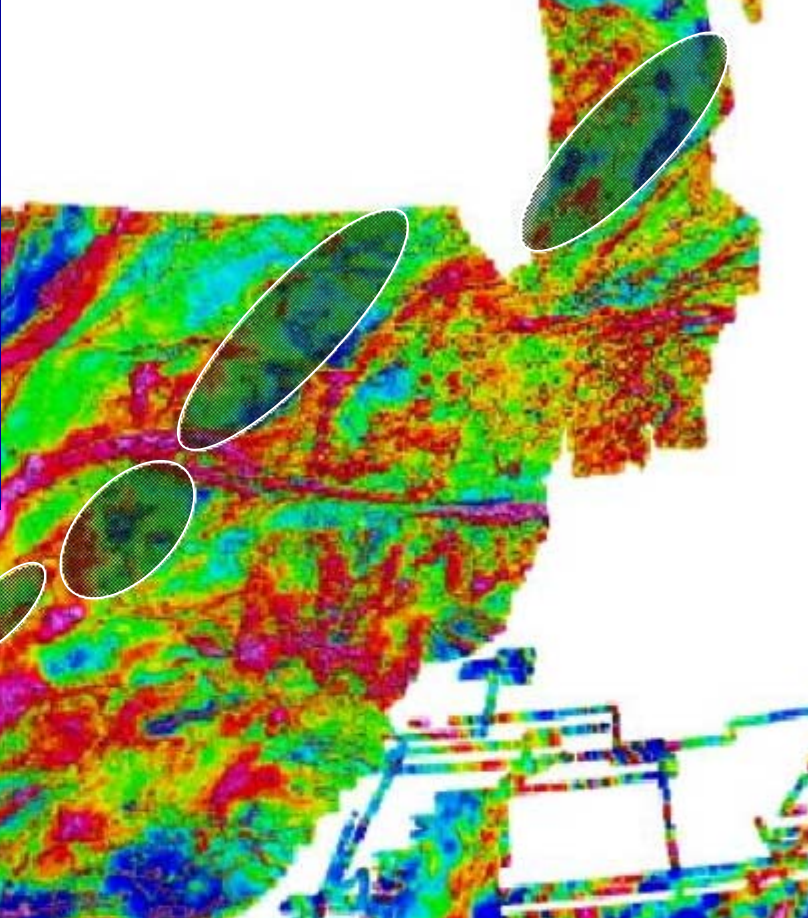
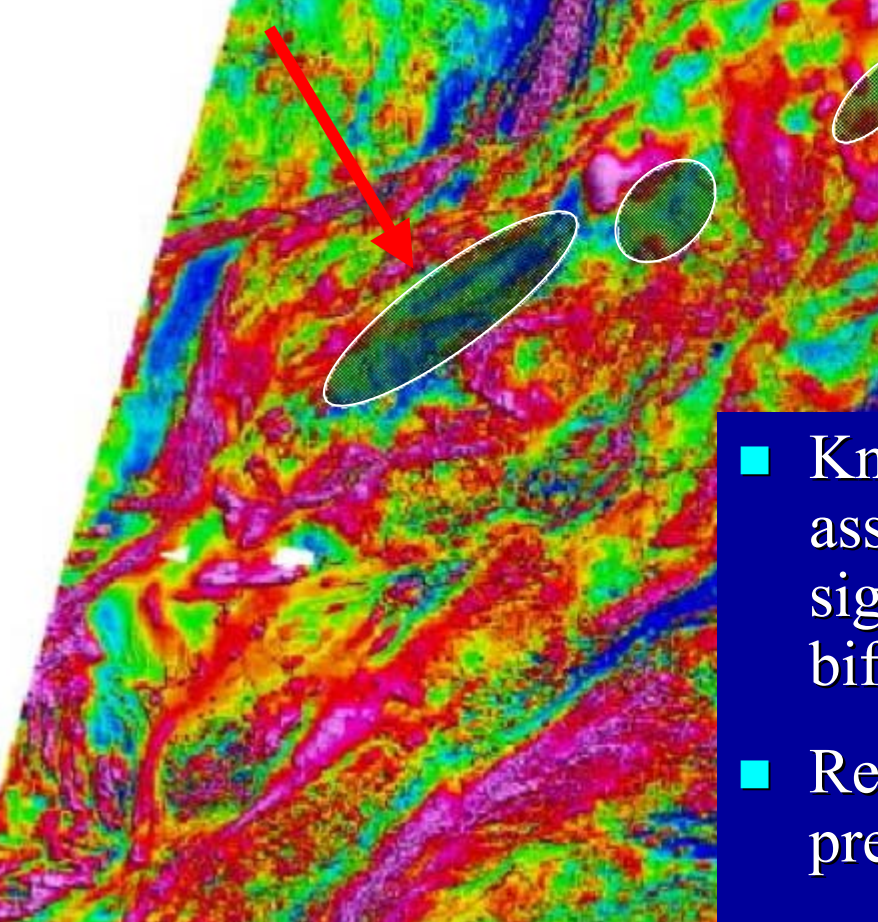
- Situated in 2730-40 Ma lower basalt-komatiite sequence of the Woodburn group
- Tectonostratigraphic control?



The regional age signature coincides with the known Woodbury-Albert groups (L... with short wave... extends to the s... the Penylan Lak... lake area last m... Taylor in the 19... question is whe... amphibolite to g... sequence is con... sequence of this... paragneisses an... metamorphosed... rocks with know... formation.... The... group of southe... thought to be co... Prince Albert, is... Paleoproterozoic... proposed by O'... and recently co... Hartlaub et al (S... OH talk, 2004) □

- Known occurrences of PAG/WLG associated with regional low mag signature punctuated by highs from bif/komatiites
- Regional 1.87-1.83 Ga low-moderate pressure metamorphism/deformation

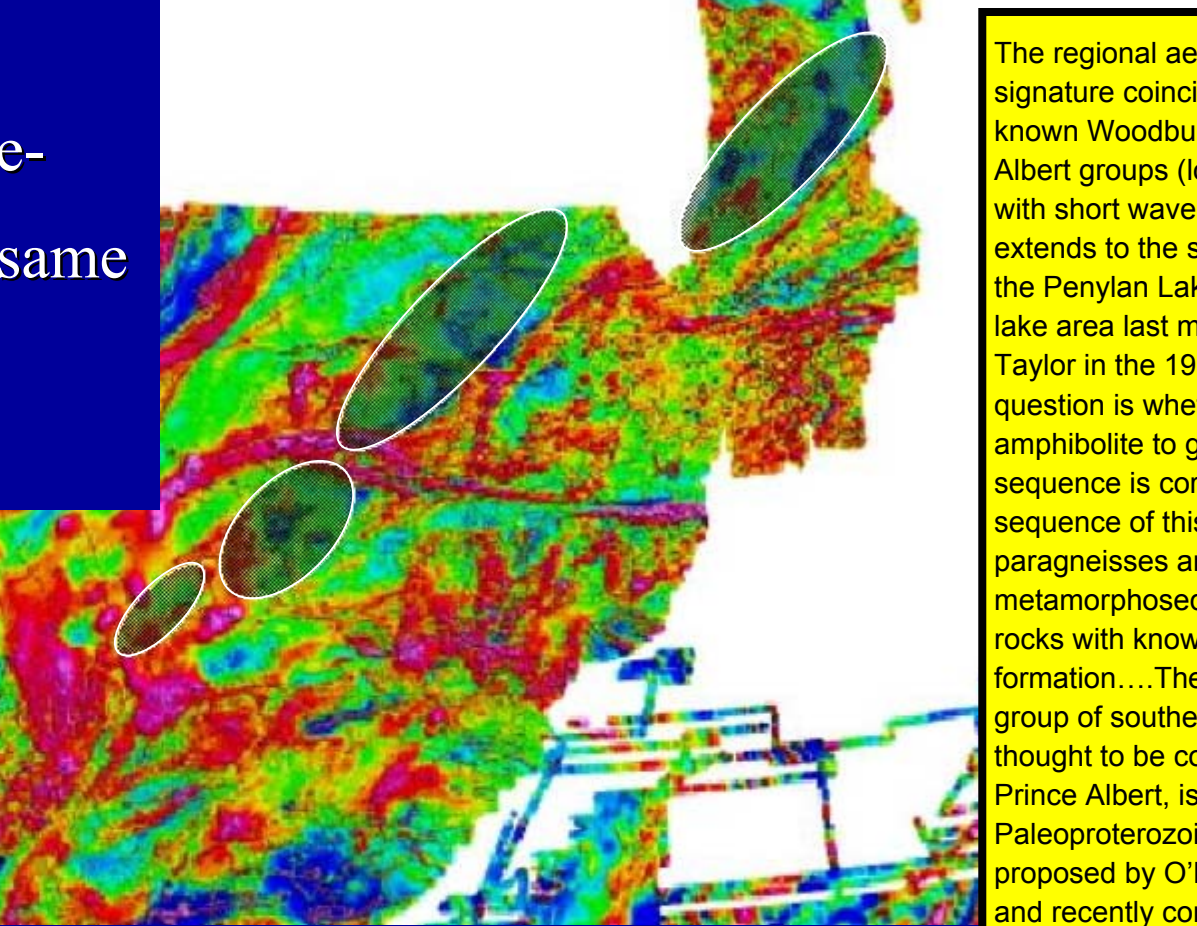
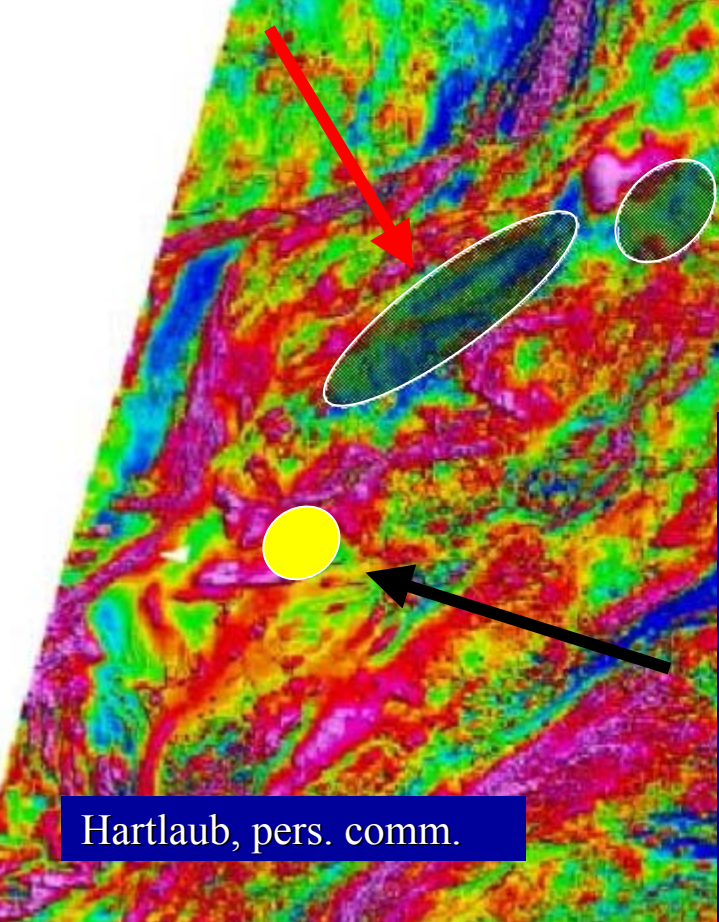
■ Penylan Lake area:
known bifs in greywacke-
volcaniclastic sequence, same
aeromag signature
?? correlative



The regional aeromagnetic signature coincides with the known Woodbury Group and other Prince Albert groups (Lamb, 1964) with short wavelength anomalies that extends to the south of the Penylan Lake area last mapped by Taylor in the 1950s. The question is whether the amphibolite to gneiss sequence is correlative with the sequence of this area. The paragneisses are metamorphosed rocks with known formation.... The group of southern Prince Albert, is thought to be correlative with the Paleoproterozoic group proposed by O'Neil and recently confirmed by Hartlaub et al (Society of Economic Geologists OH talk, 2004) □

- Known occurrences of PAG/WLG associated with regional low mag signature punctuated by highs from bif/komatiites
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■ Penylan Lake area:
known bifs in greywacke-
volcaniclastic sequence, same
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?? correlative



The regional aeromagnetic signature coincides with the known Woodburn Lake and Prince Albert groups (likely related to the Penylan Lake area last mentioned by Taylor in the 1960s). The question is whether the amphibolite to gneiss sequence is correlative with the sequence of this area. The paragneisses are metamorphosed rocks with known formation... The group of southern Prince Albert, is thought to be correlative with the Paleoproterozoic sequence proposed by O'Hanley and recently confirmed by Hartlaub et al (see O'Hanley talk, 2004) □

■ Murmac Bay group is not equivalent to Woodburn Lake and Prince Albert groups

■ Est. to be ca. 2.3 Ga sequence as first proposed by O'Hanley et al.

Hartlaub, pers. comm.

South Rae subdomain

➤ No known Prince Albert-like Archean greenstones

➤ Greater abundance of old crust

➤ Separate block or transitional?

SLAVE
3129 Ma

Older 3.0-3.3 Ga crust
in SW Rae

3186 Ma

3126 Ma

3300 Ma

3019 Ma

The S Rae subdomain is dominated by para and orthogneisses and granitoid rocks including abundant ca. 3.0-3.3 Ga basement. If the N and S. Rae blocks represent distinct sequences subsequently amalgamated or accreted (as opposed to transitions within a single Rae block) this must have occurred prior to 2.44-2.3 Ga, the time of stitching by magmatism related to an unnamed orogenic event on the west side of the Rae.

South Rae subdomain

Amalgamation must predate 2.44-2.30 Ga magmatism and orogeny

➤ No known Prince Albert-like Archean greenstones

➤ Greater abundance of old crust

➤ Separate block or transitional?

SLAVE
3129 Ma

Older 3.0-3.3 Ga crust in SW Rae

3186 Ma

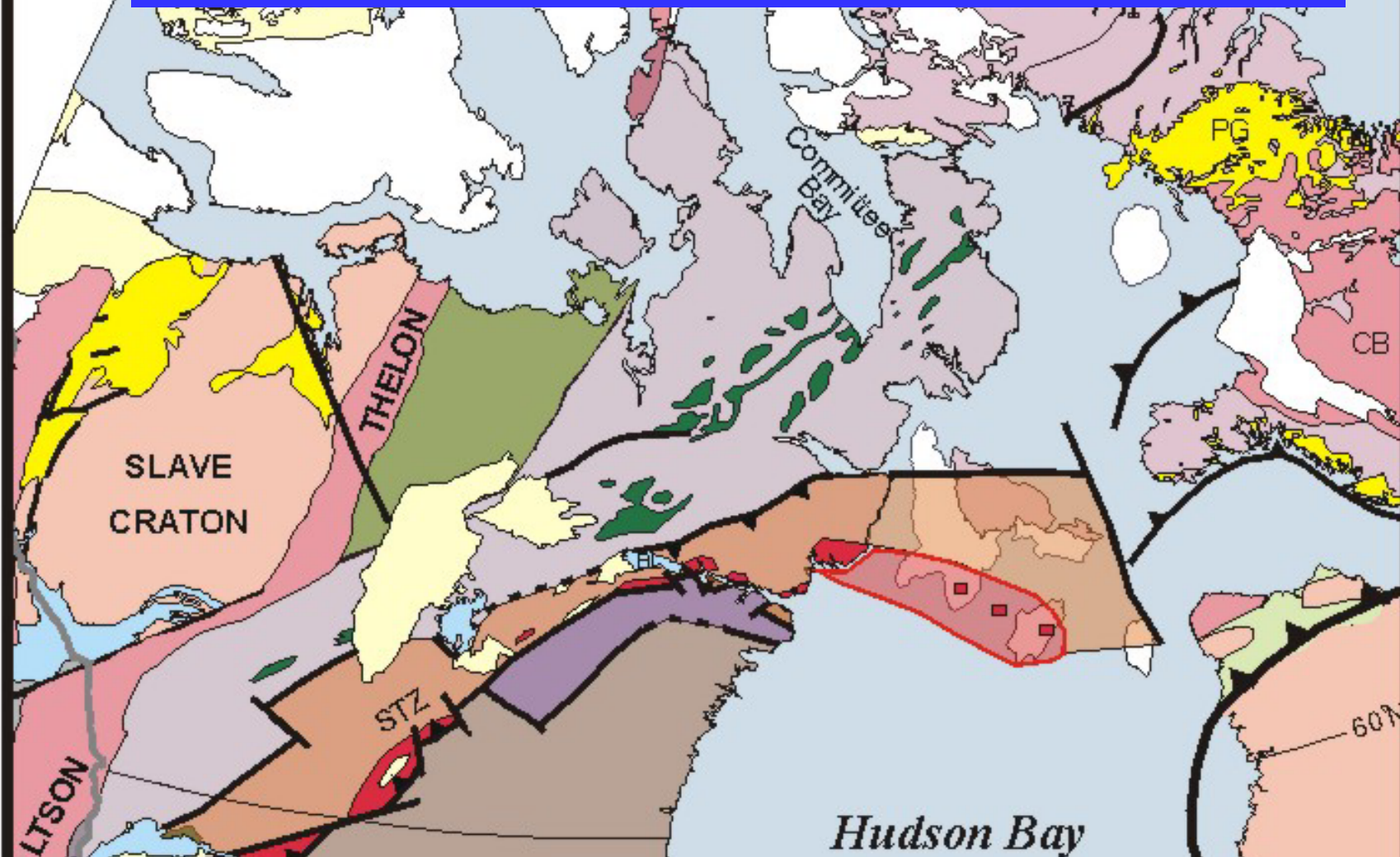
3126 Ma

3300 Ma

3019 Ma

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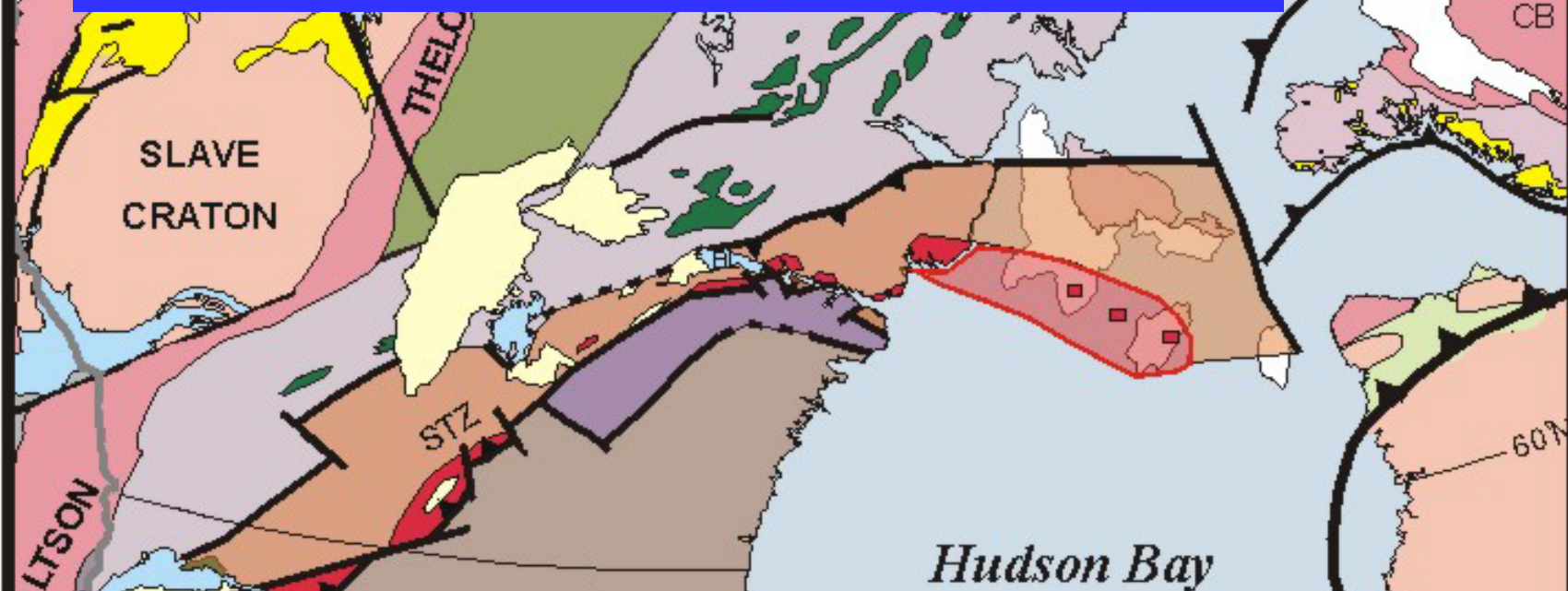
Chesterfield high-pressure block in the Rae domain



The newly identified Chesterfield regional high pressure block extends from □ Southampton Island to Lake Athabasca and is bounded to the east by the Snowbird □ Tectonic zone. Situated within the block are the high pressure granulite blocks □ associated with the STZ, which in the Daly Bay, Kramanituar, Snowbird and Tantato □ complexes may be associated with Ni mineralization and noritic magmatism □

Chesterfield high-pressure block in the Rae domain

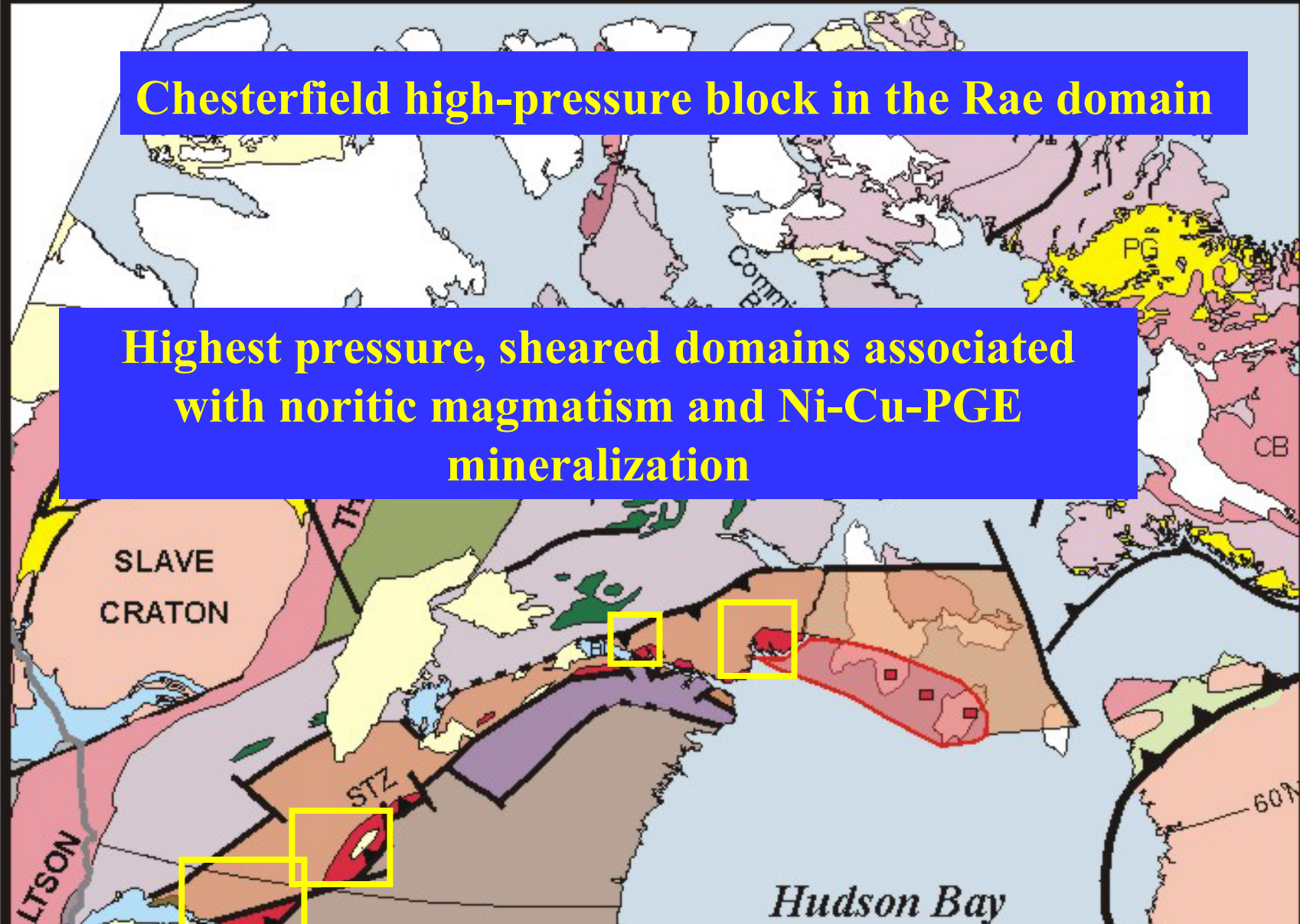
Regional 10-12 kbar metamorphism at 1.9 and 2.5 Ga with smaller subdomains of 7-8 kbar and >15 kbar



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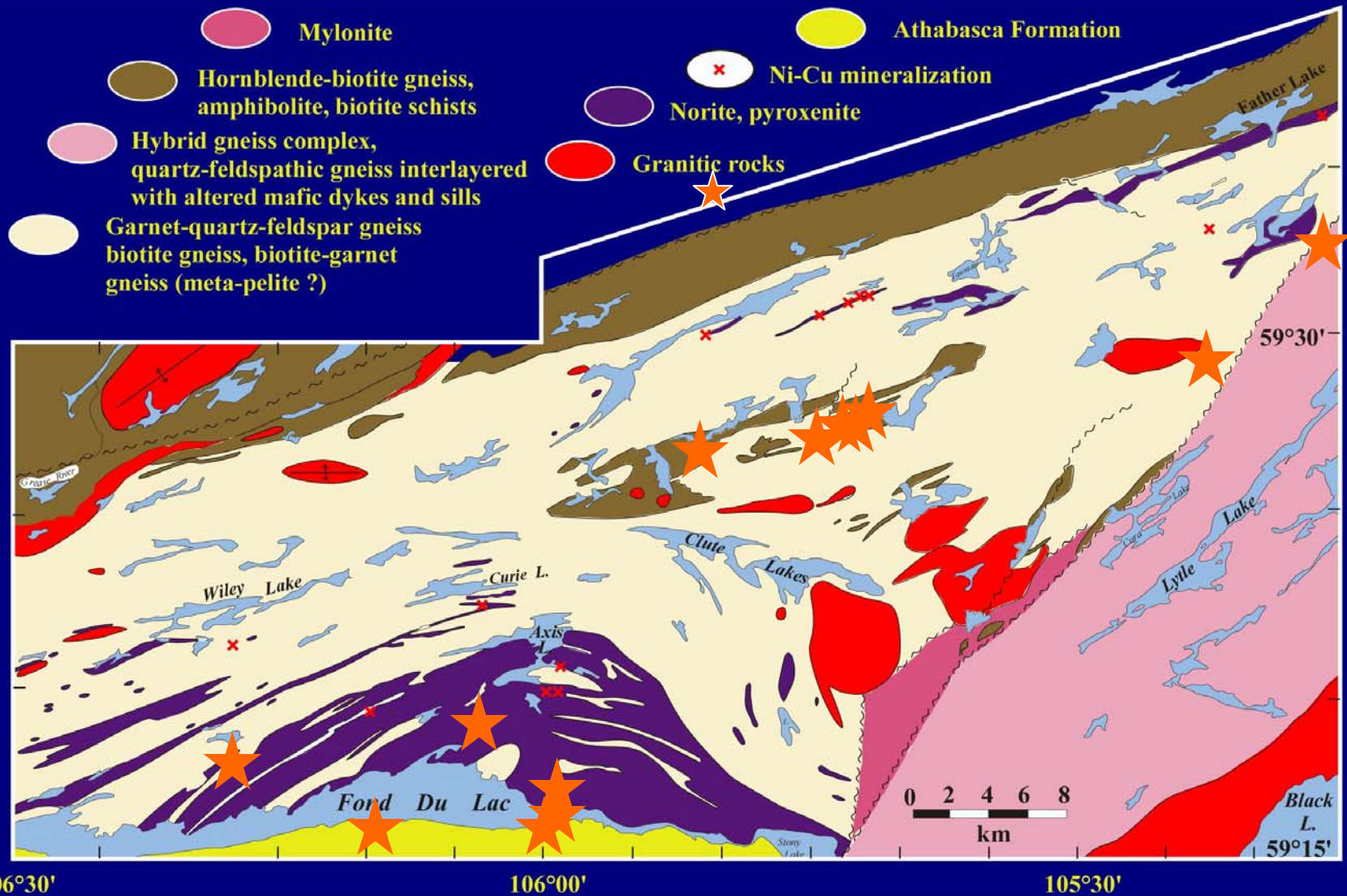
Chesterfield high-pressure block in the Rae domain

Highest pressure, sheared domains associated with noritic magmatism and Ni-Cu-PGE mineralization



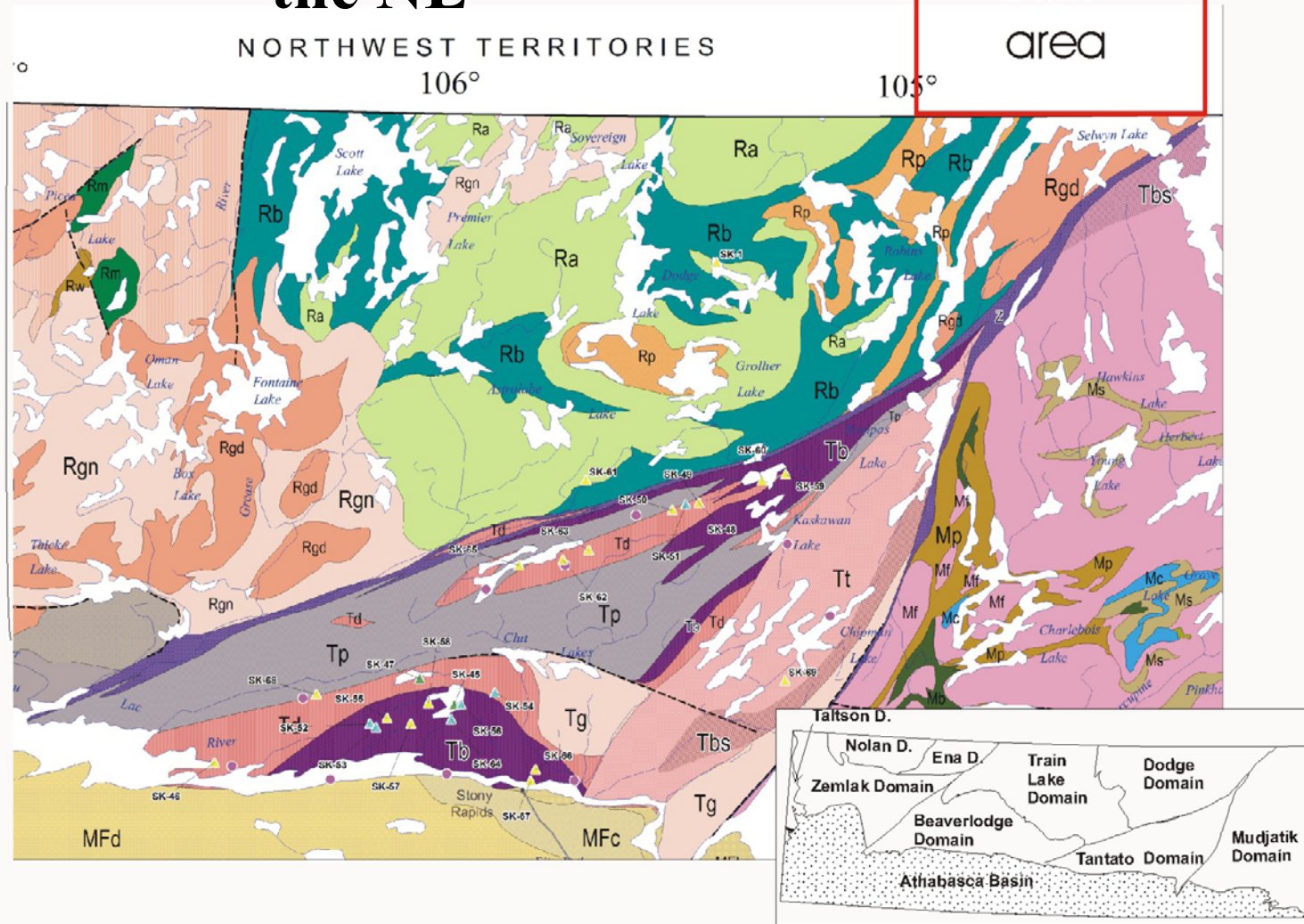
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Significant Ni-Cu mineralization associated with norites and pyroxenites of the Tantato domain

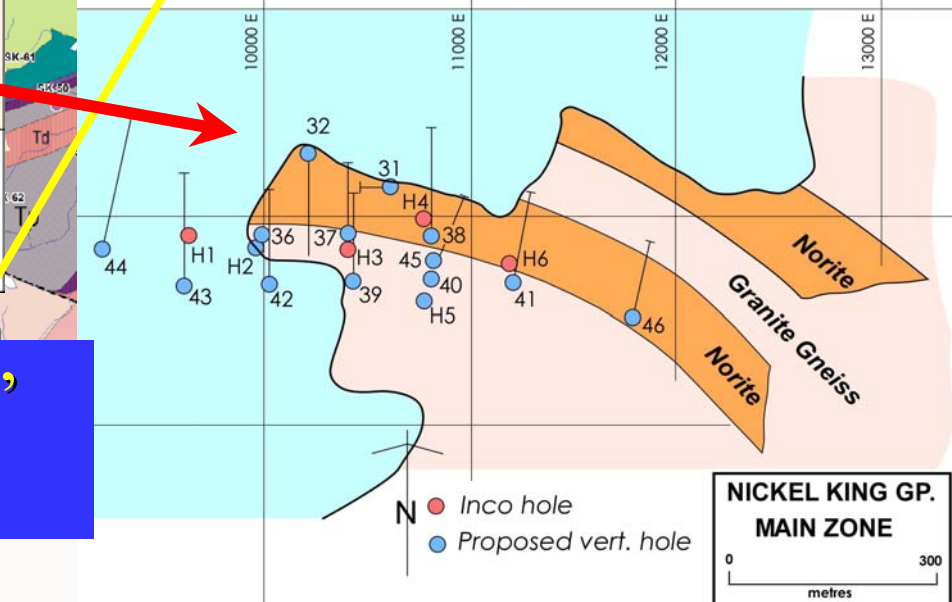
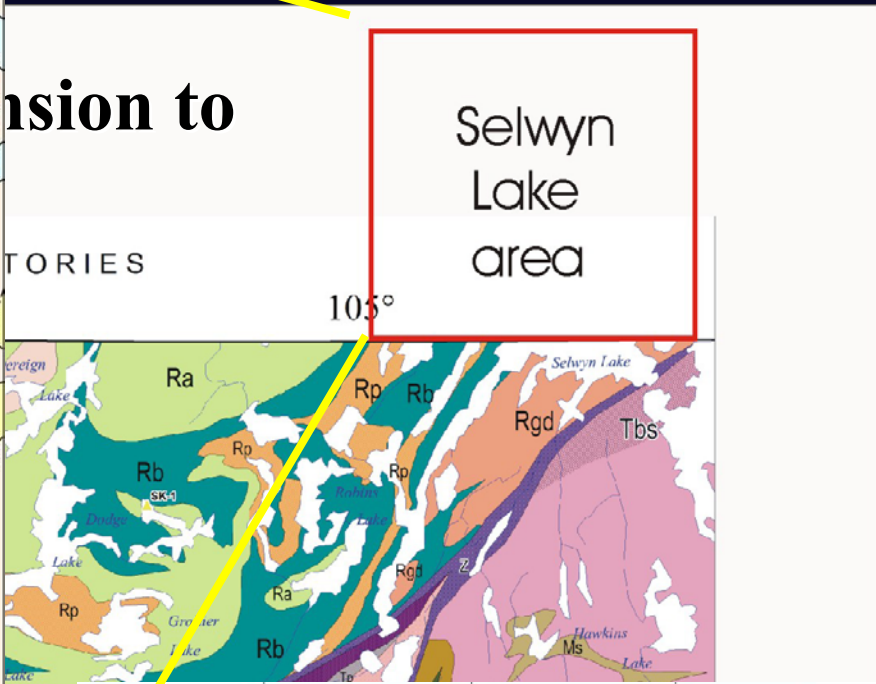
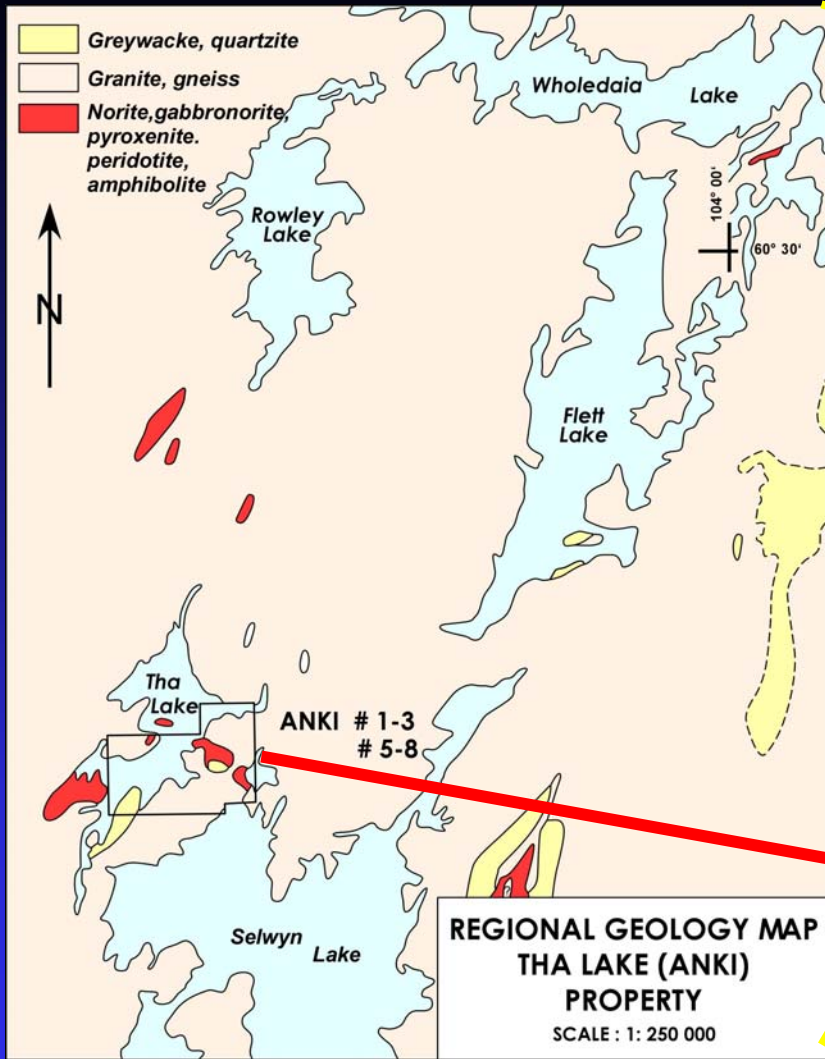


...sted Ni-Cu occurrences in East Athabasca Mylonite Triangle ("Tantato Domain"). Discovery of exploitable concentrations of Ni-Cu mineralization could lead to a railhead at Fort McMurray and then to Sherritt-Gordons nickel refinery at Fort Saskatchewan. Discoveries at Tha Lake could utilize a winter road by Rapids and 65 km of ice road along Selwyn Lake where it extends south into Sask. Because it occurs in a granulite facies terrane does not rule out potential. The Selkirk-Dikwe Ni-Cu deposit Botswana has been in continuous production since 1971 and along with diamond mining is the backbone of the country's economy.

Dodge domain extension to the NE



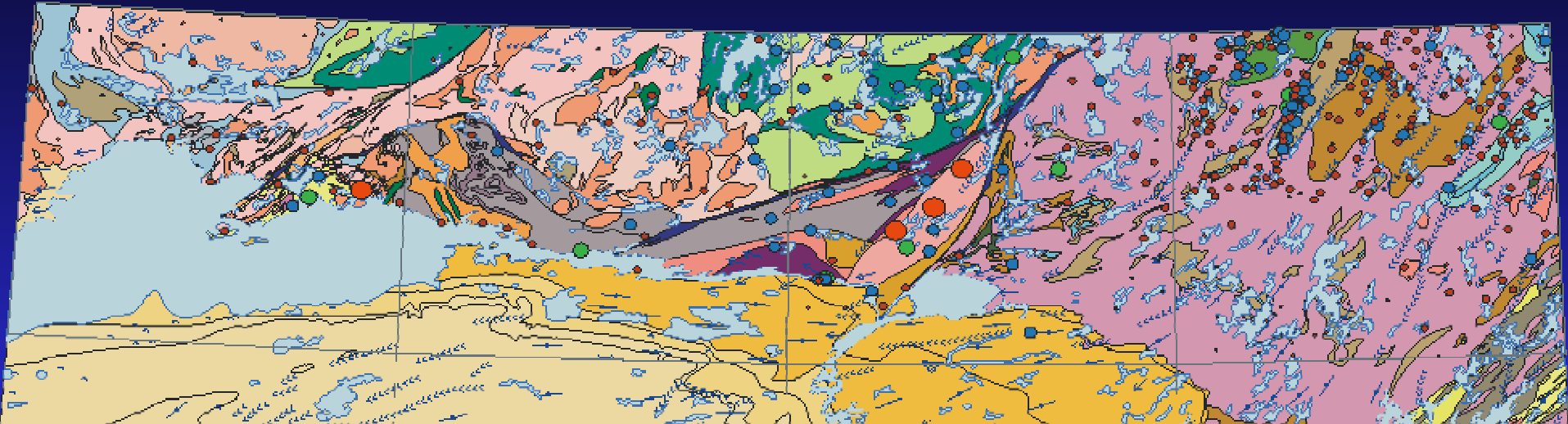
The Tha Lake prospect of the Selwyn Lake, north of the Tantato domain, is also hosted in norite enclosed by high grade para- and orthogneisses. Regionally this sequence extends into the Dodge domain of N Saskatchewan. A key question is whether the Dodge domain hosts similar mineralization.



**Tha Lake "Nickel King"
Ni-Cu prospect**

Regional till geochemistry of N Saskatchewan

Nickel



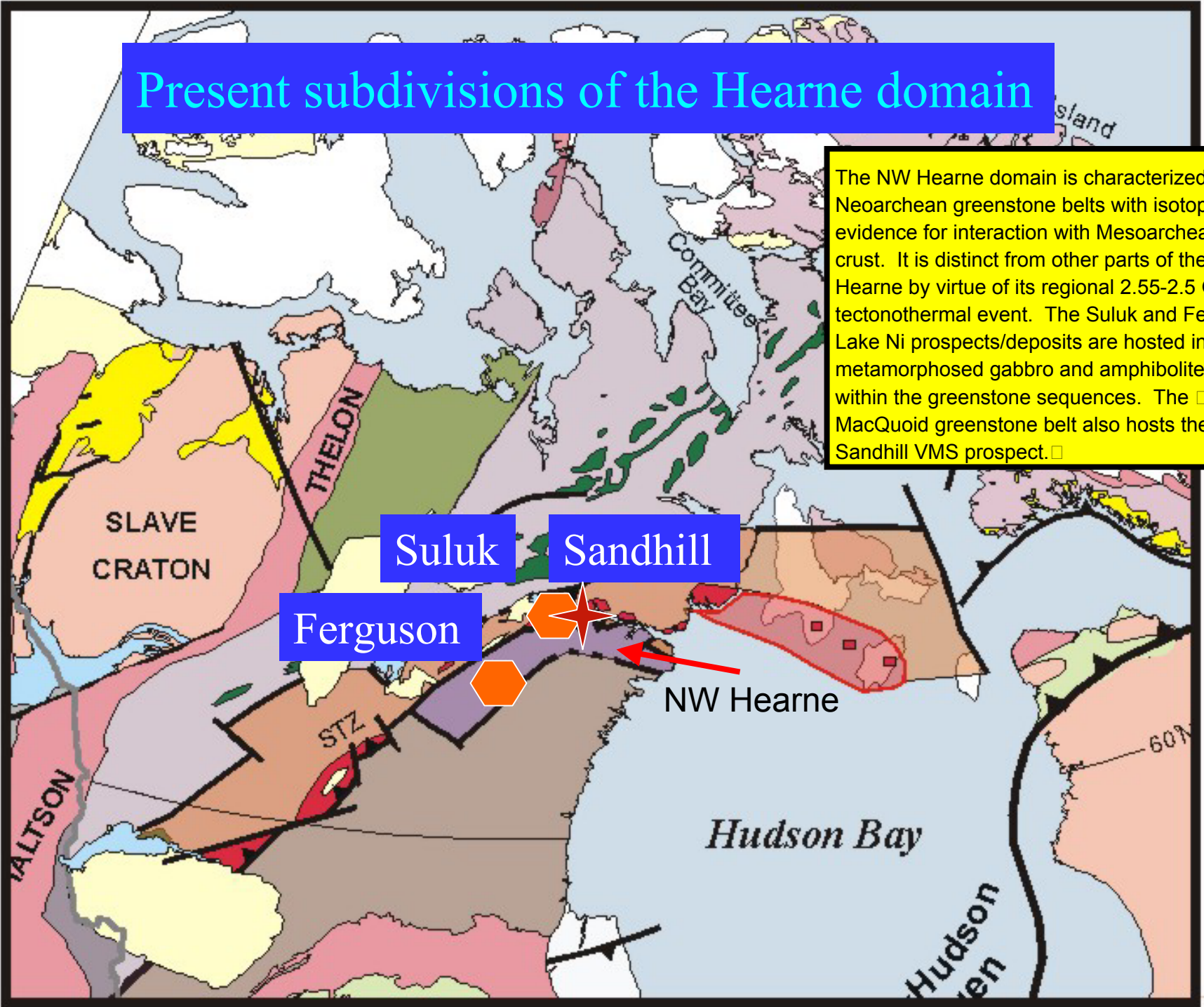
-0.063 mm size fraction

- Ni ppm**
- 3 - 14
 - 15 - 24
 - 25 - 46
 - 47 - 87 (>2 S.D.)
 - 88 - 178

The East Athabasca mylonite triangle or Tantato domain has some of the most anomalous Ni, Cr lake sediment geochemistry in Saskatchewan and as shown with one example here, highly anomalous till geochemistry also. Similar patterns of enriched Cu, Cr, Co, Mg show up associated with Tantato and regional elevations in the Dodge domain, highlighting the overall favourable background down ice from the Thy occurrence. Similar Ni-prospective geology may be present in the Dodge as noted.

Present subdivisions of the Hearne domain

The NW Hearne domain is characterized by Neoproterozoic greenstone belts with isotopic evidence for interaction with Mesoproterozoic crust. It is distinct from other parts of the Hearne by virtue of its regional 2.55-2.5 Ga tectonothermal event. The Suluk and Ferguson Lake Ni prospects/deposits are hosted in metamorphosed gabbro and amphibolites within the greenstone sequences. The MacQuoid greenstone belt also hosts the Sandhill VMS prospect.



SLAVE
CRATON

Ferguson

Suluk

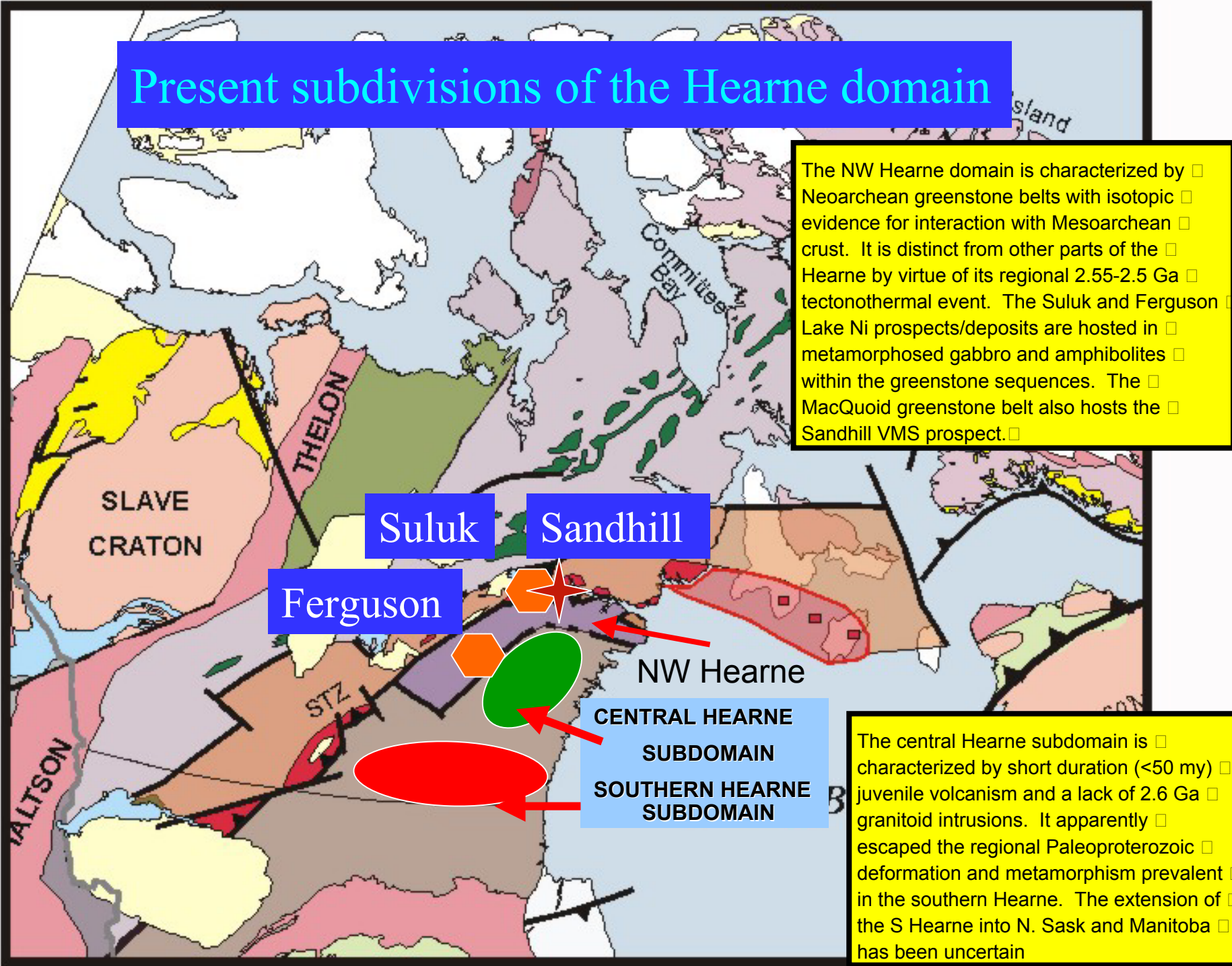
Sandhill

NW Hearne

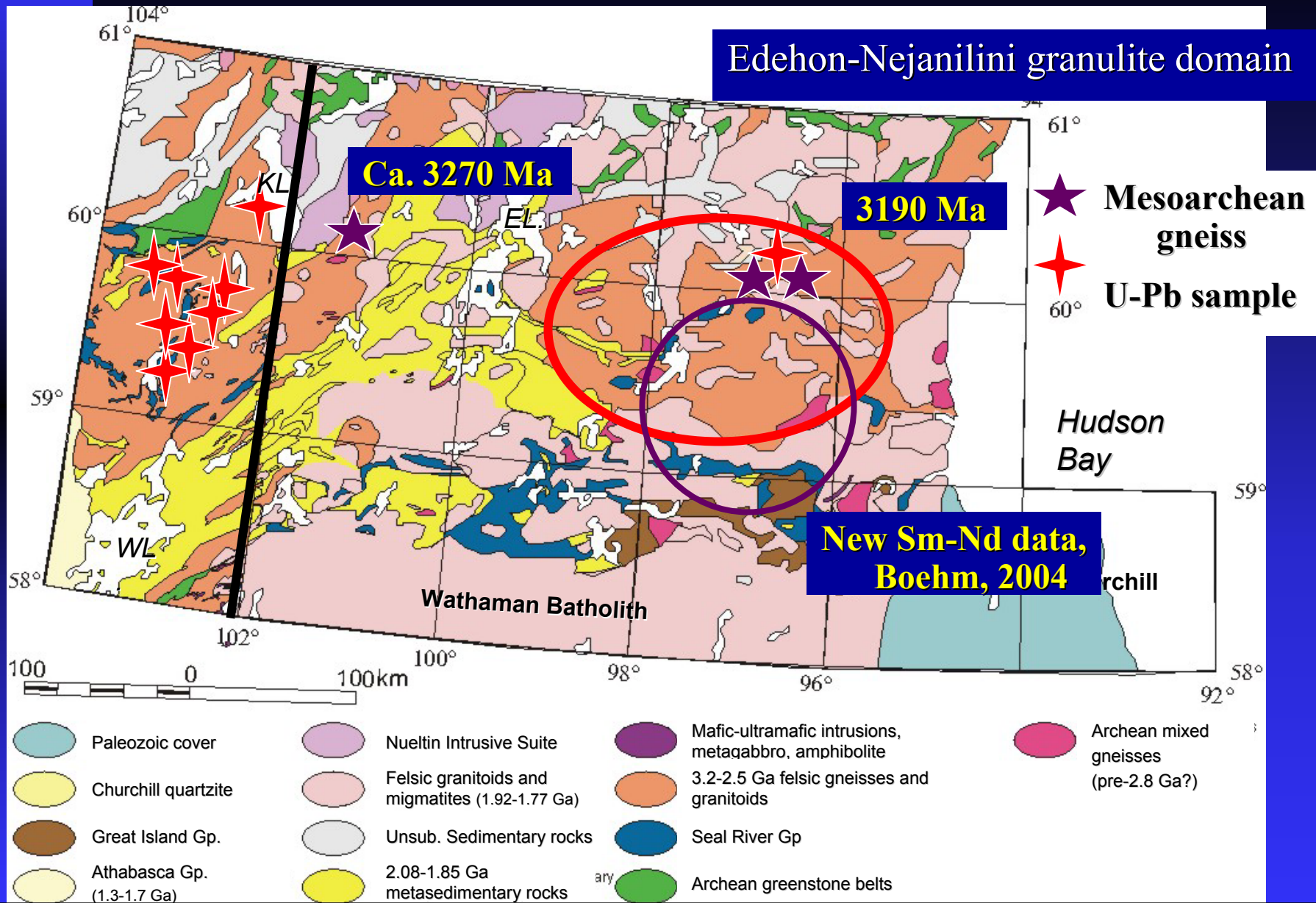
Hudson Bay

60°N

Present subdivisions of the Hearne domain



Simplified Geology of southern Hearne domain



The southern Hearne in Nunavut hosted several locales of known Mesoarchean crust, several of these are spatially associated with the Nejanilini granulite domain. New SHRIMP U-Pb and isotopic data acquisition has focused in the recently mapped Phelps Lake area of NE Saskatchewan

Summary of SHRIMP; TIMS and Sm-Nd data In S. Hearne, Wollaston basement inliers and Peter Lake domain

¹ Loveridge et al., 1988

² van Breemen and Harper, in press

³ Weber et al., 1975

⁴ Bickford and Collerson, 1987

⁵ Van Schmus et al., 1987

⁶ Chauvel et al., 1987

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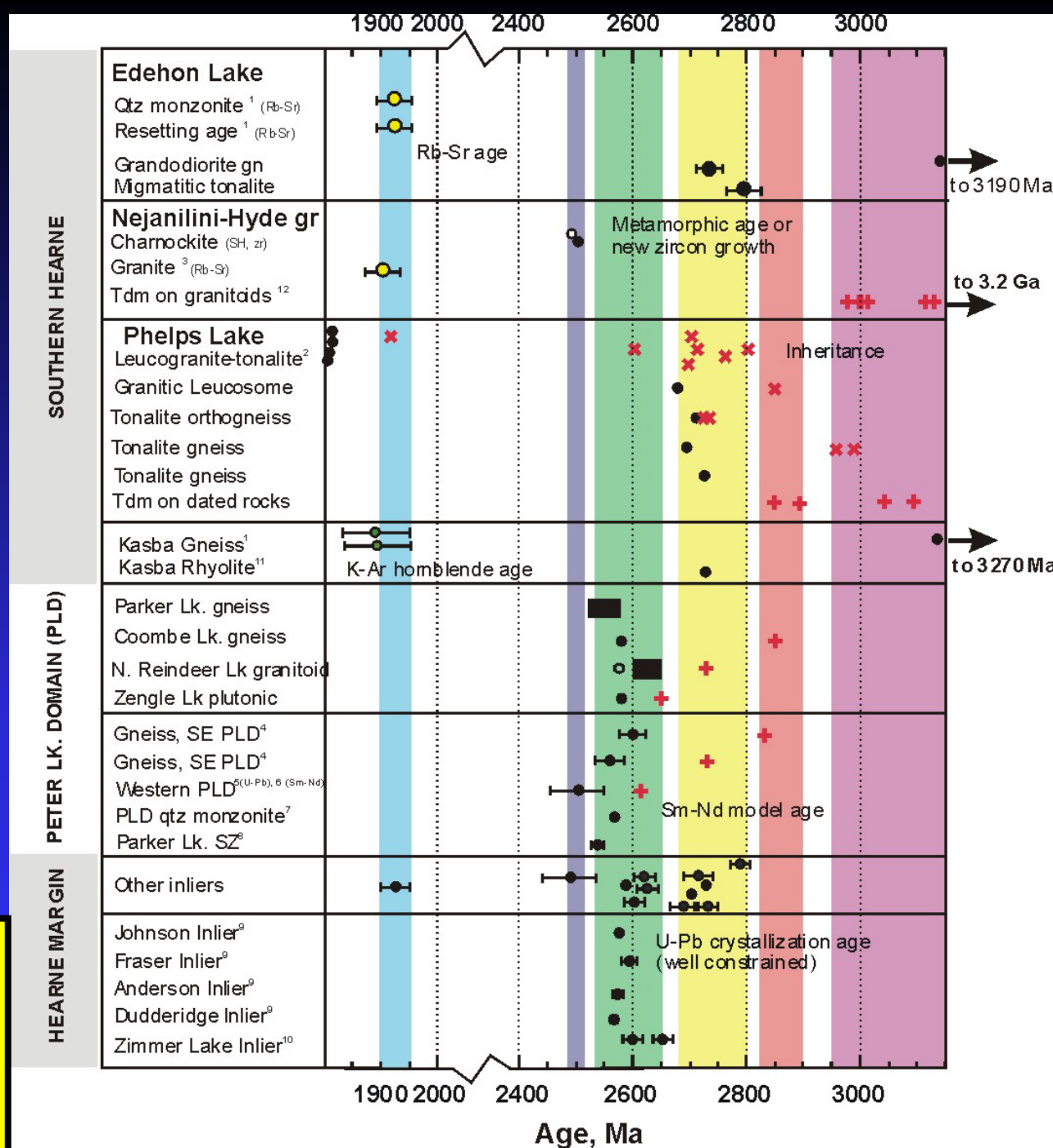
¹⁰ Krogh and Clark, 1987

¹¹ van Breemen and Martel, unpub.

¹² Boehm, 2004

Rayner et al., C.J.E.S. in press

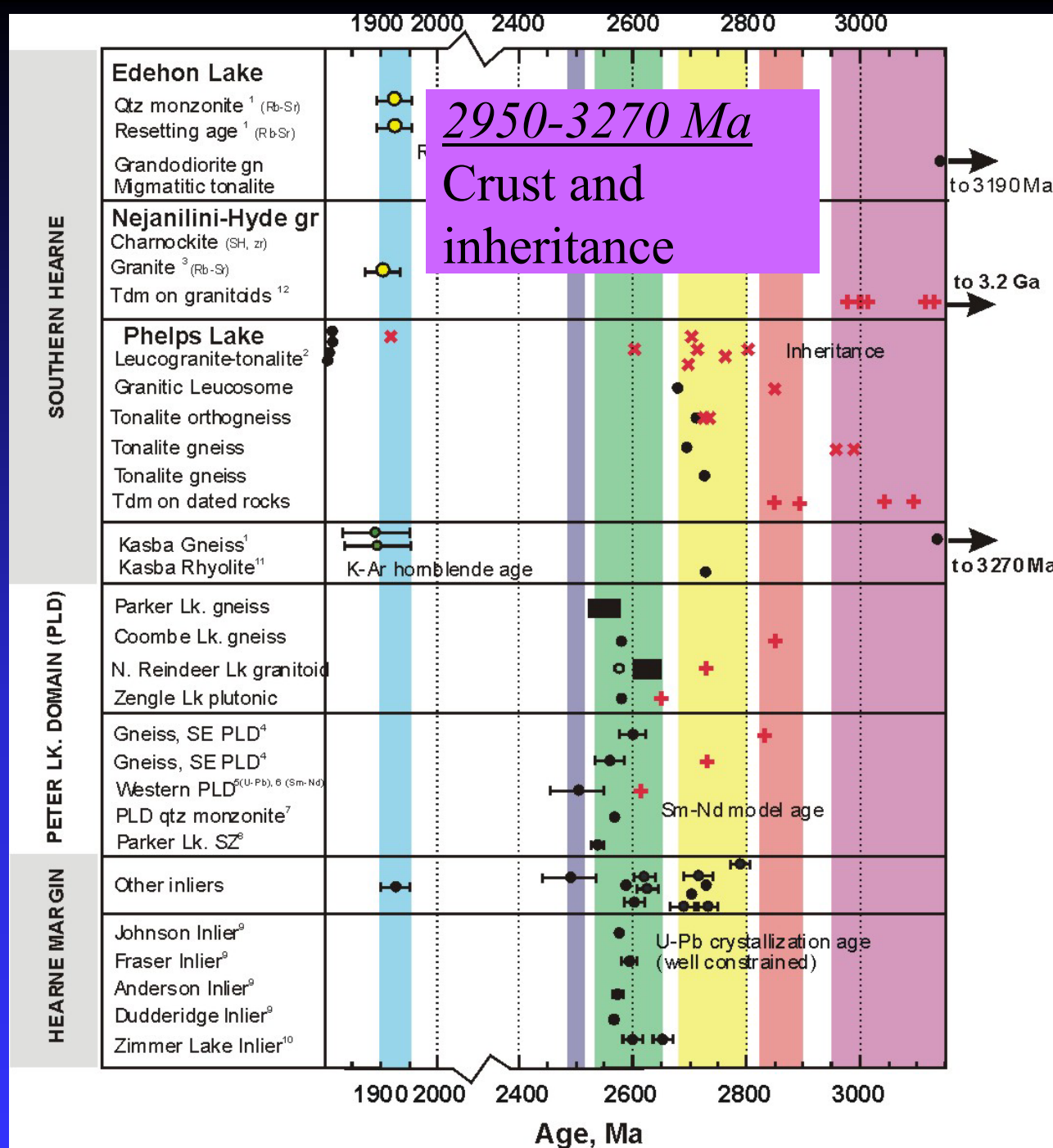
... summaries presently known age, □
... force, cooling, and Sm-Nd data for southern □
... rocks of the Edehon, Nejanilini, Phelps Lake □
... of southern Hearne, the Hearne underlying the □
... on supergroup, and Hearne of the Peter Lake □
... , SK. 6 major age modes are □
... particularly ubiquitous evidence for old □
... chean crust. Interestingly all these S. hearne □



modified after Rayner et al. CJES in press

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In S. Hearne,
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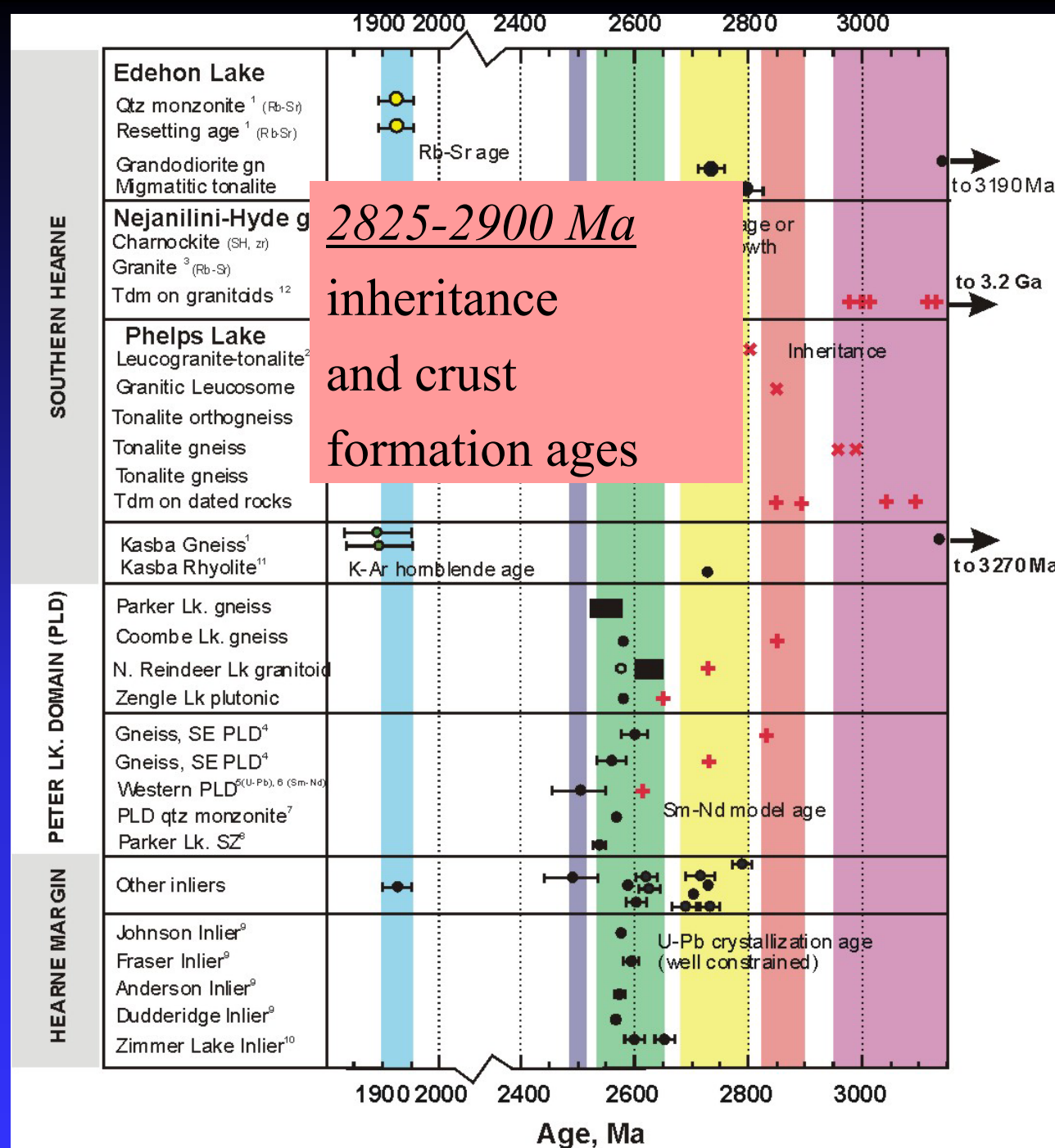
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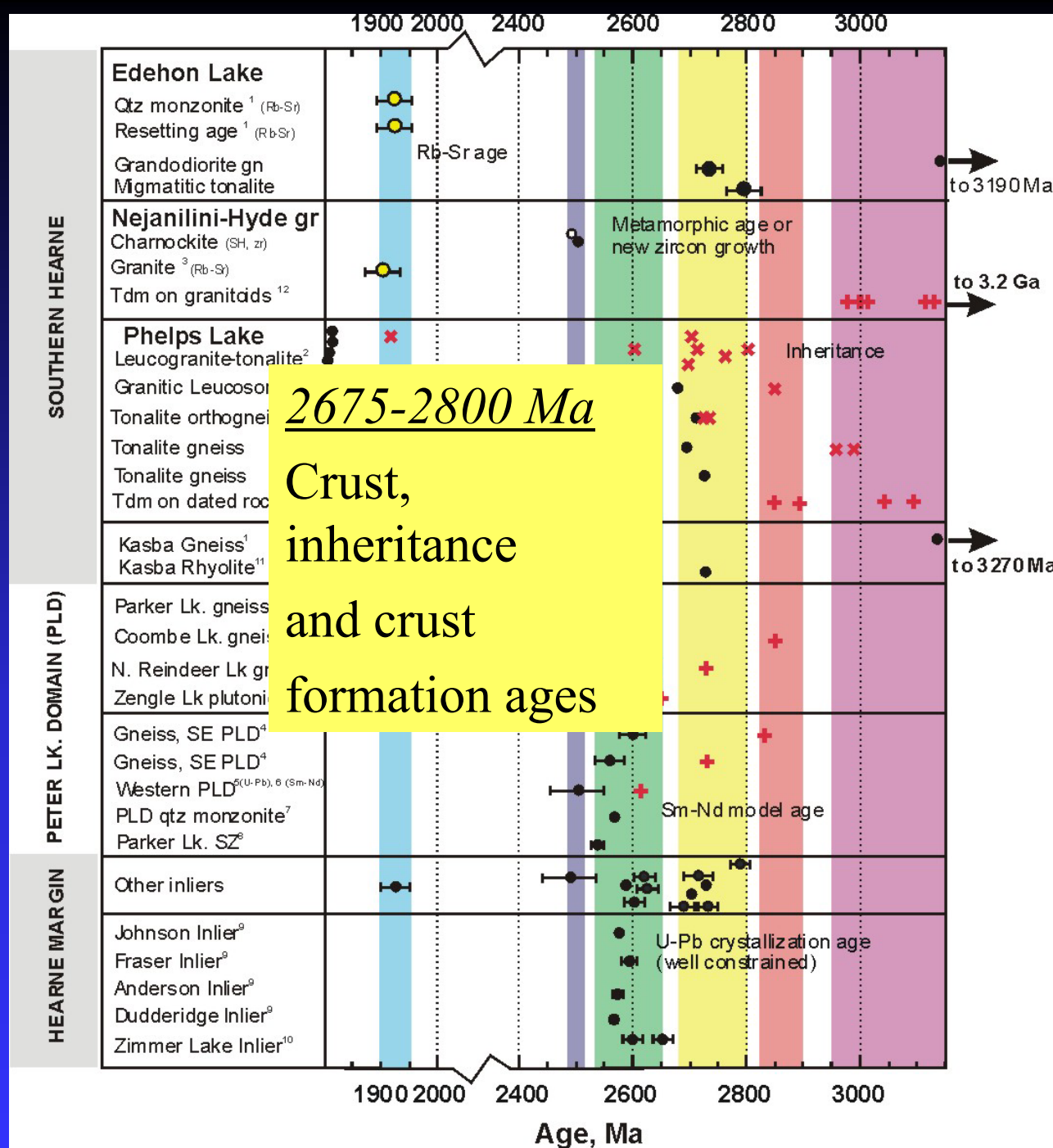
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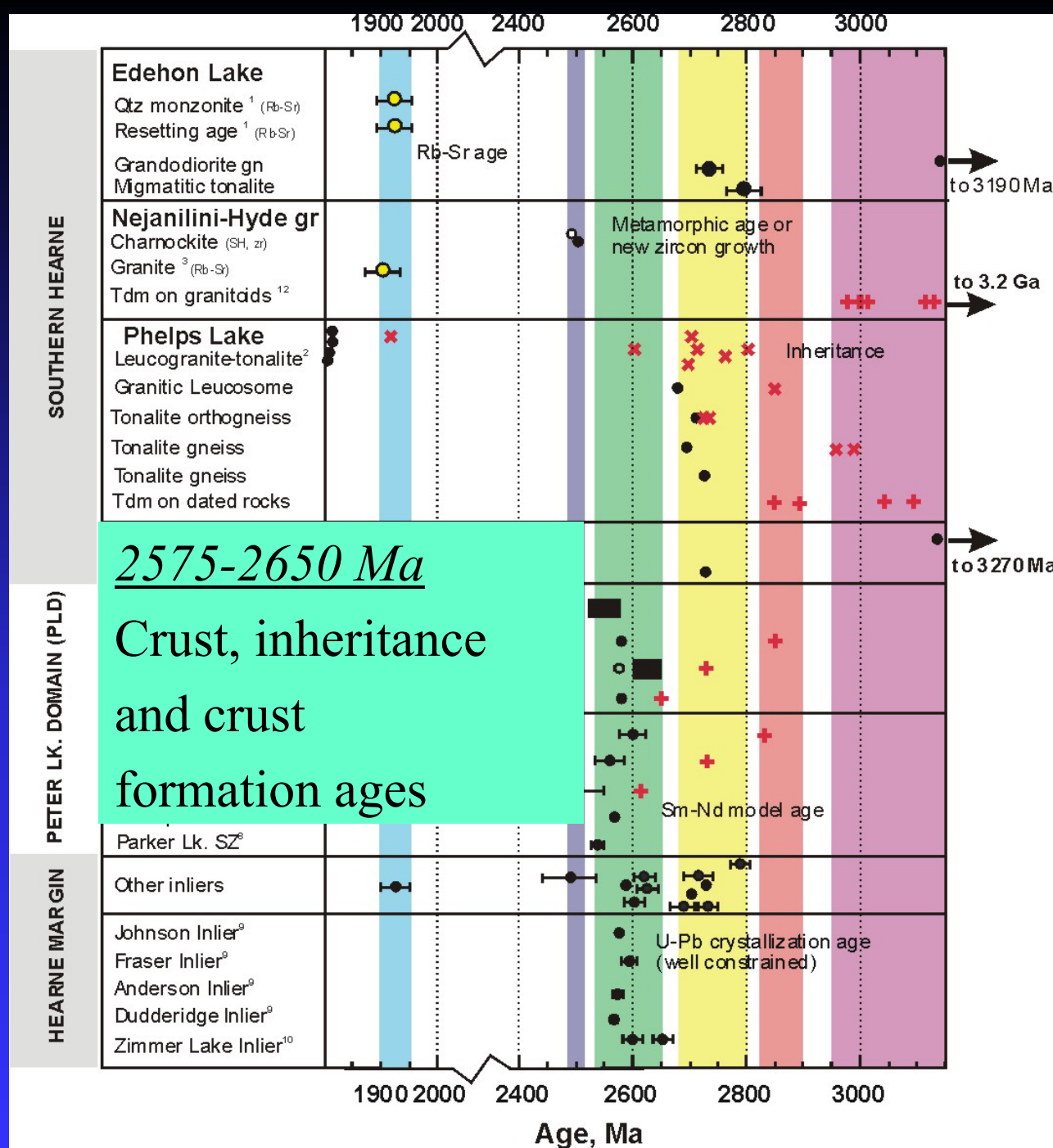
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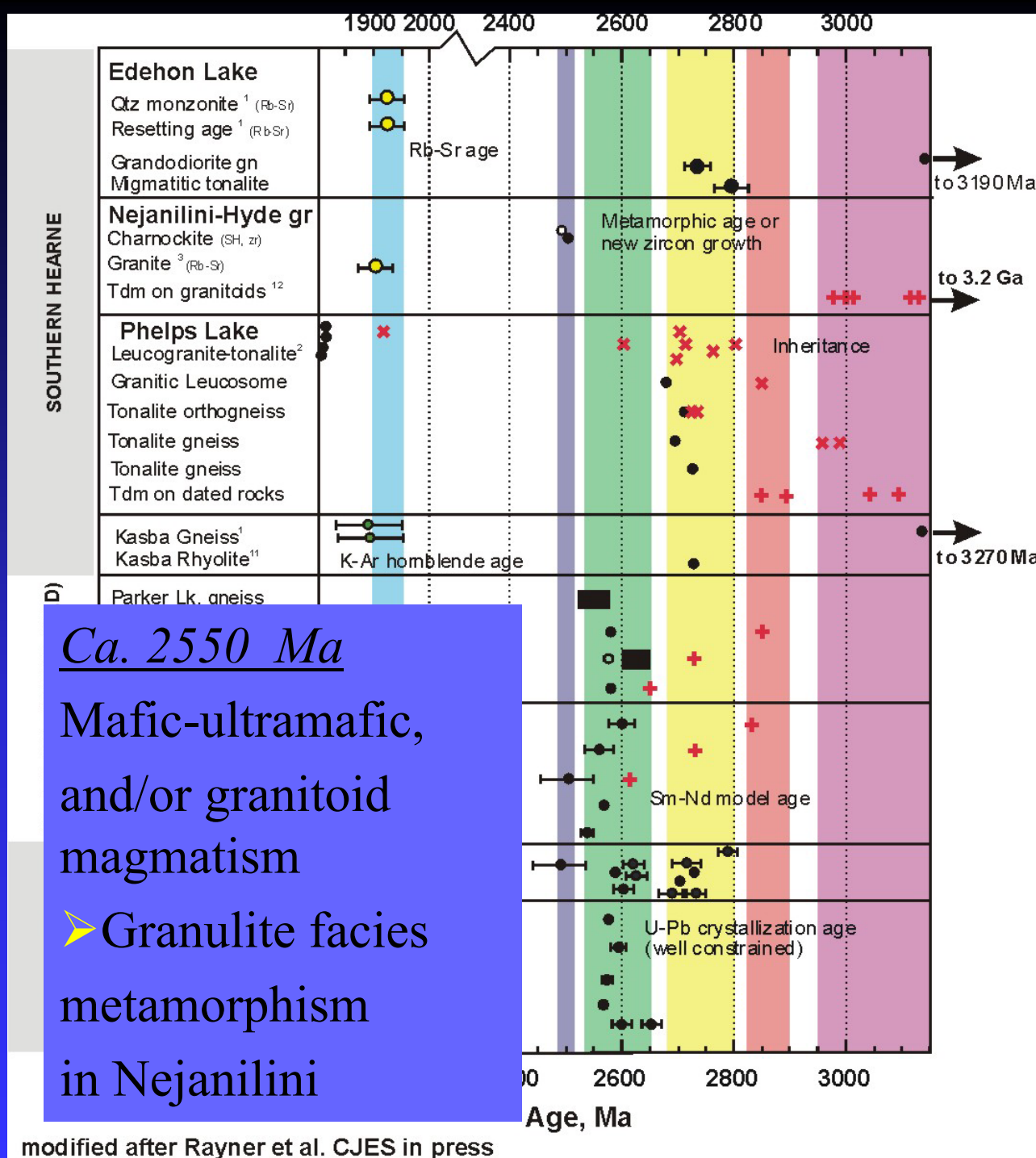
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Ca. 2550 Ma

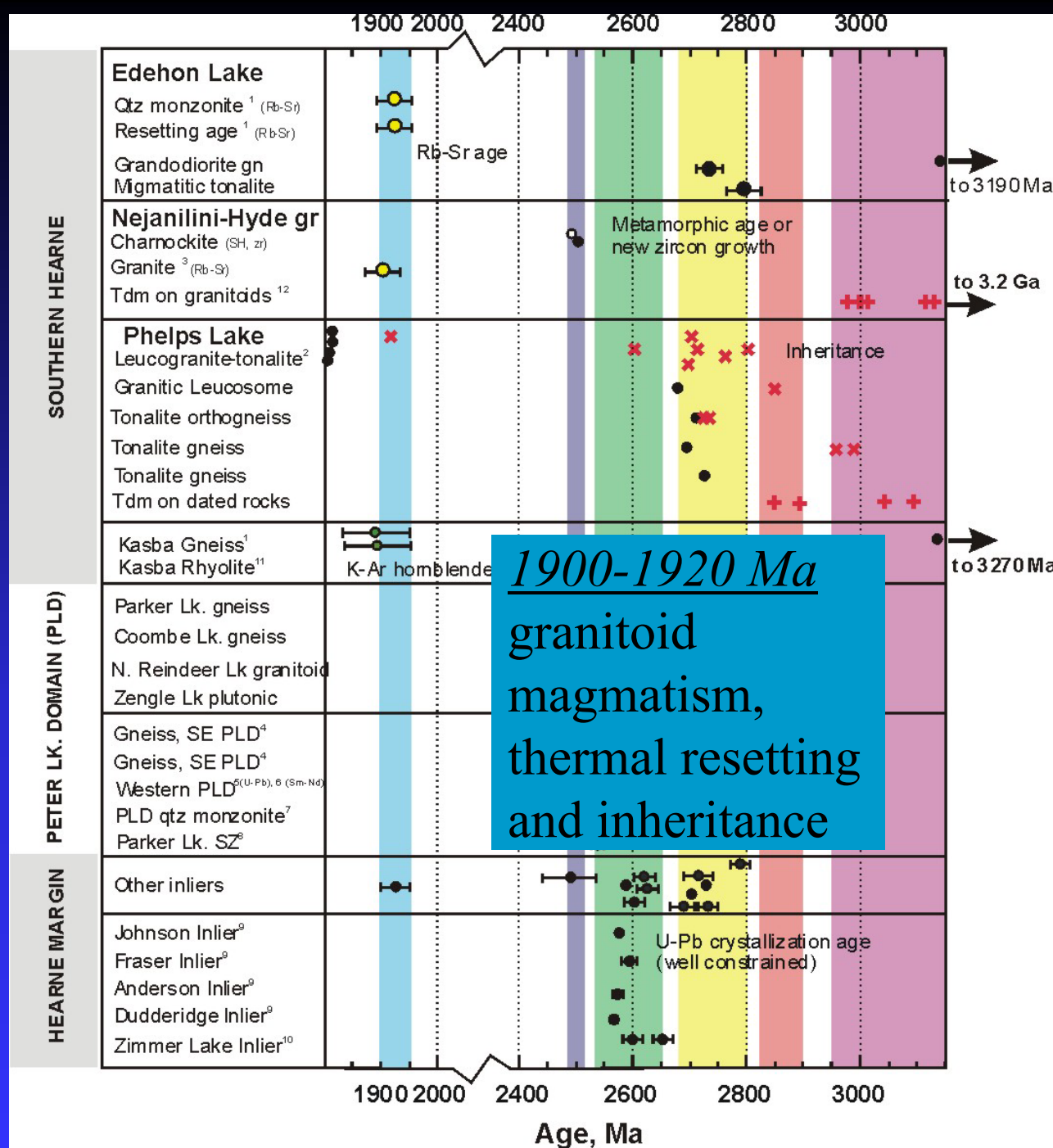
Mafic-ultramafic,
and/or granitoid
magmatism

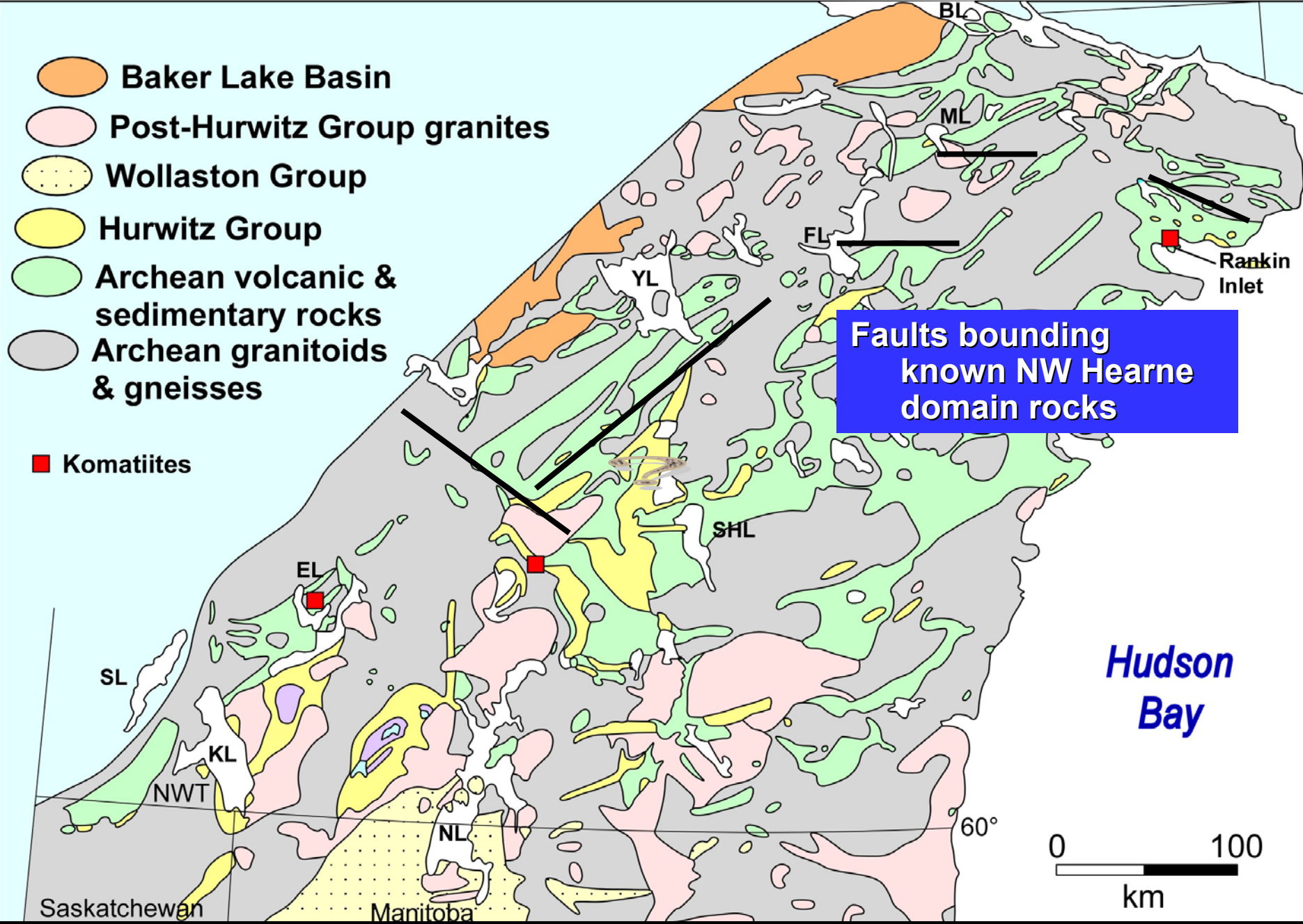
➤ Granulite facies
metamorphism
in Nejanilini

modified after Rayner et al. CJES in press







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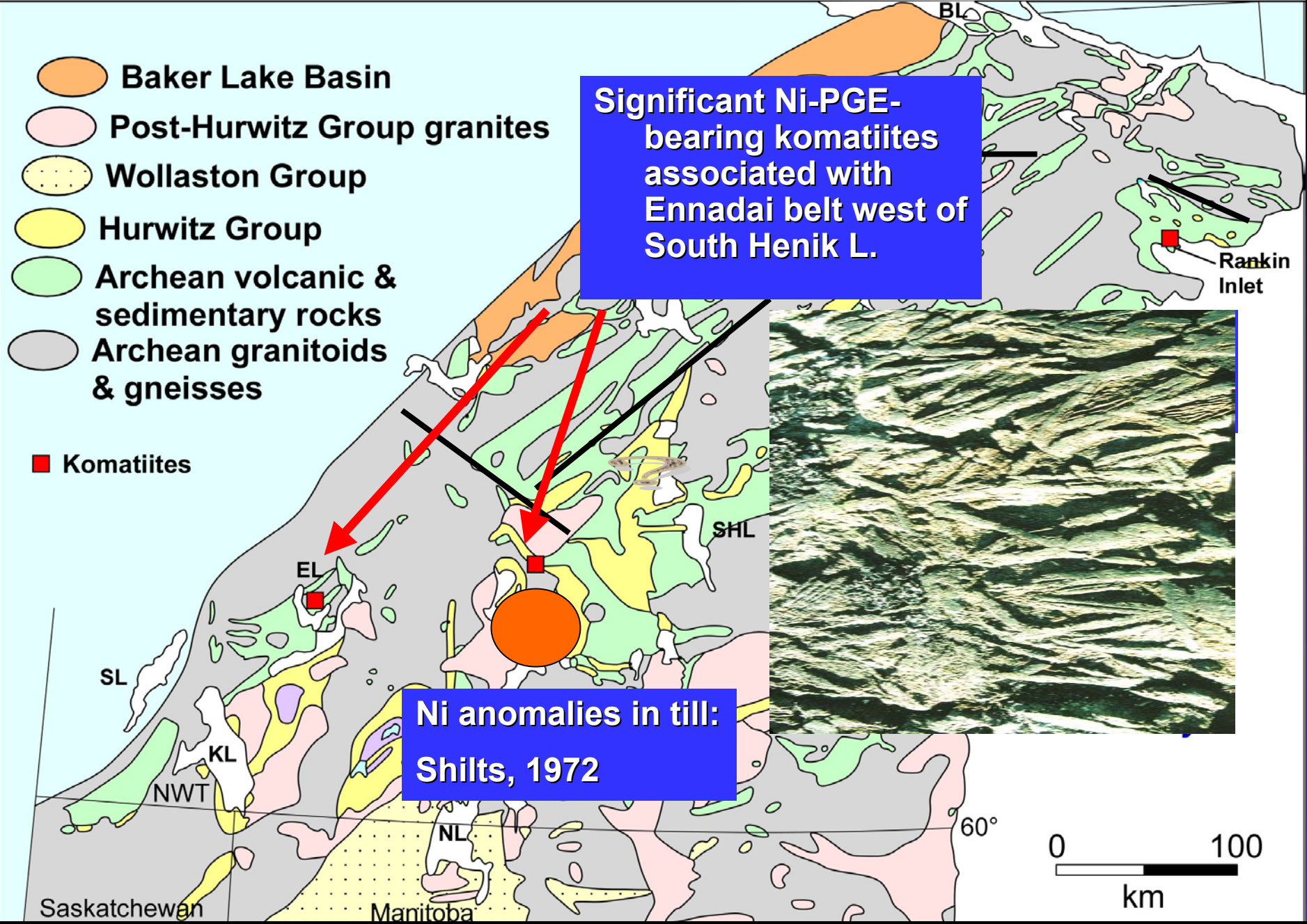


Simplified geological map of the Hearne province showing location of known komatiites, Ennadai Lake, Griffin Lake and Rankin Inlet. □ Also shows known faults bounding recognized NW Hearne and a picture of the Griffin area komatiites. A key question is whether this N-PGE □

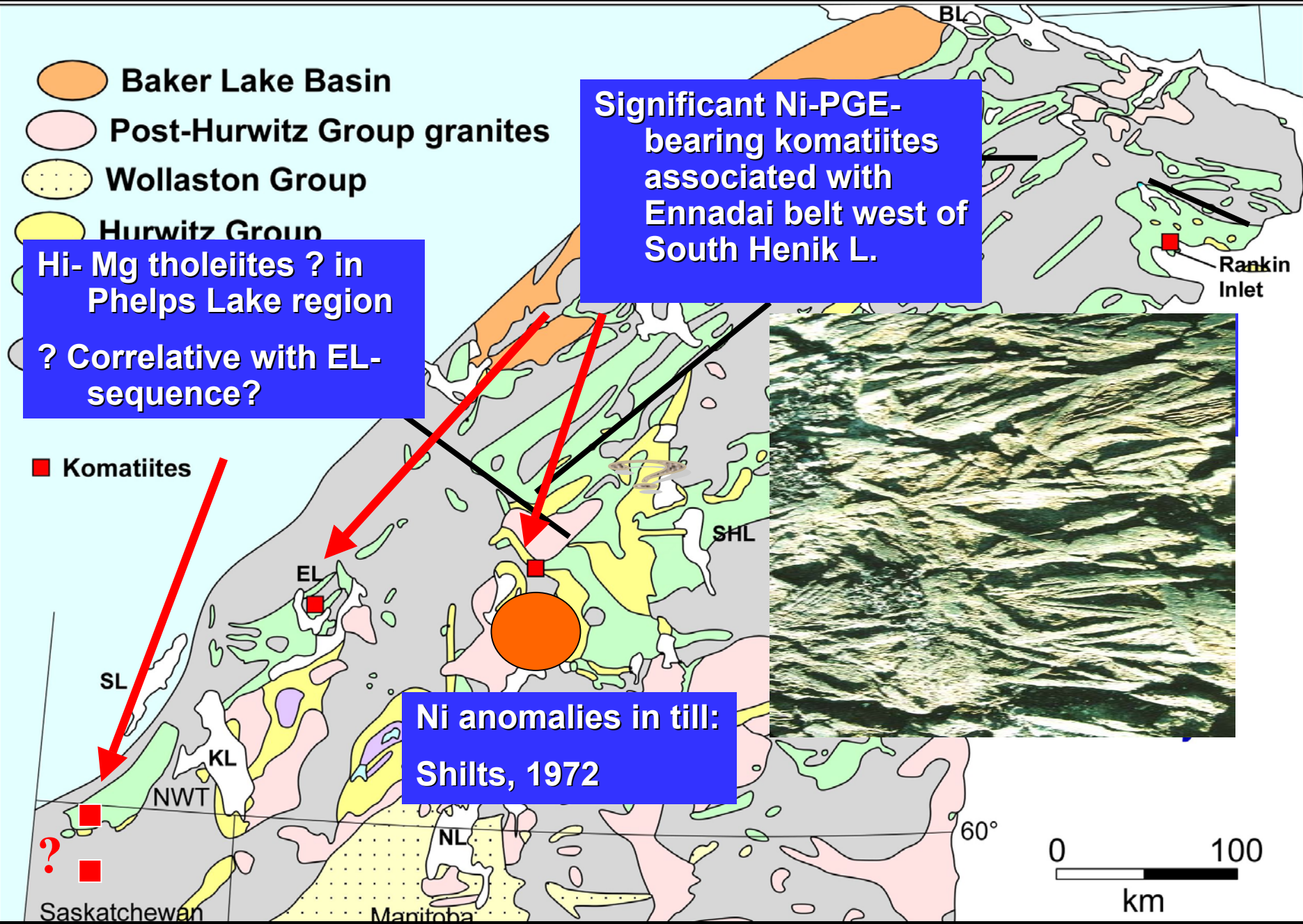
-  Baker Lake Basin
-  Post-Hurwitz Group granites
-  Wollaston Group
-  Hurwitz Group
-  Archean volcanic & sedimentary rocks
-  Archean granitoids & gneisses
-  Komatiites

Significant Ni-PGE-bearing komatiites associated with Ennadai belt west of South Henik L.

Ni anomalies in till: Shilts, 1972



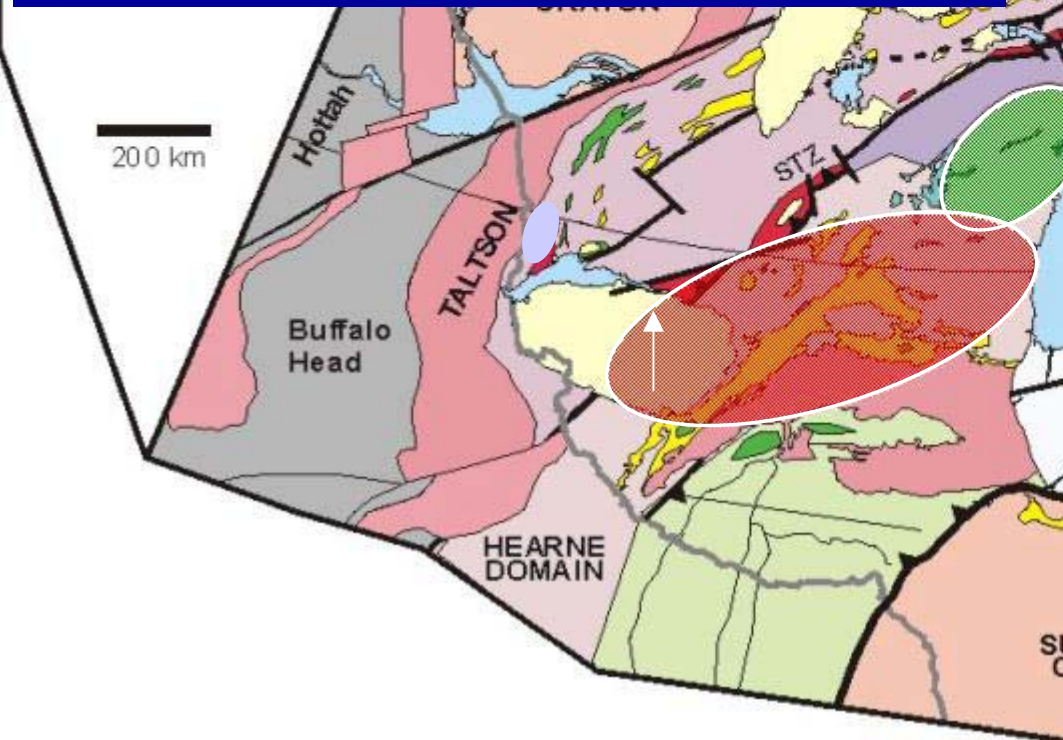
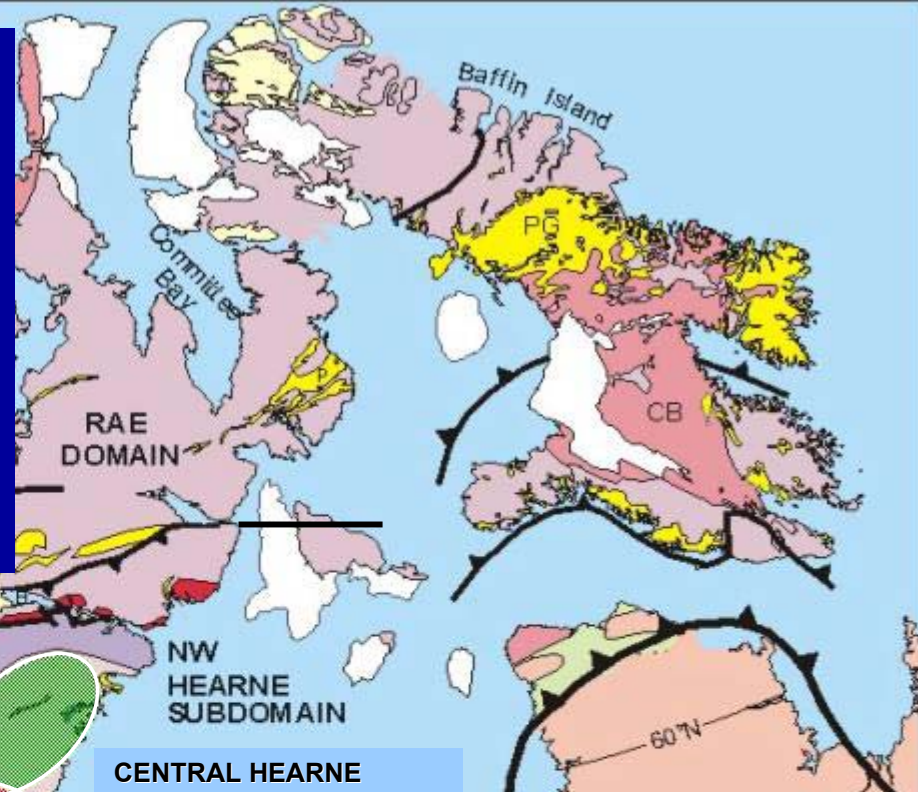
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Revised subdivision of the Hearne domain

- Southern Hearne subdomain appears to a first-degree coherent from southern Nunavut to Peter Lake domain
- Central Hearne juvenile, short duration volcanism appears restricted to Kaminak area



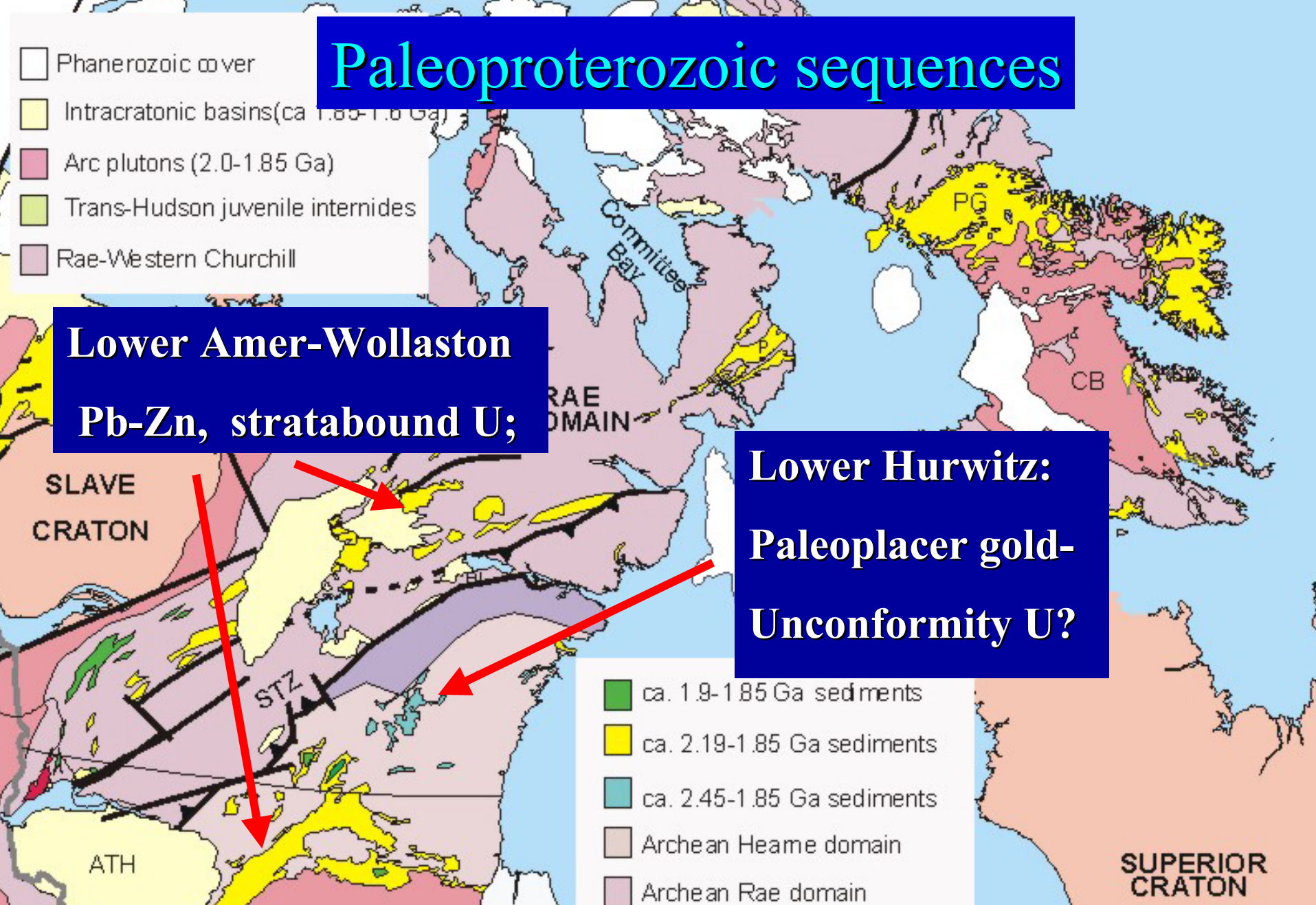
- Ni-PGE-bearing komatiites may be associated with more contaminated, long duration Ennadai sequence
- Relationship to Seal R. group?

Paleoproterozoic sequences

- Phanerozoic cover
- Intracratonic basins (ca 1.85-1.6 Ga)
- Arc plutons (2.0-1.85 Ga)
- Trans-Hudson juvenile internides
- Rae-Western Churchill

Lower Amer-Wollaston
Pb-Zn, stratabound U;

Lower Hurwitz:
Paleoplacer gold-
Unconformity U?



Key outstanding questions regarding the Paleoproterozoic stratigraphic sequences focus on the NT-Mn-Sk boundary zone where rocks mapped as Wollaston and Hurwitz appear to run into each other. Both these sequences have distinctive metallogeny...lower Hurwitz rocks (blue) are

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SLAVE
CRATON

RAE
DOMAIN

PG

CB

ca. 1.9-1.85 Ga sediments

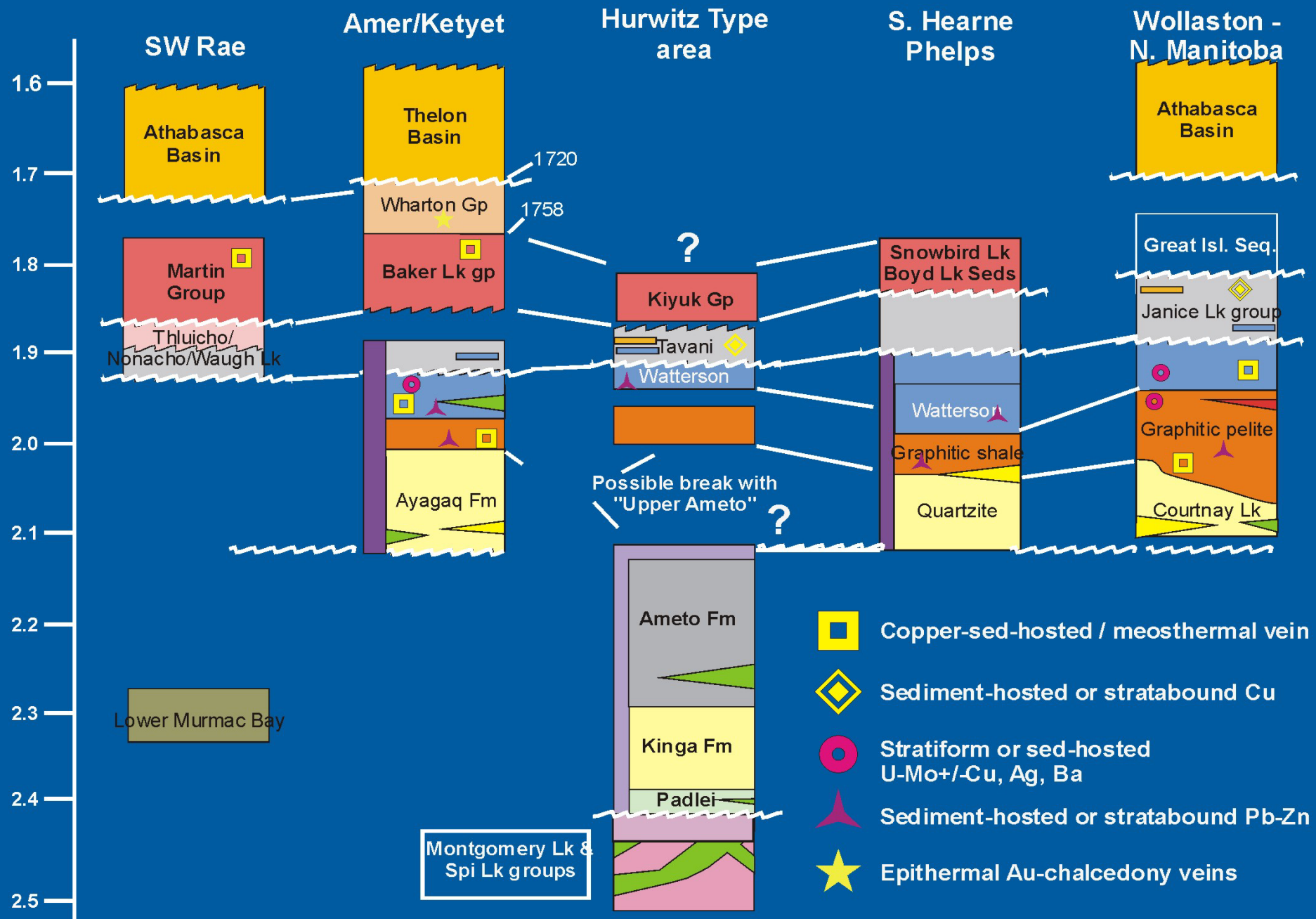
**Tri-Origin Gold exploring for
Broken-Hill-type Pb-Zn and gold**

ATH

Archean Rae domain

SUPERIOR
CRATON

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A regional comparison of the Paleoproterozoic tectonostratigraphic sequences highlights that Pb-Zn , polymetallic and Cu-bearing sequences of □

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and

Indian and Northern Affairs Canada

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