Sublithospheric diamonds and where to find them

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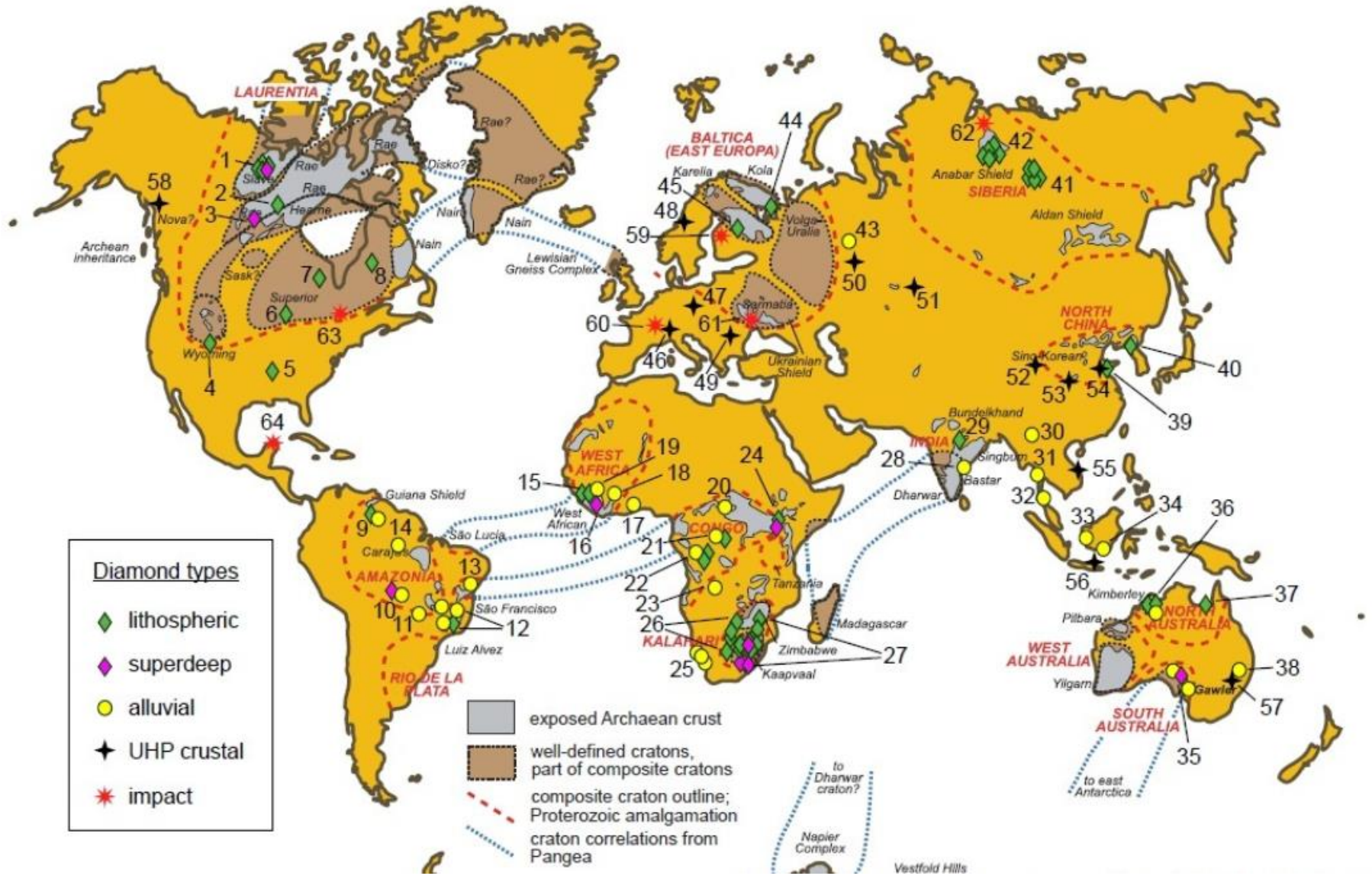
Diamond mine locations

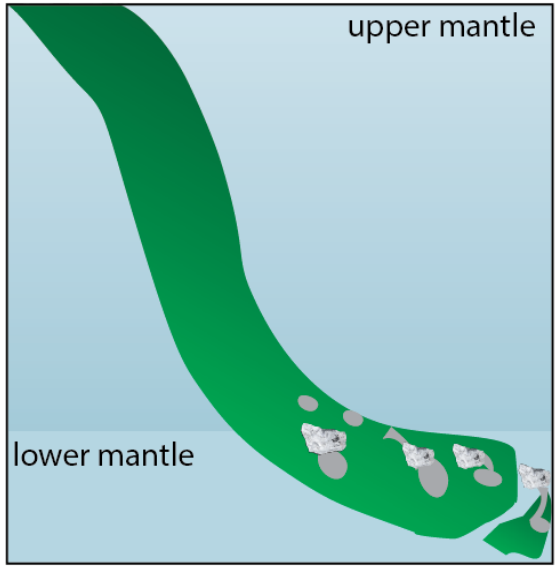


Shirey et al. 2013

Sublithospheric diamonds

CLIPPIR
Type IIa

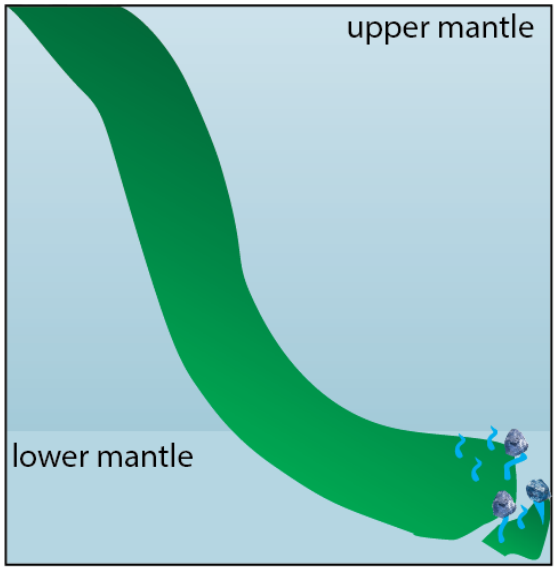
Metallic liquids



Smith et al. 2016, 2021

Type IIb
Type IIa

Hydrous fluids

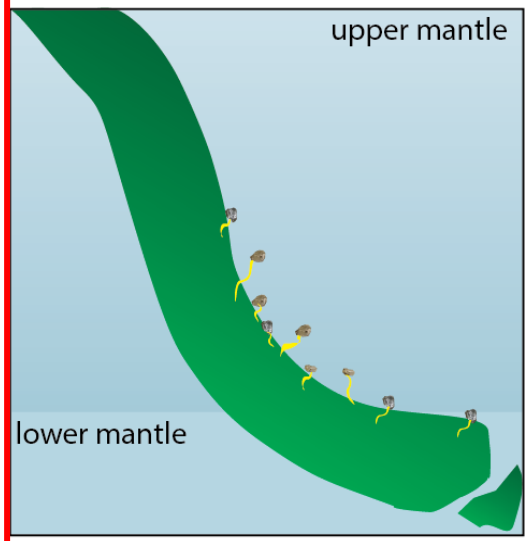


Smith et al. 2018

Sublithospheric diamonds

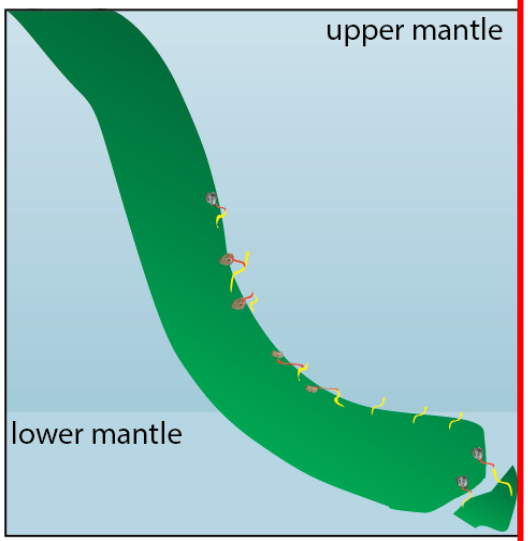
Type IaB
Type IIa

Carbonatitic fluids



Rohrbach and Schmidt 2011; Thomson et al. 2016

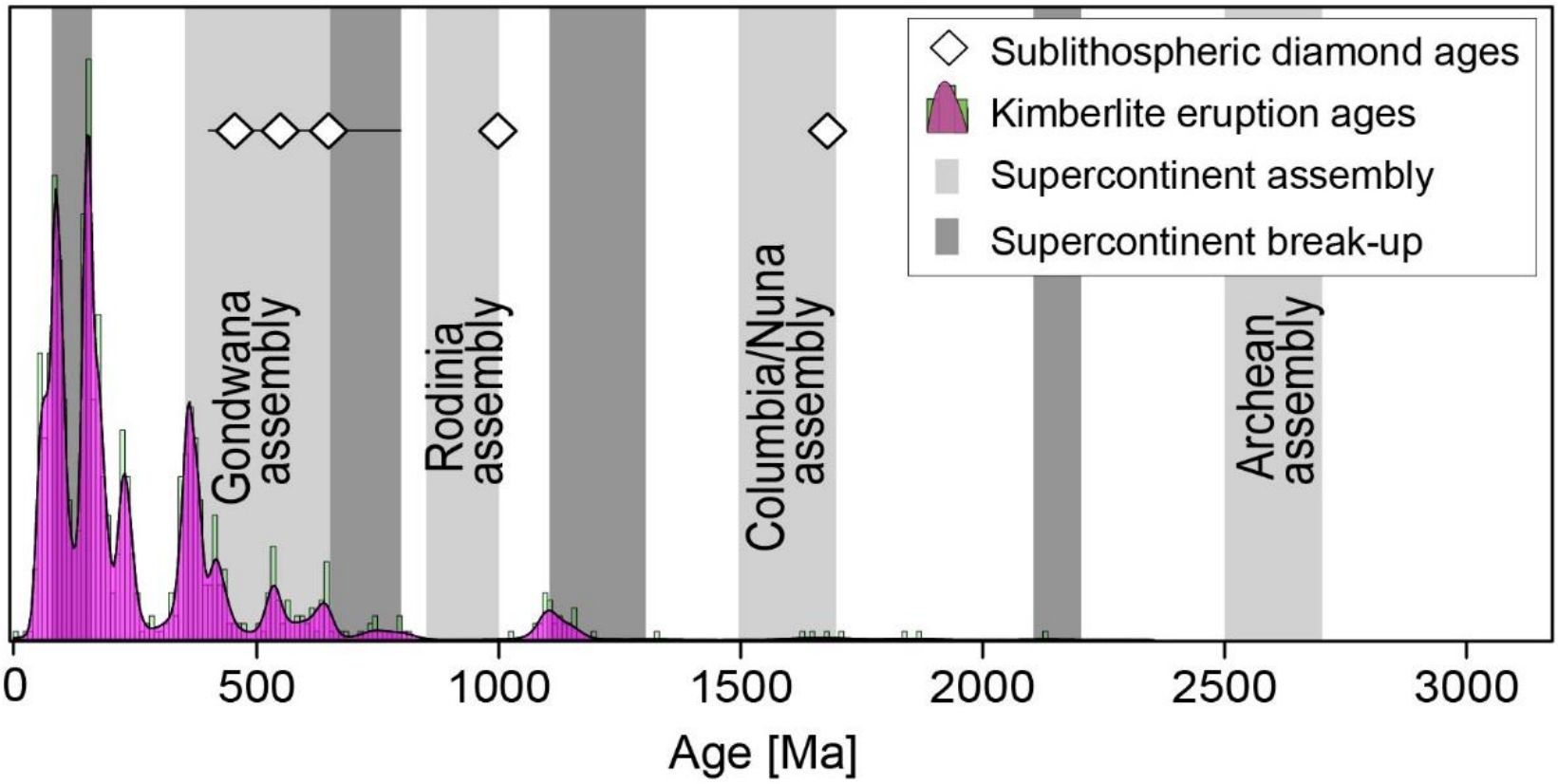
Carbonated fluids



Girnis et al. 2022

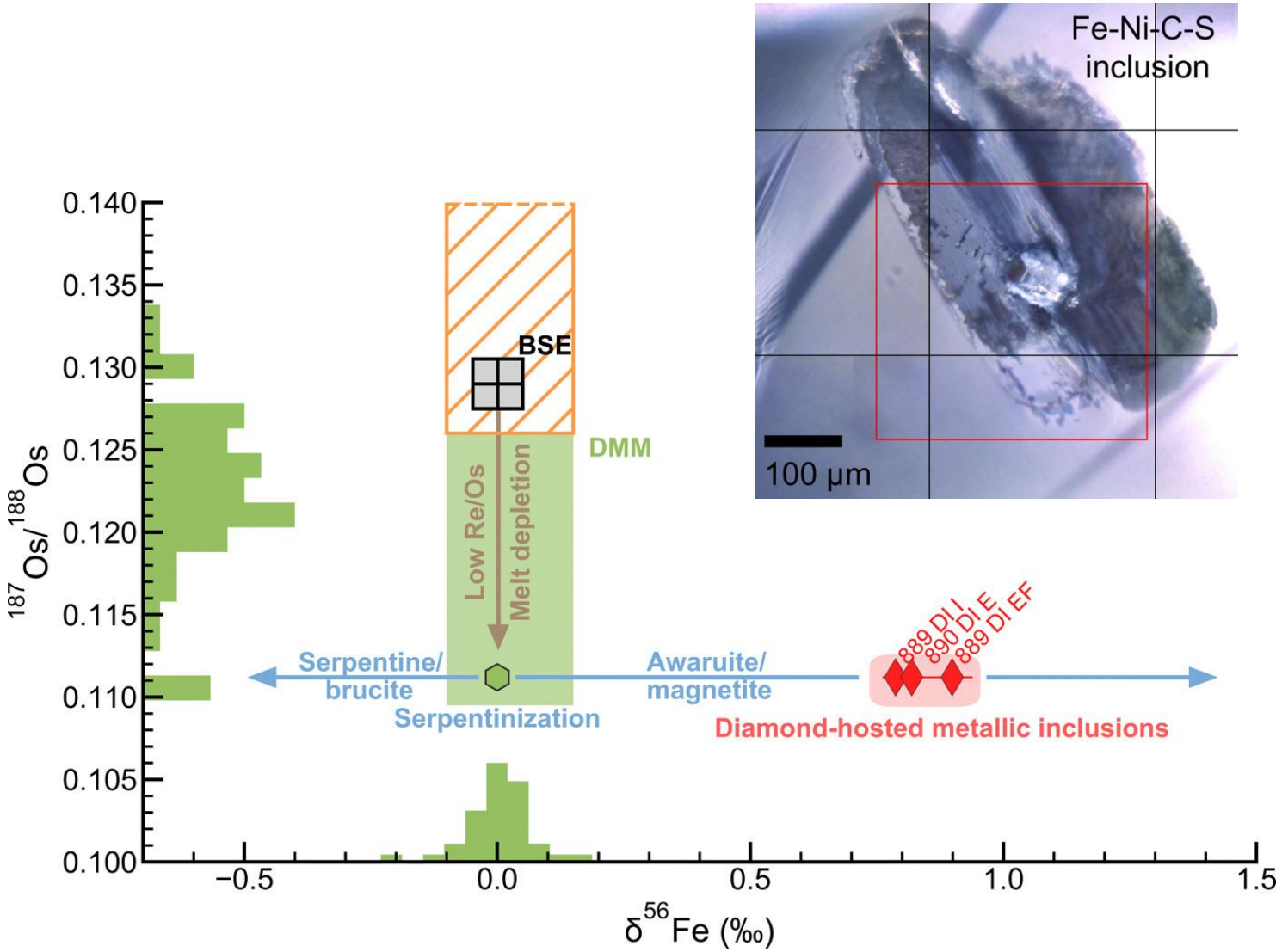
Sublithospheric diamond ages

Carbonatitic association only!



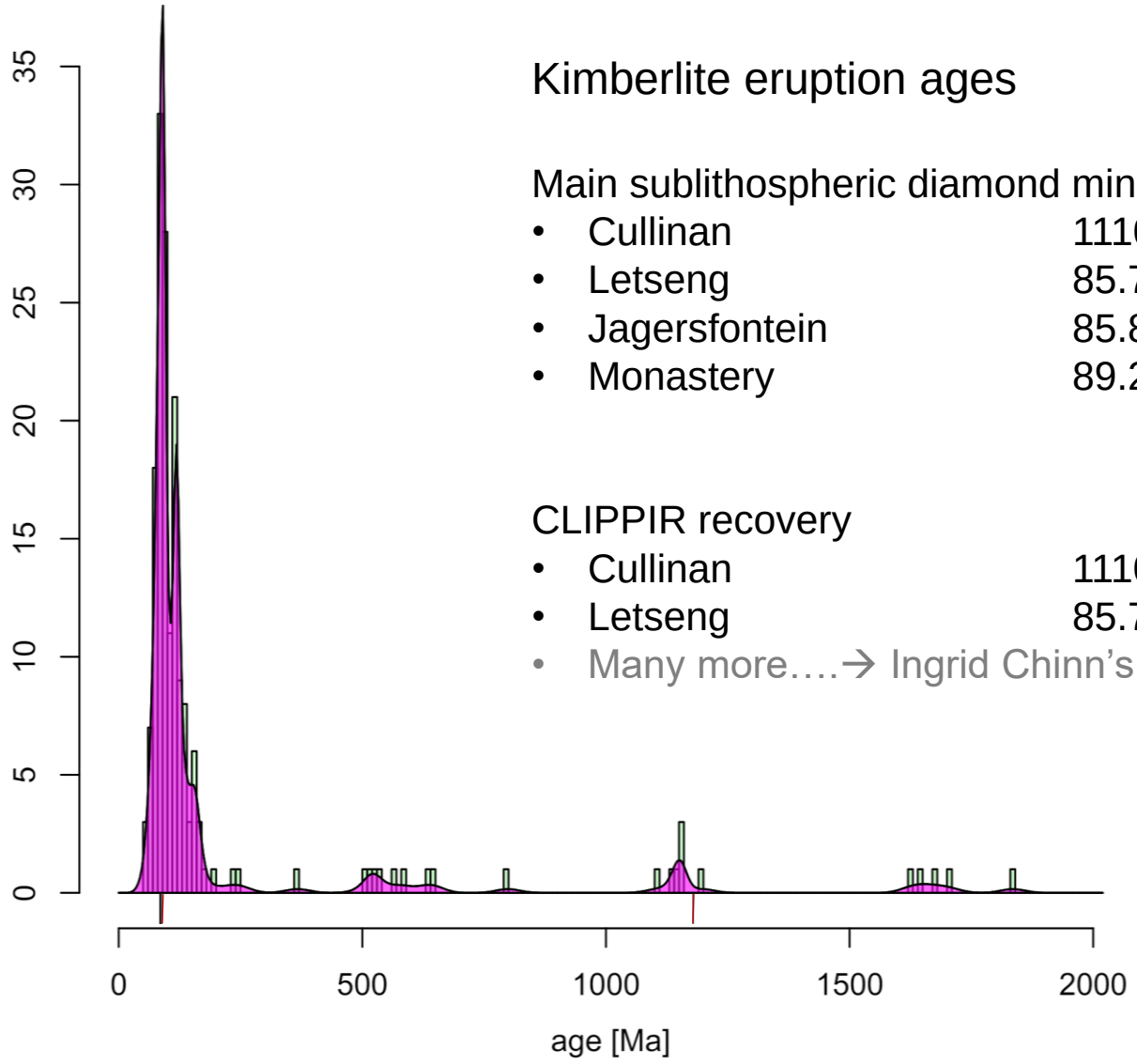
Timmerman et al. 2024 IKC; with data from Timmerman et al. 2023; Zhang et al. 2024; Condie 2015; Heaman et al. 2019

Application to Type II/CLIPPIR



Smith et al. 2016; Smith et al. 2021

Application to Type II/CLIPPIR



Kimberlite eruption ages

Main sublithospheric diamond mines in Kalahari craton

- Cullinan 1110-1200 Ma
- Letseng 85.7 Ma
- Jagersfontein 85.8 Ma
- Monastery 89.2 Ma

CLIPPIR recovery

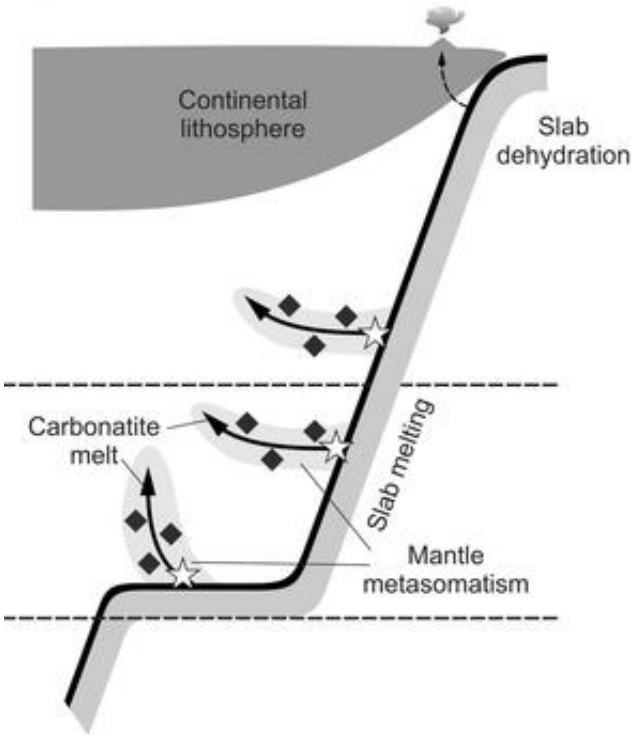
- Cullinan 1110-1200 Ma
- Letseng 85.7 Ma
- Many more….→ Ingrid Chinn's seminar

Heaman et al. 2019; Smith et al. 2021

Old models of superdeep diamond ascent

Deep melts model

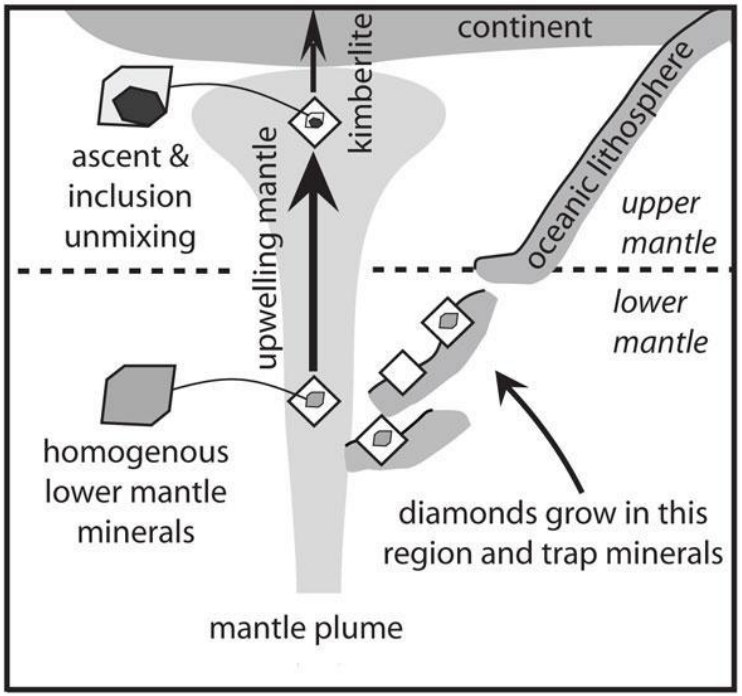
- Carbonatite melt from slab
- Can be triggered by plume



Harte and Richardson 2012, Thomson et al. 2016, Sharygin et al. 2018

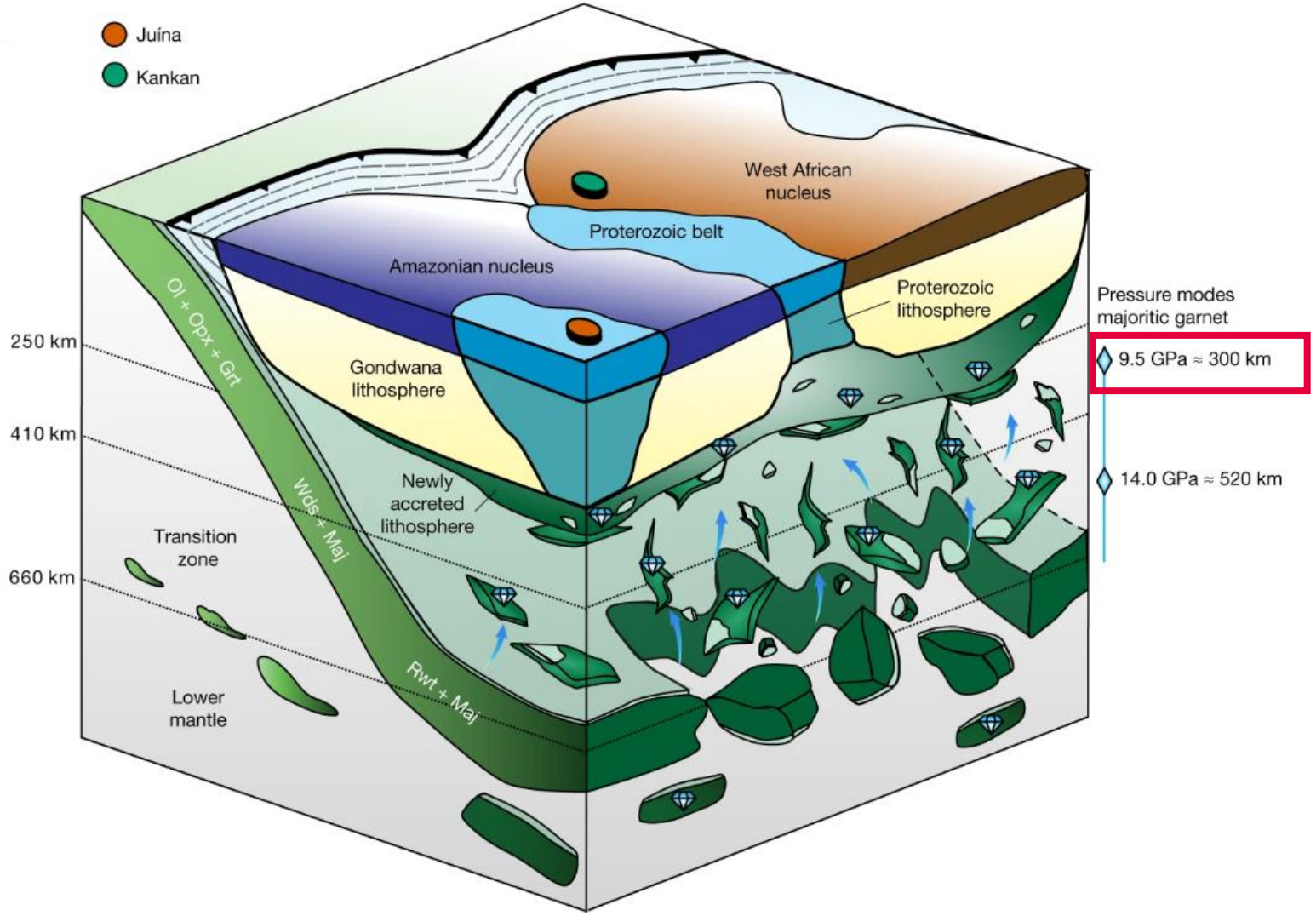
Plume model

- Ascent in plume
- Directly followed by kimberlite



Walter et al. 2011

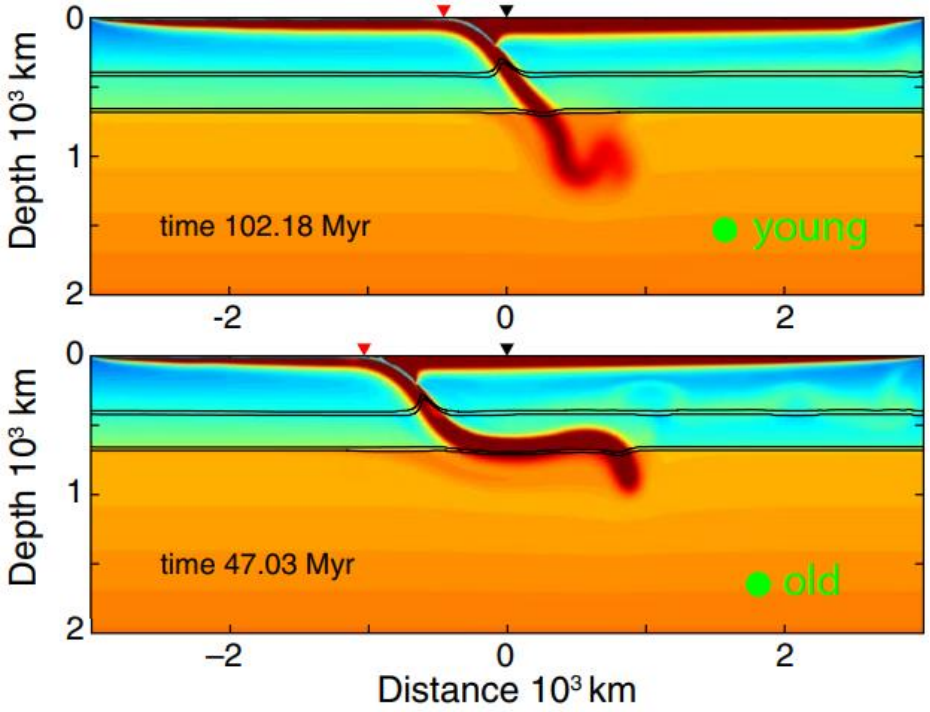
Latest model – diapiric ascent depleted material



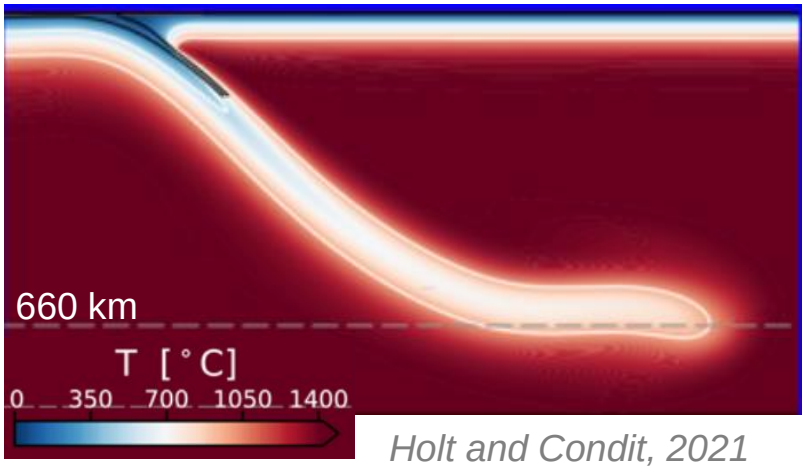
Timmerman et al. 2023

Thermal evolution - slab

- Old (cold) slabs – stagnation in the transition zone/top of lower mantle
- Time to heat up – become buoyant



Goes et al. 2017



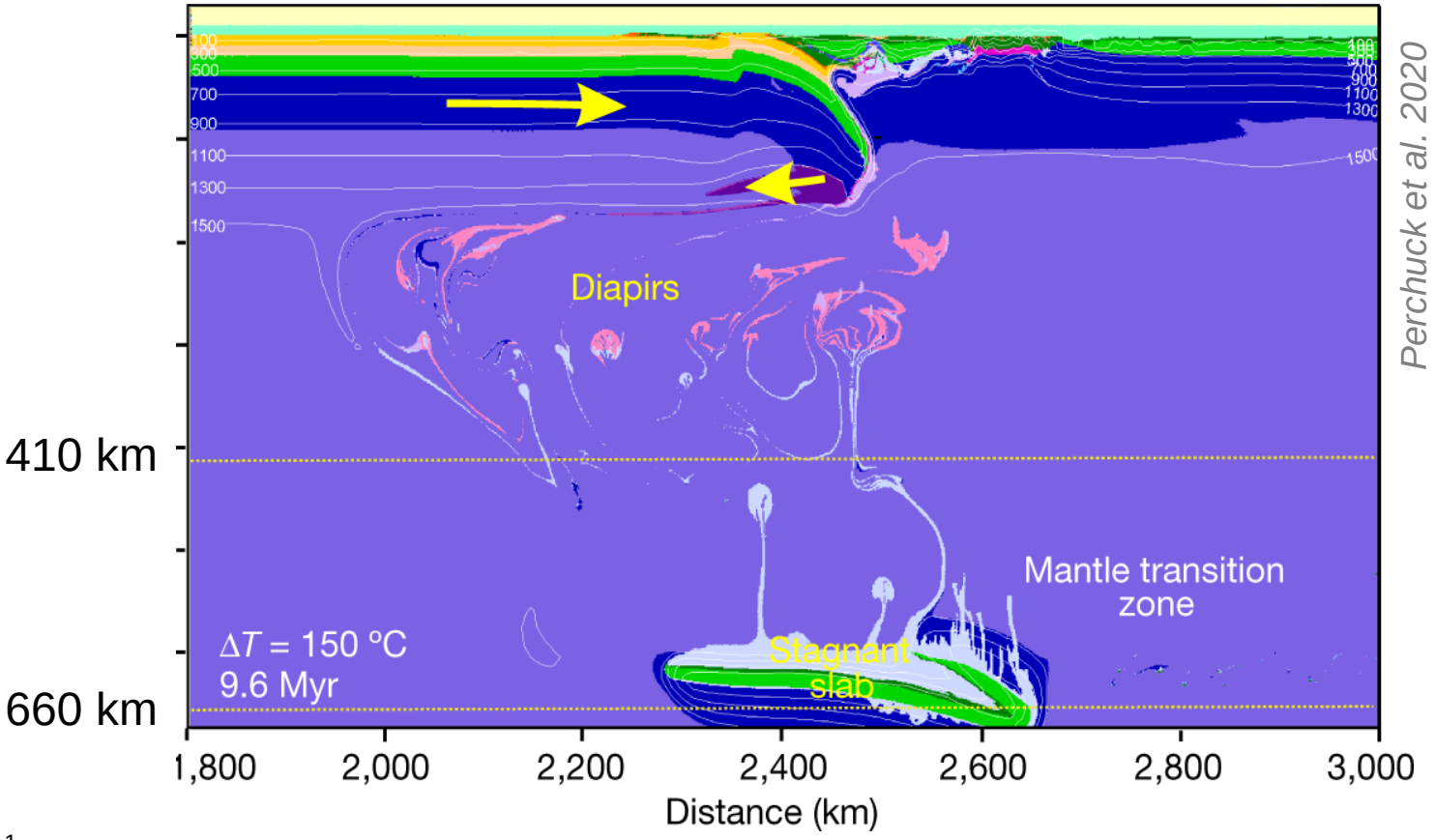
Holt and Condit, 2021

Diapiric ascent of slab material

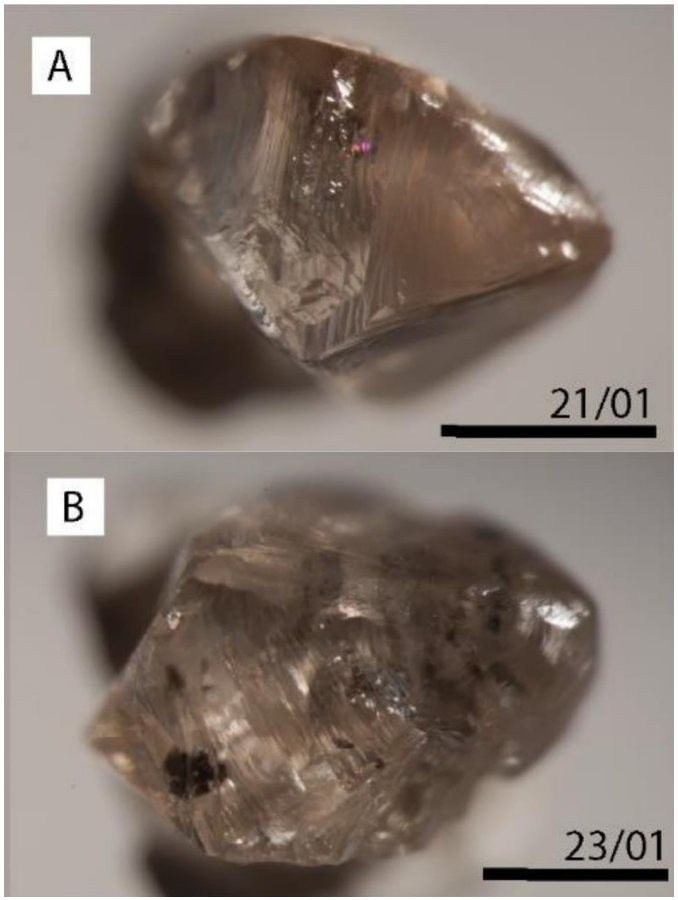
Geodynamic modelling at T_{mantle} between 3.5 and 1.8 Ga

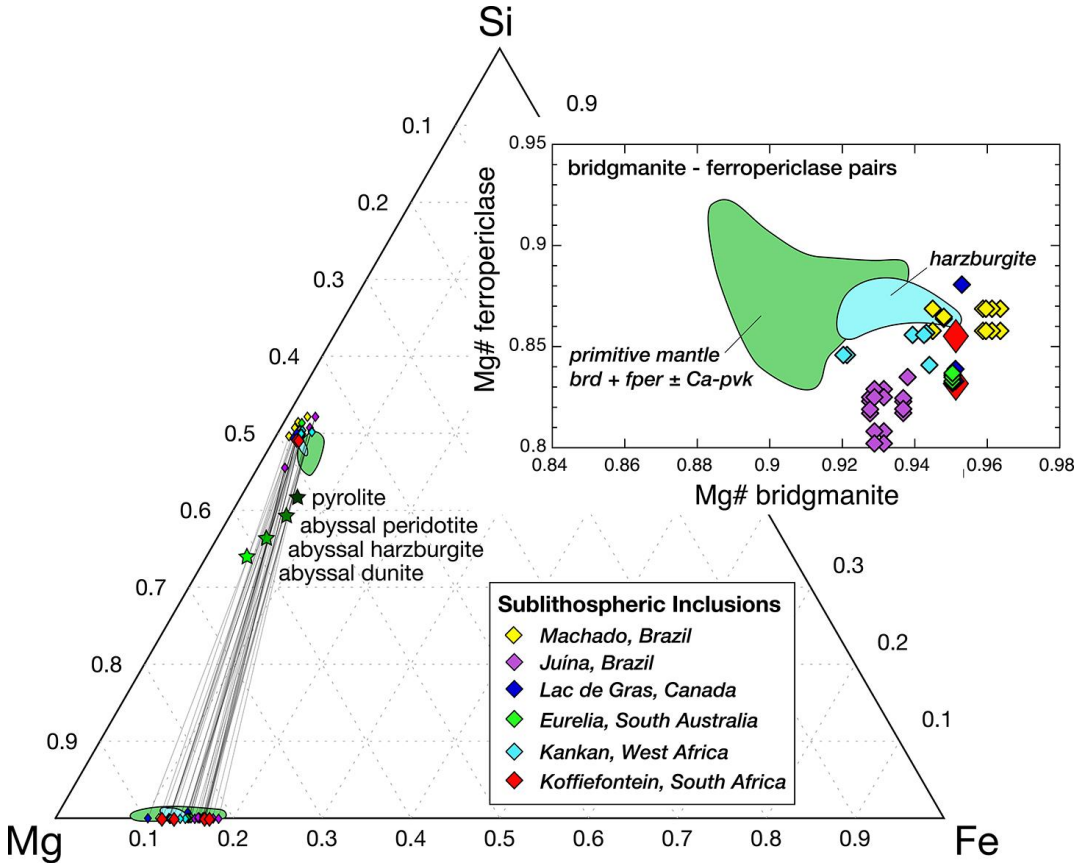
Thermal equilibration time → diapiric rise: ~10-16 Myr

Mantle convection rates: 660 → 250 km depth takes 2-41 Myr



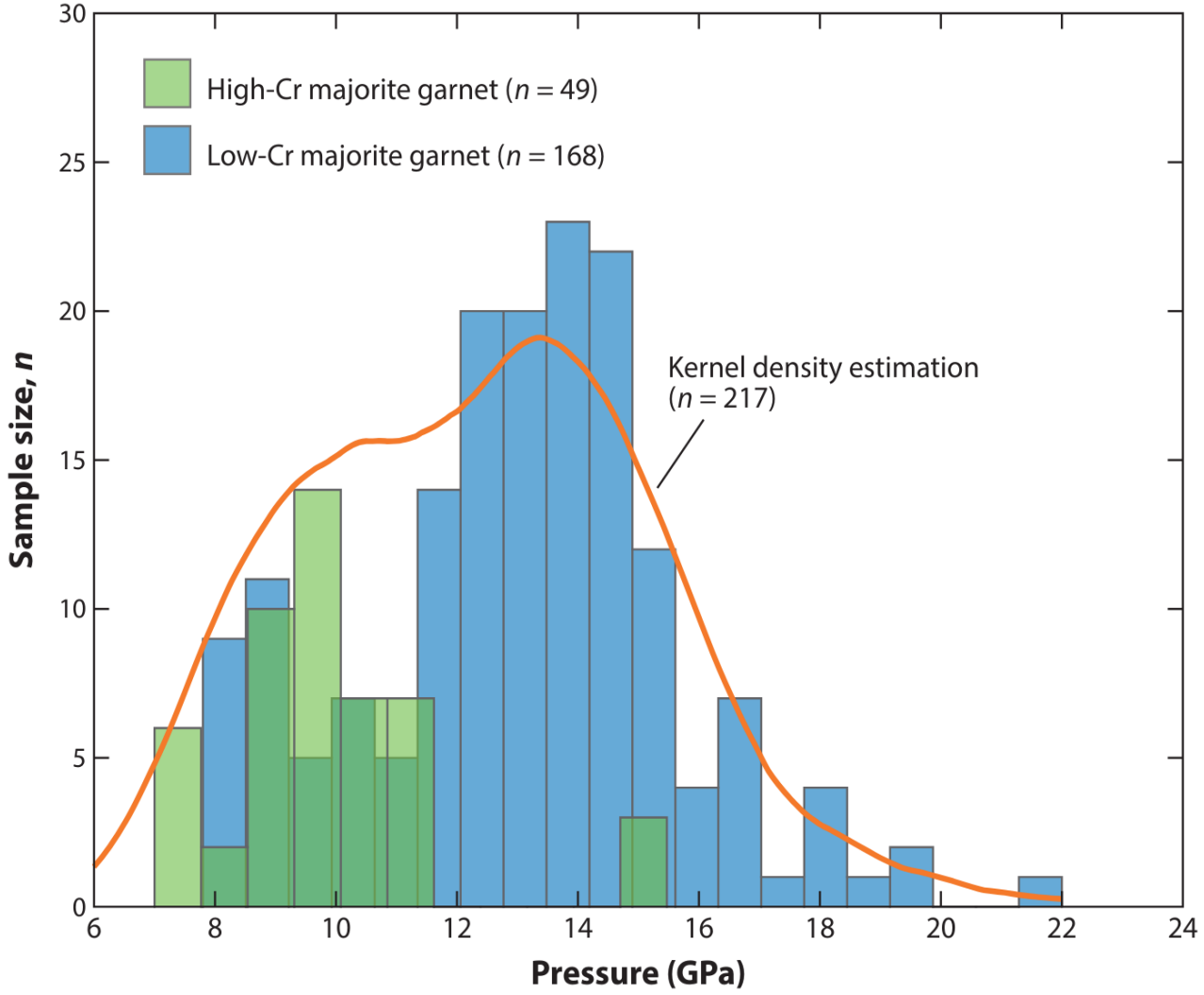
Depleted material - Koffiefontein





Meyer et al. 2023

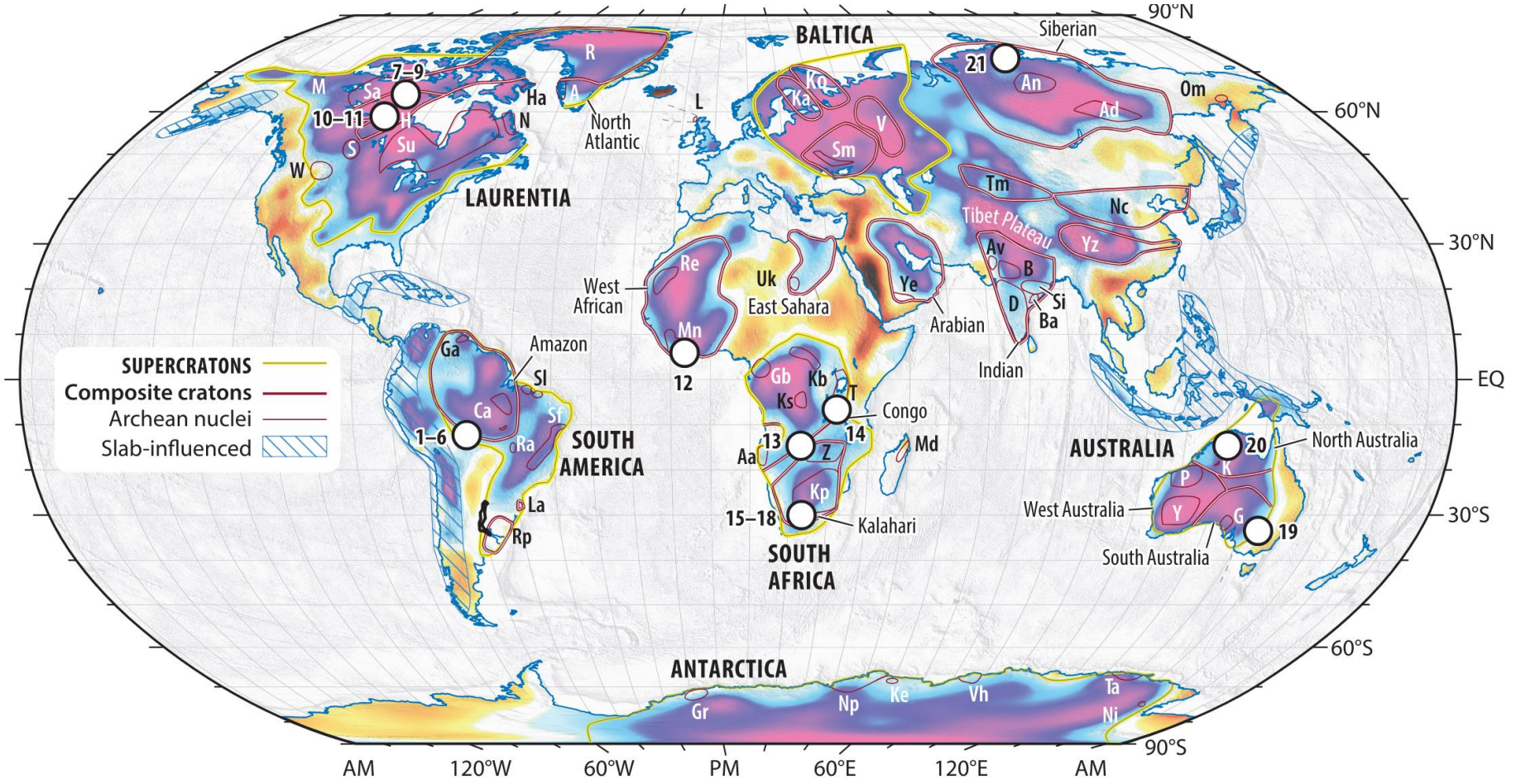
Depleted material – base of lithosphere



Shirey et al. 2024

Favourable kimberlite sampling conditions

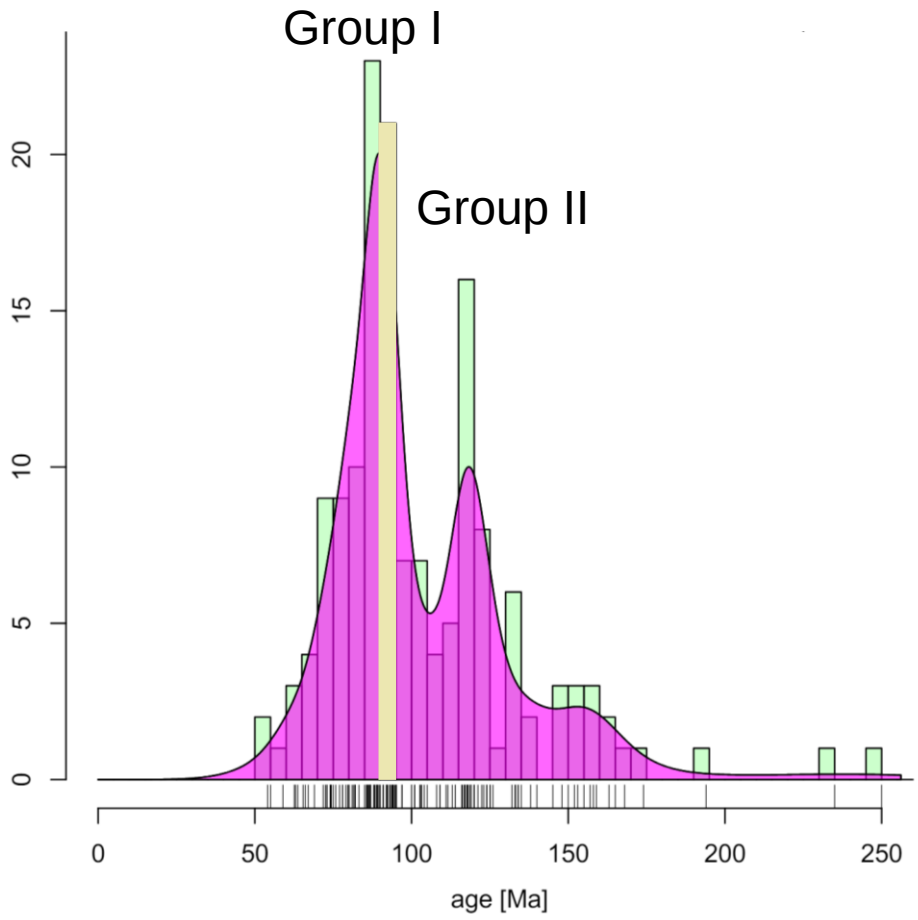
- Many at edge of craton



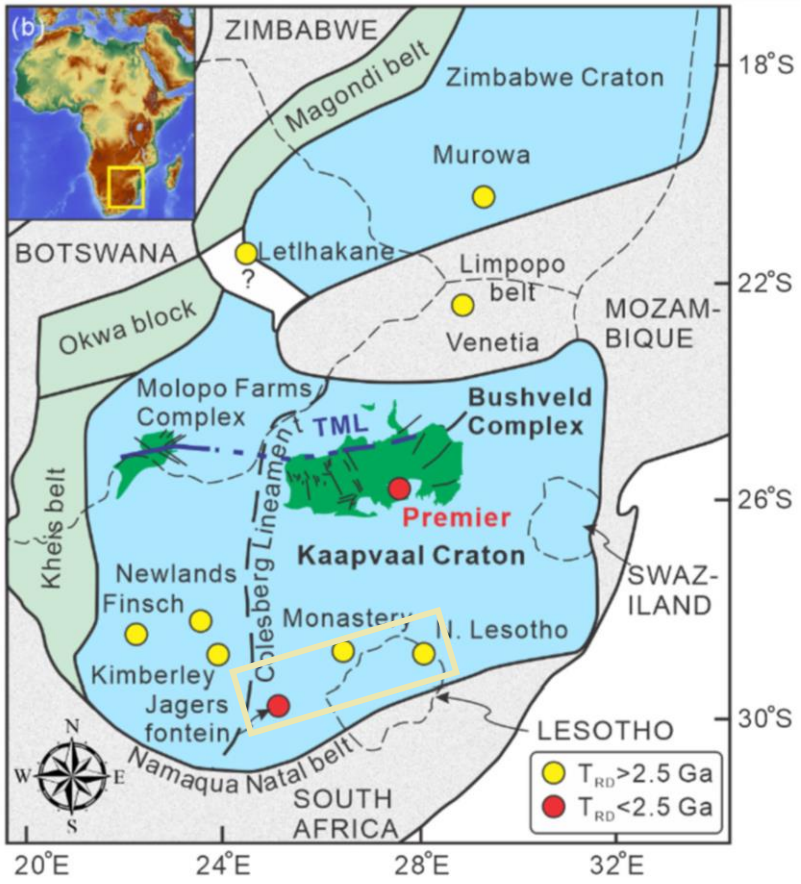
Shirey et al. 2024

Favourable kimberlite sampling conditions

- Conditioning the lithosphere by prior metasomatism/magmatism



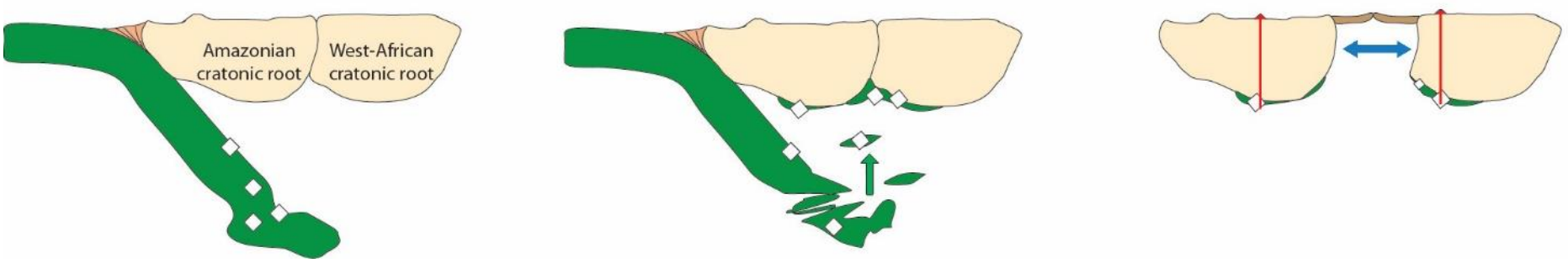
Heaman et al. 2019



Zhang et al. 2022

Summary sublithospheric diamonds

- When?
  - During supercontinent assembly (1.7 Ga, 1.0 Ga, 0.65-0.45 Ga)
- Ascent mechanism?
  - Sublithospheric residence short (10s Myrs)
  - Diapiric rise with buoyant, depleted material
  - Accreted to base of lithosphere – longer residence (>350 Myrs)
- Kimberlite sampling?
  - Pre-condition base of lithosphere
  - Younger kimberlites more likely to sample many superdeeps?



Discussion

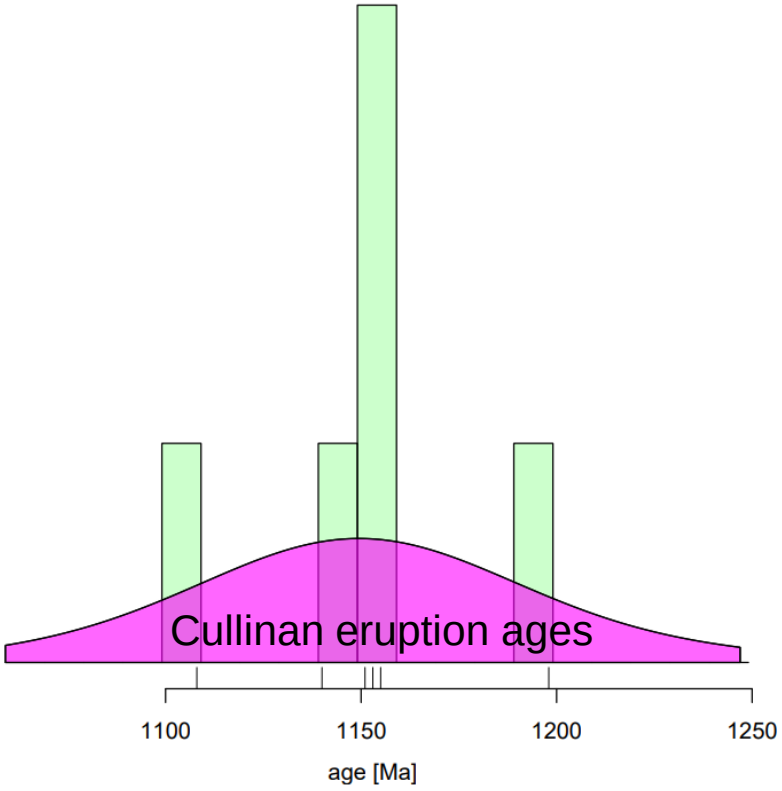
Do you want to ask an anonymous question ?

Please text it to +1 778 883 7422

Precondition lithosphere

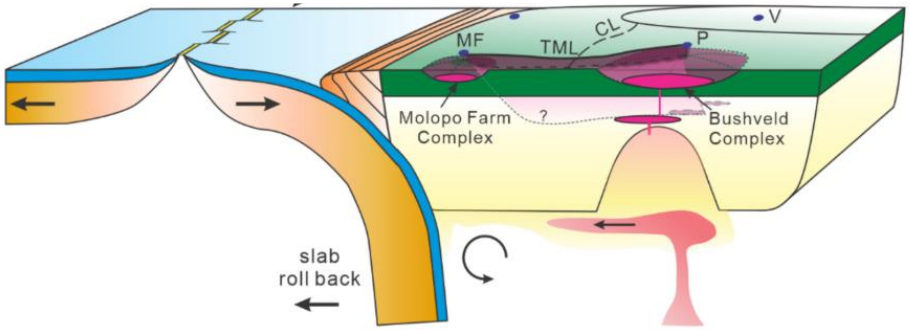
Example Cullinan

- Plume weakening lithosphere
- Filled with slab material
- Sublithospheric material…

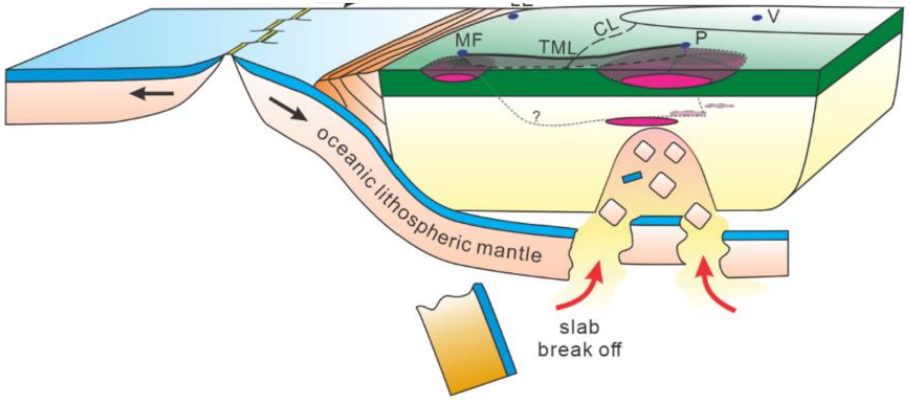


Heaman et al. 2019

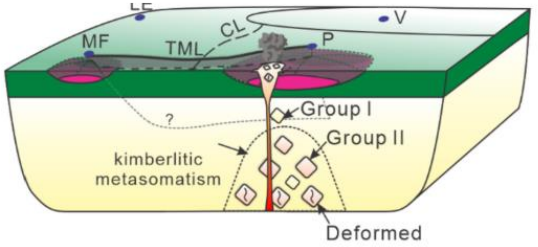
2.05 Ga



2.05-1.8 Ga



1.1-1.2 Ga



Zhang et al. 2022

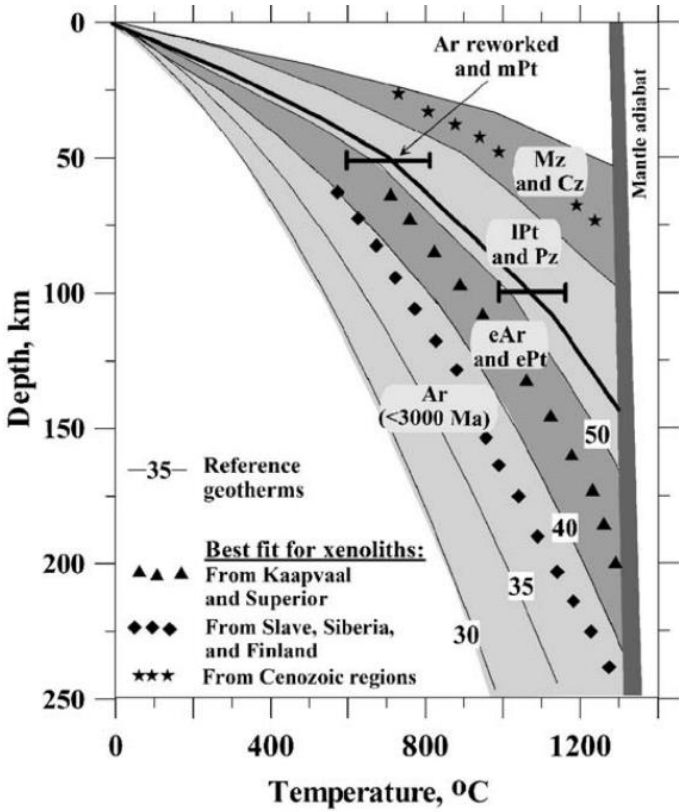
Material accretion

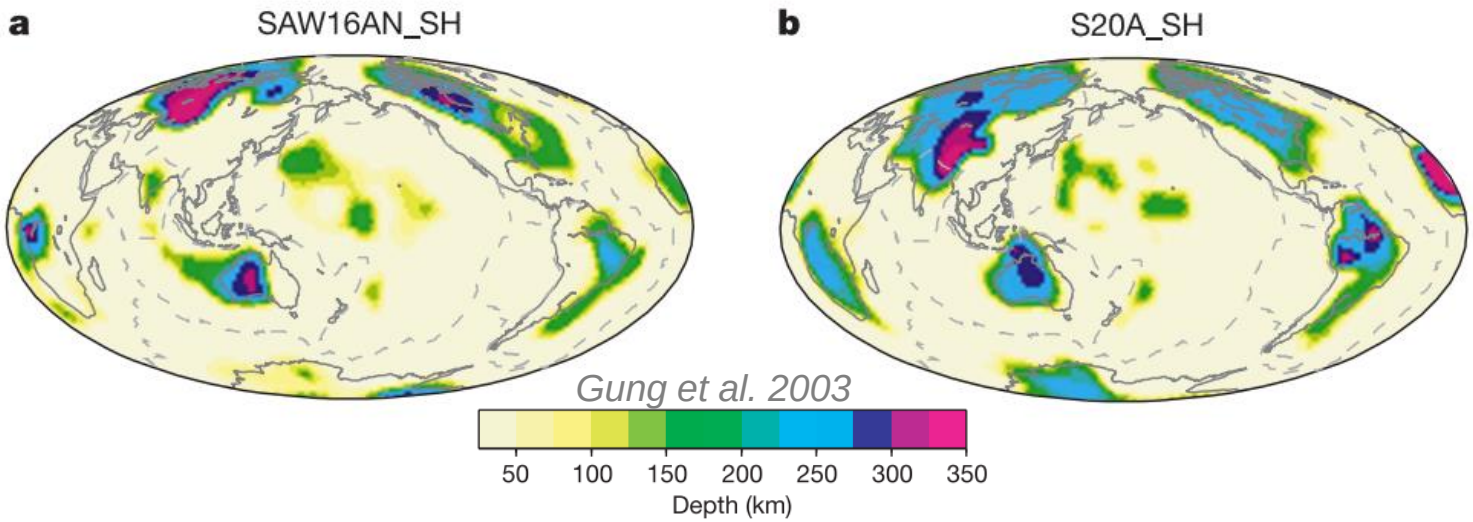
- Accretion to base of lithosphere

- Stored for >350 Myrs - Juina/Kankan
- Stored for >950 Myrs - DO-27

- Long-term stability, mantle root growth

Artemieva 2006





Gung et al. 2003