Assembly of the Superior Craton

– constraints from geophysical data & exploration implications

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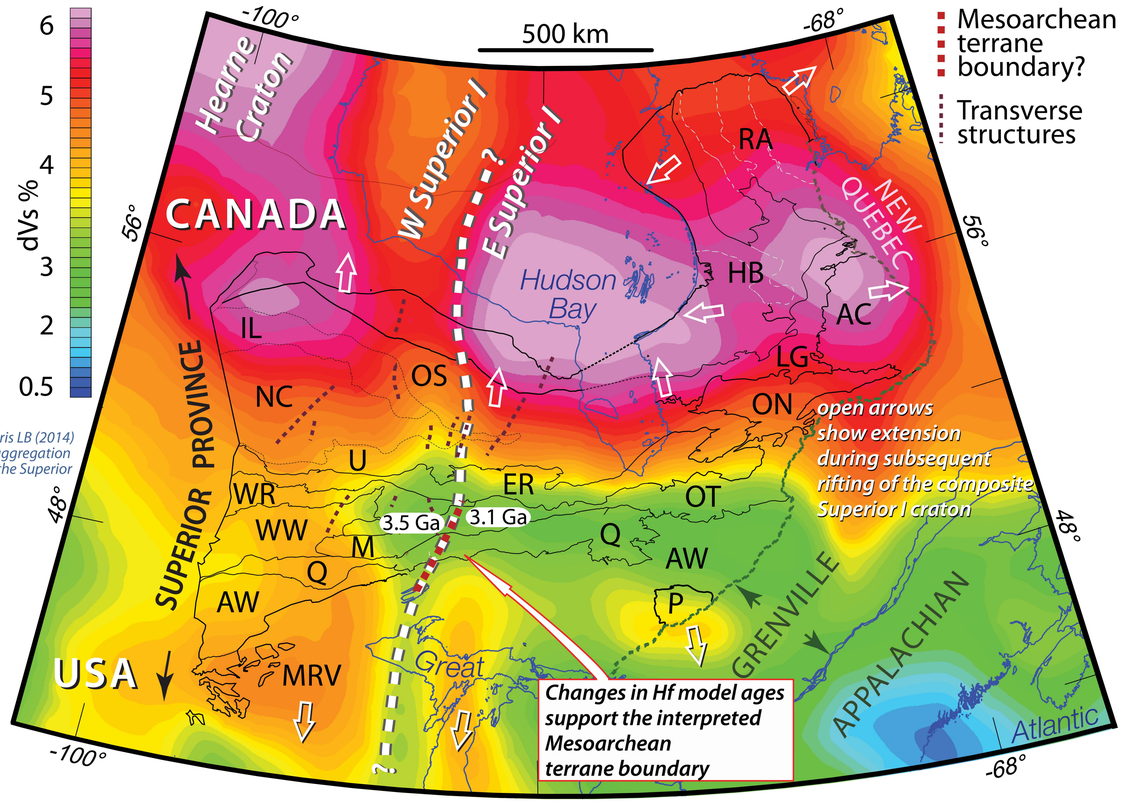
Assembly of a Mesoarchean Superior I craton



From:
Bédard JH & Harris LB (2014) Neoarchean disaggregation & reassembly of the Superior craton. Geology.

Original S-wave tomography data from Godey (2002)

Terrane boundary map of the Superior craton & adjacent orogens superposed on velocity perturbations at 120 km

– A ca. N-S mantle discontinuity = a Mesoarchean boundary between E & W blocks constituting an early, 'Superior I' craton

- **changes in Hf model ages occur across a NNE striking fault along this structure** *(Lu et al. 2013; Proc., 12th SGA Meeting, 3: 1148–1151)*
- **an early, Eoarchean Superior I craton formed through E-W terrane assembly**
- **transverse structures marked by 10 km or greater horizontal gradient edges ("worms") of NRCAN Bouguer gravity in different terranes supports fragmentation of a composite Superior I craton prior to its N-S reassembly.**

Terranes and/or domains:

AC—Ashuanipi, AW—Abitibi-Wawa, ER—English River, HB—Hudson Bay, IL—Island Lake, LG—La Grande, MRV—Minnesota River Valley, M—Marmion, NC—North Caribou, ON—Opinaca, OS—Oxford-Stull, OT—Opatica, P—Pontiac, Q—Quetico, RA—Rivière Arnaud, U—Uchi, WR—Winnipeg River, WW—western Wabigoon

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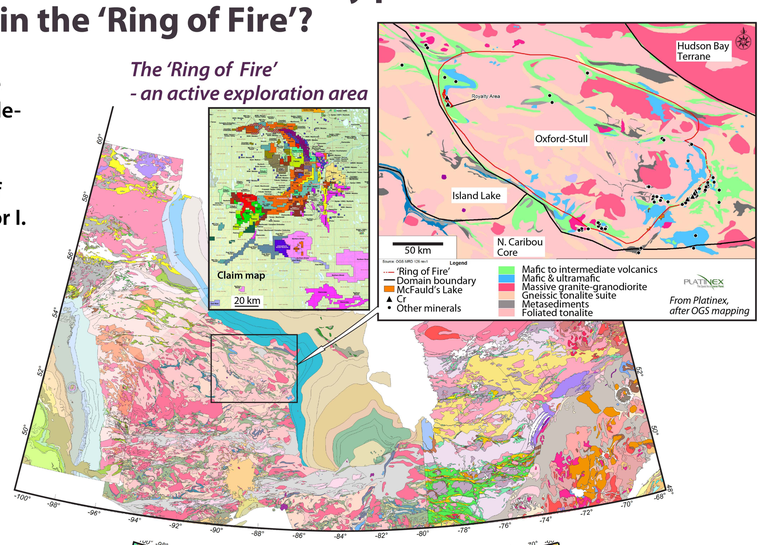
The reactivated Mesoarchean terrane boundary & sub-parallel, ca. N-S faults localize mineralization

Did a reactivated N-S Mesoarchean terrane boundary provide conduits for mantle-derived intrusions in the 'Ring of Fire'?

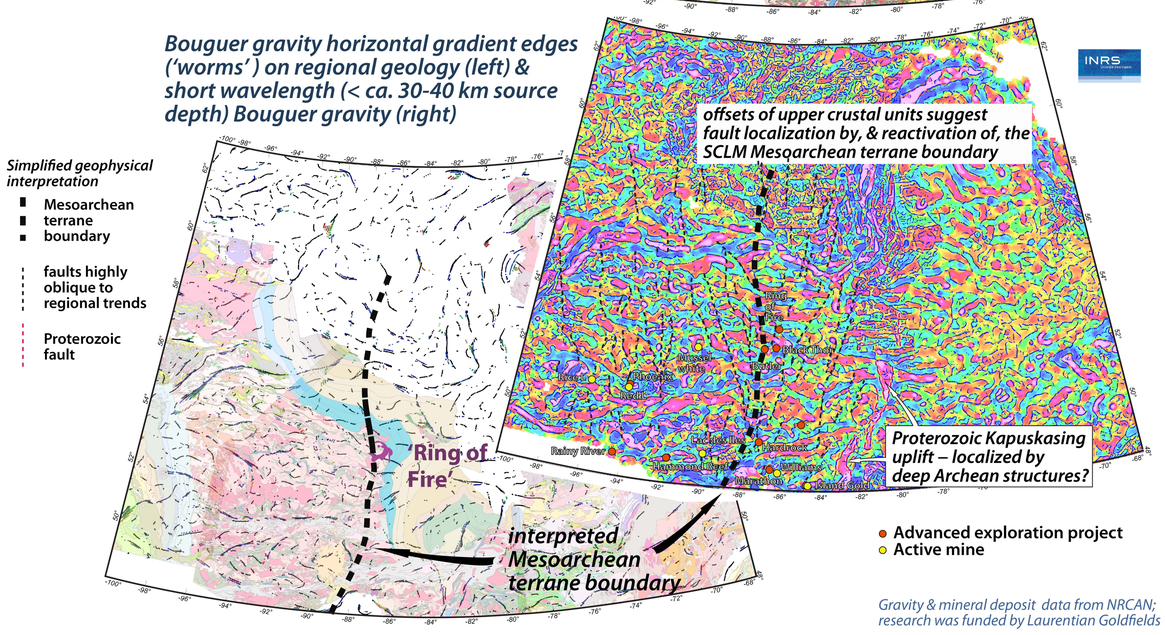
Cr-PGE, Fe-Ti-V, Ni-Cu-(PGE) mineralization in the 'Ring of Fire' in N Ontario is associated with mantle-derived peridotite & other large mafic to ultramafic intrusions in the 2828-2702 Ma McFaulds Lake greenstone belt, on the margin of the interpreted boundary between E & W Superior I.

- ***multiple intrusive events***
- ***emplacement along margins of a regional granodiorite intrusion***
- ***faults in granodiorite trend N-S, i.e. oblique to regional WNW-ESE trends but parallel to the Mesoarchean terrane boundary***

There is therefore the potential for similar intrusion-related mineralization along the margins of this & sub-parallel regional structures.



Bouguer gravity horizontal gradient edges ('worms') on regional geology (left) & short wavelength (< ca. 30-40 km source depth) Bouguer gravity (right)

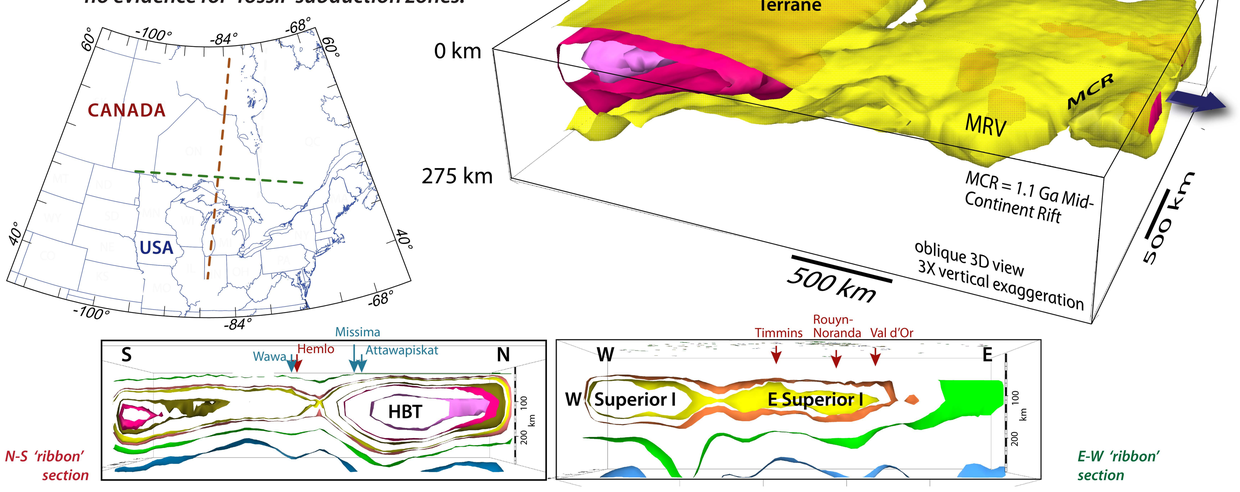


Gravity & mineral deposit data from NRCAN; research was funded by Laurentian Goldfields

Disaggregation & reassembly of the Superior craton

Tomographic evidence for rifting & disaggregation of the Superior I craton

Seismic tomographic dVs % isosurfaces portray Neoarchaean rifting of SCLM
- no evidence for 'fossil' subduction zones!



N-S 'ribbon' section

E-W 'ribbon' section

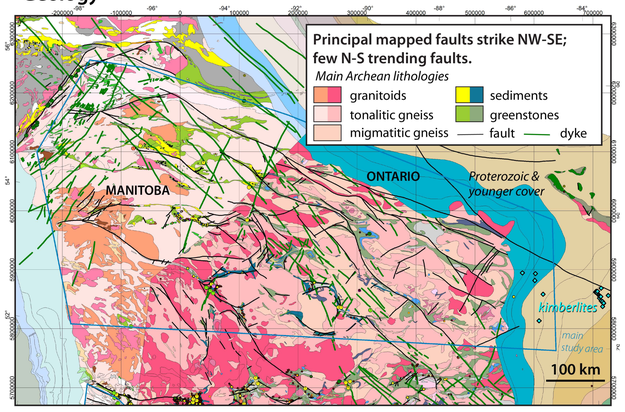
Major Au deposits (red) & kimberlites (blue) occur above SCLM rift / terrane margins

From:
Harris LB & Bédard JH (2014a) Crustal evolution and deformation in a non-plate-tectonic Archaean Earth: Comparisons with Venus. Evolution of Archean crust and early life, 215–291, Springer

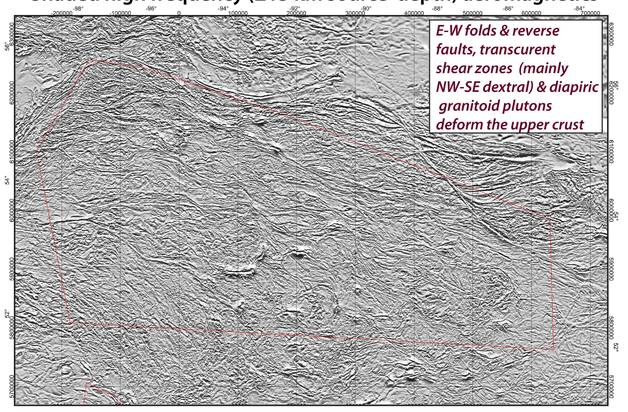
Deep ca. N-S faults localize mineral deposits in the NW Superior

– are they controlled by Mesoarchaean structures in reassembled, rifted 'ribbon continents'?

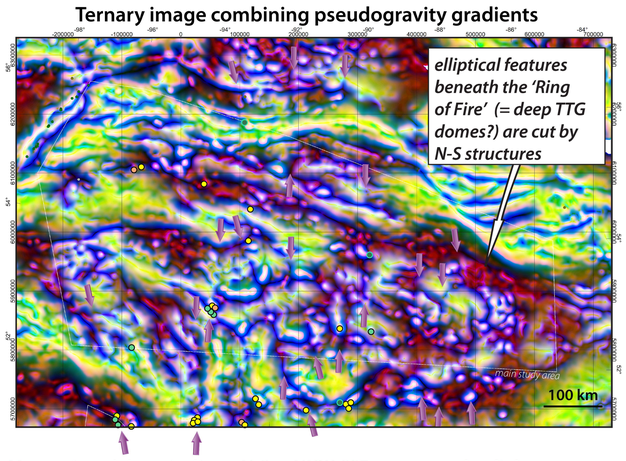
Geology



Shaded high frequency (≤15 km source depth) aeromagnetics

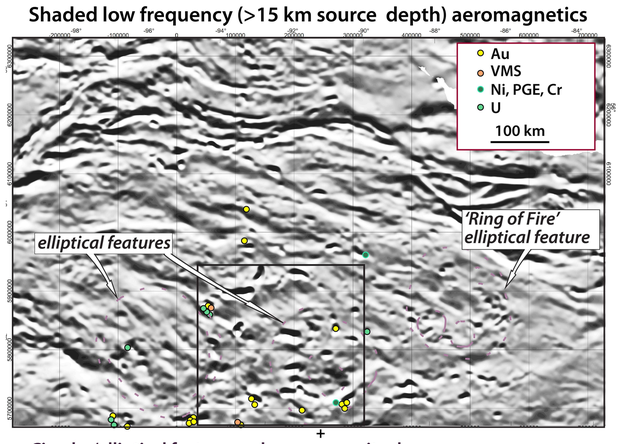


Ternary image combining pseudogravity gradients



Many mineral deposits lie on N-S to NNW-SSE structures that link across terrane boundaries
– extensional reactivation of deep (Mesoarchean?) structures during N-S shortening

Shaded low frequency (>15 km source depth) aeromagnetics



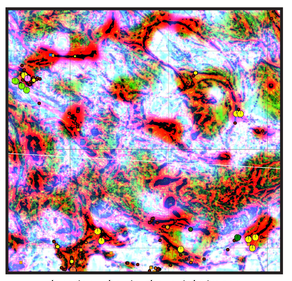
Circular/elliptical features = deep composite domes
– regional-scale vertical tectonics is important (the almost circular form of deep domes suggests possible decoupling from upper crustal deformation)

Combined enhanced gravity & aeromagnetics highlight prospective areas

Mineral deposits lie within areas of coincident positive gravity & magnetic anomalies, commonly near margins to regional domes
- greenstones coincident with gravity highs (red) are black in image

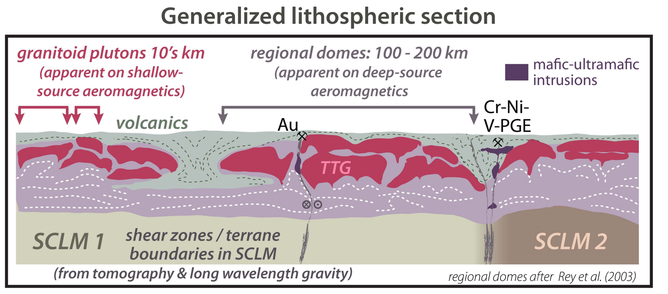
Are gravity anomalies due to deep mafic intrusions along early lithospheric structures?

100 km



location = box in above right image

Generalized lithospheric section



Tectonic model

– disaggregation & reassembly without plate tectonics

The W Superior craton of Canada is widely considered to be a tectonic collage accreted N-S by multiple coeval subduction zones. We propose an alternative non–plate tectonic scenario:

1. Partial disaggregation of a heterogeneous older (Superior I) craton in response to a mantle overturn event that started at ca. 2780 Ma; continental fragments are not exotic.

SCLM—subcontinental lithospheric mantle (purple);
orange-pink—older crustal rocks;
red patches—reworked older felsic crust
TTG—tonalite-trondhjemite-granodiorite;
HB—Hudson Bay terrane or Northern Superior block;
MRV—Minnesota River Valley terrane.

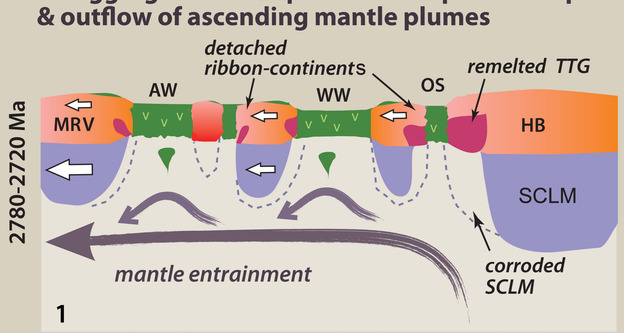
Where older continental blocks rafted apart completely, isotopically juvenile oceanic tracts formed
(dark green; AW—Abitibi-Wawa terrane,
WW—western Wabigoon Subprovince, OS—Oxford-Stull domain)
without interacting with any older lithosphere.
Synrift volcanic rocks (green, v pattern) **are locally preserved above older cratonic blocks.**

Flow patterns in mantle are inspired by Faccenna and Becker (2010; Nature, v. 465, p. 602–605)

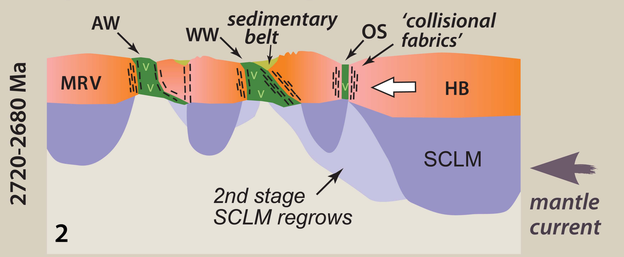
2. Reassembly of ribbon continents detached from Superior I & intervening oceanic tracts in response to southward drift of the deep-rooted Hudson Bay terrane.

Accreted terranes are imbricated ahead of the drifting continent, & the SCLM regrows to weld the blocks together.

Disaggregation of Superior I in response to upflow & outflow of ascending mantle plumes



Reassembly of ribbon continents detached from Superior I & intervening oceanic tracts



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