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12 IKC 12TH INTERNATIONAL KIMBERLITE CONFERENCE

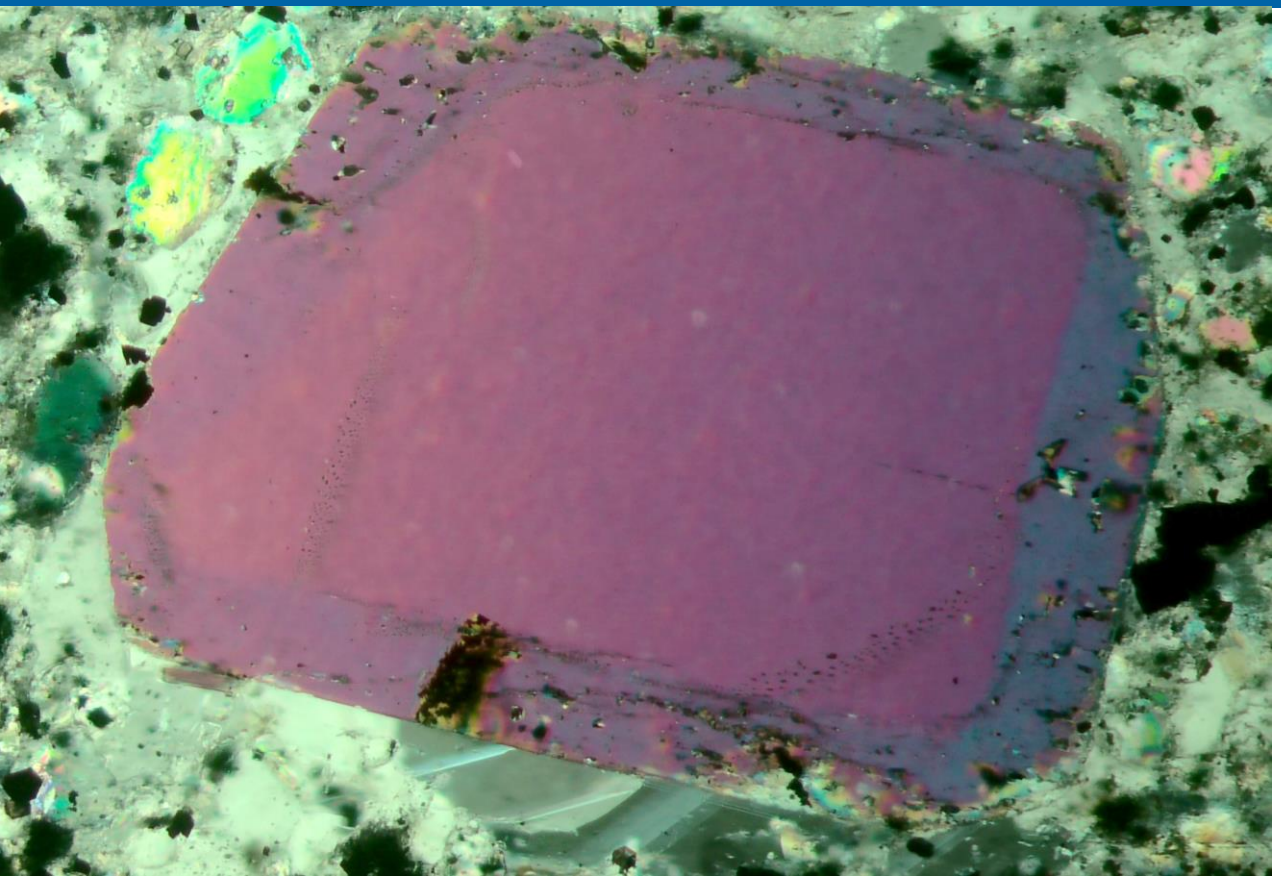
30 YEARS OF DIAMONDS IN CANADA

8–12 July 2024 • Yellowknife

FWF Der Wissenschaftsfonds.

LM Projekt M-3080-N
Esprit Project ESP 605-N

Olivine-hosted mineral inclusions in kimberlites: insights on the liquid line of descent and T-fO_2 path



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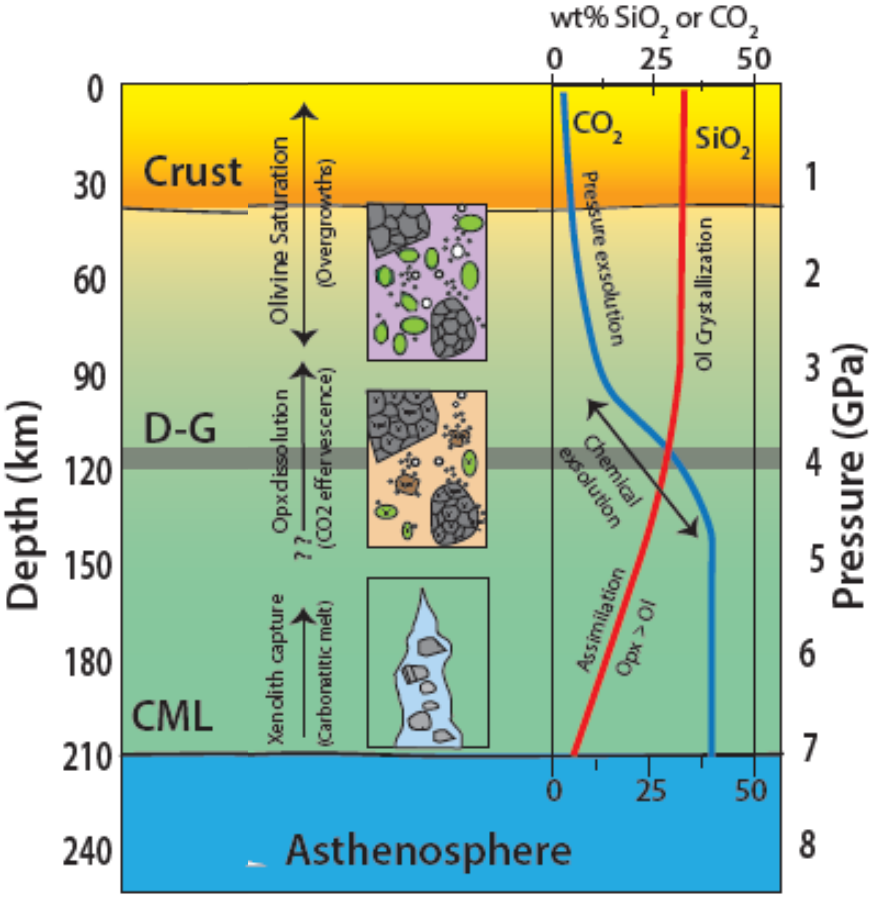
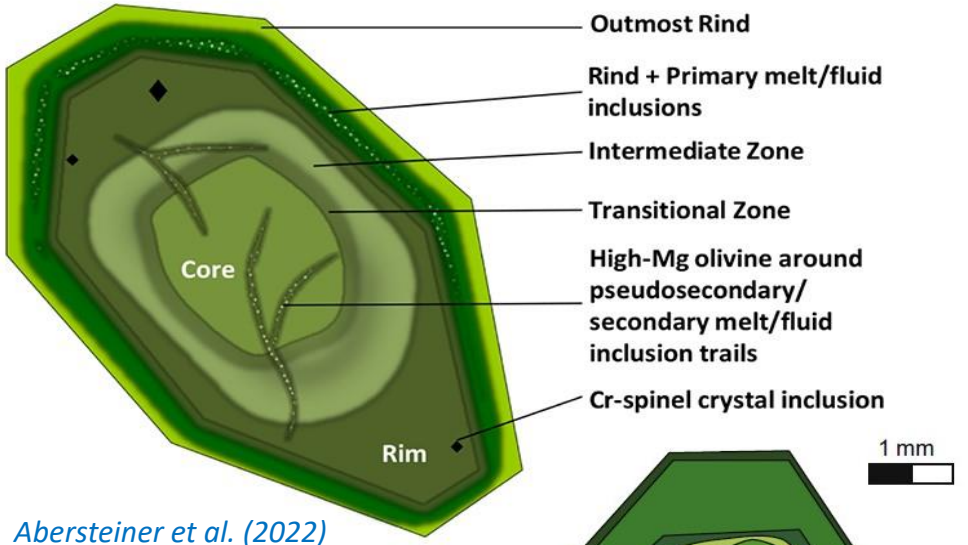
Kimberlitic features & problems

- Mixture of mantle-derived xenocrysts and magmatic phenocrysts
- Fast ascending melts (150-200 km of lithosphere in 2-4 hours to 10-20 days): low-density and/or progressive CO_2-enrichment
- Genesis, composition and evolution of kimberlite-related melts?
- Degree and style of interaction with the lithospheric mantle?

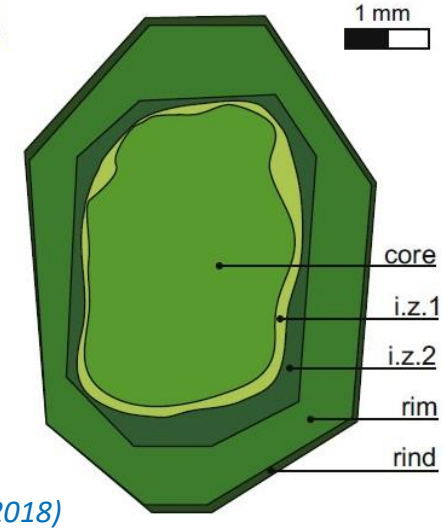


Russell et al. (2019)

Olivine zoning and mineral inclusions



Abersteiner et al. (2022)



Giuliani (2018)

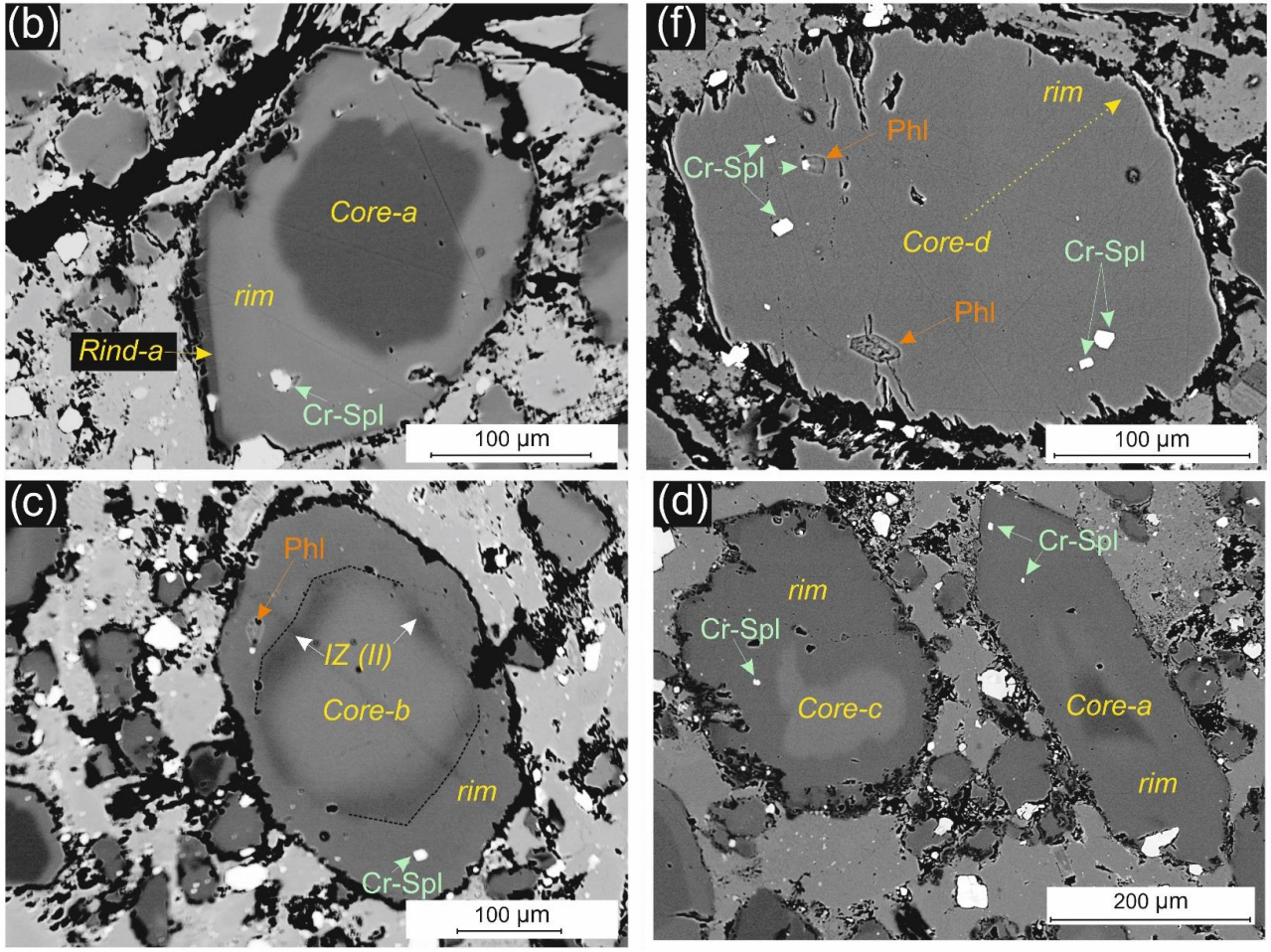
Typical mineral inclusions in euhedral rims → magmatic

- Cr-spinel
- Ilmenite
- Rutile

Can we associate specific mineral inclusions to each domain of zoned olivine crystals and use this information to unravel the LLD?

Olivine from Udachnaya-East kimberlite

Casetta et al. (2023a)



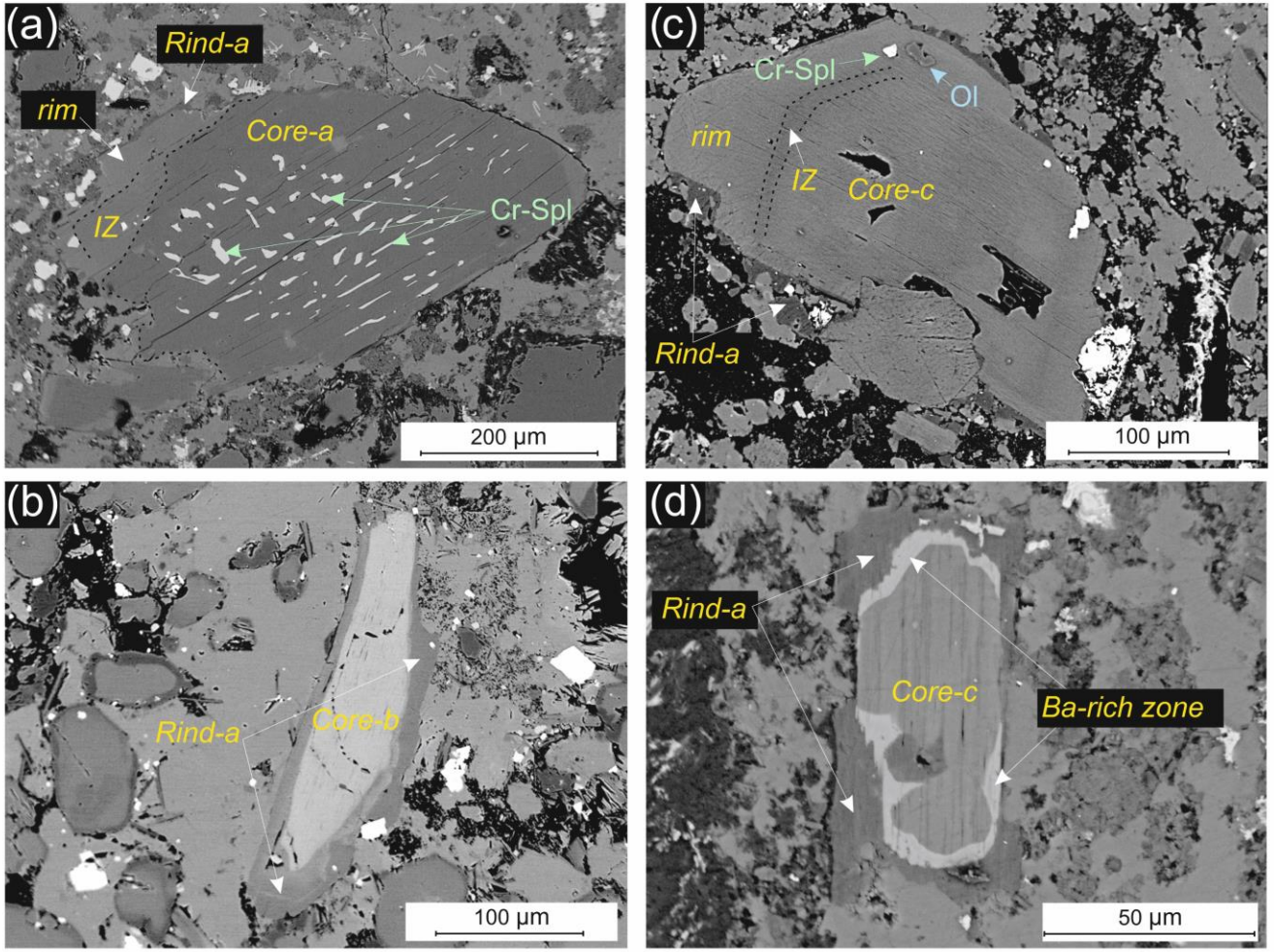
Cores a, b, c (Fo_{85-93}): xenocrystic, inclusions-free

Core d (Fo_{89}): magmatic, inclusions of Ti-Mg-chromite

Rim (Fo_{89}): inclusions of
- Ti-Mg-chromite
- Rutile
- Phlogopite (Mg# 89-90)

Phlogopite from Udachnaya-East kimberlite

Casetta et al. (2023a)



Core a (Mg# 91): xenocrystic, exsolution of Ti-Mg-chromite

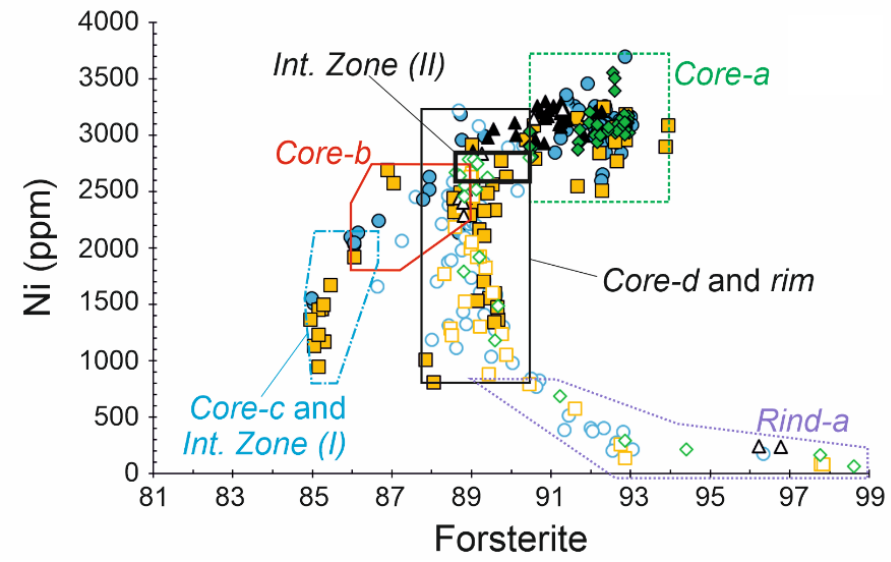
Core b, c (Mg# 76-90): xenocrystic, inclusions free

Rim (Mg# 89-86): inclusions of

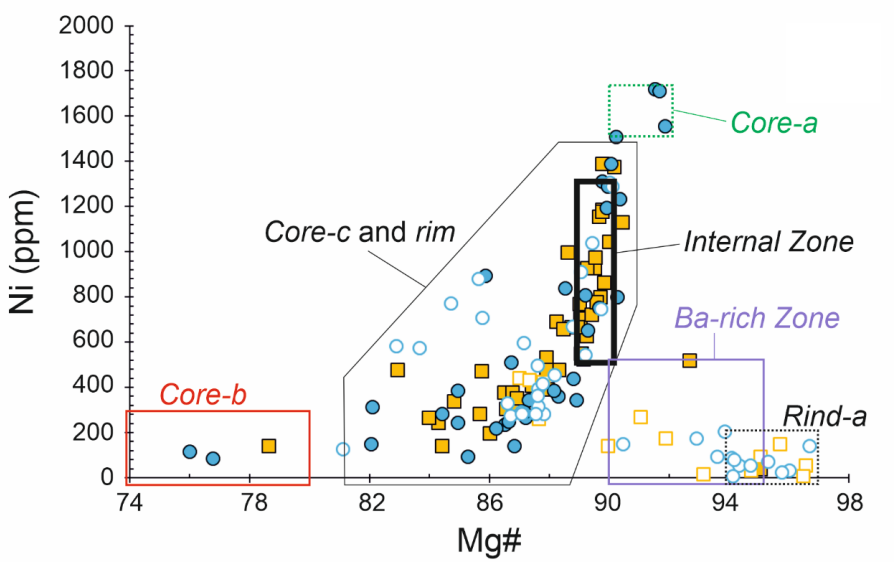
- Ti-Mg-chromite
- Perovskite
- Mg-Ti-rich ilmenite
- Olivine (Fo_{89})

Ni vs. Mg# trends

OLIVINE



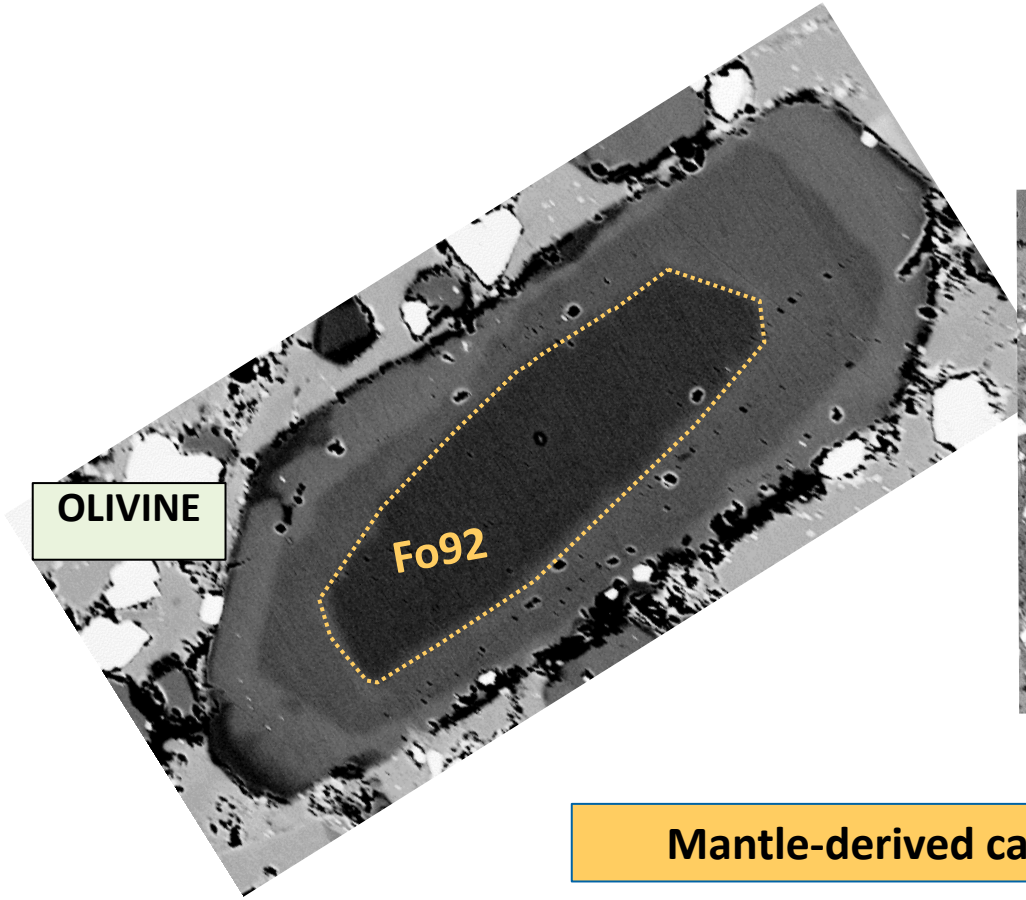
PHLOGOPITE

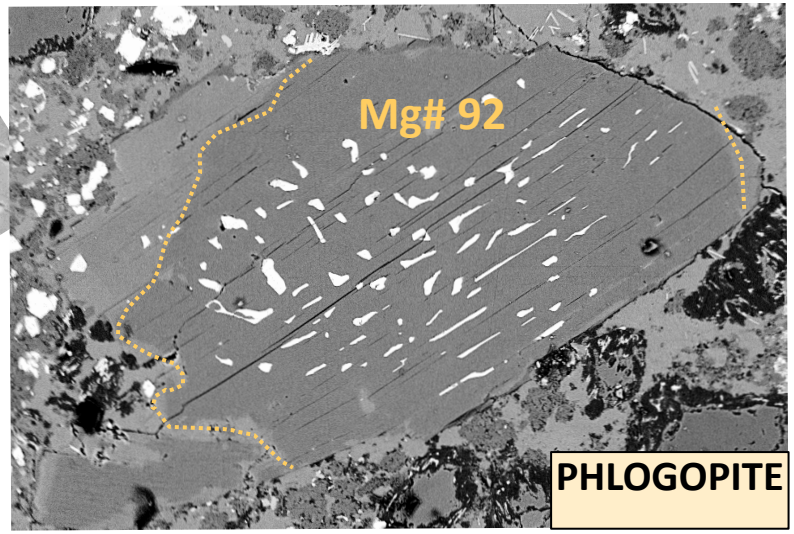


>5000 µm core
>5000 µm ext.
200-5000 µm core
200-5000 µm ext.
<200 µm core
<200 µm ext.
Monomineralic aggregate core
Monomineralic aggregate ext.

Mutual inclusions and the liquid line of descent (LLD)

Stage 0: xenocrysts entrainment



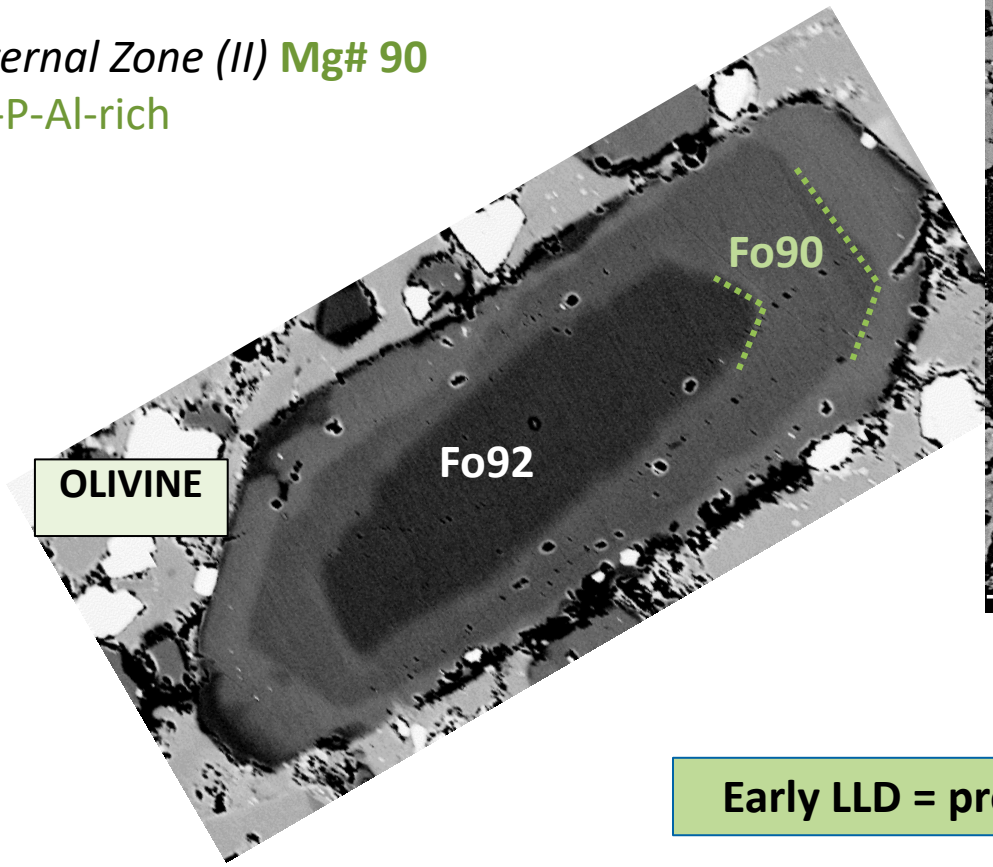


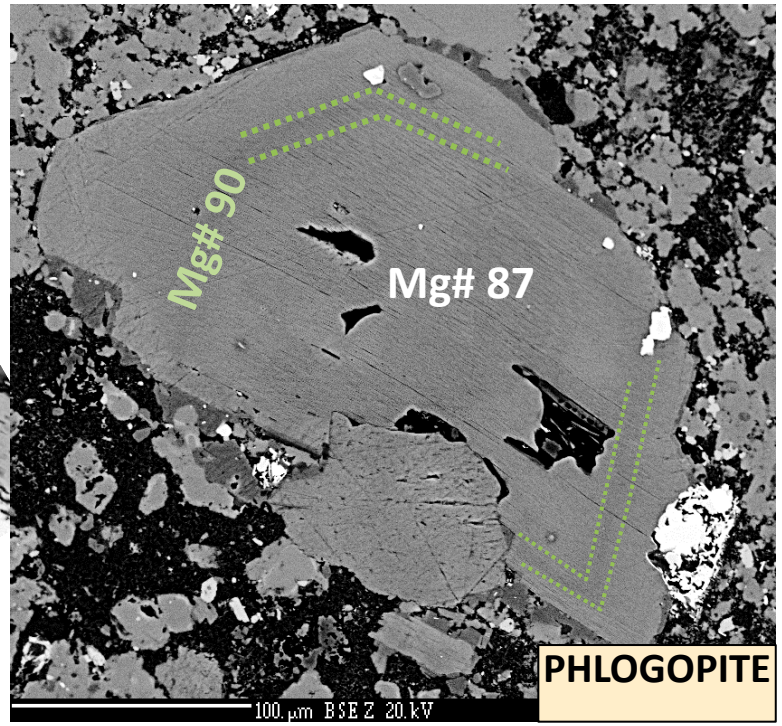
Mantle-derived cargo

Mutual inclusions and liquid line of descent (LLD)

Stage 1:

Internal Zone (II) **Mg# 90**
Cr-P-Al-rich



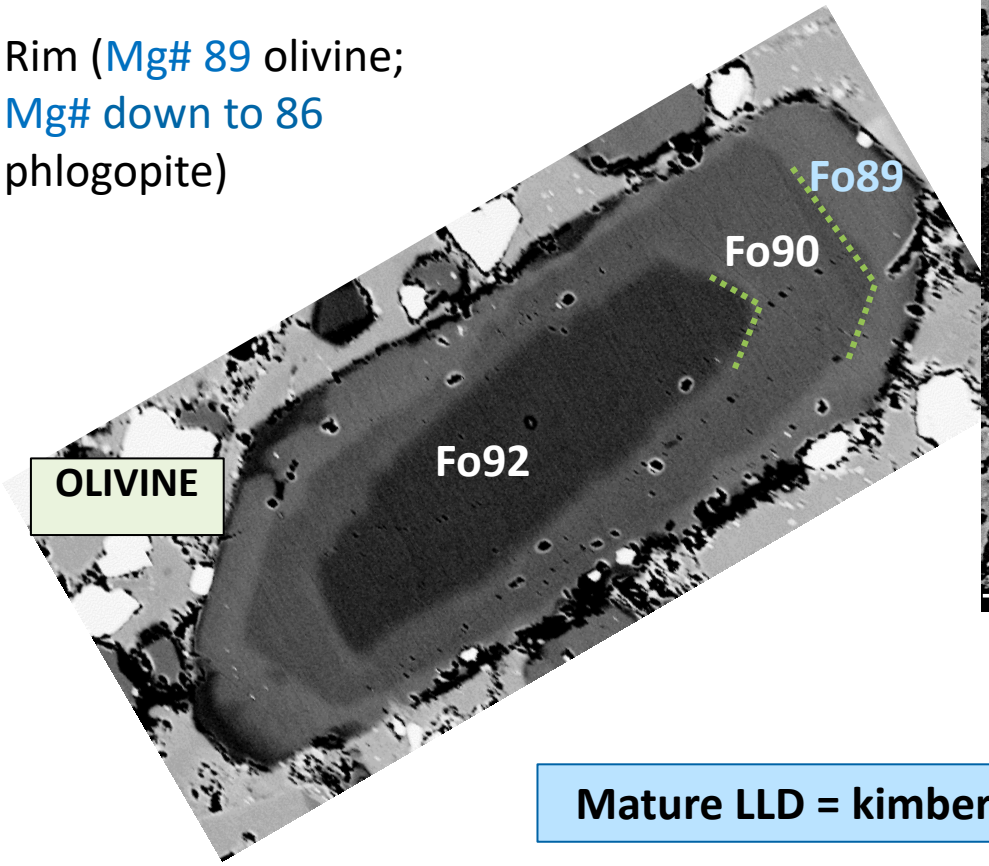


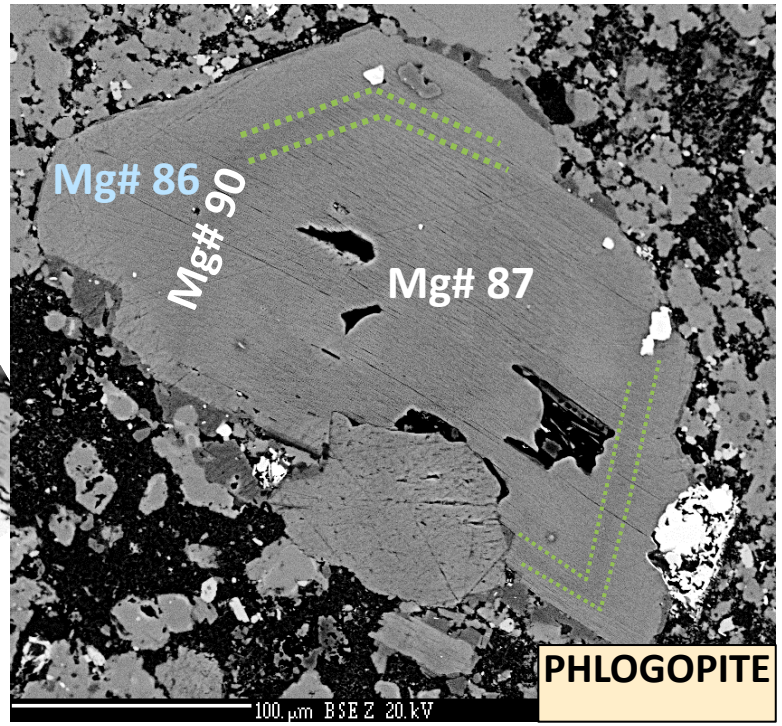
Early LLD = proto-kimberlite melt

Mutual inclusions and the liquid line of descent (LLD)

Stage 2:

- Rim (Mg# 89 olivine; Mg# down to 86 phlogopite)





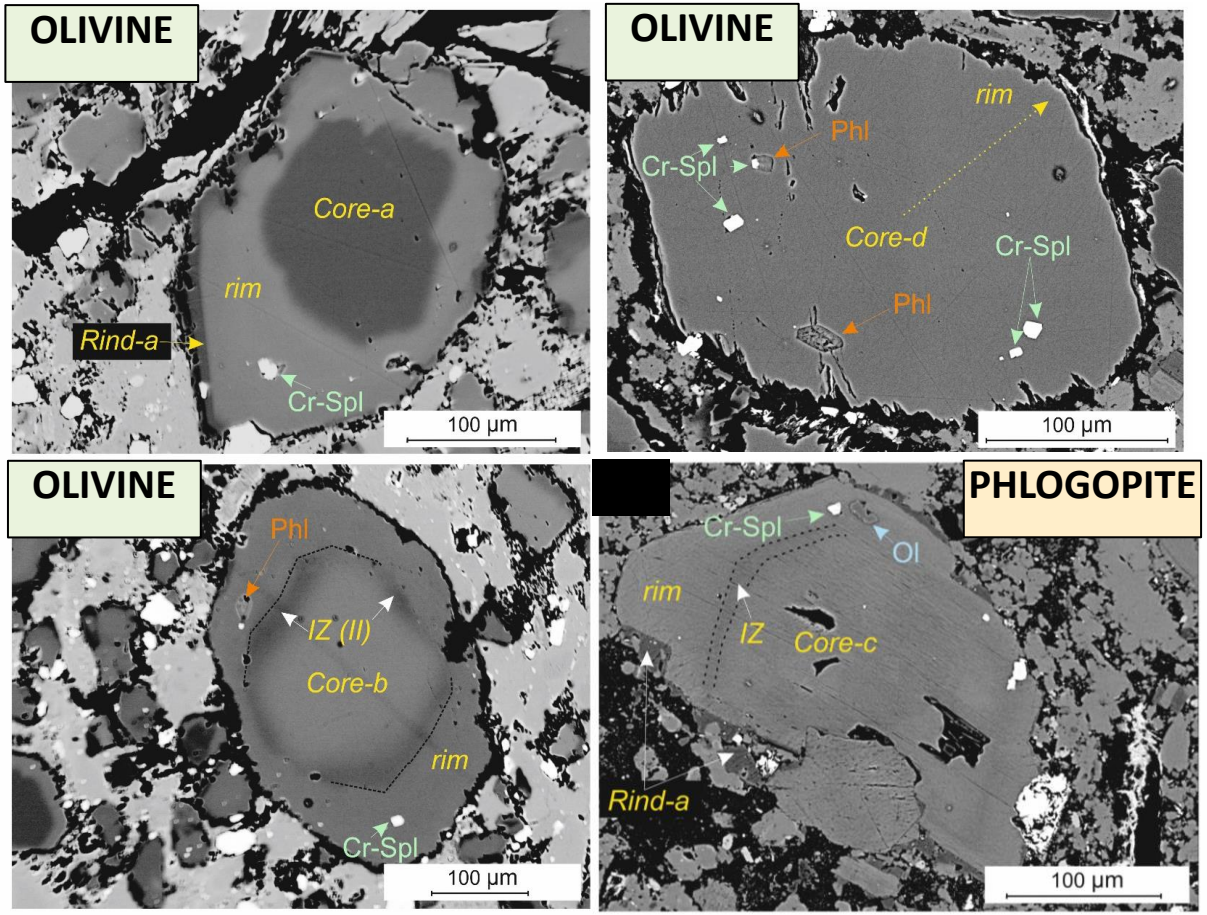
Mature LLD = kimberlite melt

Mutual inclusions and the liquid line of descent (LLD)

Stage 2:

Rim (Mg# 89), inclusions of:

- Ti-Mg chromite
- Rutile
- Phlogopite (in olivine)
- Olivine (in phlogopite)

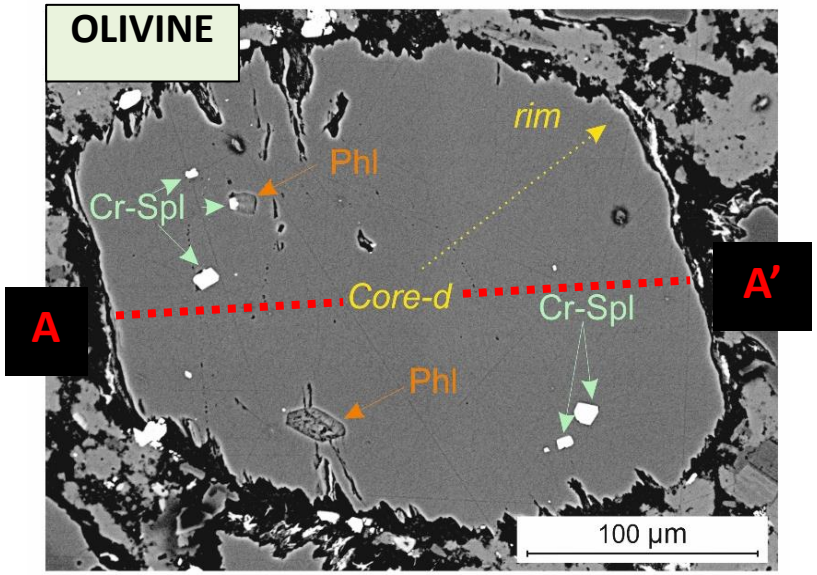


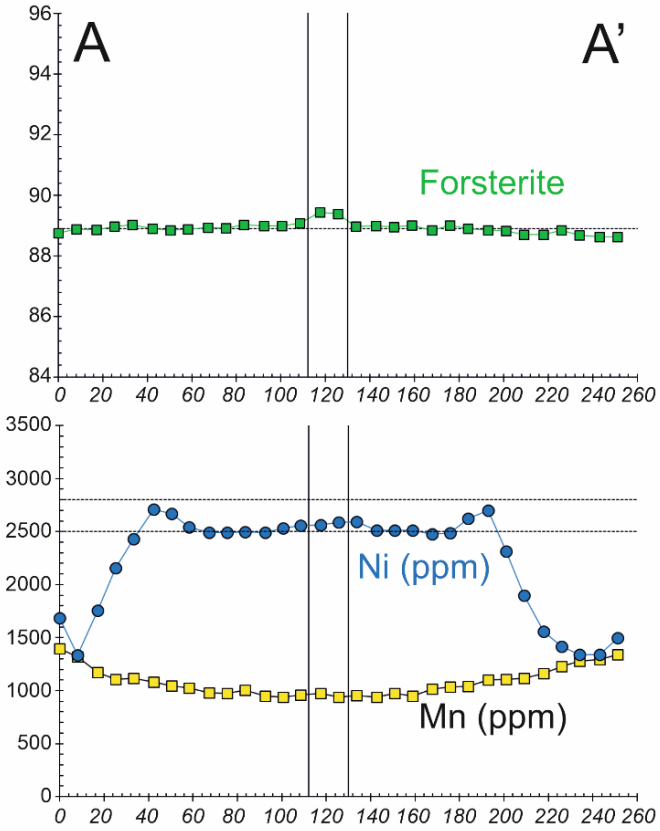
Mature LLD = kimberlite melt

Mutual inclusions and the liquid line of descent (LLD)

Stage 3:

- Core-to-rim Ni decrease at constant Mg#



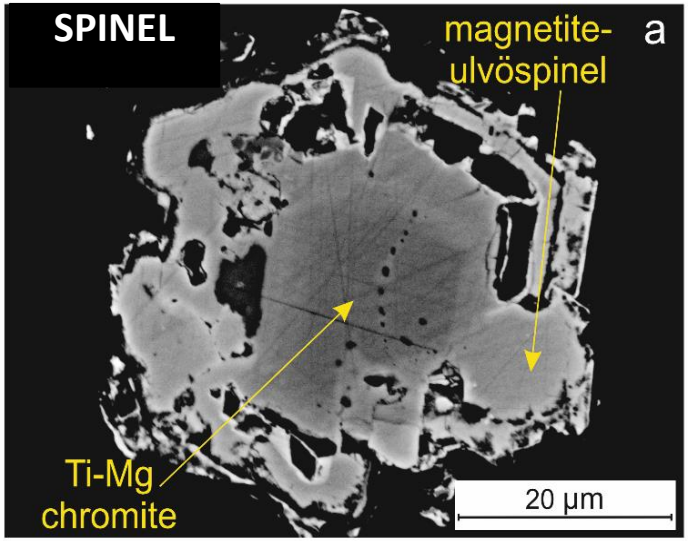


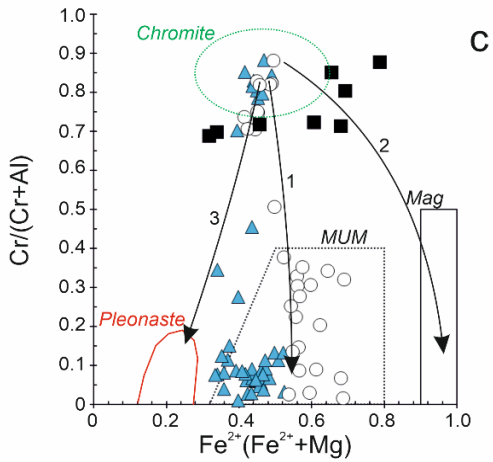
Mature LLD = kimberlite melt

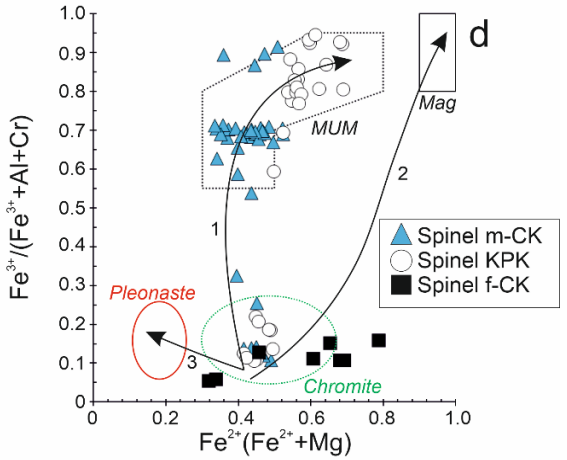
Mutual inclusions and the liquid line of descent (LLD)

Stage 3:

- Core-to-rim Ti decrease in phlogopite
- Magnetite-ulvospinel around chromite
- Perovskite and Ti-Mg-rich ilmenite





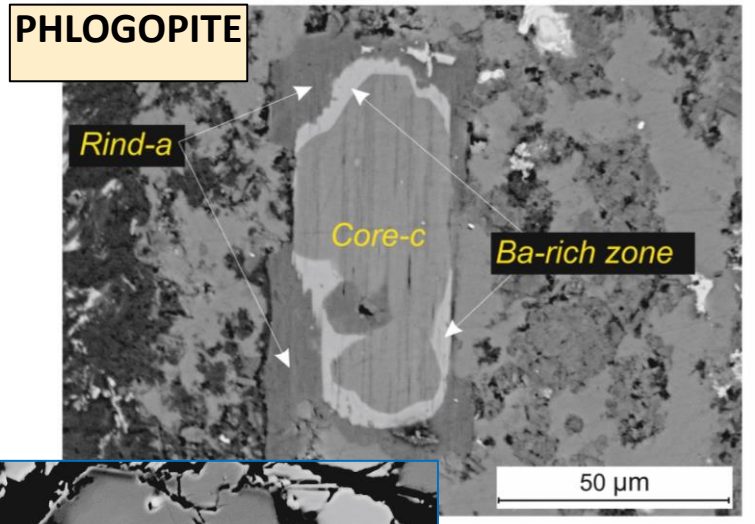


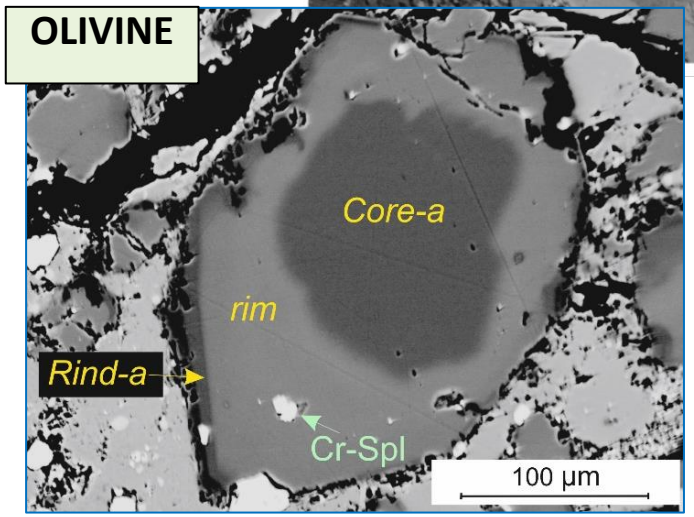
Mature LLD = kimberlite melt

Mutual inclusions and the liquid line of descent (LLD)

Stage 4:

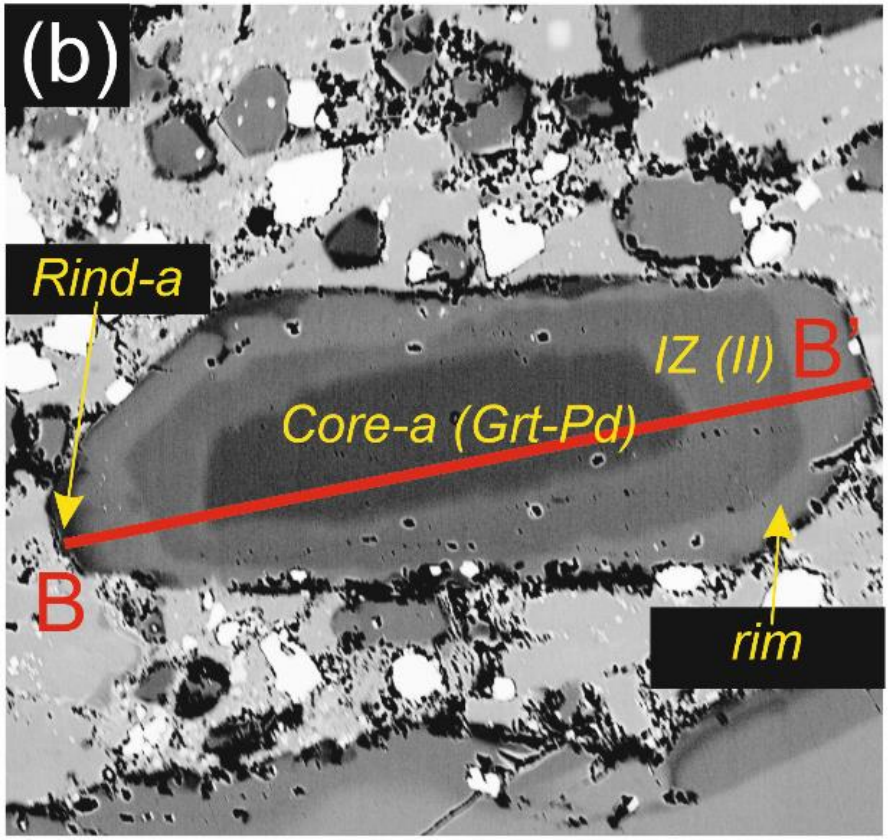
- Mg# 94-95 rinds
- Ca-Mn-Al-rich olivine rinds
- Ca-Mn-K-F-rich phlogopite rinds
- Occasional Ba-rich zones in phlogopite
- Groundmass apatite and calcite

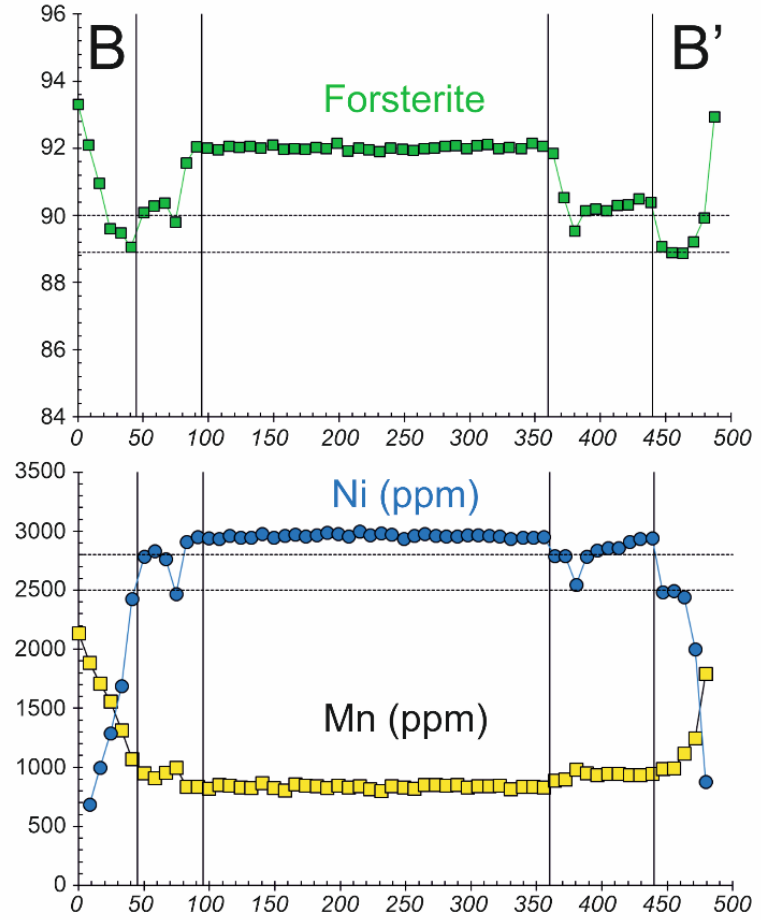




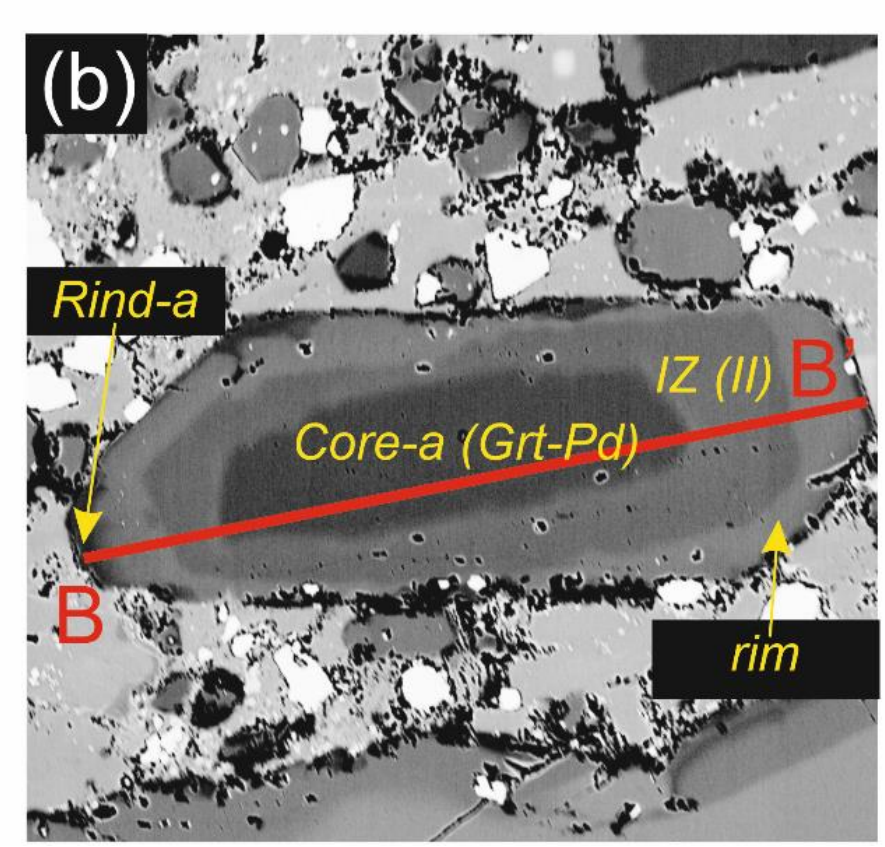
Late LLD = matrix assemblage

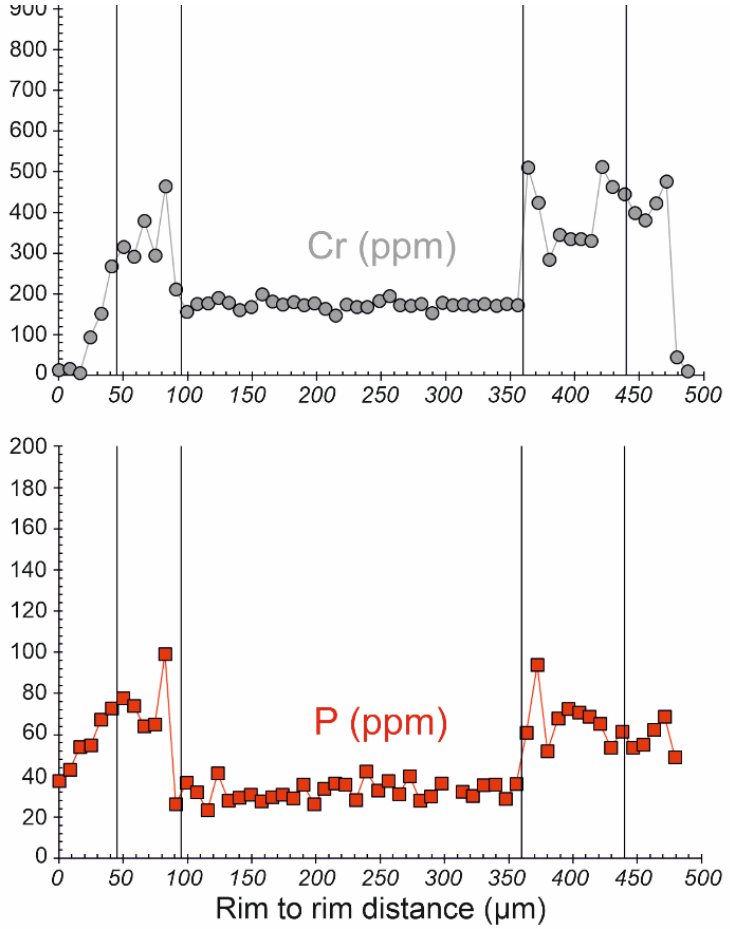
Olivine zoning: core - IZ (II) – rim - rind





Olivine zoning: core - IZ (II) – rim - rind





How about the (*P*)-*T*-fO_2 conditions?

The *T-P-fO*$_2$ path of Udachnaya-East melts

Stage 0 – mantle-derived cargo

Stage 1 - Early LLD:

Internal Zone (II) at Mg# 90

After Opx assimilation

<3.5 GPa
>1100°C
$fO_2 > fO_2$ mantle

Stage 2 - Mature LLD:

T-fO_2 from Olivine- Cr spinel

1.5-3.0 GPa
1120-1250°C
-2.8 to -1.7 ΔFMQ

Stage 3 - Mature LLD:

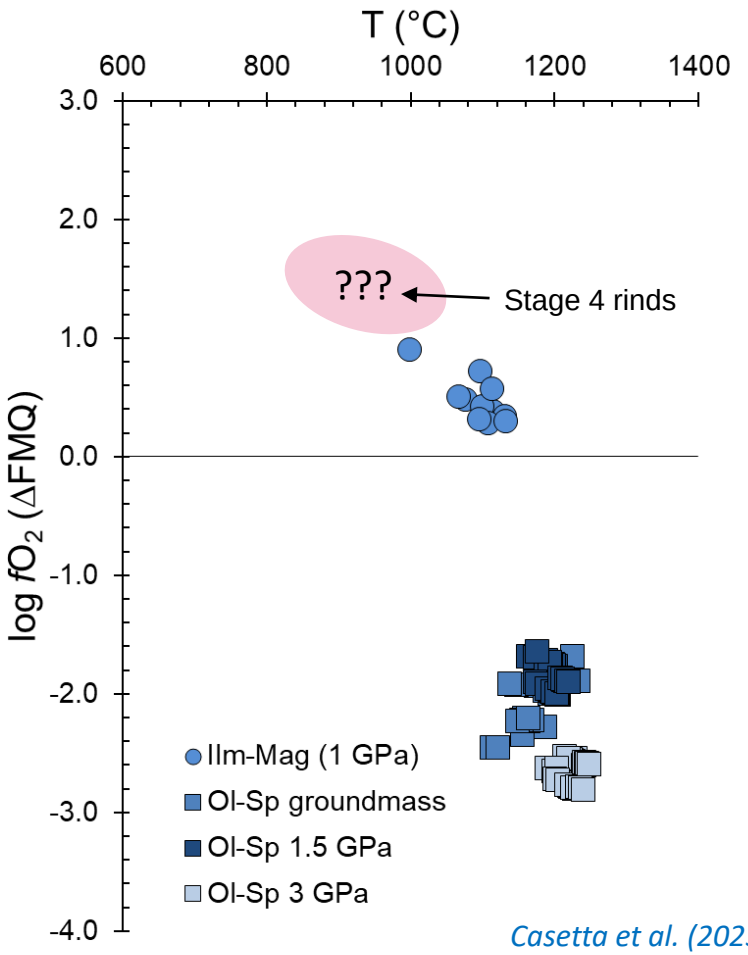
T-fO_2 from Ilmenite-Magnetite

1.0-1.5 GPa
1000-1130°C
+0.3 to +0.9 ΔFMQ

Stage 4 - late LLD:

Rinds at Mg# 94

CO_2-rich, high Fe^{3+}/Fe^{2+} ratio



Casetta et al. (2023a)

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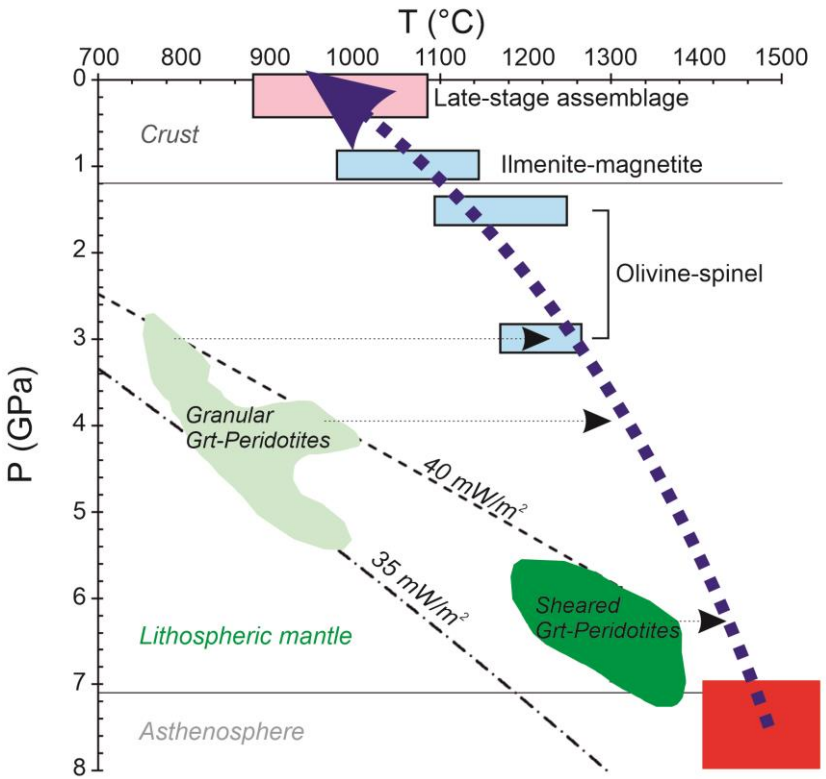
Stage 4 - late LLD:

Rinds at Mg# 94

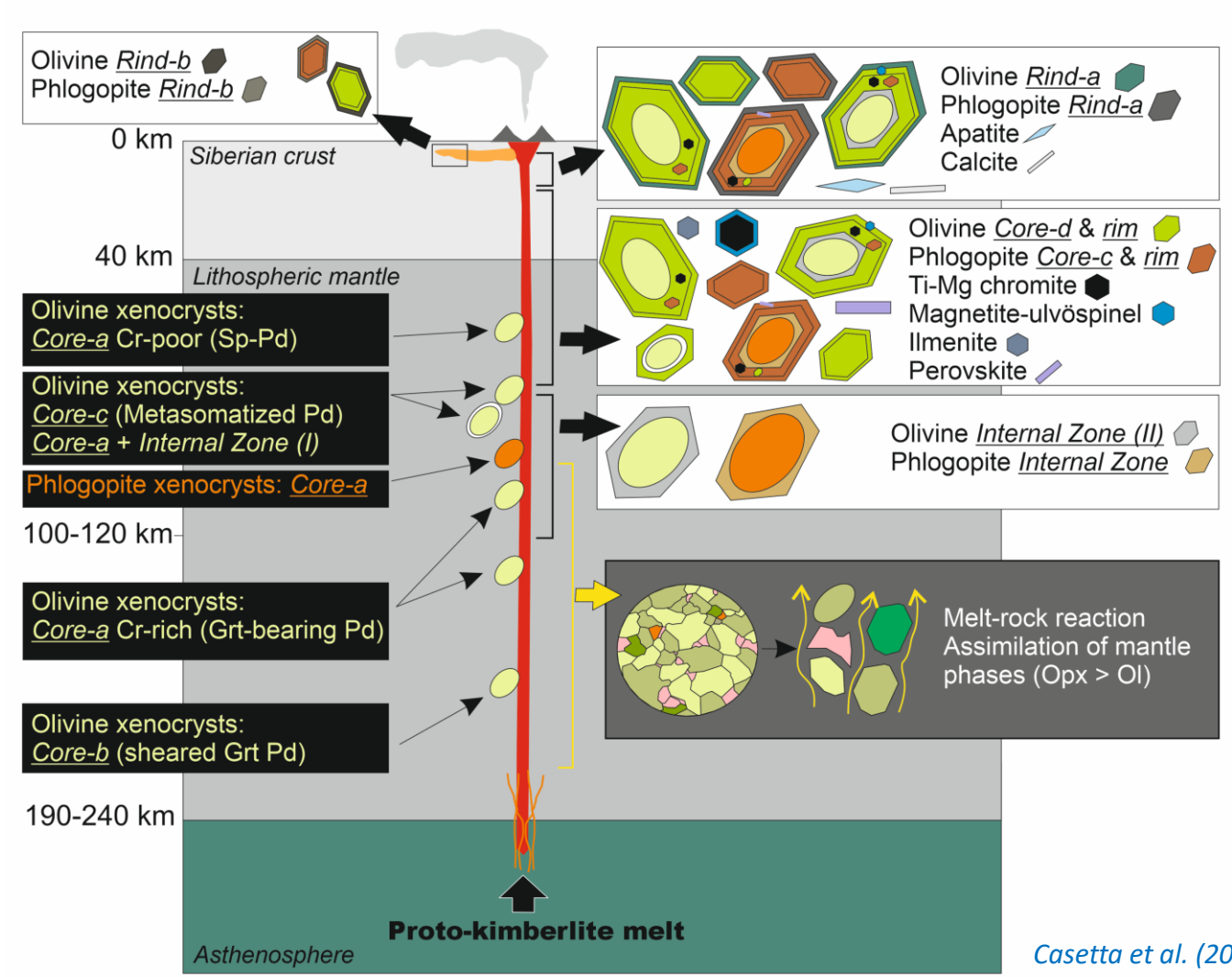
CO_2-rich, high Fe^{3+}/Fe^{2+} ratio

<1.0 GPa
<1000°C
> +0.9 ΔFMQ



Casetta et al. (2023b)

The crystallization sequence



Casetta et al. (2023a)

Summary and open questions

Stage 1 (Early LLD) Cr-P-rich olivine Fo_{90}, phlogopite Mg# 90

- High P and H_2O content of the melt
- Where do Al and Cr come from? Assimilation of mantle orthopyroxene?

Stage 2 (Mature LLD) Olivine Fo_{89} , phlogopite Mg# 89, Ti-Mg-chromite ± rutile

- High H_2O content of the melt

Stage 3 (Mature LLD) Cr-Ni-poor olivine and phlogopite, ulvöspinel-magnetite, ilmenite, perovskite

- Incorporation of Ti in MUM and Mg-Ti-ilmenite

Stage 4 (Late LLD) Mg-rich olivine and phlogopite, apatite, calcite

- Enrichment in H_2O, CO_2 and P, evolution towards alkali-carbonated melt
- Ultimate F-rich phlogopite rinds → H_2O exsolution
- Oxidation of the system
- Buffering by assimilated mantle? Interaction with crust? Role of volatiles?

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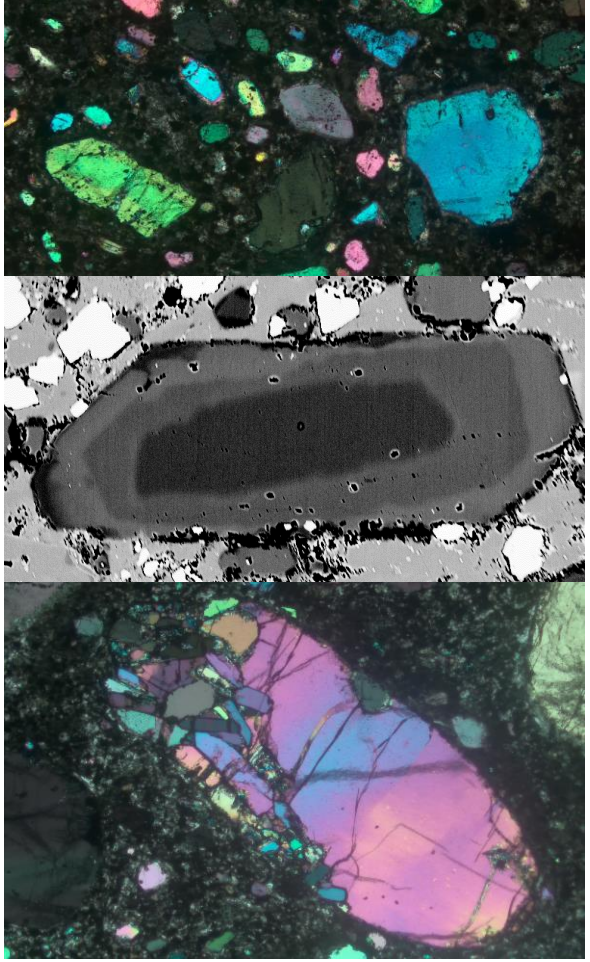
Thank you for your attention!



Do you want to ask an anonymous question?

Pse text it to:
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Special thanks to:

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Rainer Abart
Rene Asenbaum
Olga Ageeva
Igor Aschchepkov

FWF Der Wissenschaftsfonds.

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Esprit Project ESP 605-N