12TH INTERNATIONAL KIMBERLITE CONFERENCE

Kimberlitic olivine

research directions, implications, and tracking mantle cargo

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Bultfontein kimberlite, Kimberley

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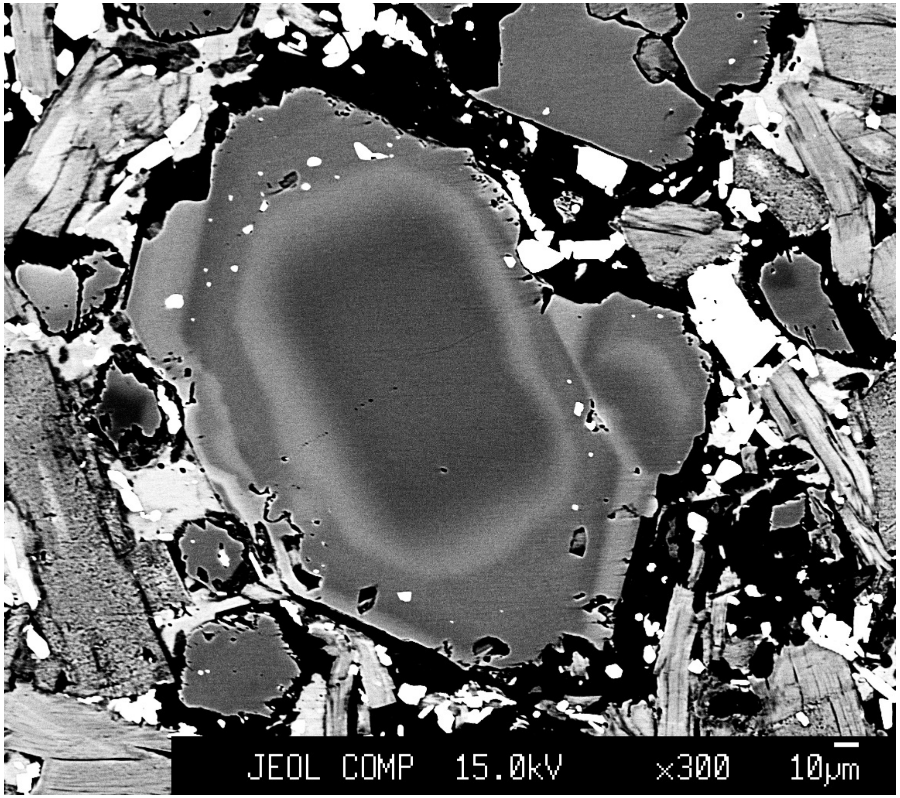
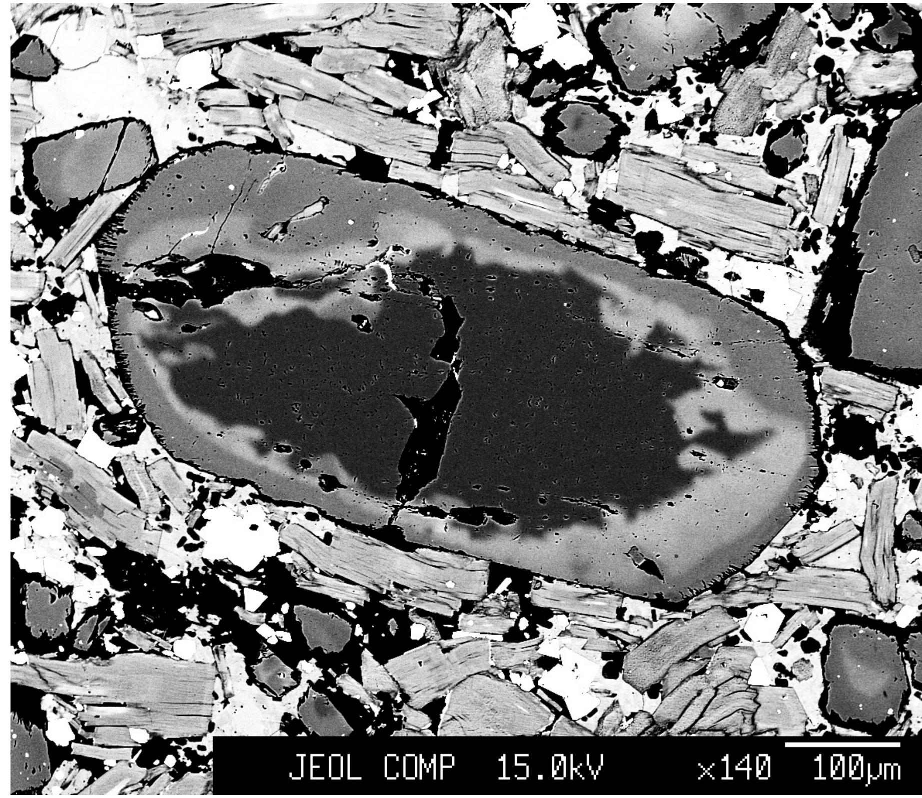
Why has research on kimberlitic olivine become so popular?

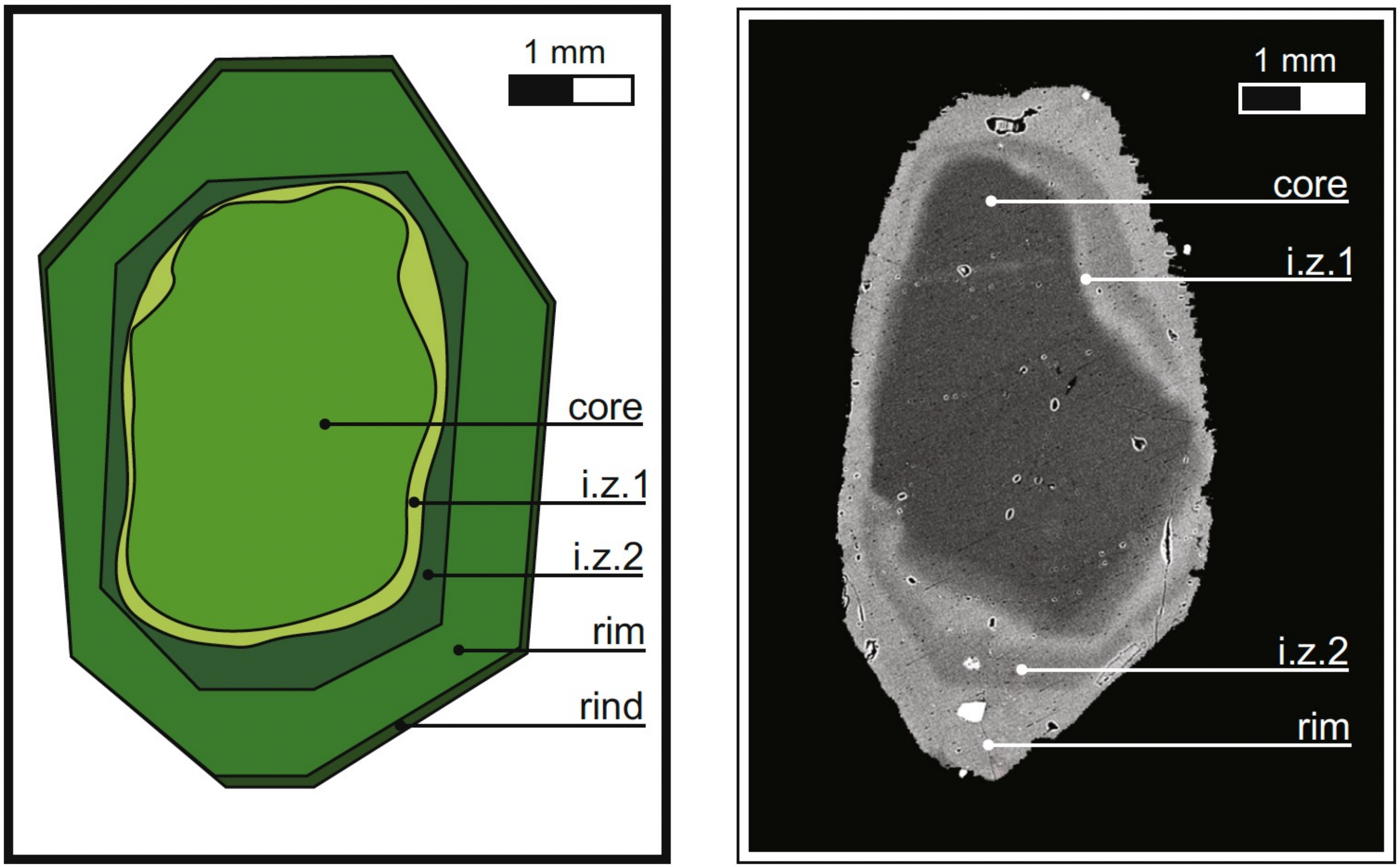
Viljoen et al. (2022 – Lithos)





- BSE images of olivine from the Lando dike, Tongo-Tonguma, Sierra Leone

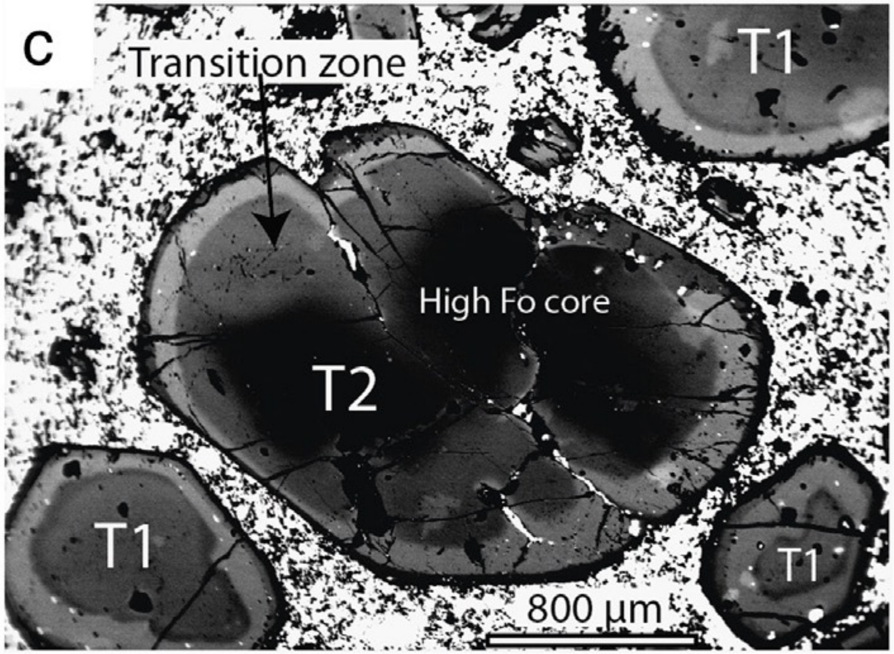
Terminology based on zoning



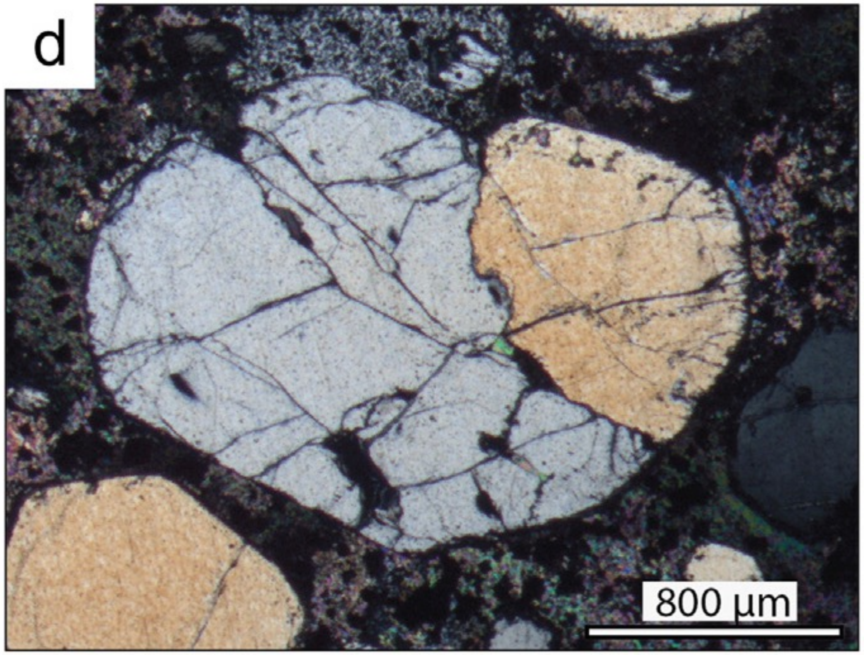
Giuliani (2018 – Lithos)

Complexity of zoning

Howarth and Taylor (2016 – Lithos)



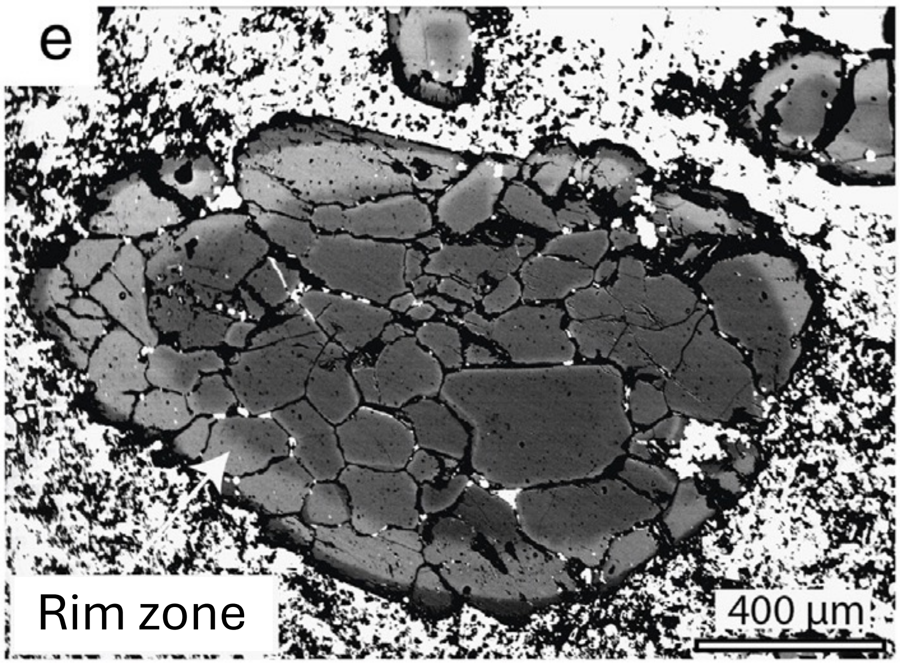
BSE image



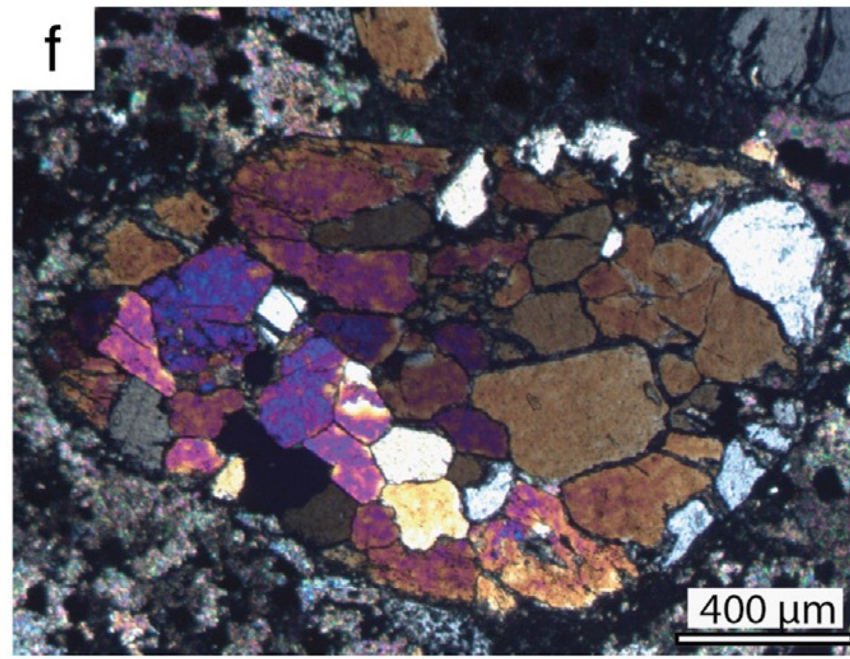
XPL image

Complexity of zoning

Howarth and Taylor (2016 – Lithos)

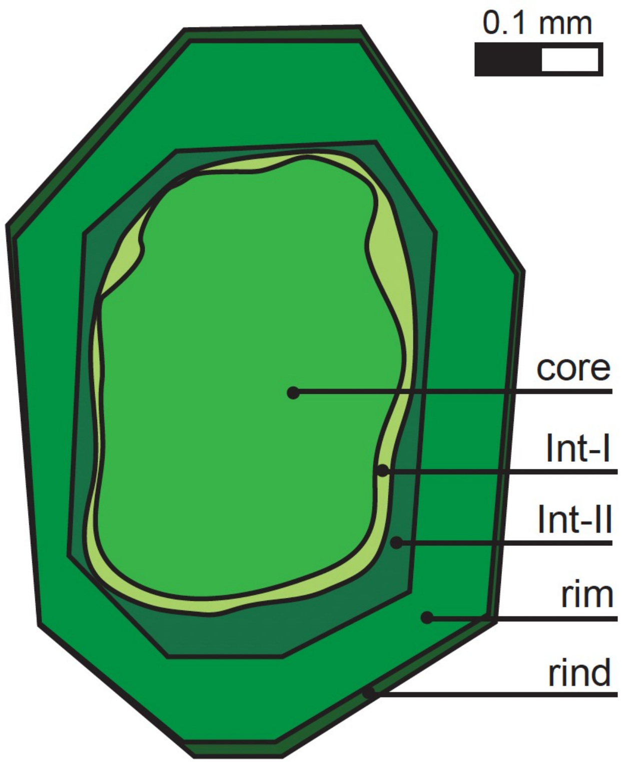


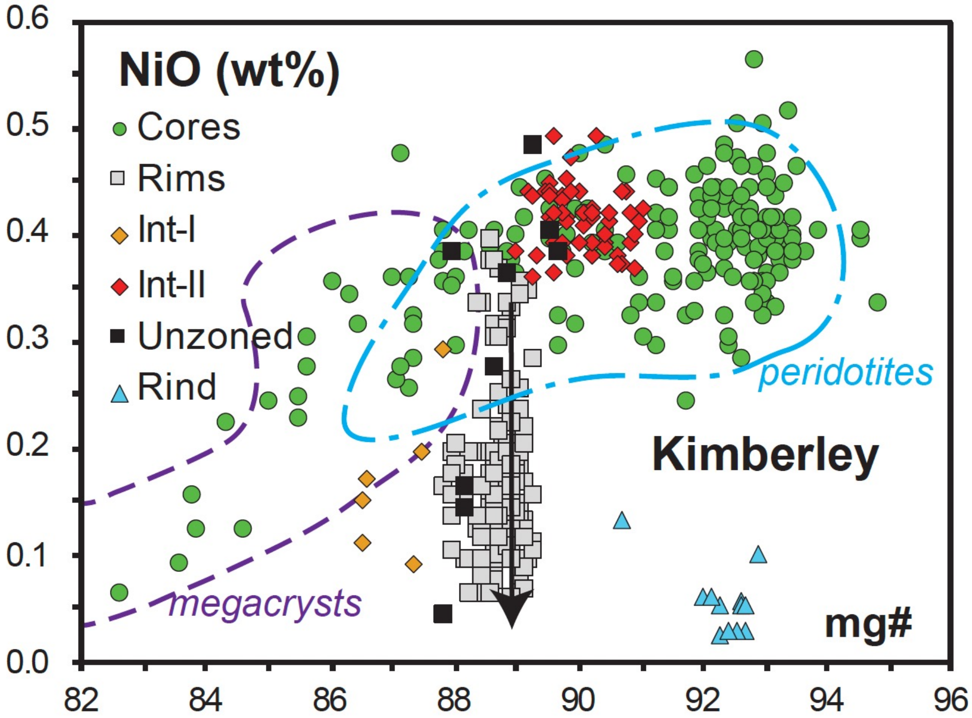
BSE image



XPL image

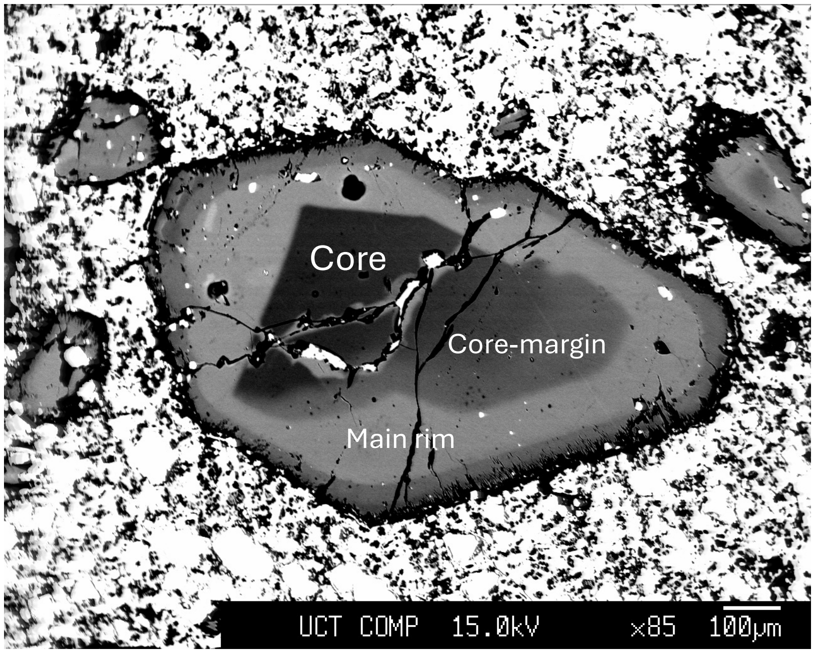
Compositional zoning of olivine



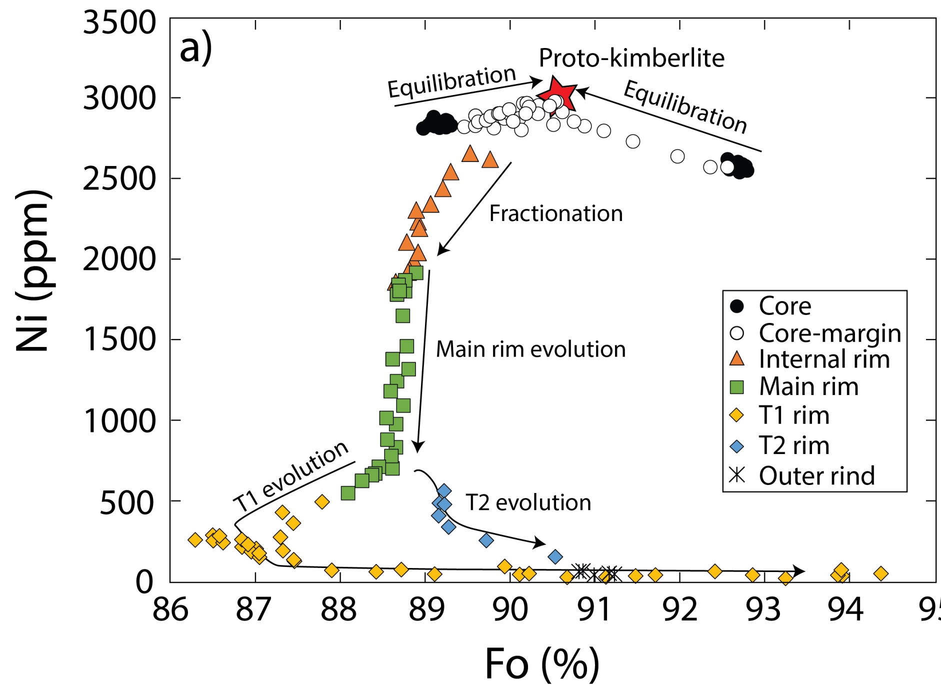


Mitchell et al. (2019 – Elements)

Electron probe microanalyser



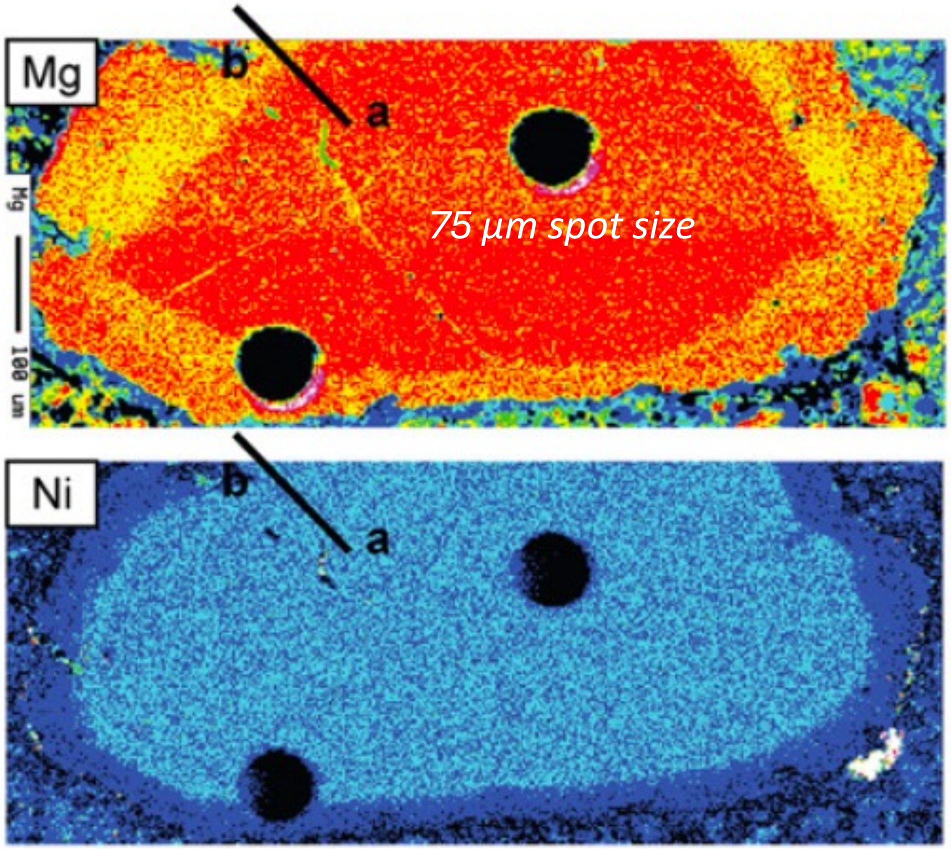
Howarth and Gross (2019 – GCA)



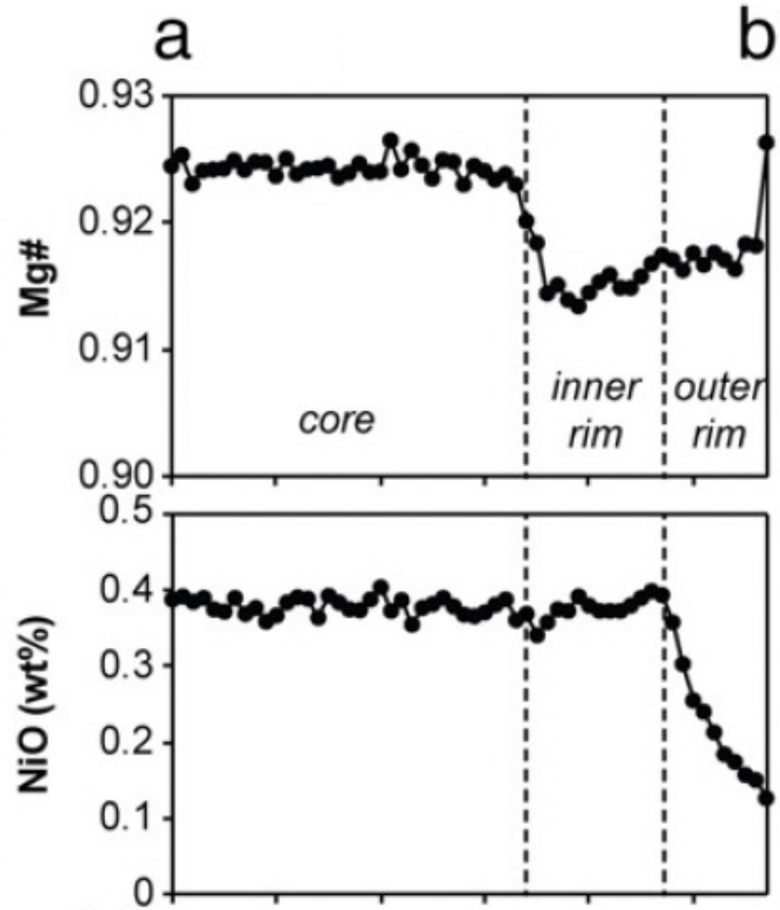
- High resolution but cannot accurately analyse full suite of trace elements

Laser ablation ICP-MS

Laser



EPMA



Bussweiler et al. (2015 – Lithos)

Recent research directions

1. Al-in-olivine thermometry used to understand SCLM sampling depths
2. Correlations between core and rim compositions indicate kimberlite melt influenced by SCLM assimilation
3. Complex rim zoning used to constrain kimberlite petrogenesis from source to surface
4. Melt/fluid inclusions can be used to understand kimberlite melt compositions and evolution

Global olivine core-rim correlation

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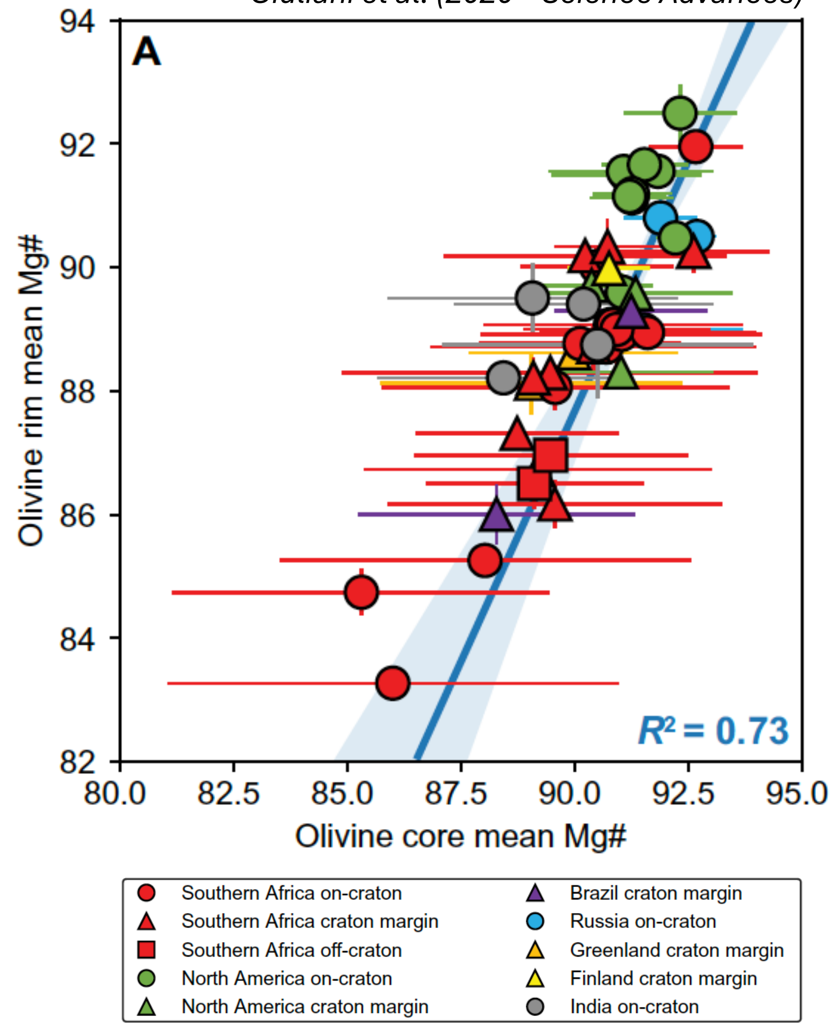
- Olivine core-rim correlations indicate kimberlite melt is influenced by the mantle material sampled

Giuliani et al. (2020 – Science Advances)



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Department of Geological Sciences
Isebe Lenzululwazi Zomhlaba
Department Geologiese Wetenskappe

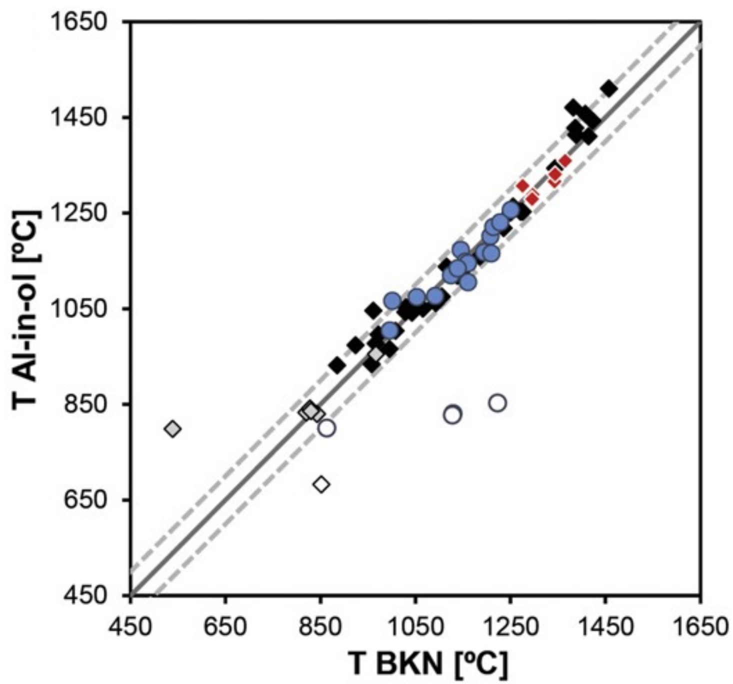
Tips on use of the Al-in-olivine thermometer

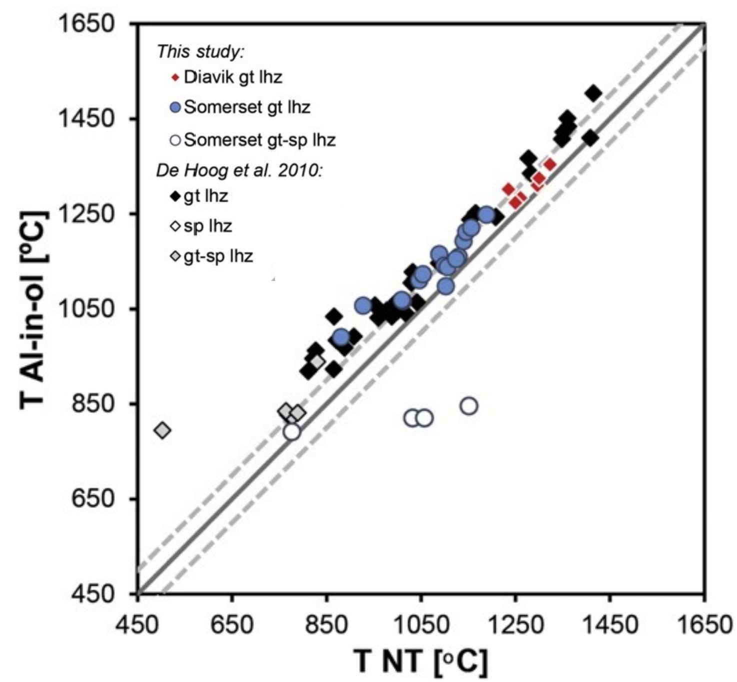
$$T[^\circ C] = (11245 + 46.0 * P[kbar])/(13.68 - \ln(Al[ppm])) - 273$$

Bussweiler et al. (2017 - *Lithos*)

Al-in-olivine thermometry

- Performs well compared to two pyroxene thermometer of Brey and Köhler (1990)
- Slight overestimation of T relative to single cpx thermometer of Nimis and Taylor (2000)





Bussweiler et al. (2017 - *Lithos*)

Data filtering

Step 1:

Olivine xenocryst filtering

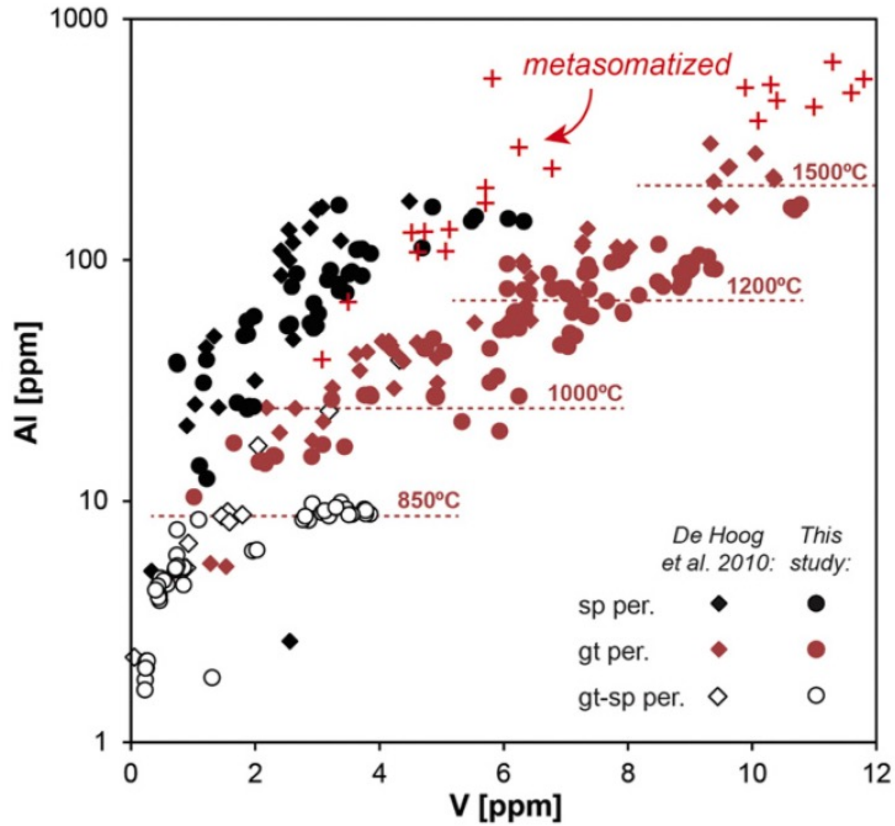
- Mg# >90
- Ni >2350 ppm
- Ca <715 ppm
- Mn <1160 ppm

Step 2:

Al-V discrimination diagram

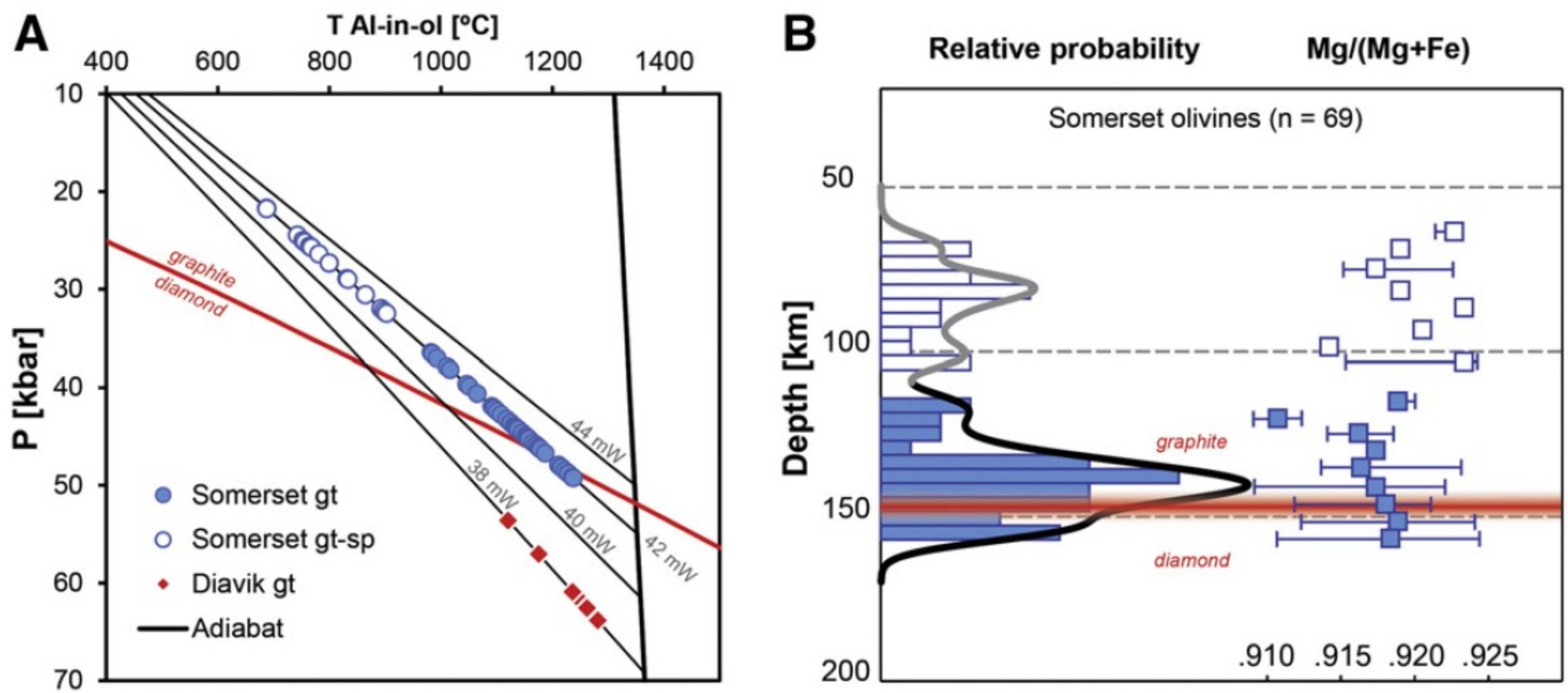
- Al-in-olivine thermometry only applicable to gt-peridotite

Bussweiler et al. (2017 - *Lithos*)



Al-in-olivine thermometry

- Al-in-olivine thermometry can be used to calculate equilibration P-T-depth
- Team diamond - https://cms.eas.ualberta.ca/team-diamond/downloads/



Bussweiler et al. (2017 - *Lithos*)

Practical application of the Al-in-olivine thermometer – Koidu kimberlites

Andrea Giuliani, Yannick Bussweiler, Merrily Tau, Sinelethu Hashibi, Phil Janney, and Tom Nowicki

Mantle sampling – Koidu example

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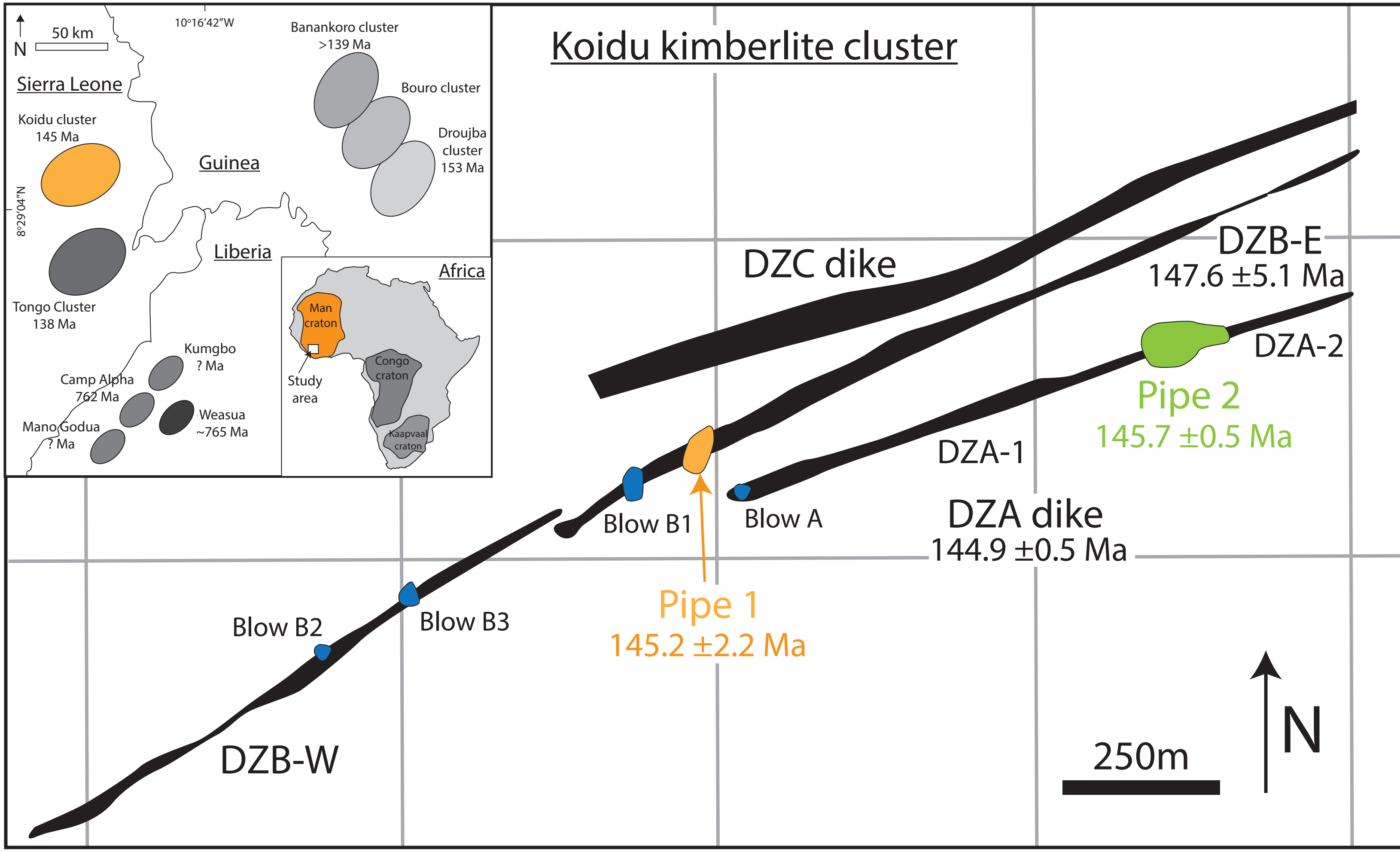
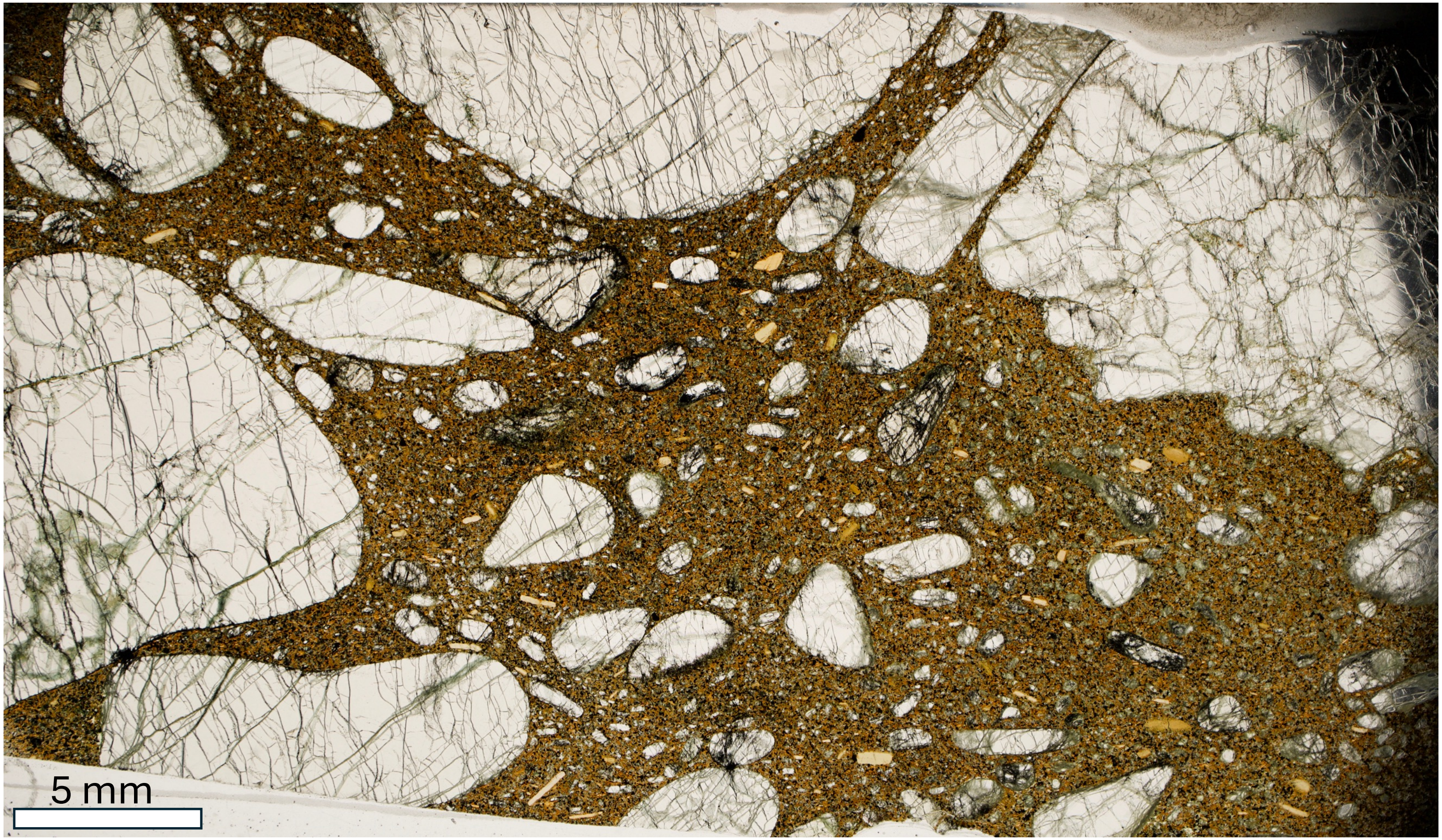


Howarth et al. (in revision – *Min. deposita*)

Mantle sampling – Koidu example

DZA dike



Howarth et al. (in revision – *Min. deposita*)

Mantle sampling – Koidu example

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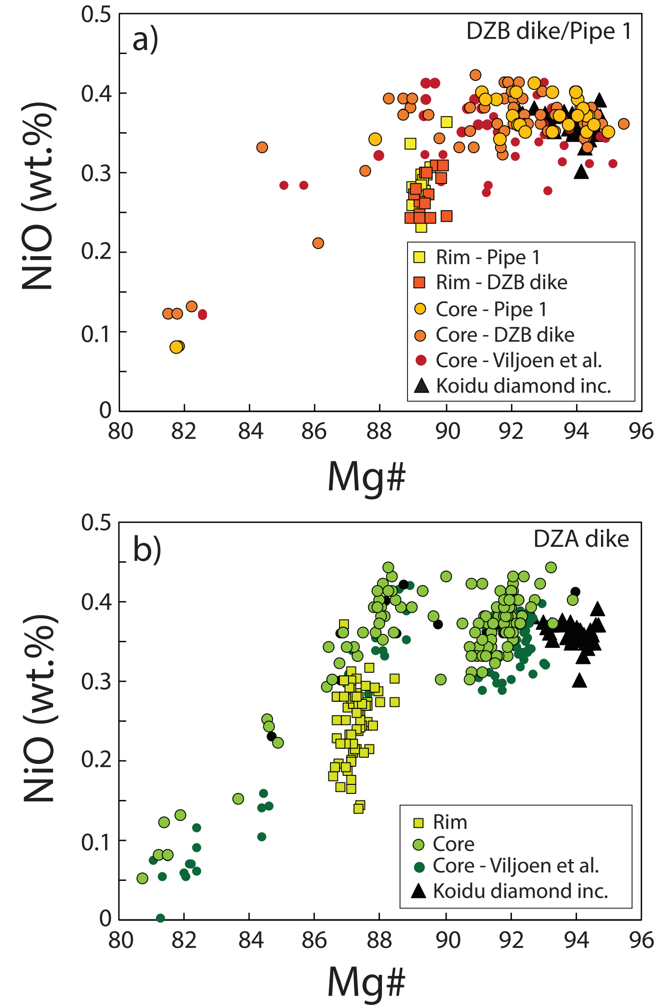
- EPMA data for kimberlite phases
- DZA dike has notable break in Mg# ~90

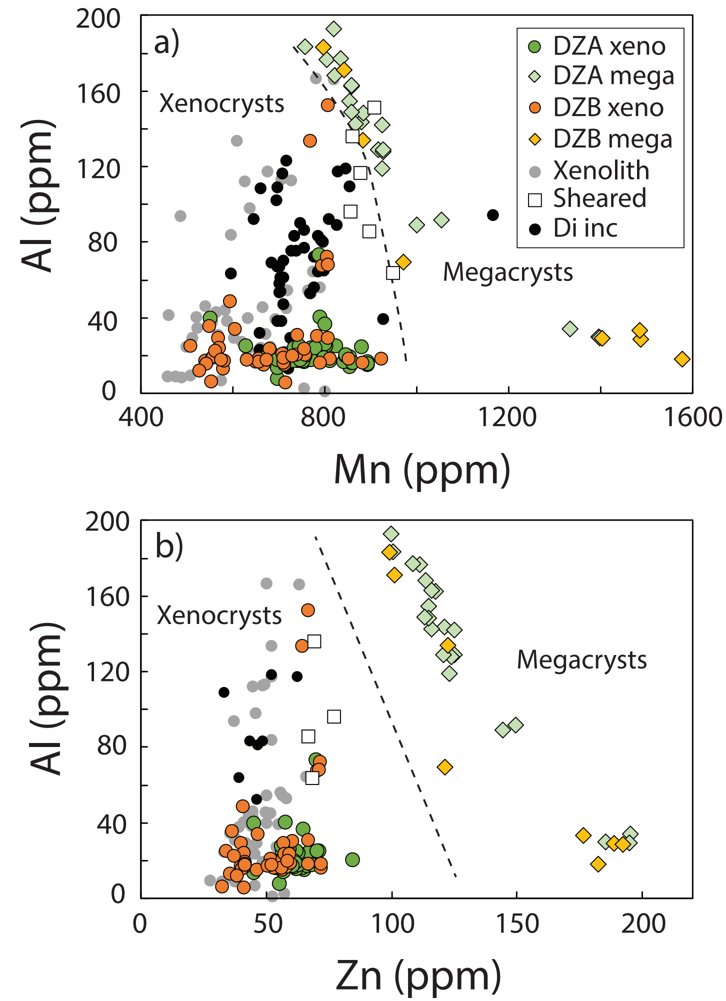


Howarth et al. (in revision – *Min. deposita*)

Mantle sampling – Koidu example

Megacryst filtering:

- LA-ICP-MS trace element data
- Al-Zn-Mn discriminate megacrysts

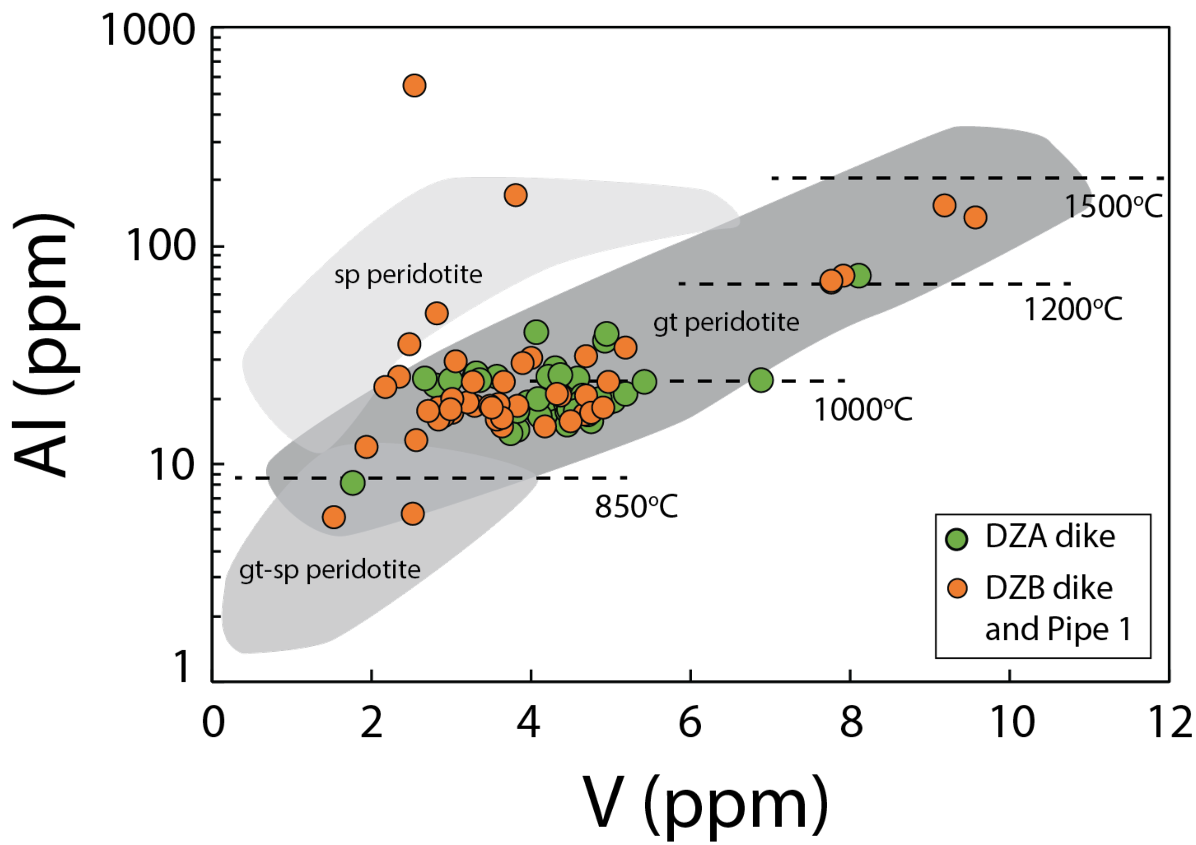


Howarth et al. (in revision – *Min. deposita*)

Mantle sampling – Koidu example

Spinel peridotite filtering

- Al-V discriminate spinel peridotites



Howarth et al. (in revision – *Min. deposita*)

Mantle sampling – Koidu example

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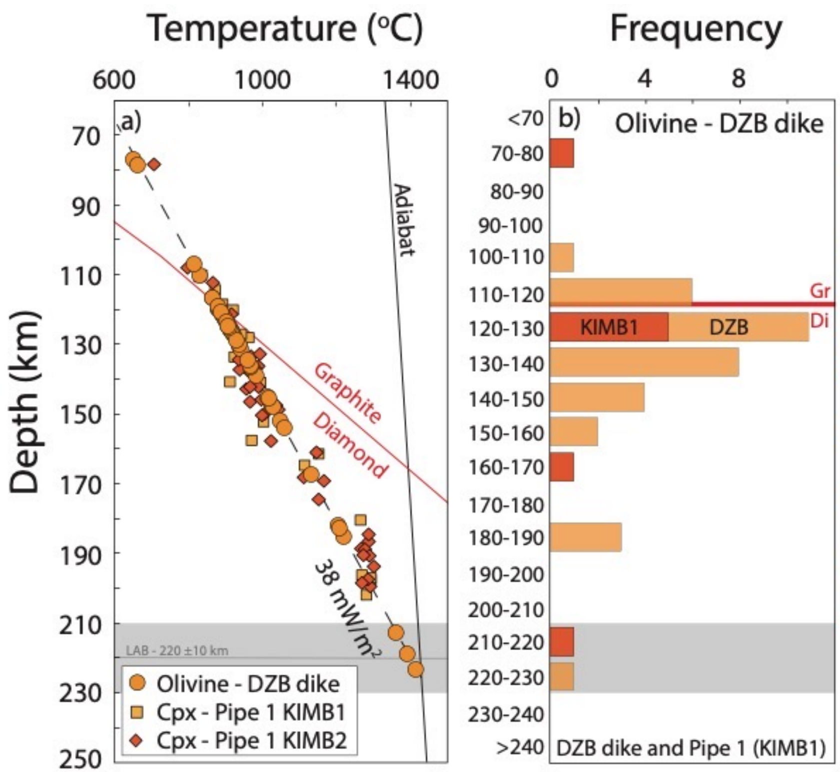
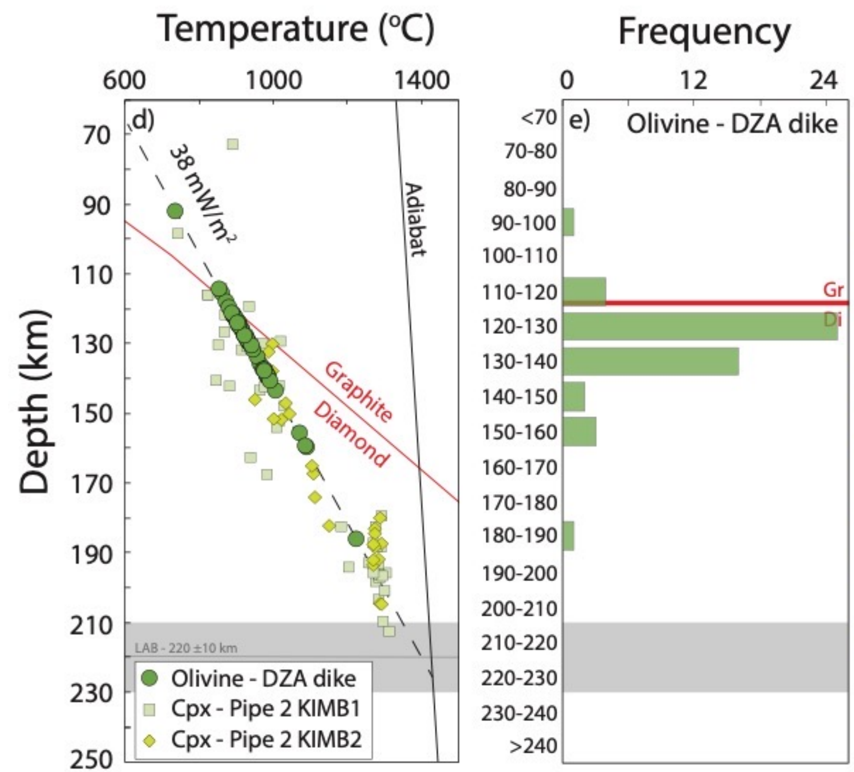
DZB dike/Pipe 1



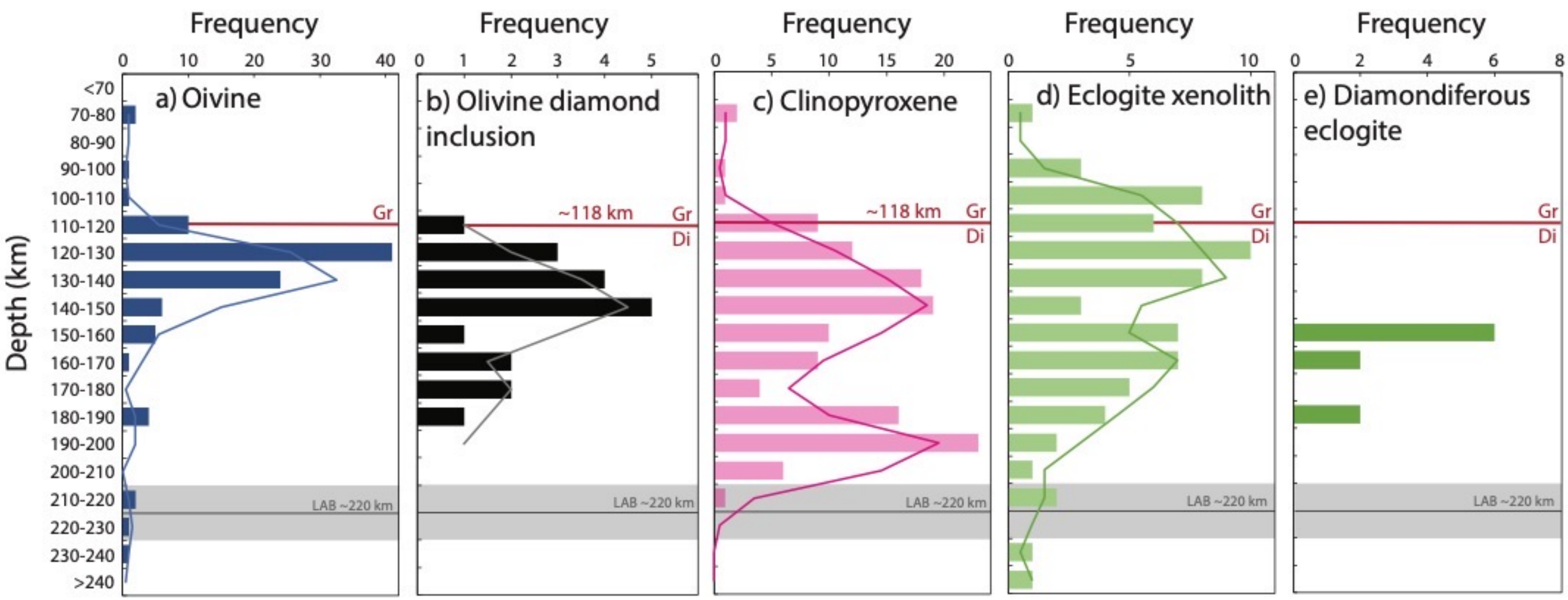
DZA dike



Olivine data – Howarth et al. (in review)
Cpx from Koidu ltd. using single cpx thermometer of Nimis and Taylor (2000)
Diamond stability and geotherm from Smit et al. (2016; Precambrian research)

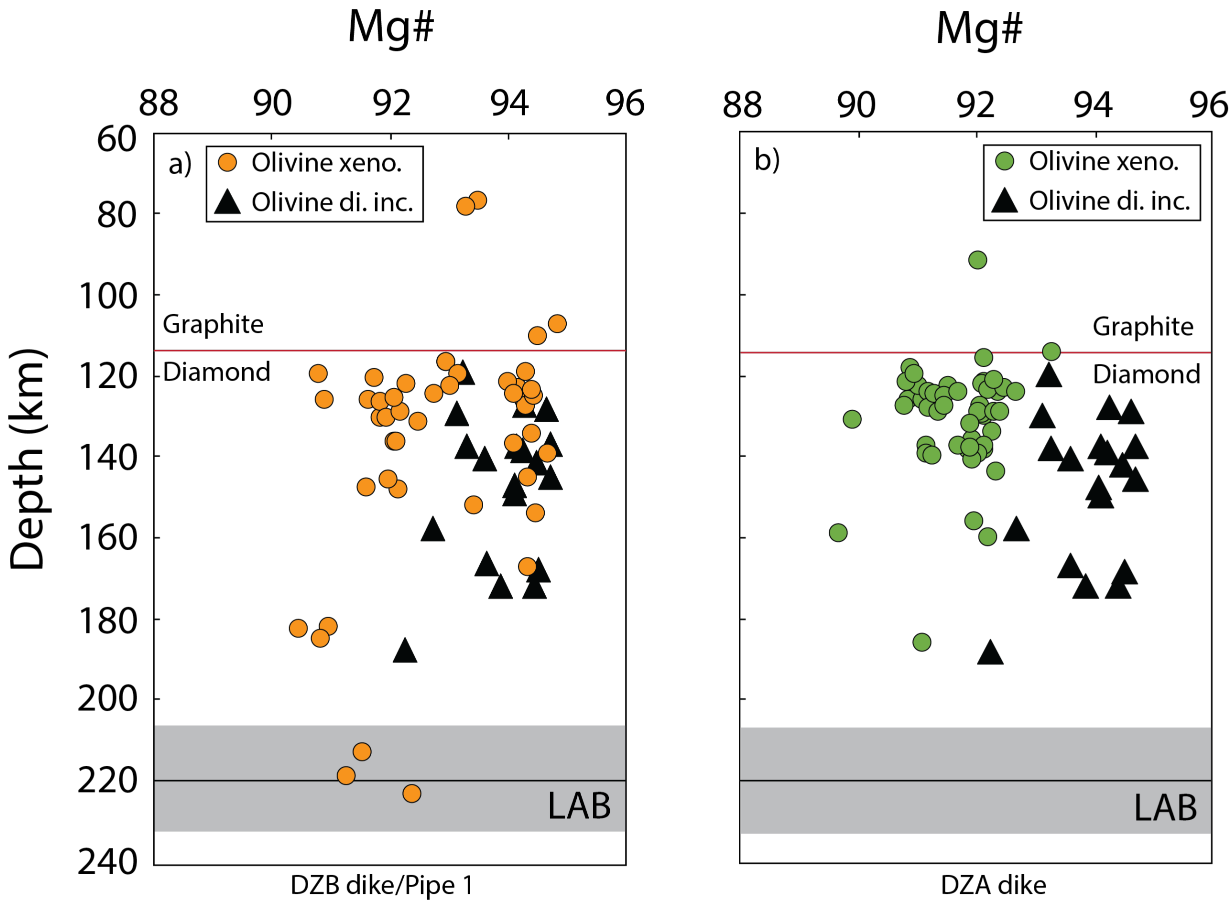
Howarth et al. (in revision – *Min. deposita*)

Mantle sampling – Koidu example



Olivine data – Howarth et al. (in review)
Diamond inclusion data – Lai et al. (in review)
Eclogite xenolith data from Aulbach et al. (2019; J. Pet.) using gt-cpx thermometer of Krogh (1988)
Diamondiferous eclogite data from Hills and Haggerty (1989; Contributions) and Lai et al. (in review) using Krogh (1988)
Cpx from Koidu ltd. using single cpx thermometer of Nimis and Taylor (2000)
Diamond stability and geotherm from Smit et al. (2016; Precambrian research)

Mantle sampling – Koidu example



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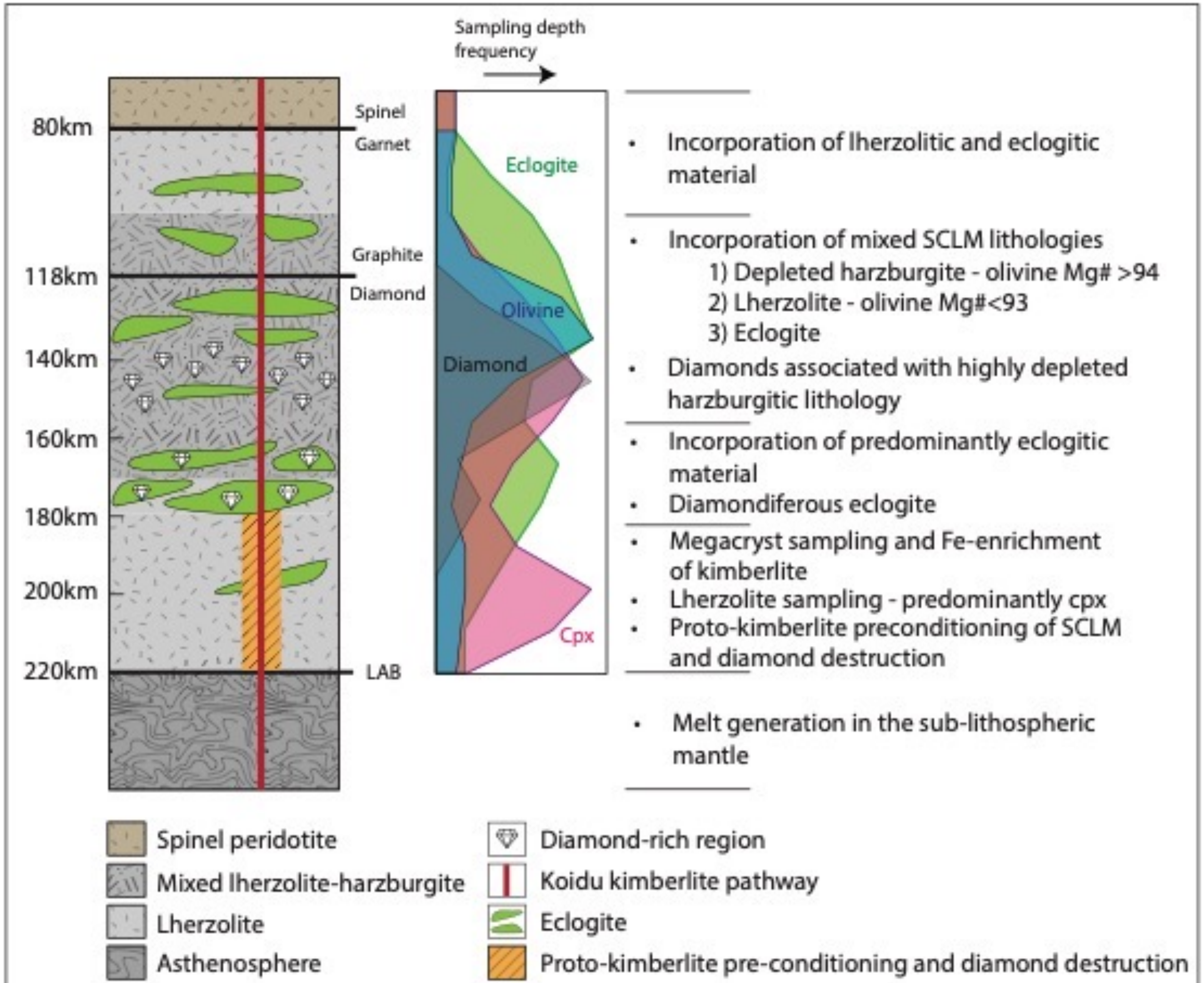

Howarth et al. (in revision – *Min. deposita*)

Summary/future directions

1. We need a trace element in olivine dataset for mantle xenoliths and diamond inclusions
   - e.g., Korolev et al. (2018); Meyer (2021; PhD); Lai (2022; PhD)
2. Olivine xenocryst and mantle xenolith data from single locations
   - e.g., Greene et al. (2023)
3. Olivine xenocryst data from more kimberlites where traditional indicator mineral data is available
   - e.g., Tau et al. (2024; IKC)

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Questions

Do you want to ask an anonymous question?

Text it to +1 778 883 7422

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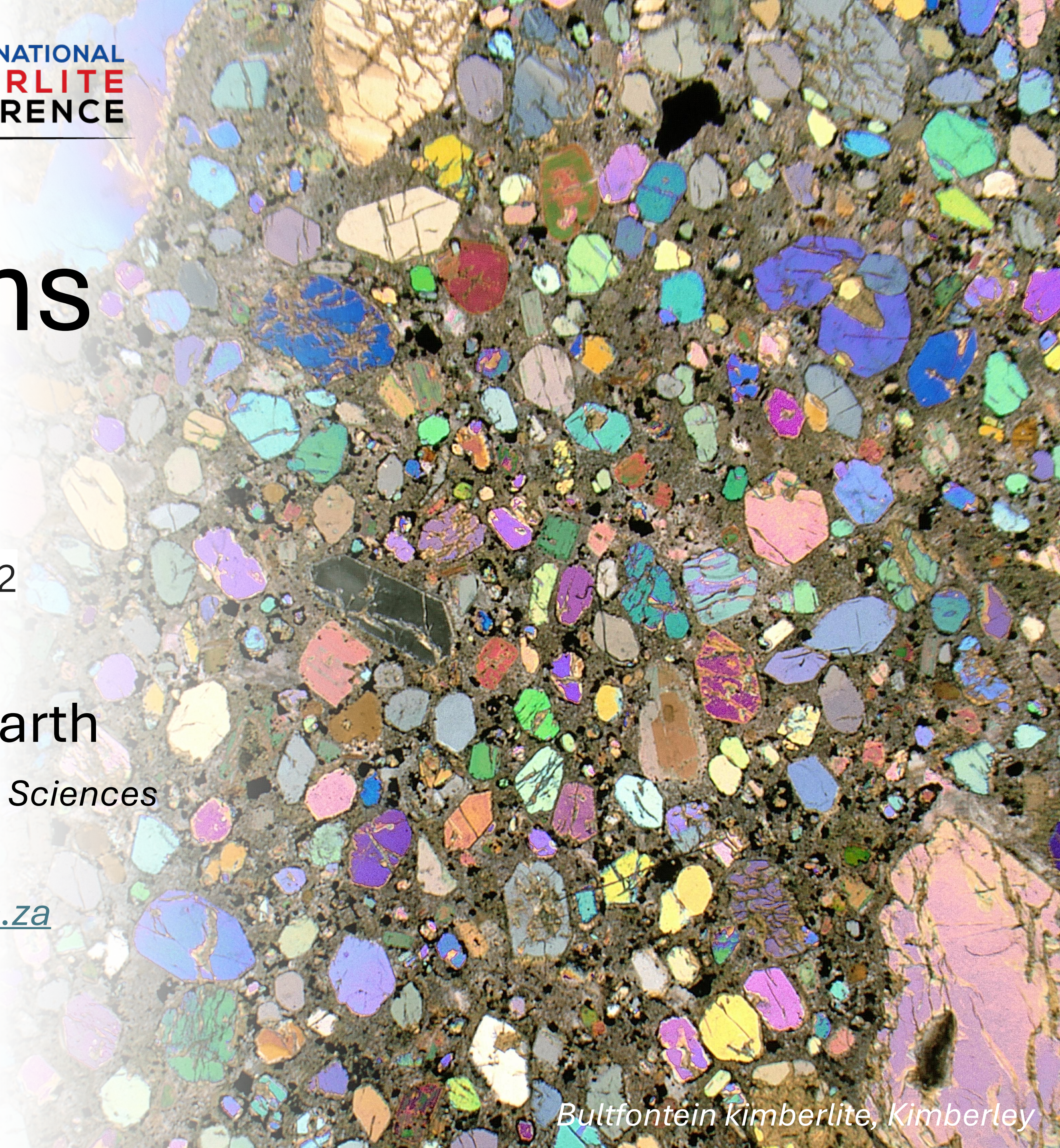

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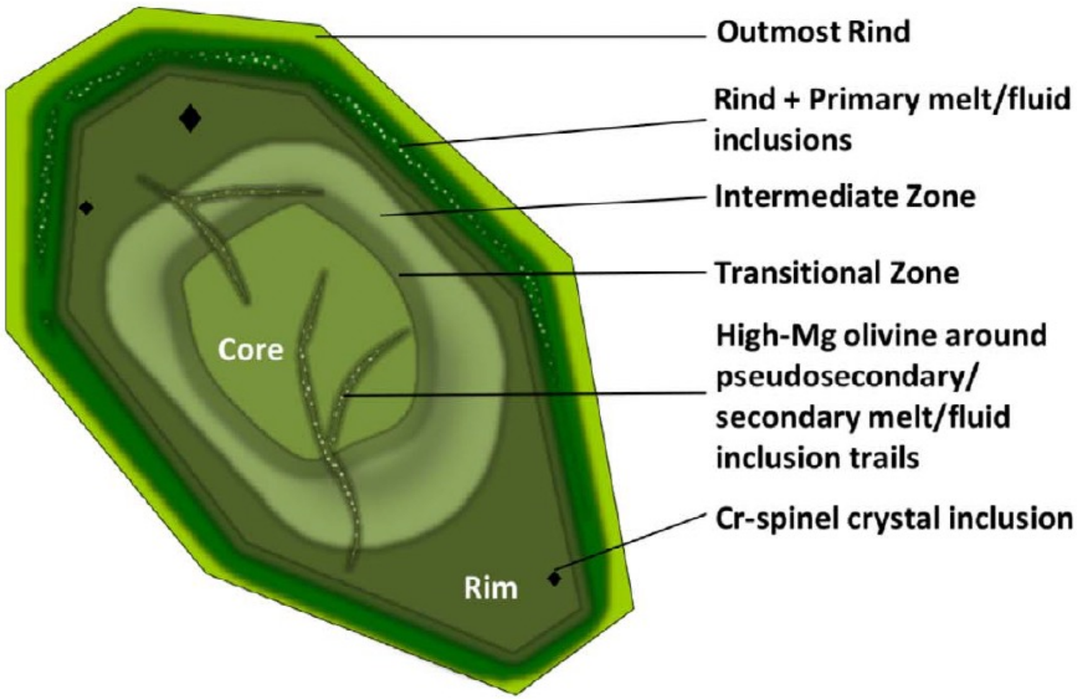
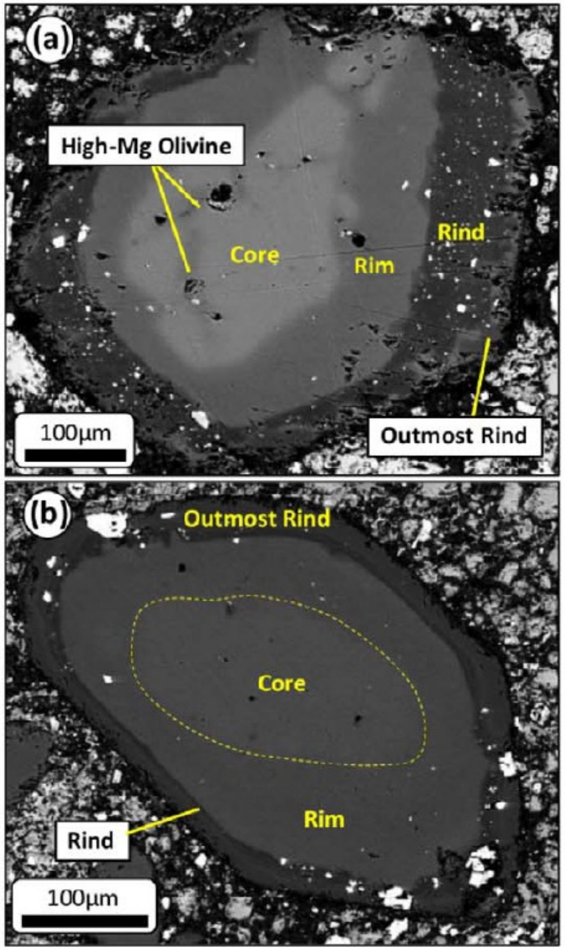
Terminology based on zoning



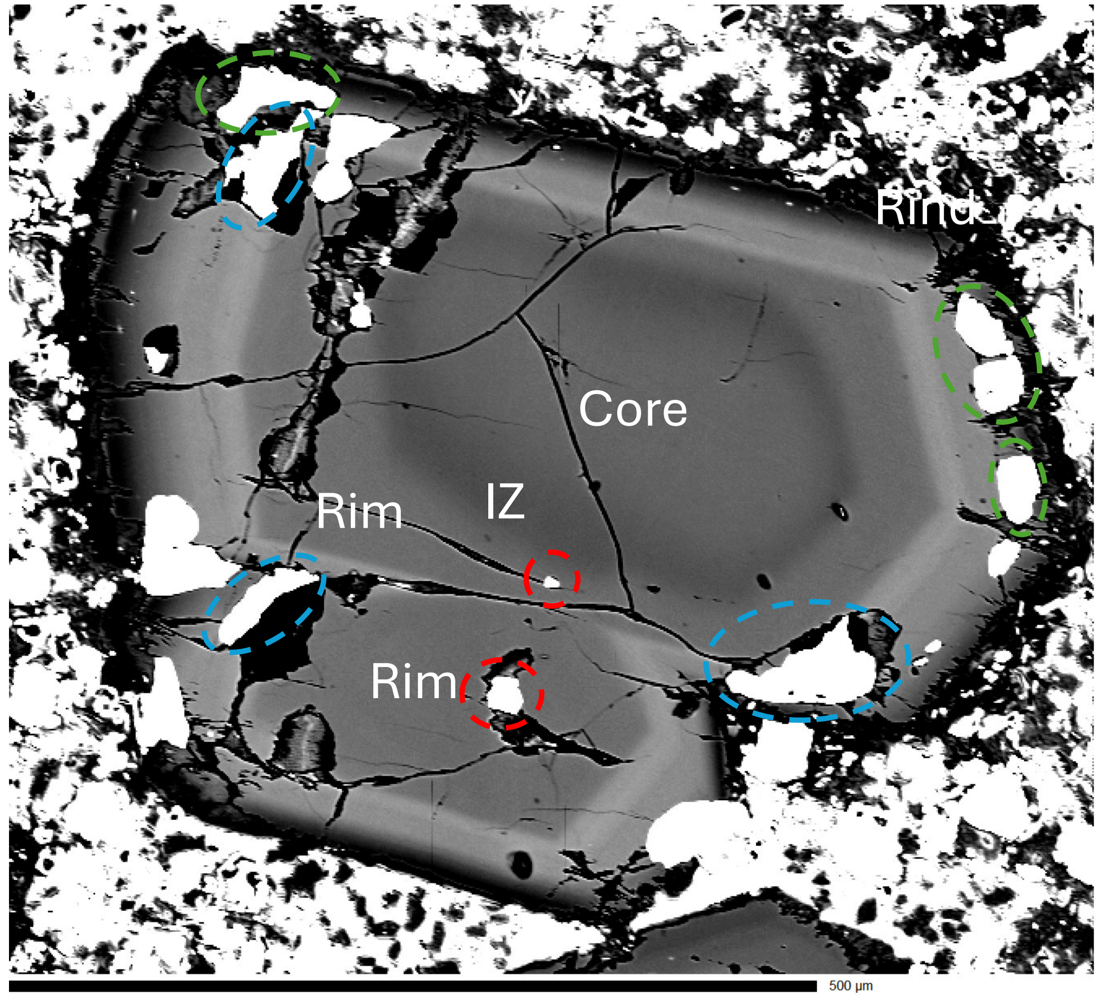


Abersteiner et al. (2022 – J.Pet)

Complexity of olivine zoning

Howarth and Gross (2019 – *GCA*)

Macrocryst and true phenocryst

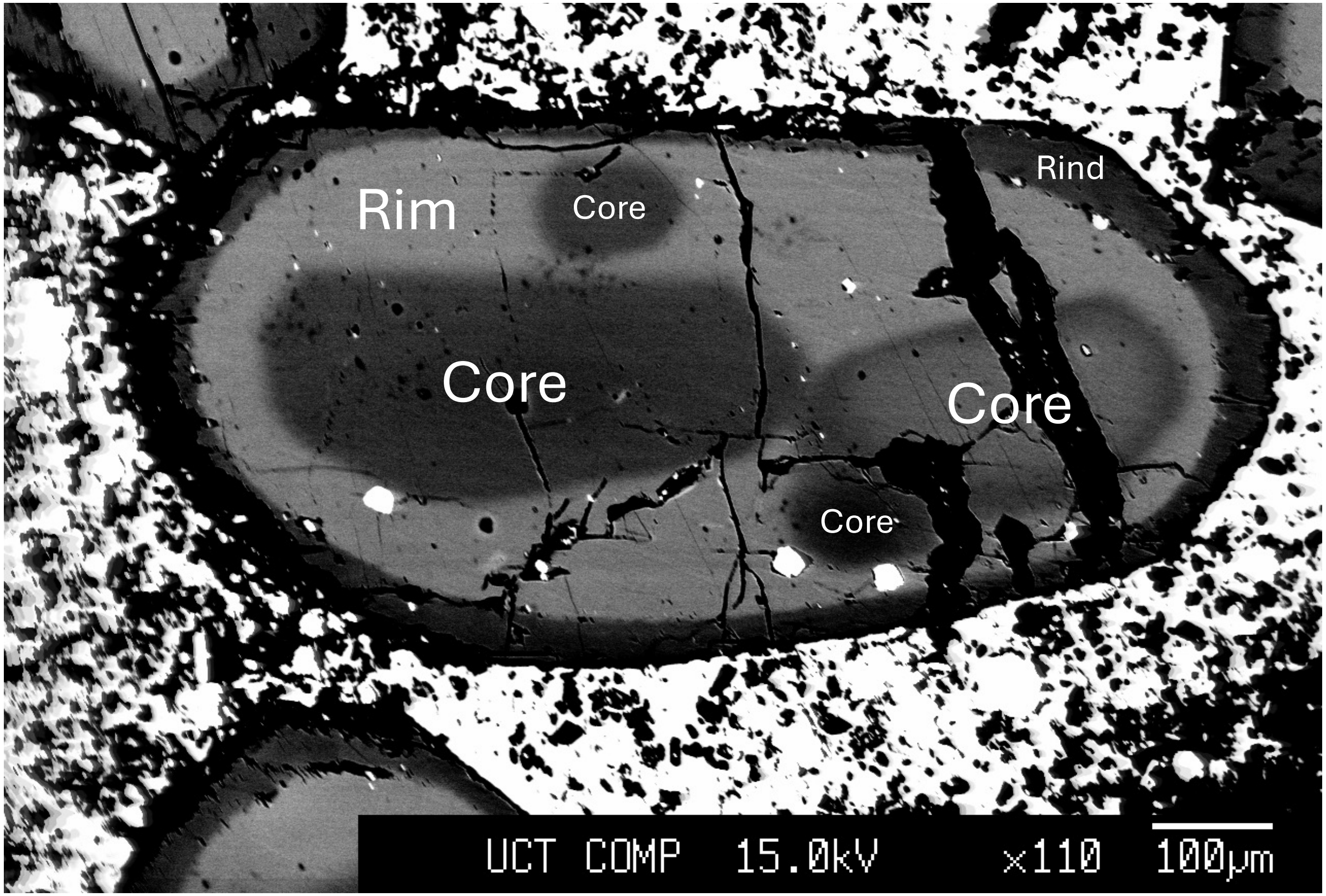


Benfontein sill

Oxide inclusions in olivine:

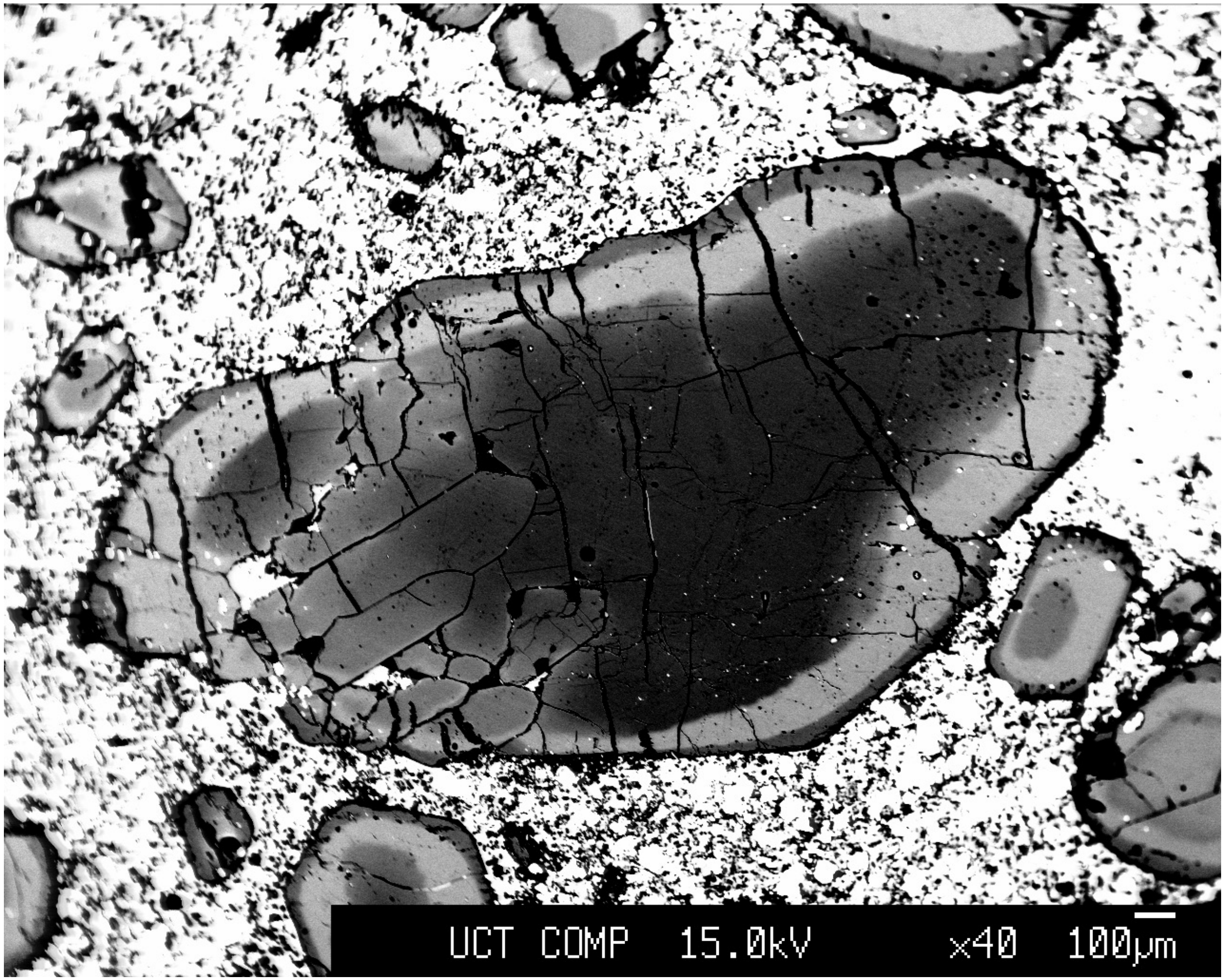
- Chromite
- Ilmenite
- MUM

Complexity of zoning



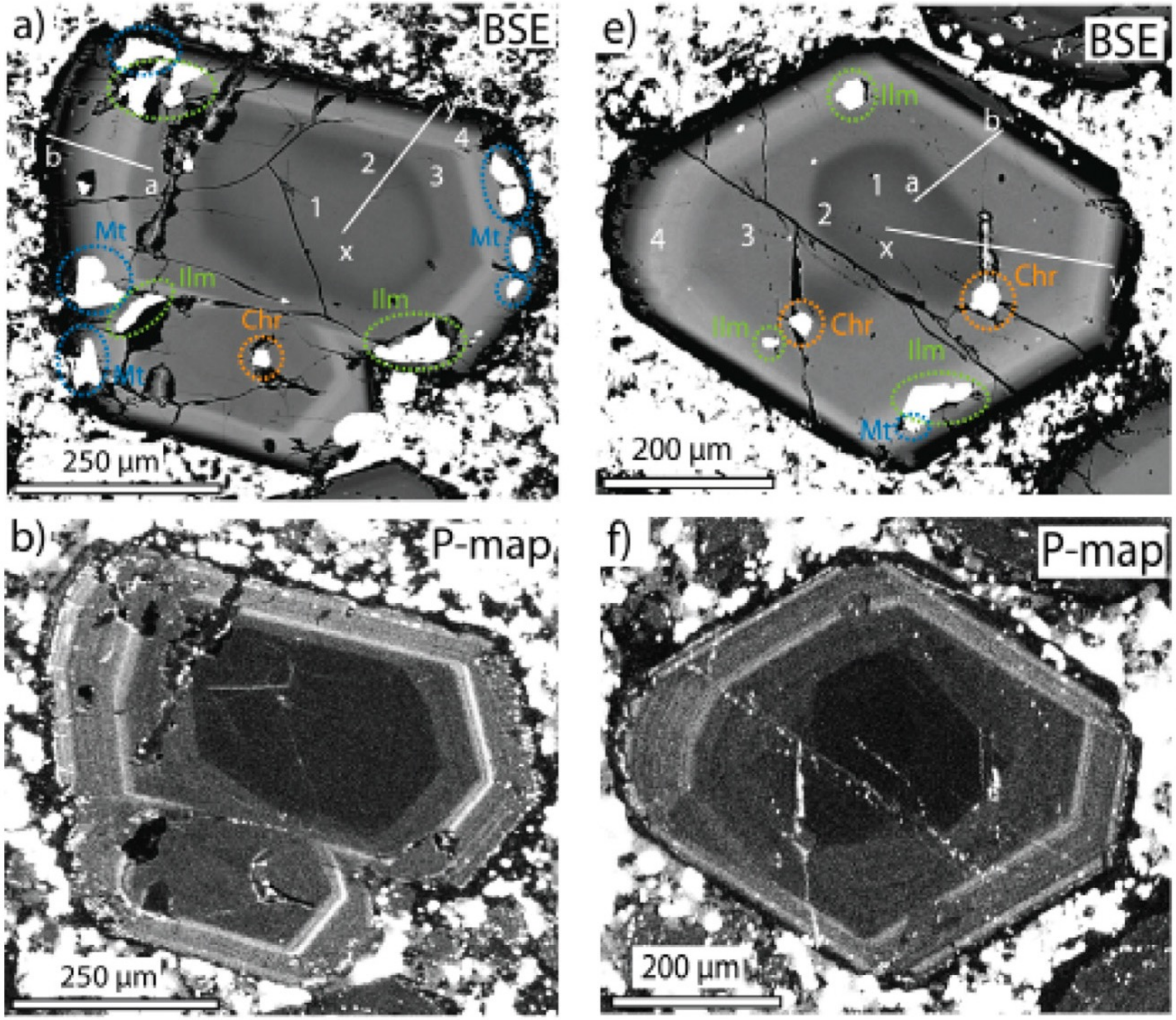
Benfontein kimberlite, Kimberley

Complexity of olivine zoning



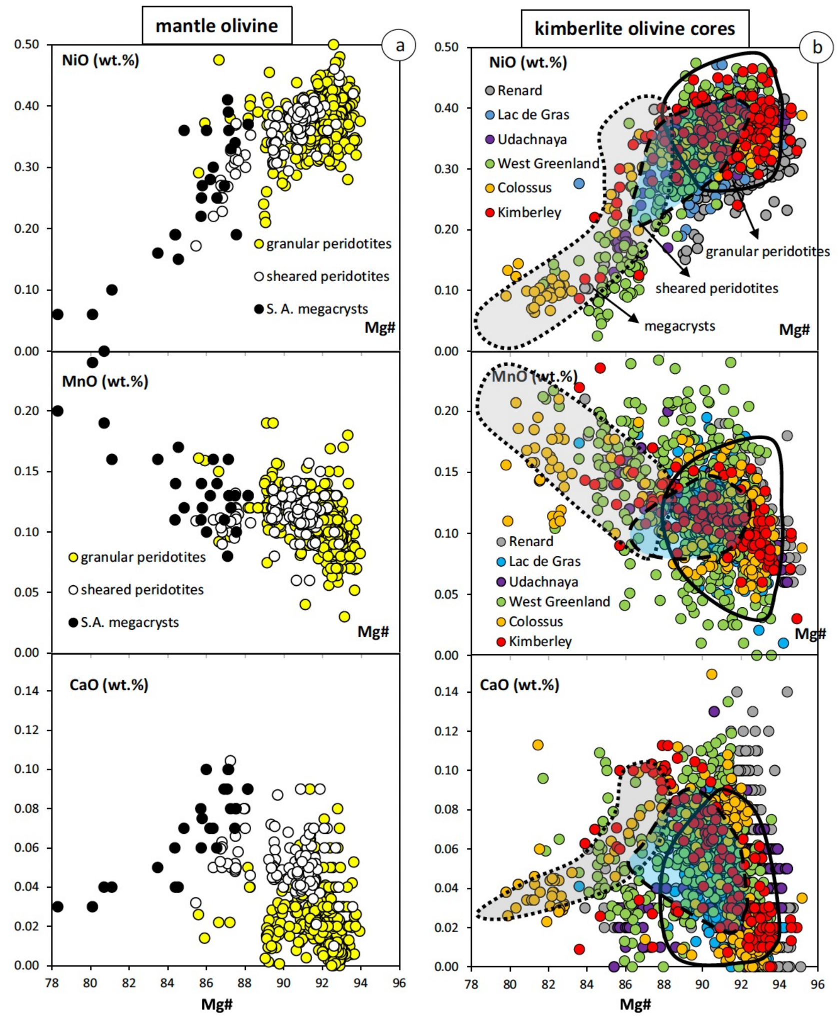
Benfontein kimberlite, Kimberley

Phosphorus zoning



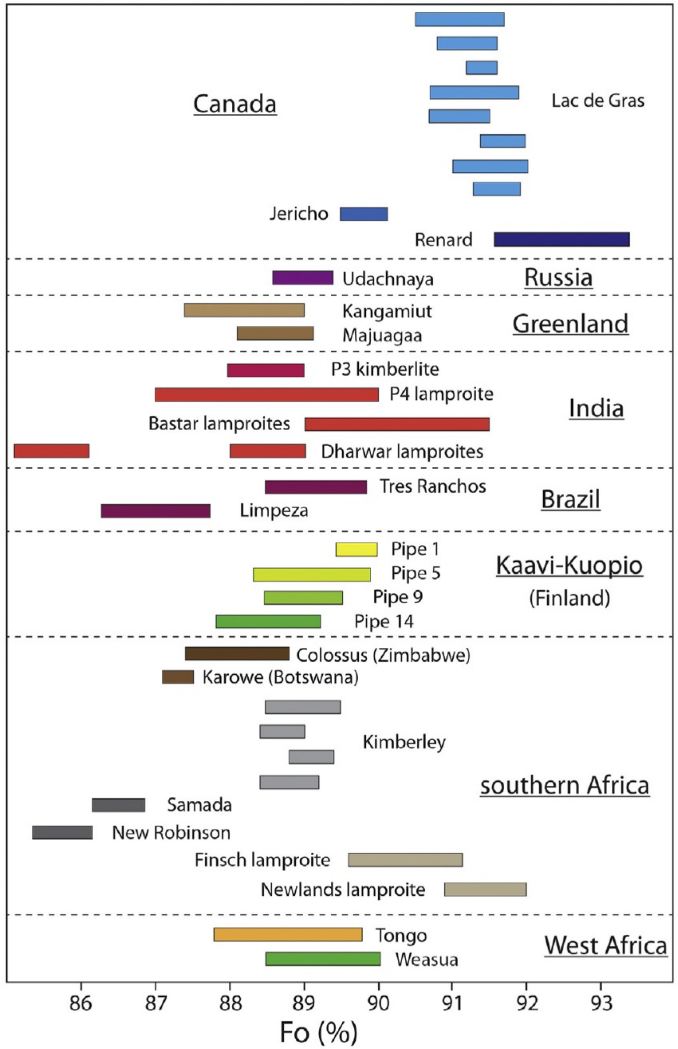
Howarth and Gross (2019 – *GCA*)

Global olivine core compositions



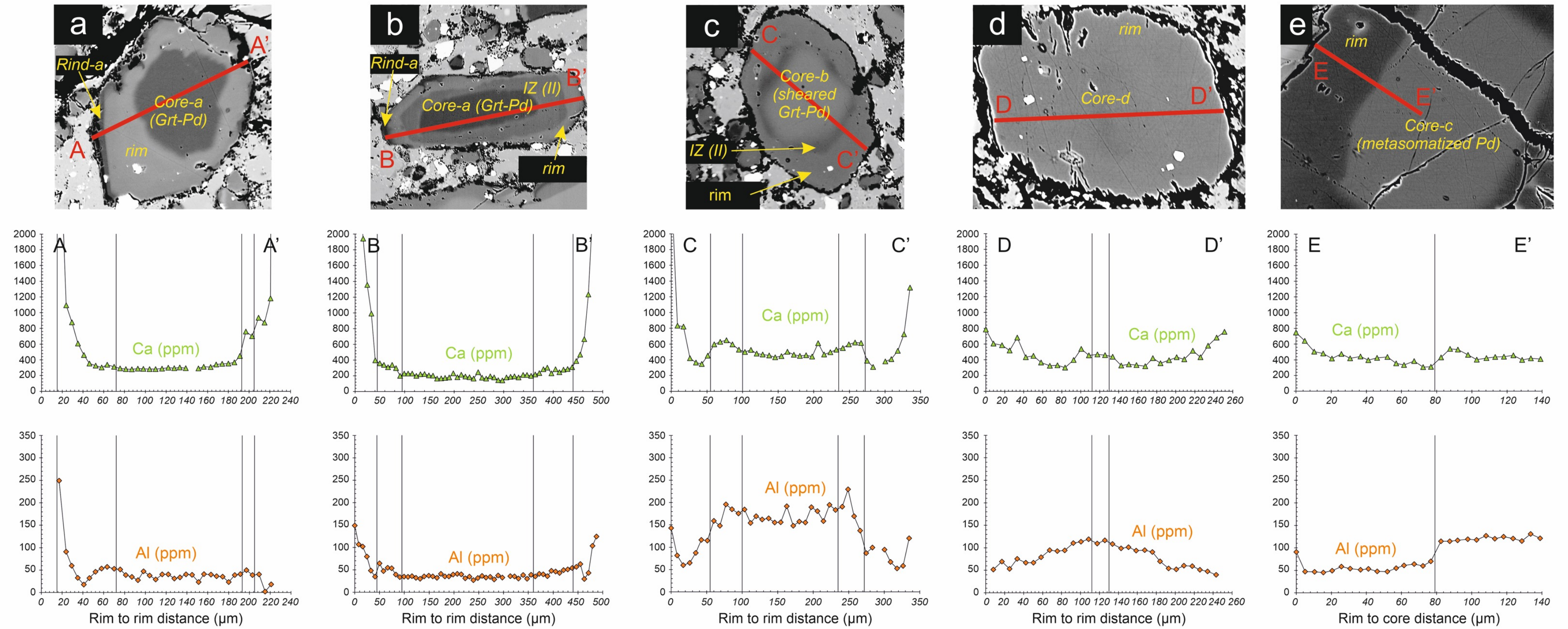
Giuliani (2018 – *Lithos*)

Global olivine rim compositions



Howarth and Giuliani (2020 – *Lithos*)

Global olivine rim compositions



Casetta et al. (2023 - EPSL)

Olivine evolution stages - Benfontein

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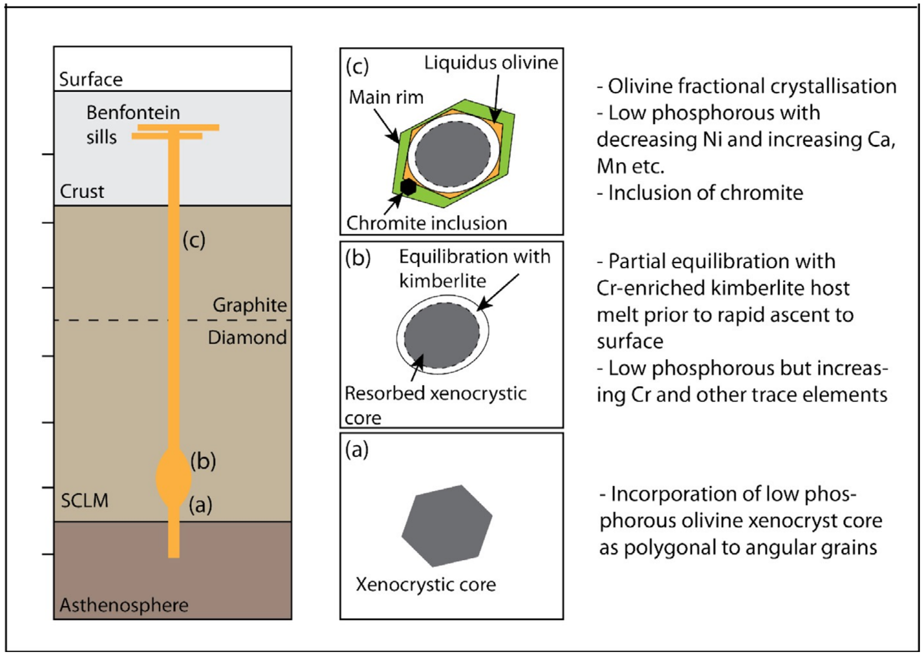
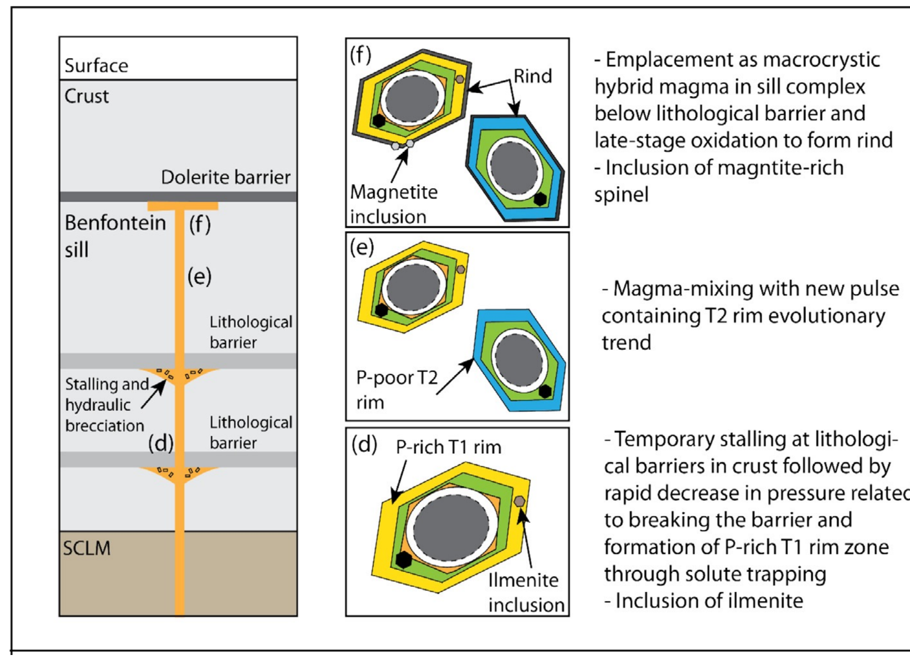
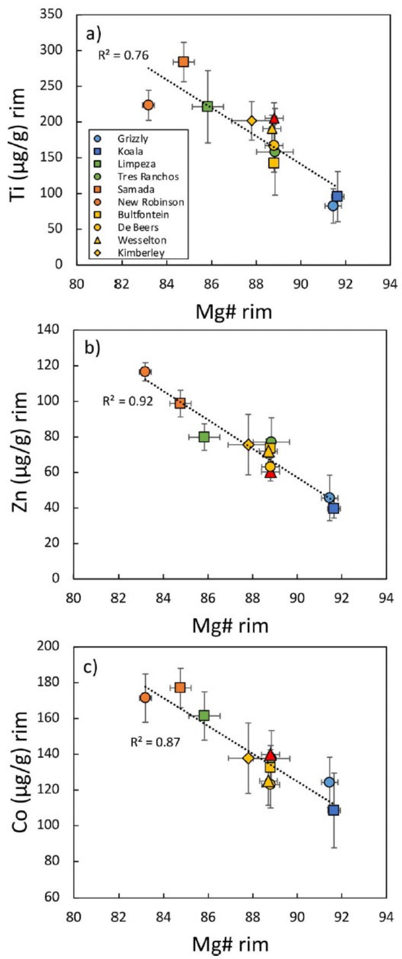
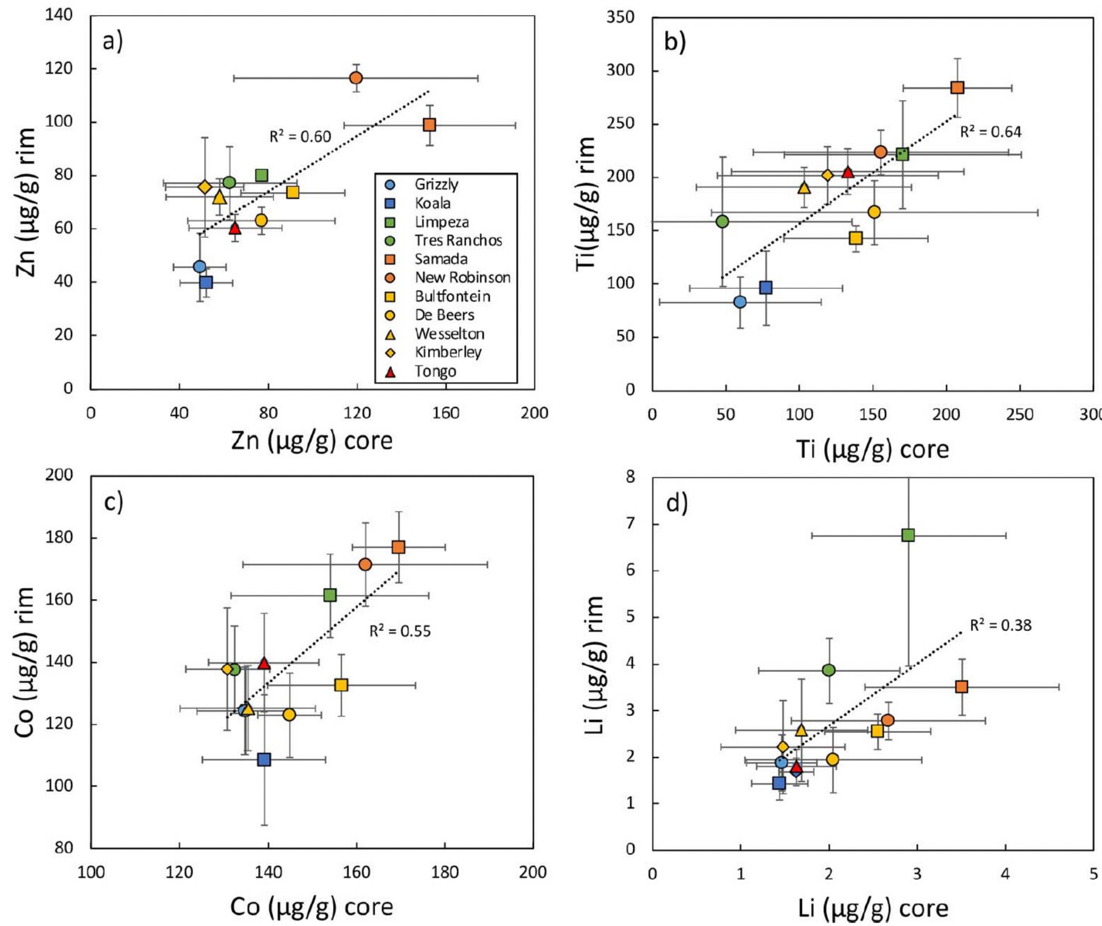




Howarth and Gross (2019 – *GCA*)

Global olivine core-rim correlation

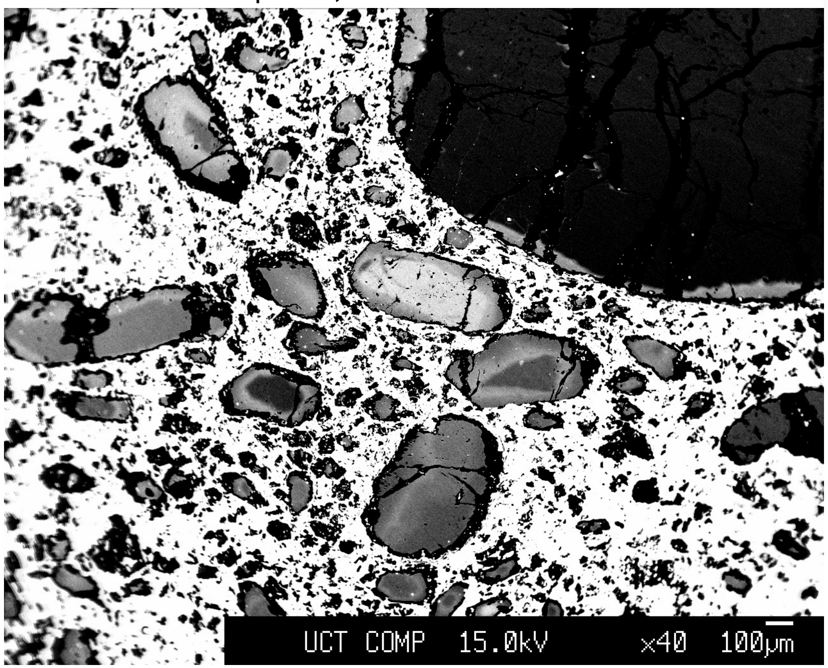




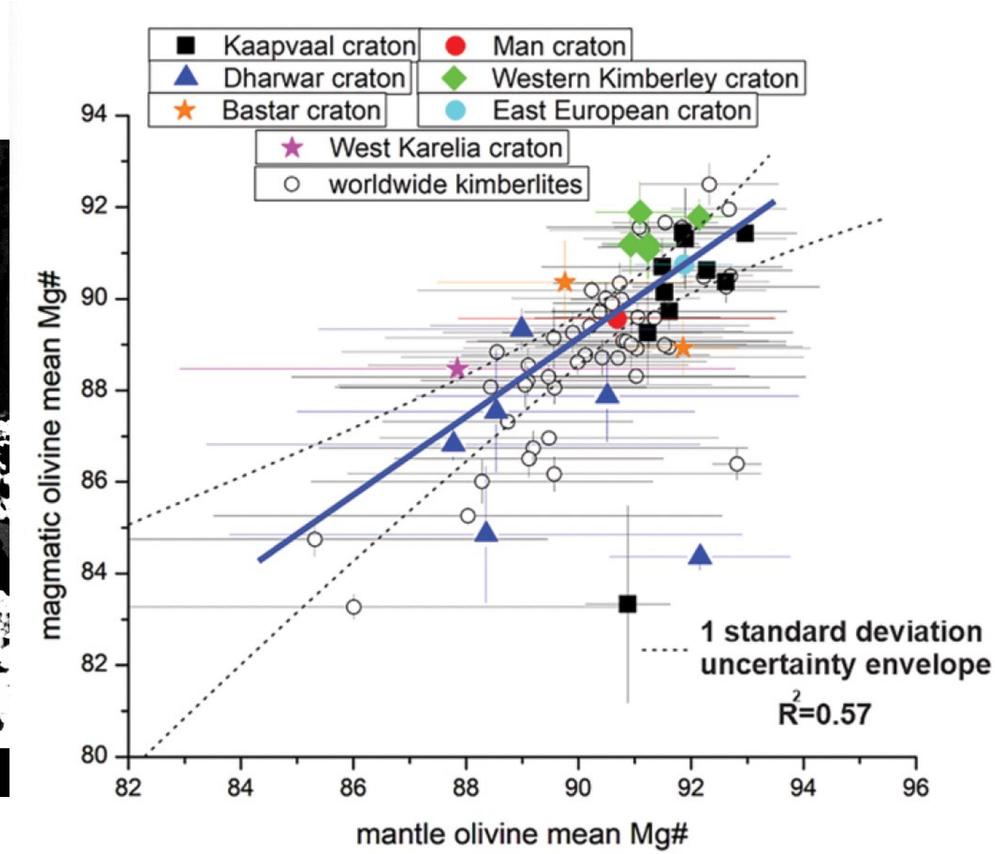
Howarth et al. (2022 – *J.Petrology*)

Cratonic lamproite olivine core-rim correlation

Finsch olivine lamproite, South Africa

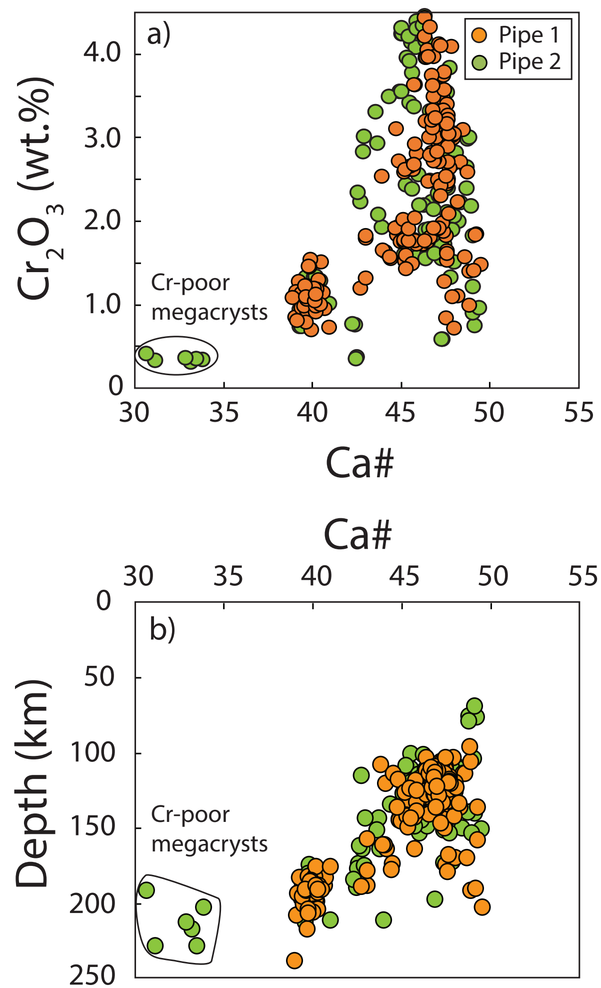


Howarth and Nembambula (2021 – *Lithos*)

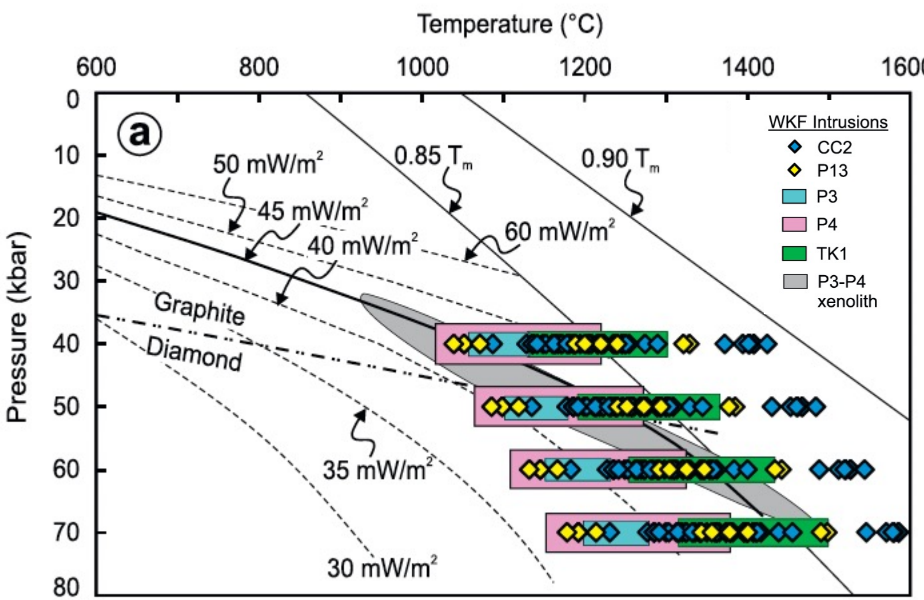


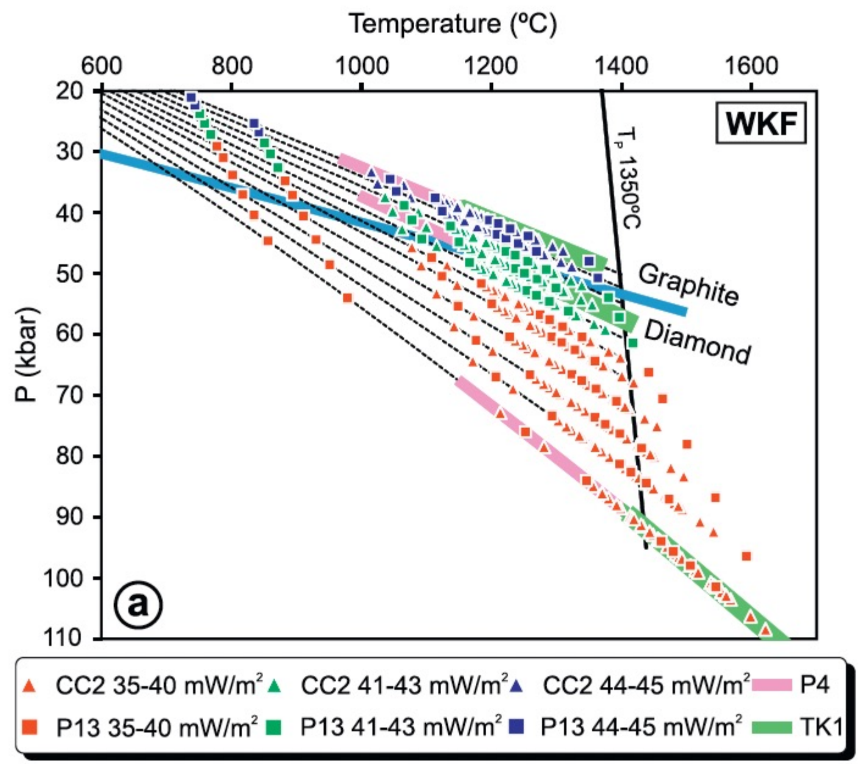
Sarkar et al. (2023 – *GEOLOGY*)

Mantle sampling – Koidu example



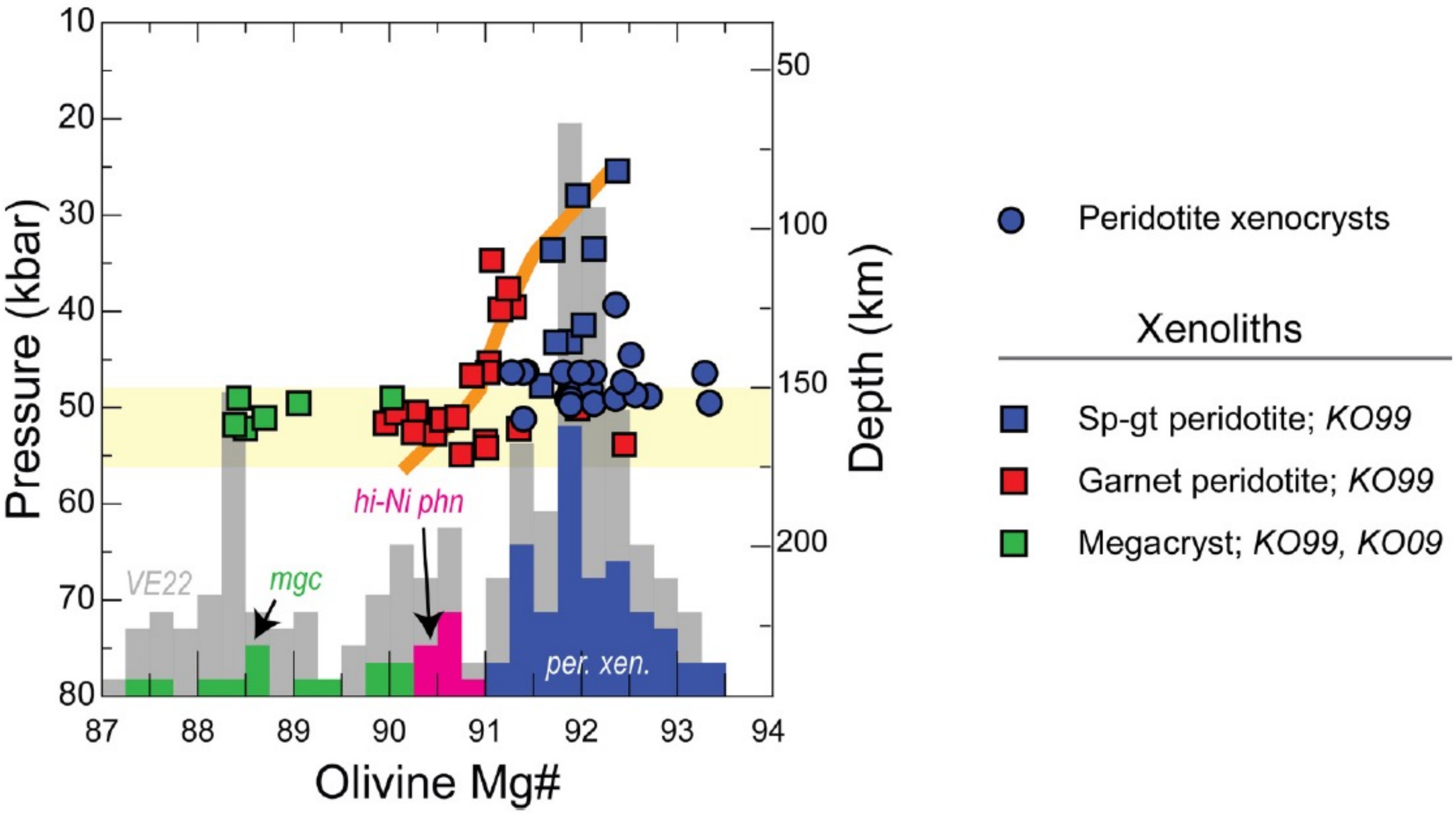
Diamondiferous lamproites - India





Shaikh et al. (2019 – Lithos)

Jericho kimberlite example



Greene et al. (2023 – *Lithos*)

Jericho kimberlite example

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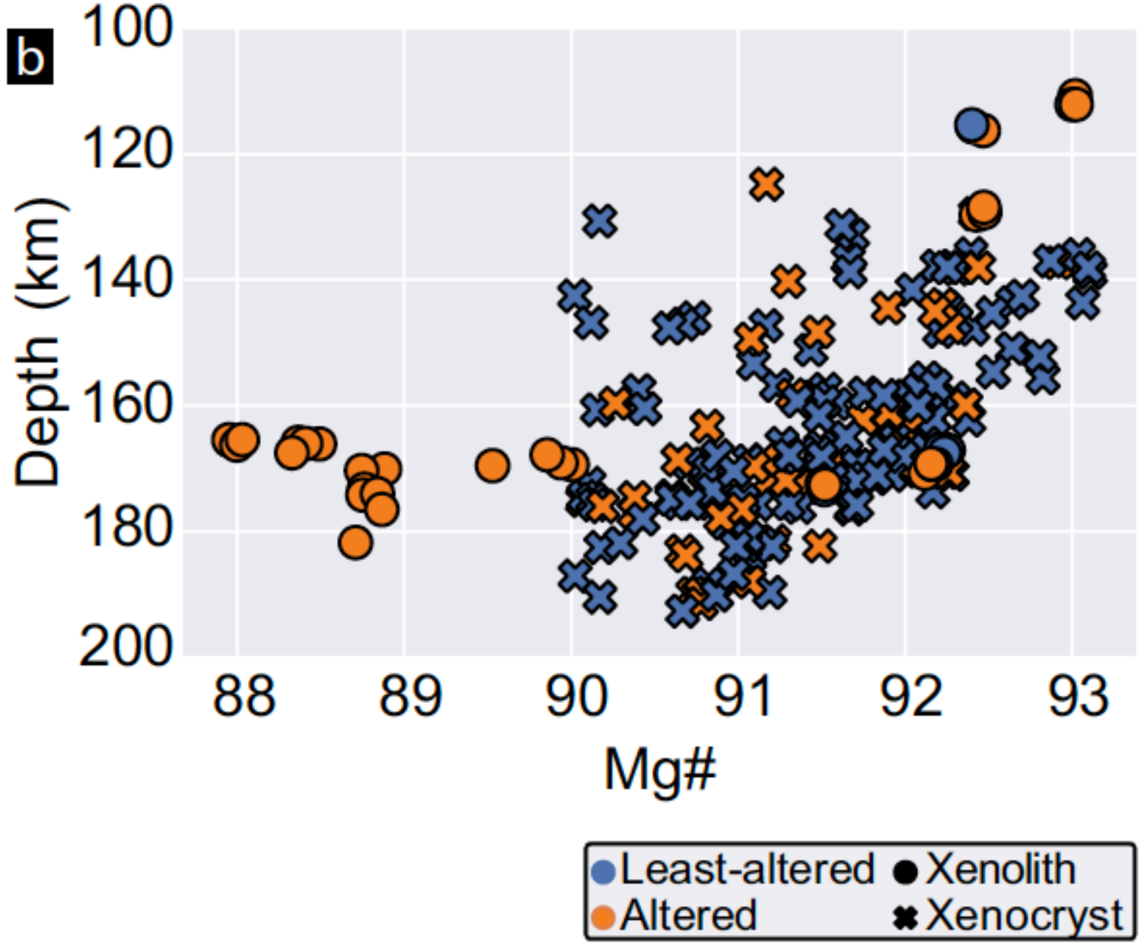
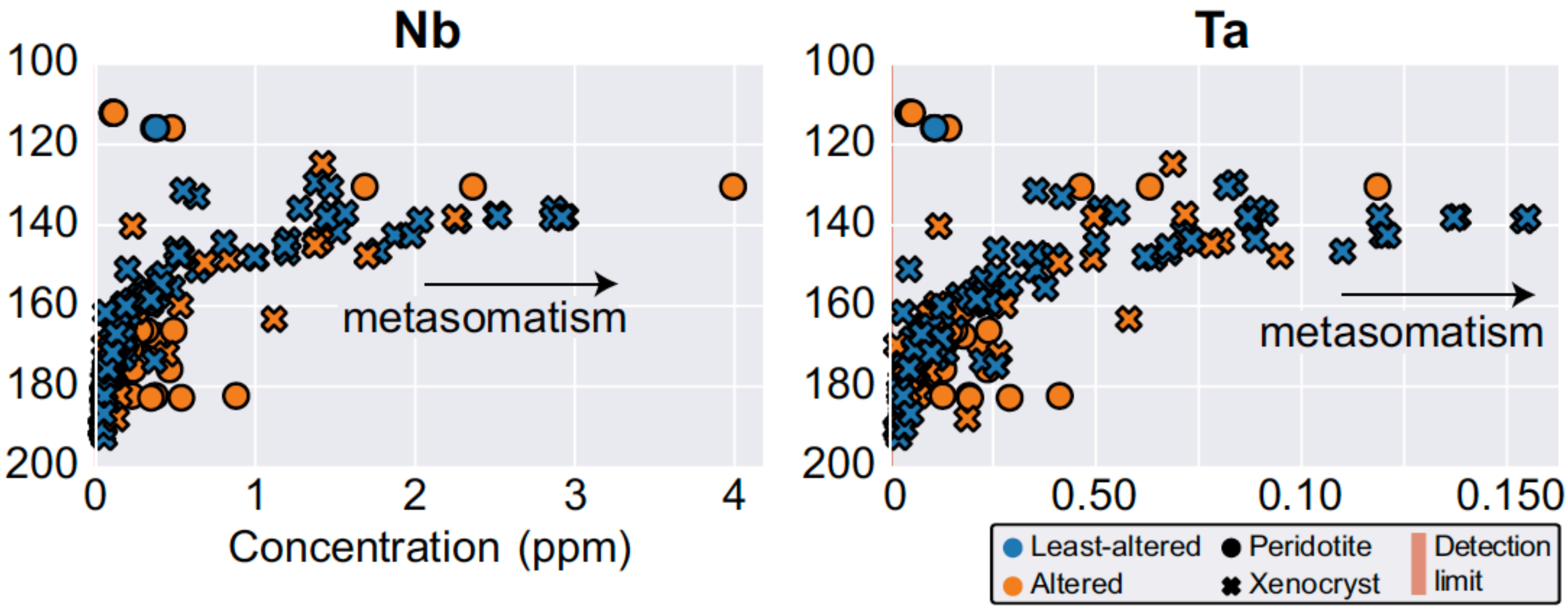


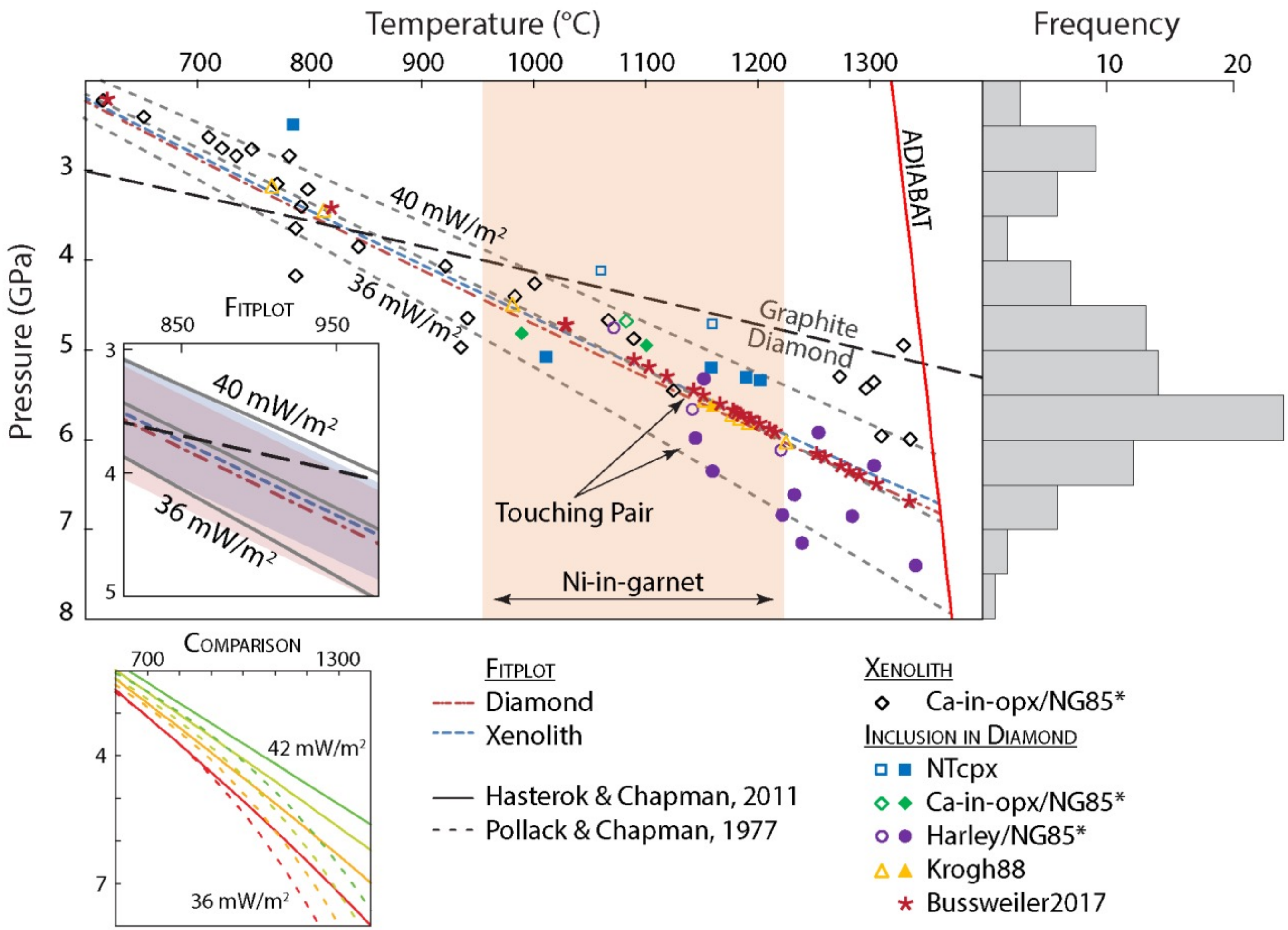
Veglio et al. (2022 – *Lithos*)

Jericho kimberlite example



Veglio et al. (2022 – *Lithos*)

Koffiefontein kimberlite



Meyer (2021 – PhD, University of Alberta)

Cullinan diamond inclusions

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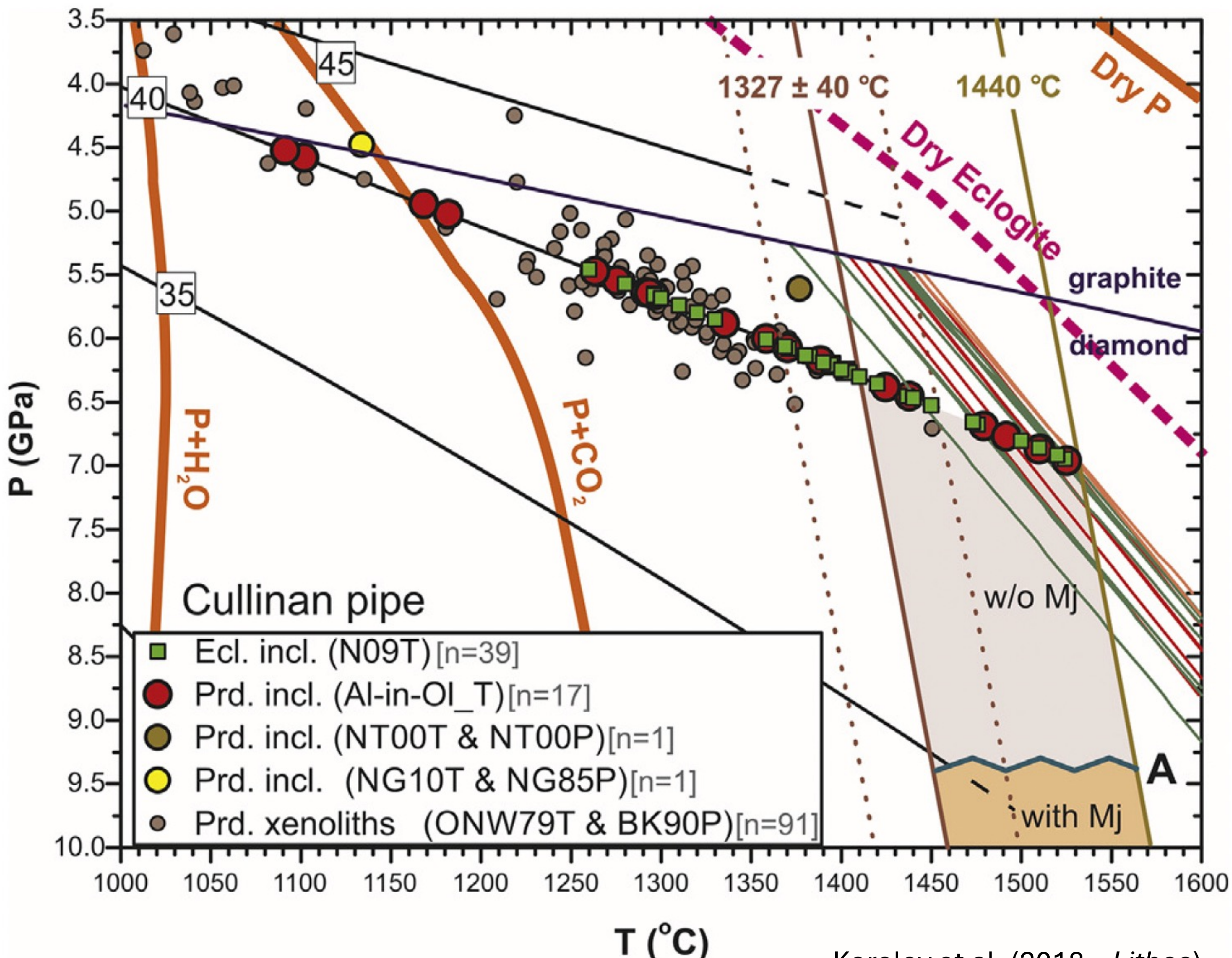

Korolev et al. (2018 – *Lithos*)

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Origin of dunitic nodules

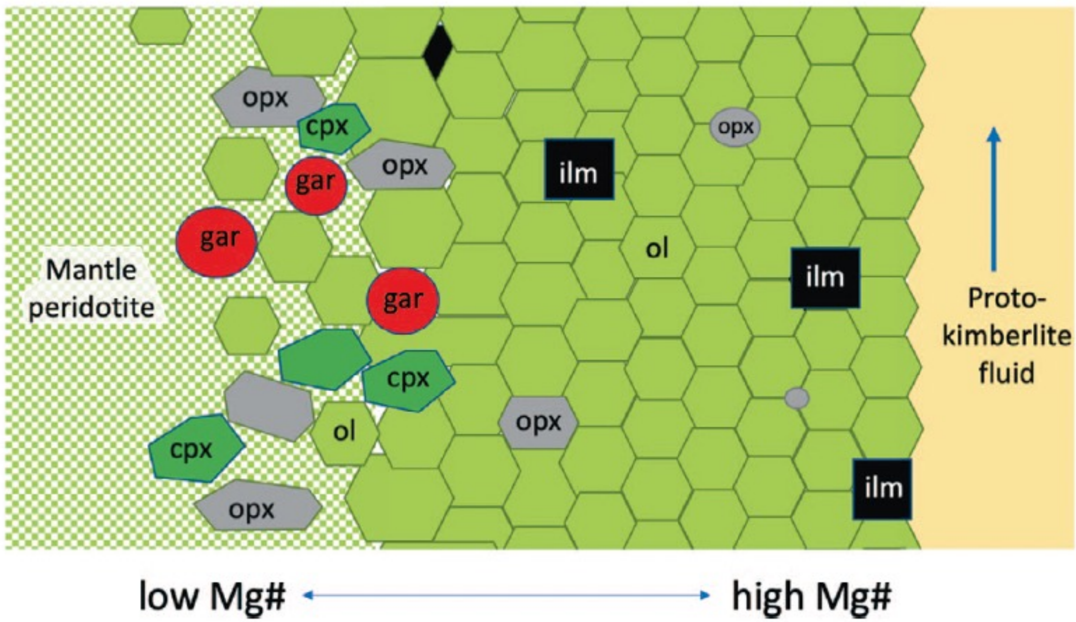

Fig. 14. Diagram illustrating a possible mechanism for the formation of megacrysts, macrocrysts and dunitic nodules in kimberlites. Reaction between protokimberlite fluid and mantle peridotite extracts pyroxene and garnet from zone closest to conduit leaving dunite with rare ilmenite crystals. Farther from the conduit, interaction between fluid and peridotite facilitates the growth of large crystals of olivine, pyroxene and garnet. The Mg# is higher than in mantle peridotite close to the conduit and lower far from the conduit.

Arndt et al. (2022 – *J.Pet.*)