Sublithospheric diamonds and where to find them

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Sublithospheric diamonds

CLIPPIR
Type IIa

Type IIb
Type IIa

Metallic liquids

Hydrous fluids

Smith et al. 2016, 2021

Smith et al. 2018
Sublithospheric diamonds

Type IaB
Type IIa

Carbonatitic fluids
Carbonated fluids

Rohrbach and Schmidt 2011; Thomson et al. 2016
Girmis 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

**Plume model**
- Ascent in plume
- Directly followed by Kimberlite

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

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

Holt and Condit, 2021

Goes et al. 2017
Diapiric ascent of slab material

Geodynamic modelling at $T_{\text{mantle}}$ between 3.5 and 1.8 Ga
Thermal equilibration time $\rightarrow$ diapiric rise: $\sim$10-16 Myr
Mantle convection rates: 660 $\rightarrow$ 250 km depth takes 2-41 Myr

\[ \Delta T = 150 \, ^{\circ}\text{C} \]
9.6 Myr

Perchuck et al. 2020
Depleted material - Koffiefontein
Depleted material – base of lithosphere
Favourable kimberlite sampling conditions

- Many at edge of craton
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…

2.05 Ga

1.1-1.2 Ga

Cullinan eruption ages

2.05-1.8 Ga

Heaman et al. 2019

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