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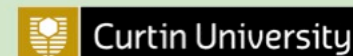


Archean SCLM: What do we (think we) know?

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(CCFS)***

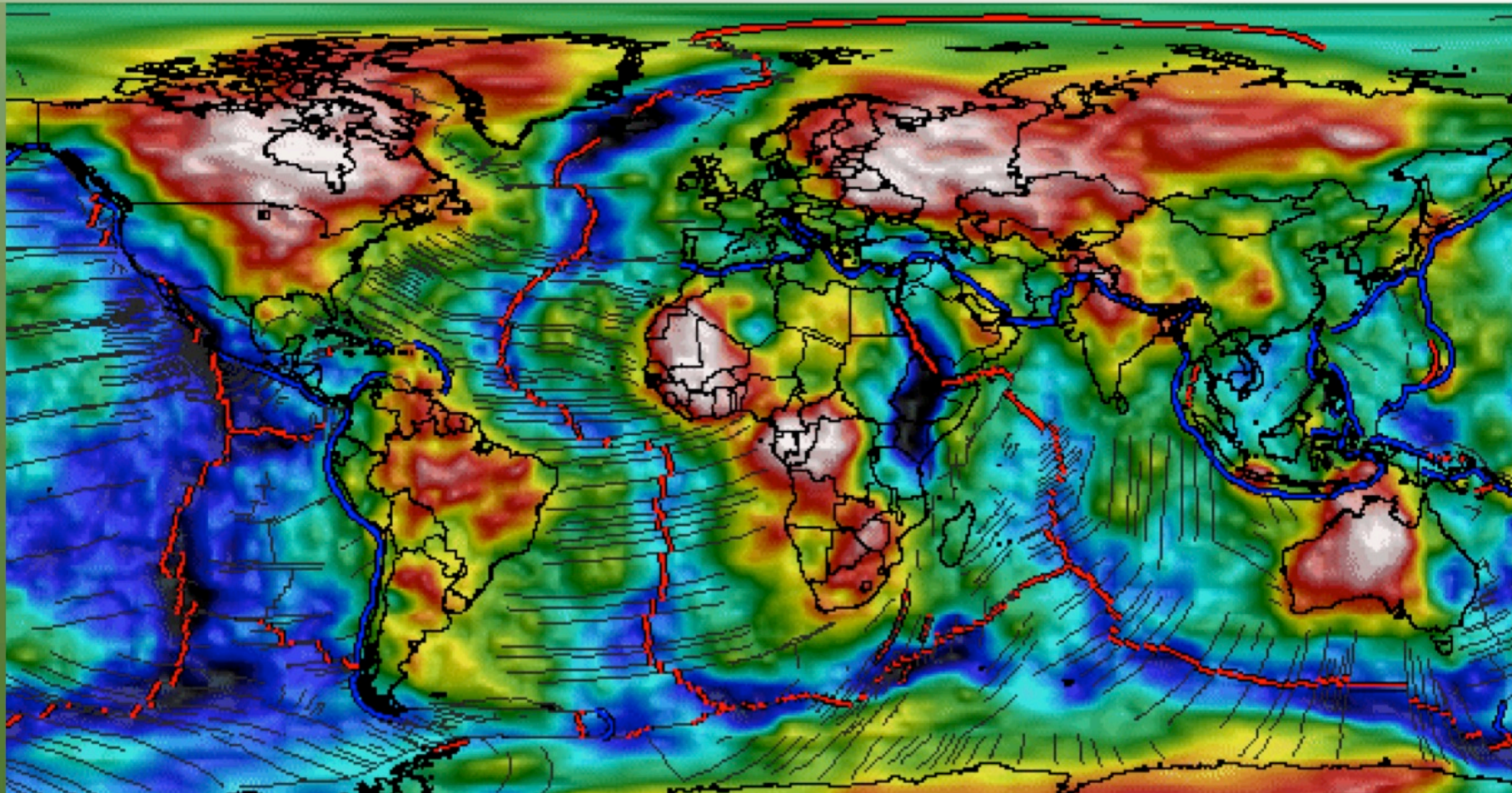


What is the Sub-Continental Lithospheric Mantle (SCLM)?



- **Non-convecting uppermost mantle formed**
 - ★ as partial melting residues
 - ★ by cooling of upwelling asthenosphere
 - ★ by plume accretion to existing lithosphere
- **Depleted in basaltic components, then *overprinted by metasomatic processes* -- geochemically complex**
- **Base of depleted SCLM = Lithosphere-Asthenosphere Boundary (LAB) -- recognisable chemically, ?seismically**
- **Temperature at LAB \approx 1200-1300 °C**

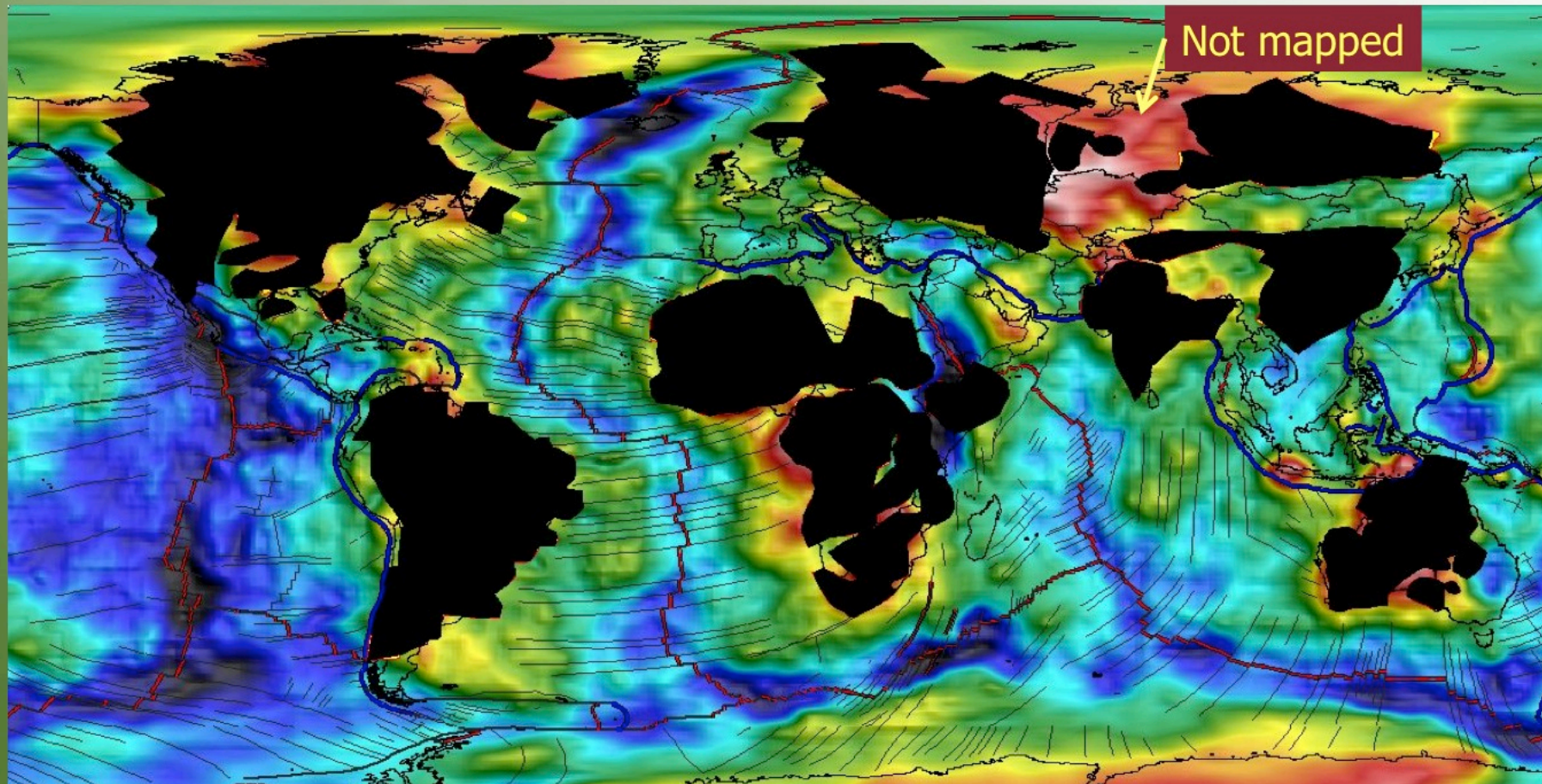
Global Vs tomography shows old SCLM



V_{SH} seismic velocity (Grand, 2002), 100-175km depth range (Red=fast; Blue=slow)

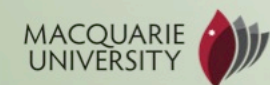
High velocity roots = minimum extent of highly depleted (generally old) SCLM

SCLM with Archean Heritage



We have mapped ~70% of the continental area so far....

Around 70% of ALL SCLM seems to be **Archean**

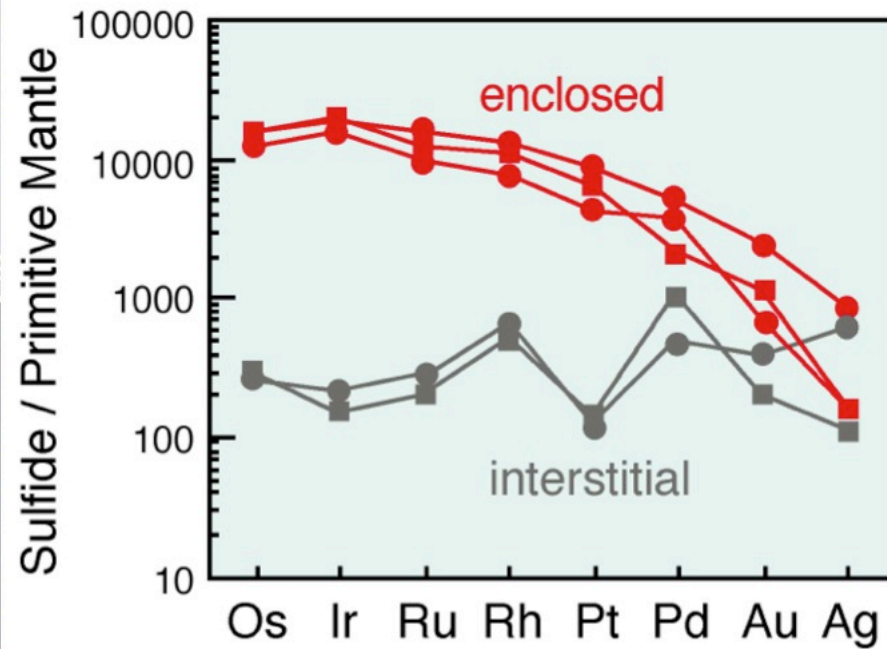
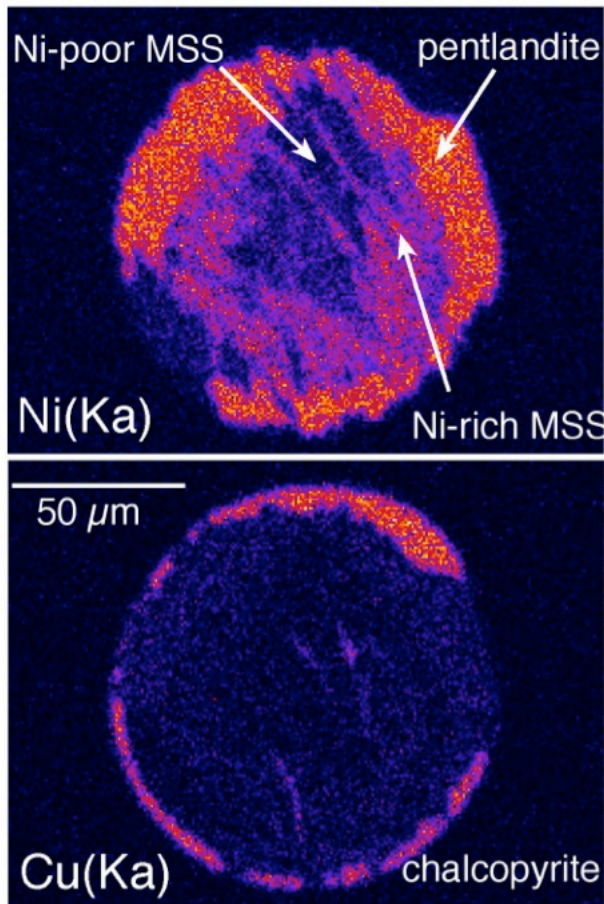


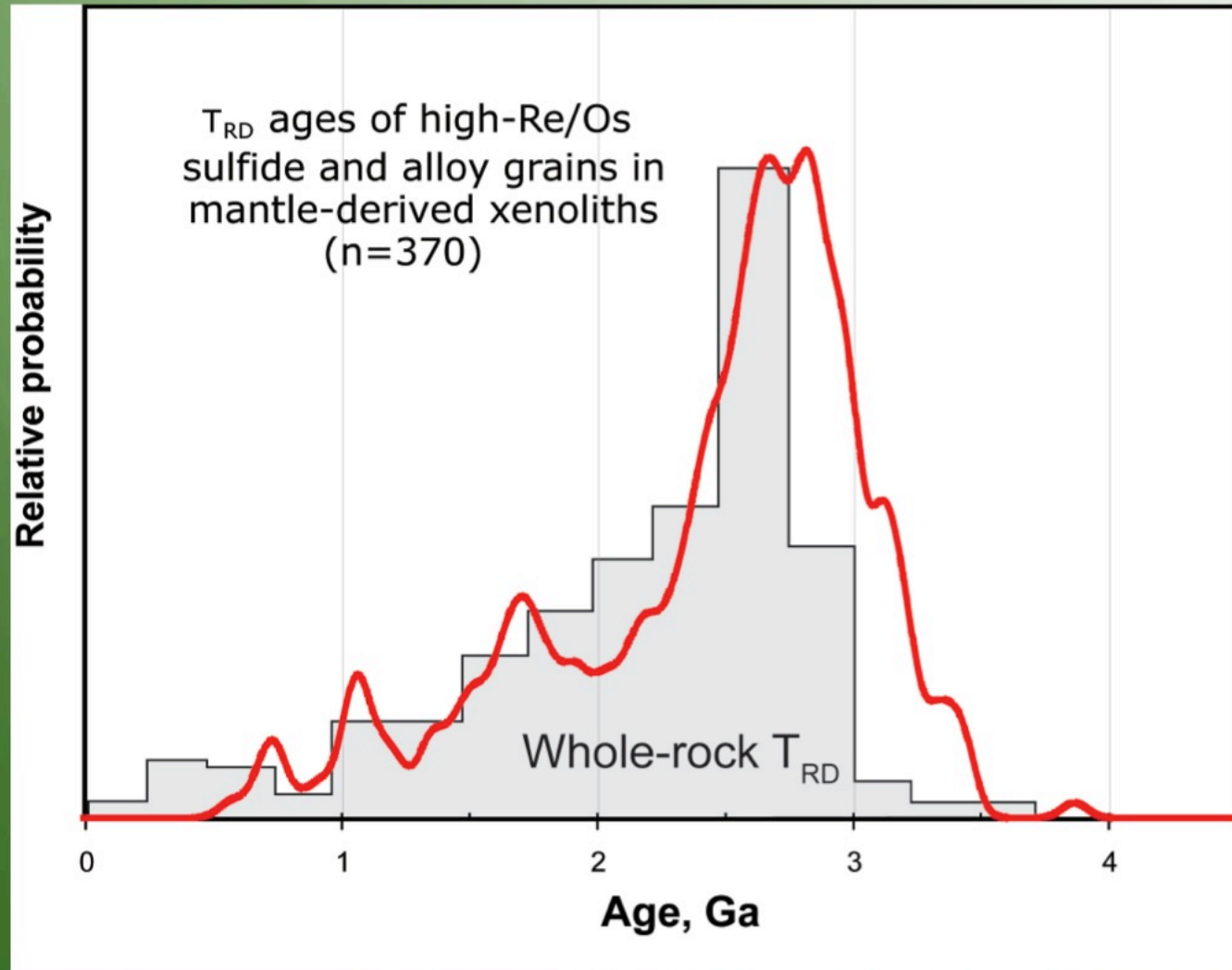
What do we *need* to know about the Archean SCLM?



- **Age – relative to crust, etc. One hit, or a long process?**
- **Composition – bulk; stratification?**
- **Origin – subduction, or what?**
- **Tectonic effects – what changed once we had an SCLM, and why?**

LAM-MC ICP-MS mantle sulfides – enclosed





SCLM age=

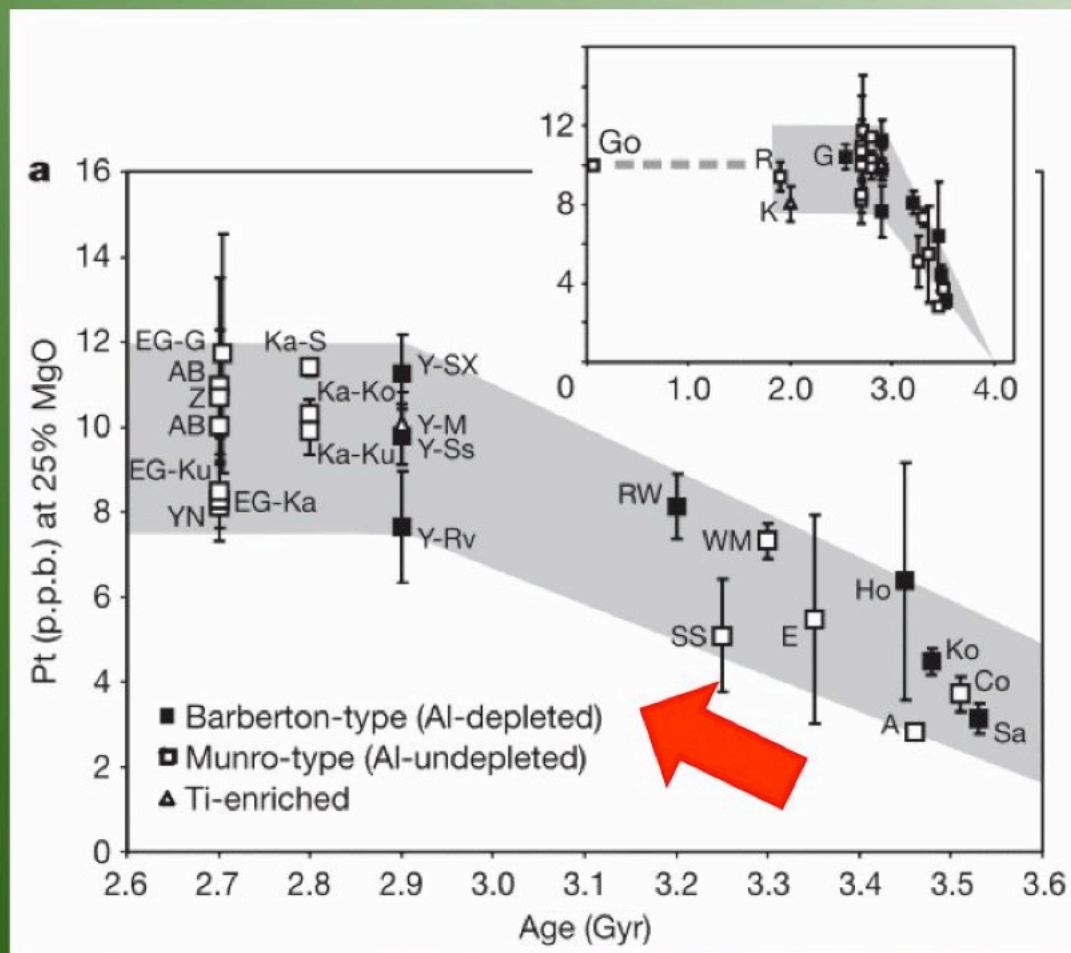
3 ± 0.5 Ga

Griffin et al,
Lithos 189, 2014

Whole-rock model ages = minimum values, because of mixing >1 sulfide generation – but overall agreement on the oldest T_{RD}



How old is the SCLM? PGE contents of komatiitic magmas



Variations in the PGE content of komatiites through time indicate that the mantle was homogenised between 3.5 and 3.0 Ga.

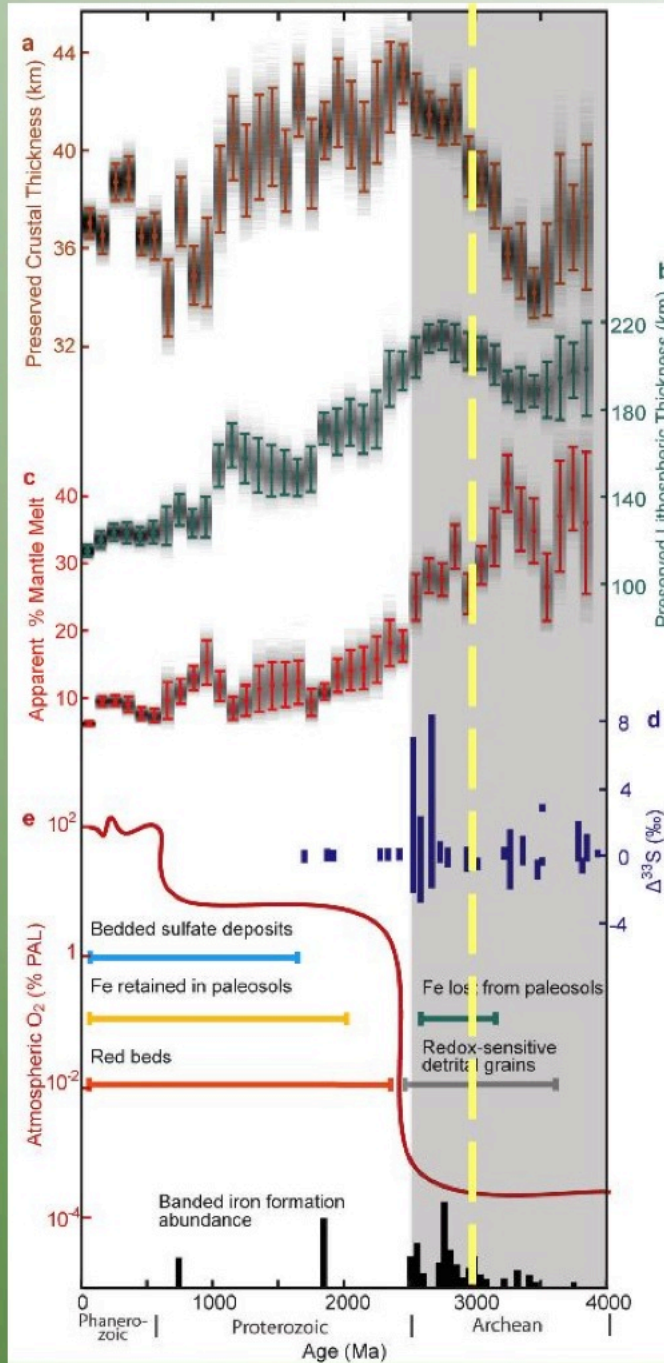
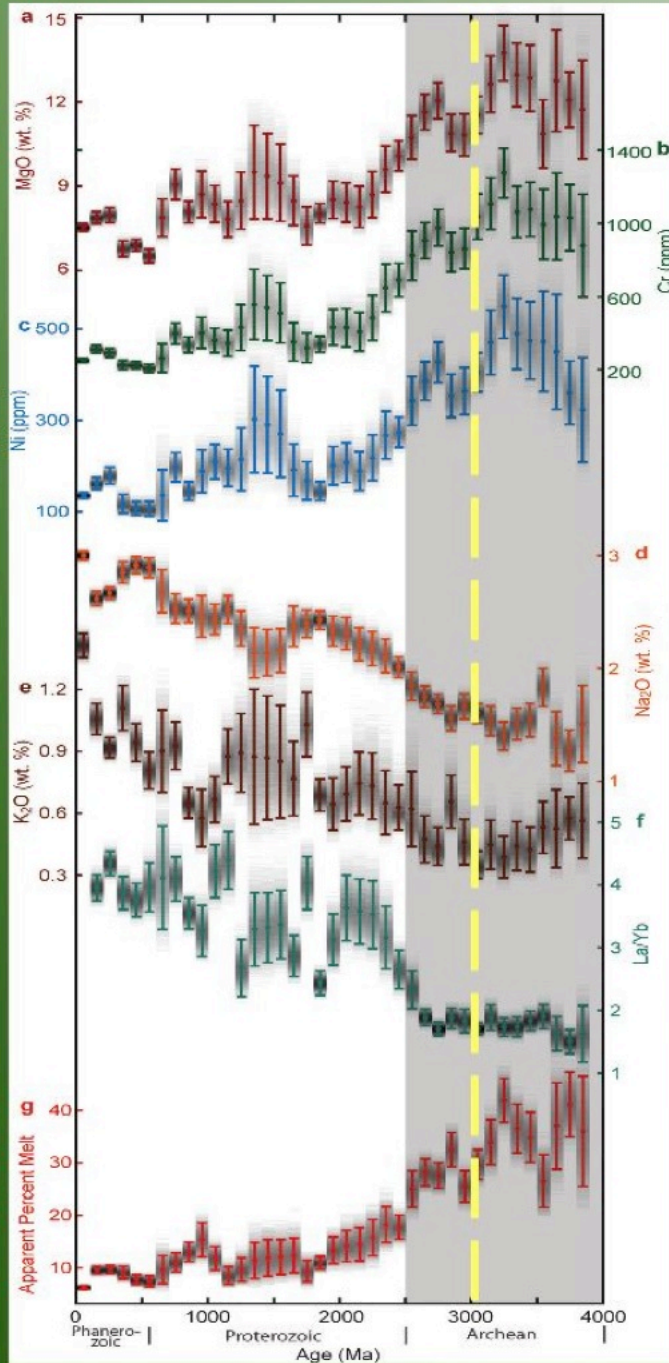
Consistent with stirring of the mantle by a burst of deep-sourced plumes between 3.5-3.0 Ga (Major Mantle Overturn)

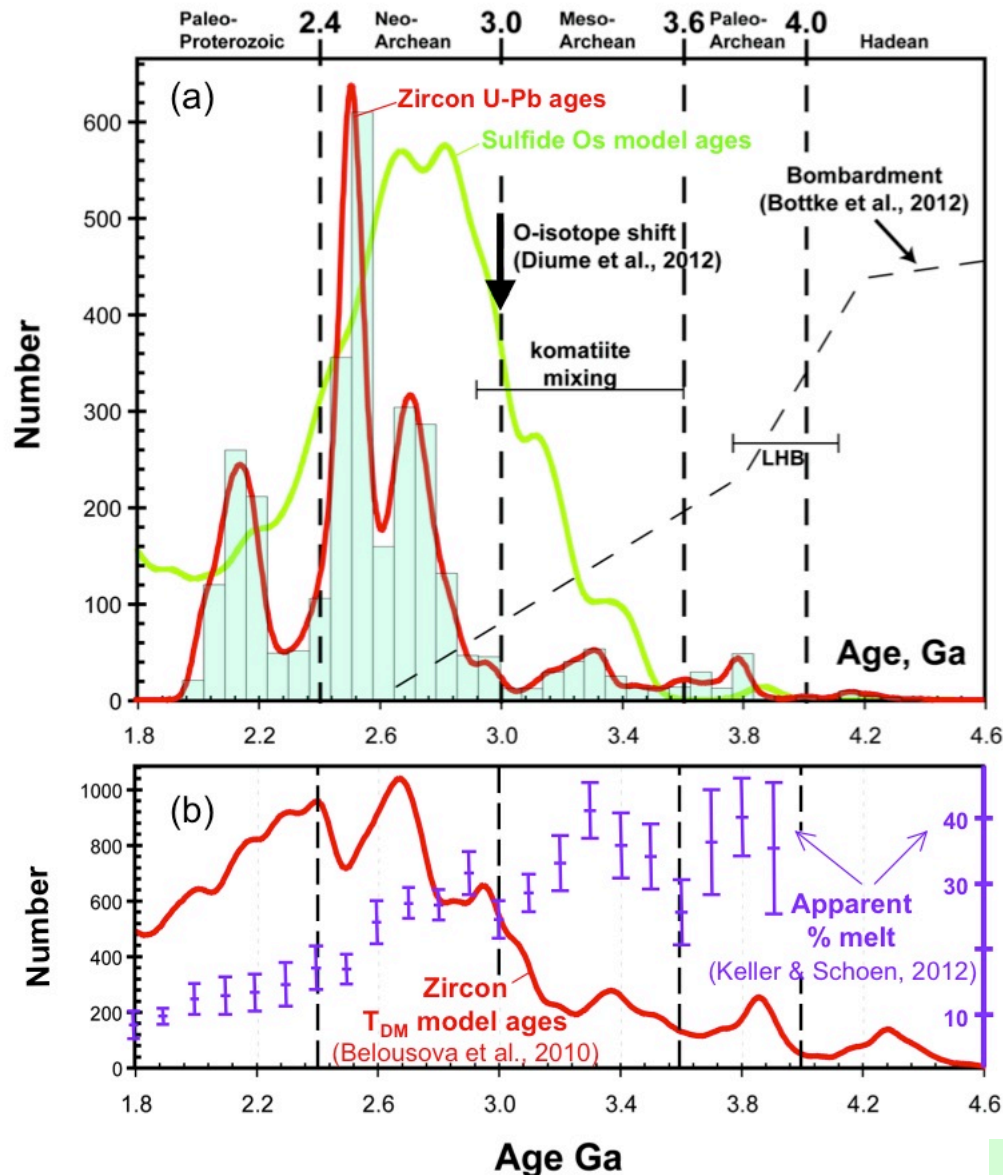


Keller & Schoene
Nature 5/2012

Major changes in
chemistry/origin of
mafic rocks, and
crustal dynamics,
at 2.5 Ga ----

Or by 3 Ga?





Summary: Linked Evolution of SCLM and continental crust

-- SCLM formed mainly 3.5-3.0 Ga – massive overturns, mixing – buoyant because of Fe removal

Provided basis for continents, “modern” plate tectonics (and Archean pseudo-plate tect.)

4-fold division of Archean (4.0-2.4 Ga)/Hadean?

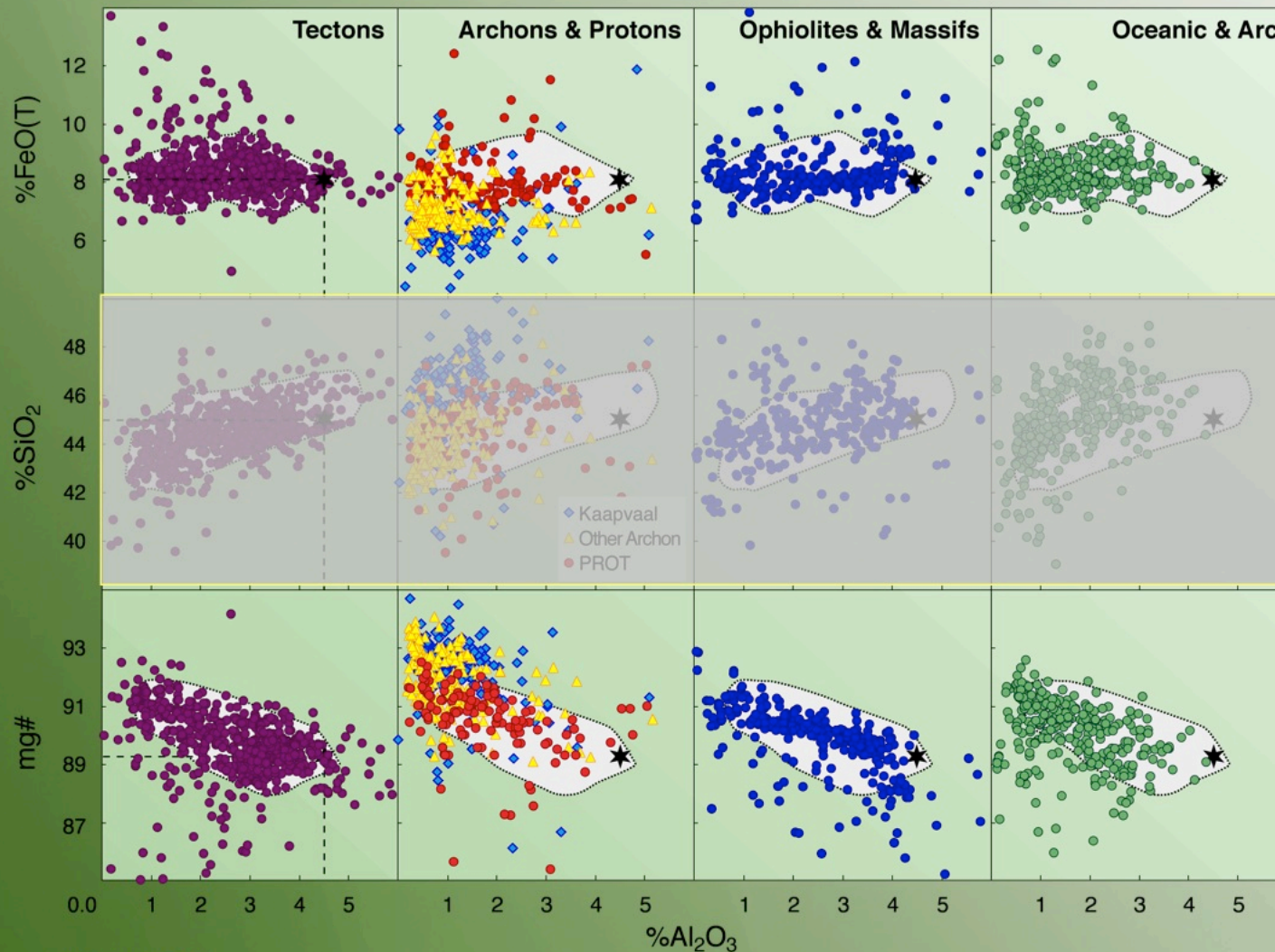
“Pristine” Archean SCLM: More depleted than we think?



Gusdal quarry
and Ugelvik gnt
peridotite,
Norway

- Western Norway:
huge bodies of
dunite/harzburgite
- Zones of garnet
lherzolite \pm eclogite
- Re-Os: dunites are
Archean, lherzolites
are *Proterozoic*
- *Refertilisation*
process -- an
analogue for most
Archean SCLM?

Archean SCLM's unique Fe depletion -- a signature of high-P melting?



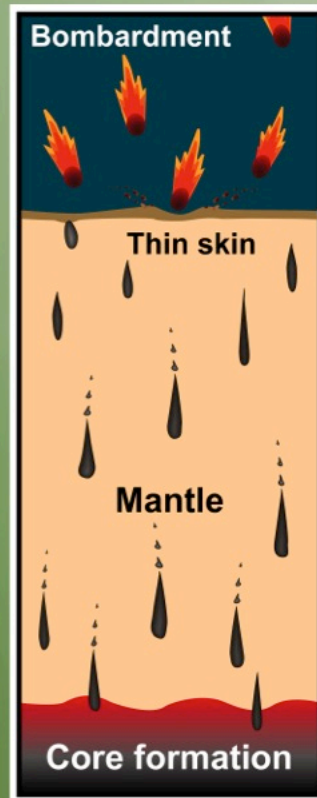
Young
peridotites have
FeO = 8±1% at
any degree of
depletion

*Shallow melting
processes.....*

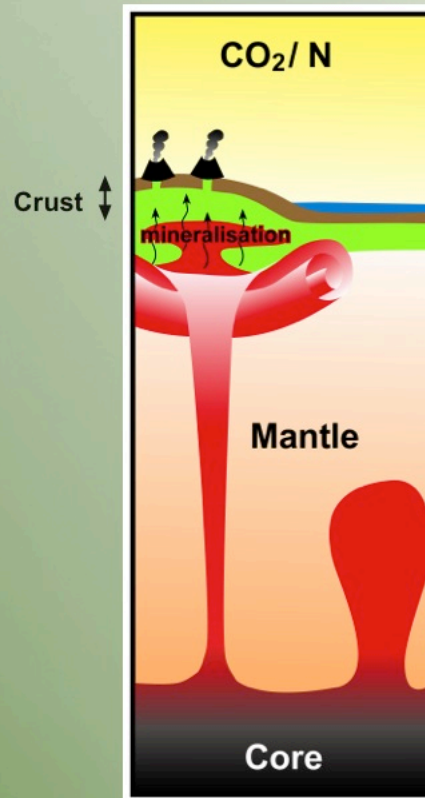
Most **Archon**
SCLM lower-Fe

High-P melting !

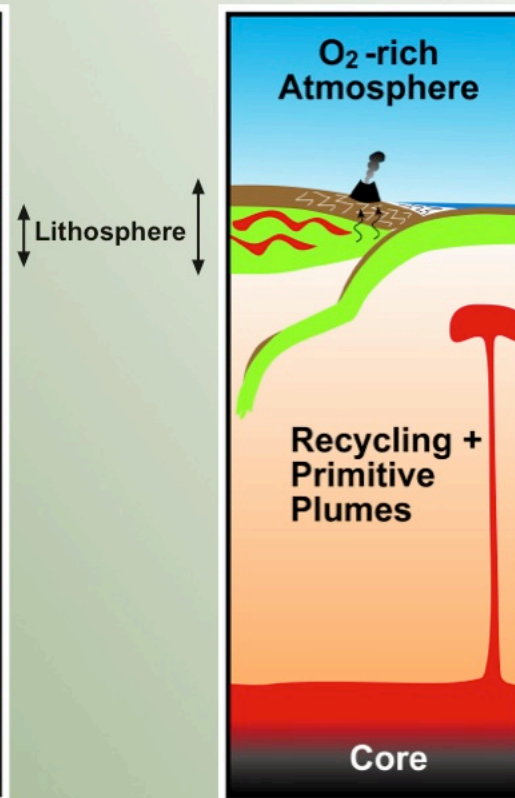
SCLM -- An Archean Genesis



- Early Earth**
- no stable SCLM
 - little preserved crust



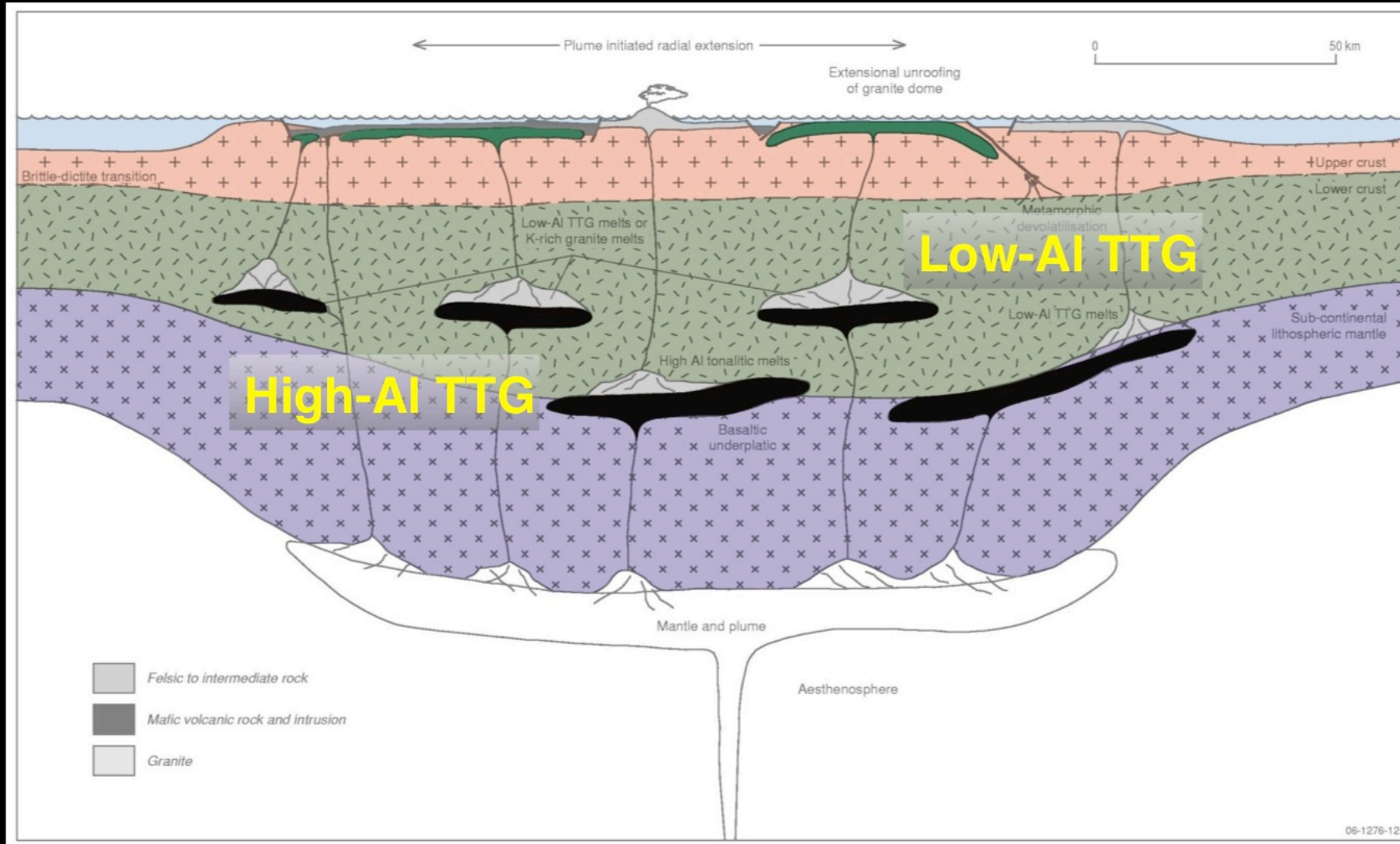
- Archean (3.6-3.0 Ga)?**
- mantle overturns form stable SCLM
 - some subduction?



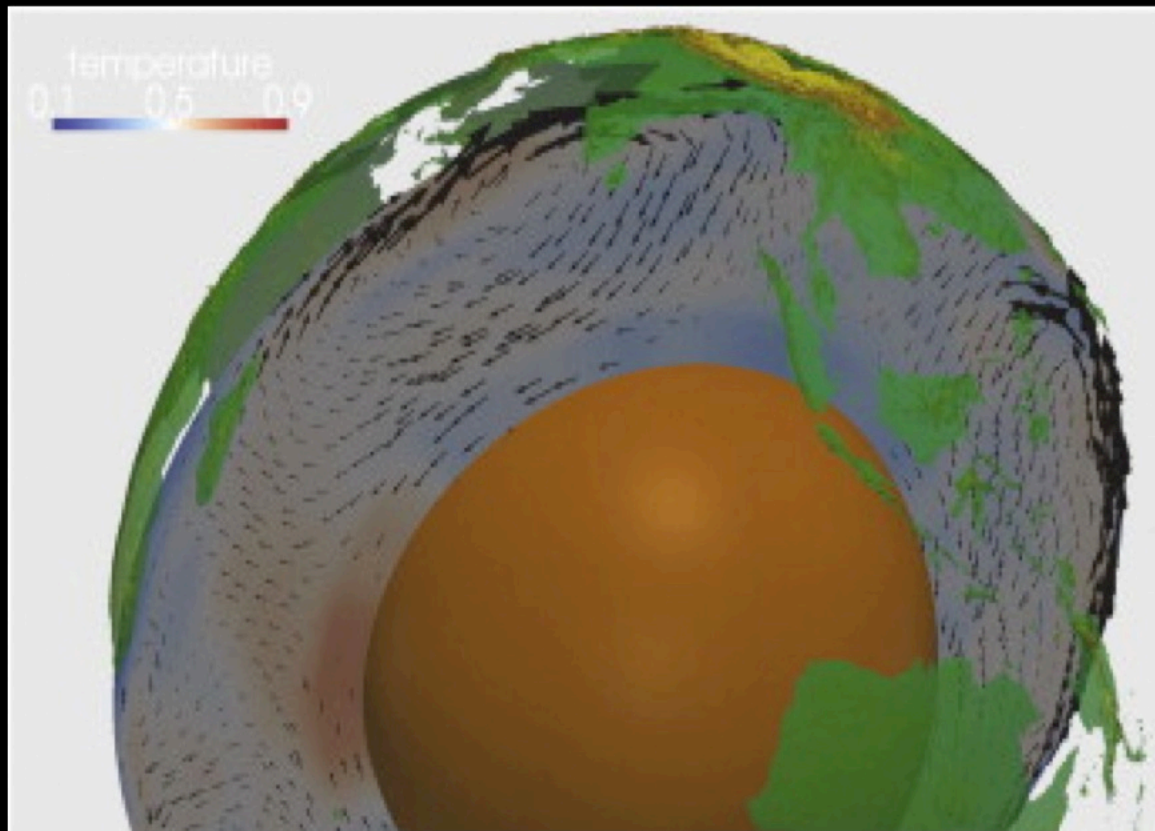
- Present Day**
- subduction
 - steady-state recycling
 - no stable SCLM formed



Most robust hypothesis is Plateau model of craton formation



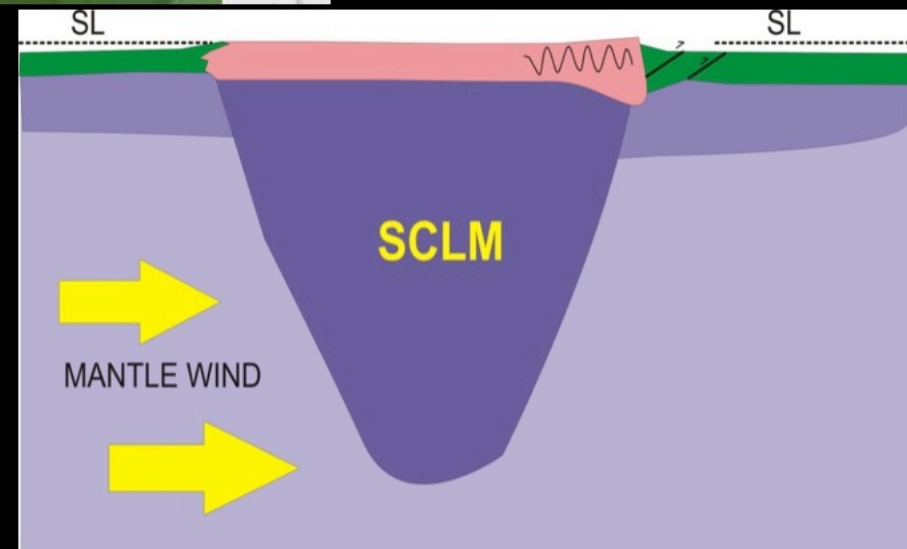
Champion & Smithies, 2007. *In: Earth's Oldest Rocks*



If continents with deep lithospheric roots migrate due to mantle traction, subduction is not needed to explain terrane accretion & orogenesis !

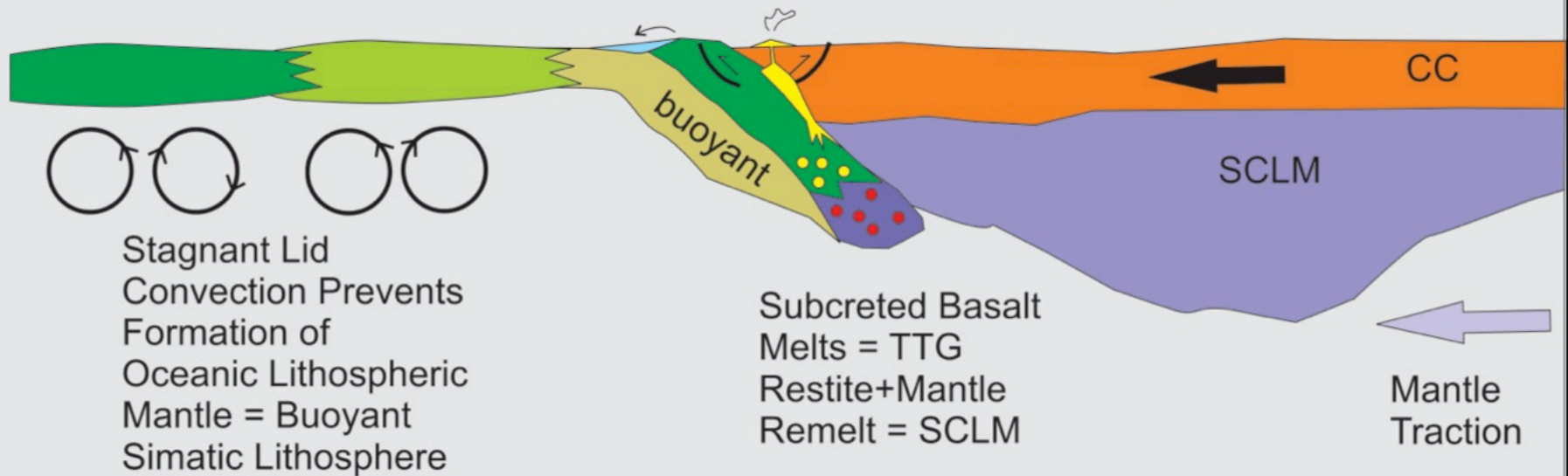
Becker & Facenna, 2011, EPSL
 Alvarez 2010, EPSL

So if the SCLM is of Archaean age, then Cratons would have started drifting in the Archaean !

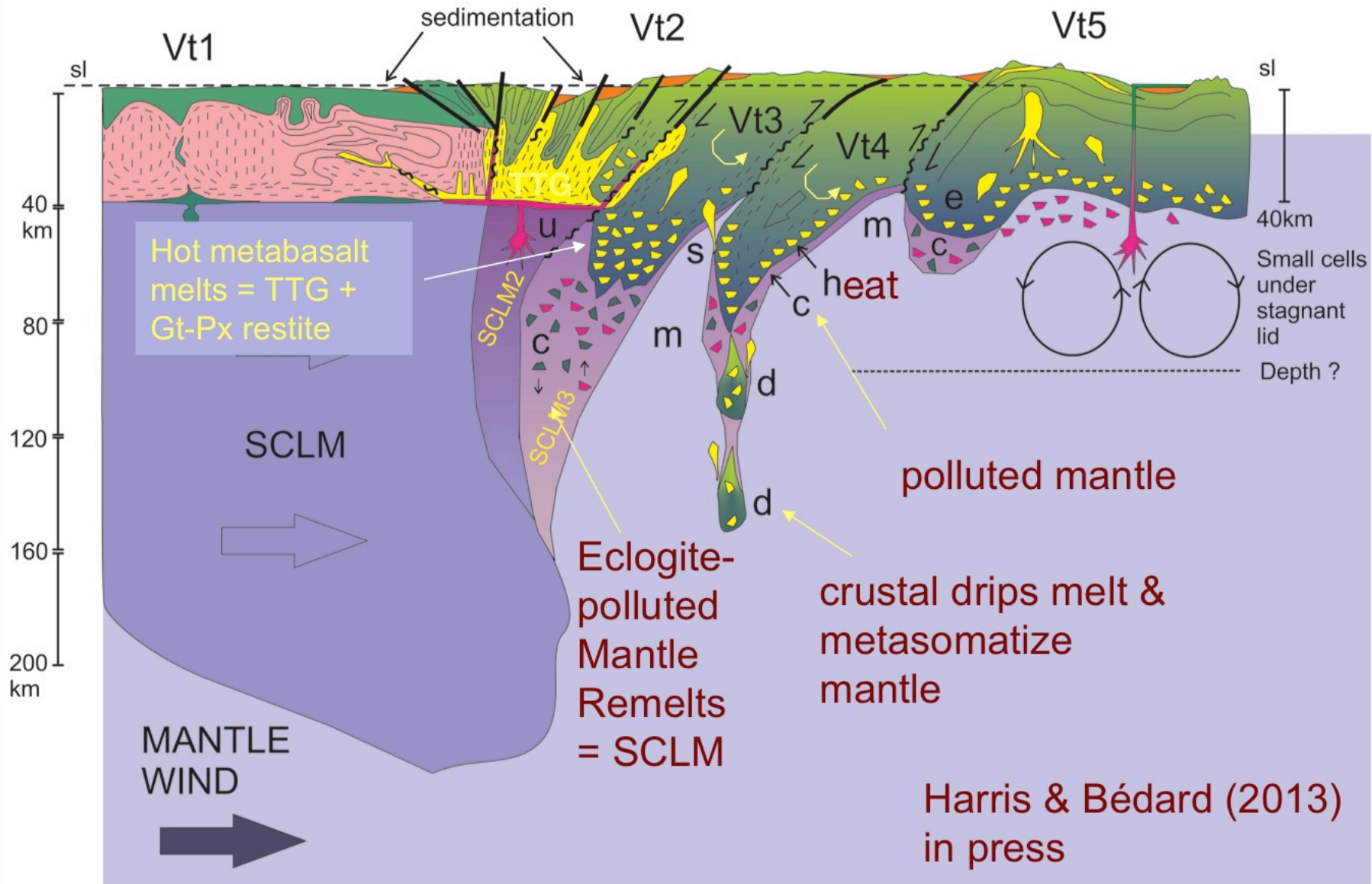


Archaean Continental Drift
Causes Accretion of Buoyant Oceanic
Plateau Type Crust. Transient
Tectonic Relief Feeds Sedimentary Belts

Archaean Continental
Crust Has No
Relief (Too Soft)



Harris and Bédard 2013 in press

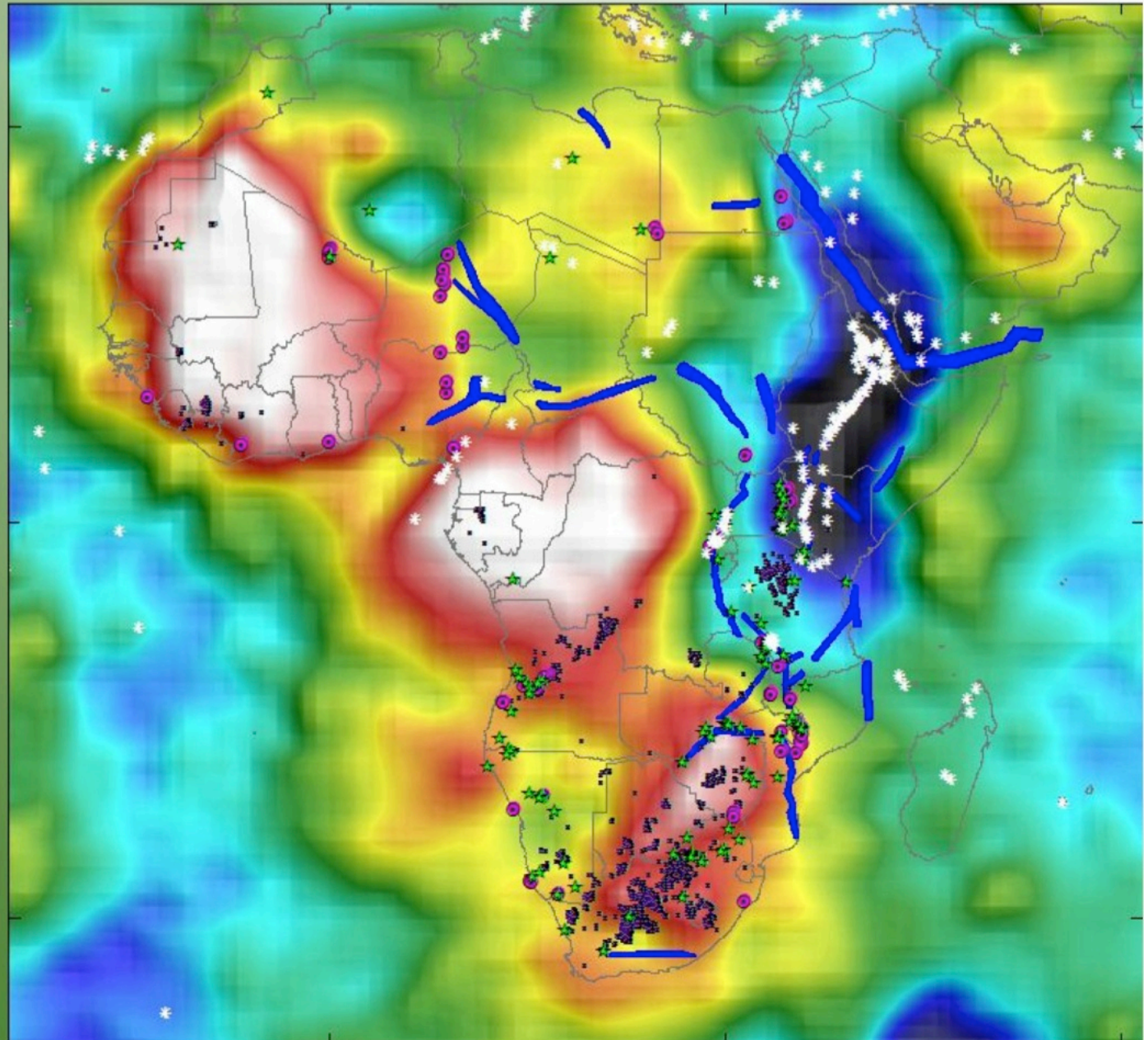


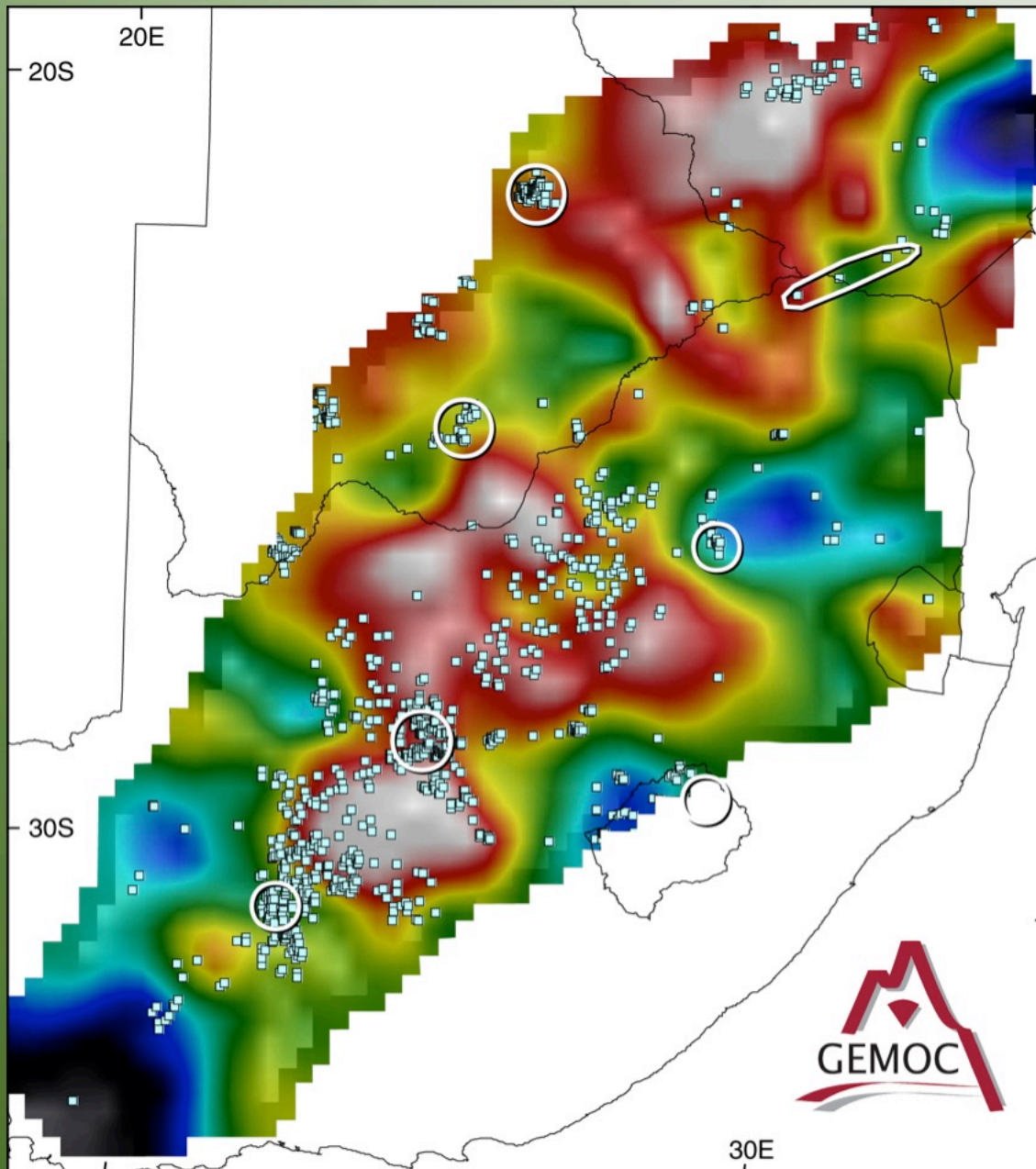


SCLM Control on Rifts and Alkaline Magmas

Cratonic margins act as focal point

Squares = Kimberlites
Stars = Carbonatites
Circles = Syenites
Polygons = Rifts





Detailed Vs model
200±50 km

Fouche et al. 2004

+ kimberlites

Kimberlites cluster
around high-Vs domains
-- no samples of these
depleted cores

Circles -- best xenolith -
xenocryst suites:
sampling refertilised low-
Vs SCLM

Griffin et al., J Pet 2009

Conclusions: Archean SCLM



- Primitive Archean SCLM is much more depleted than estimates from xenoliths -- inconsistent with shallow origin
- Most (all?) formed >3 Ga ago, by deep high-degree melting
- Archean lithosphere (lower crust and SCLM) is much more widespread laterally and vertically than previously thought
- It is (virtually) indestructible, and the bulk of continental volume is built up of domains accumulated (and separated, and rejoined) over Earth history since ca 2.5 Ga
- **The boundaries of these domains serve as pathways for mantle-derived melts/fluids, and become metasomatically enriched in elements that can be remobilized to generate ore deposits**