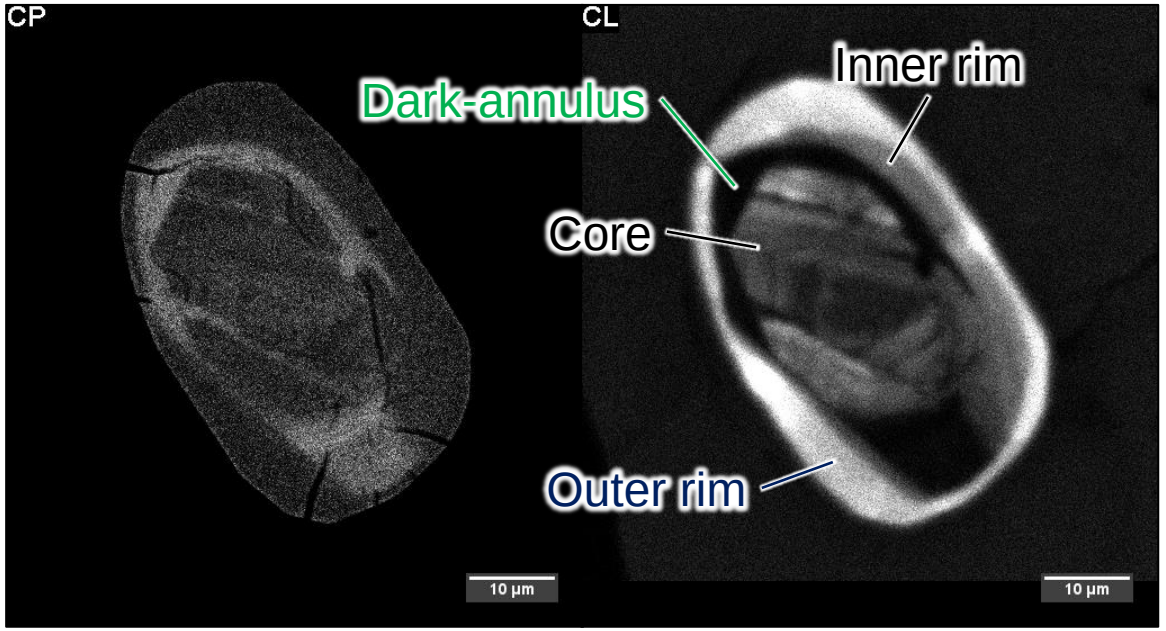
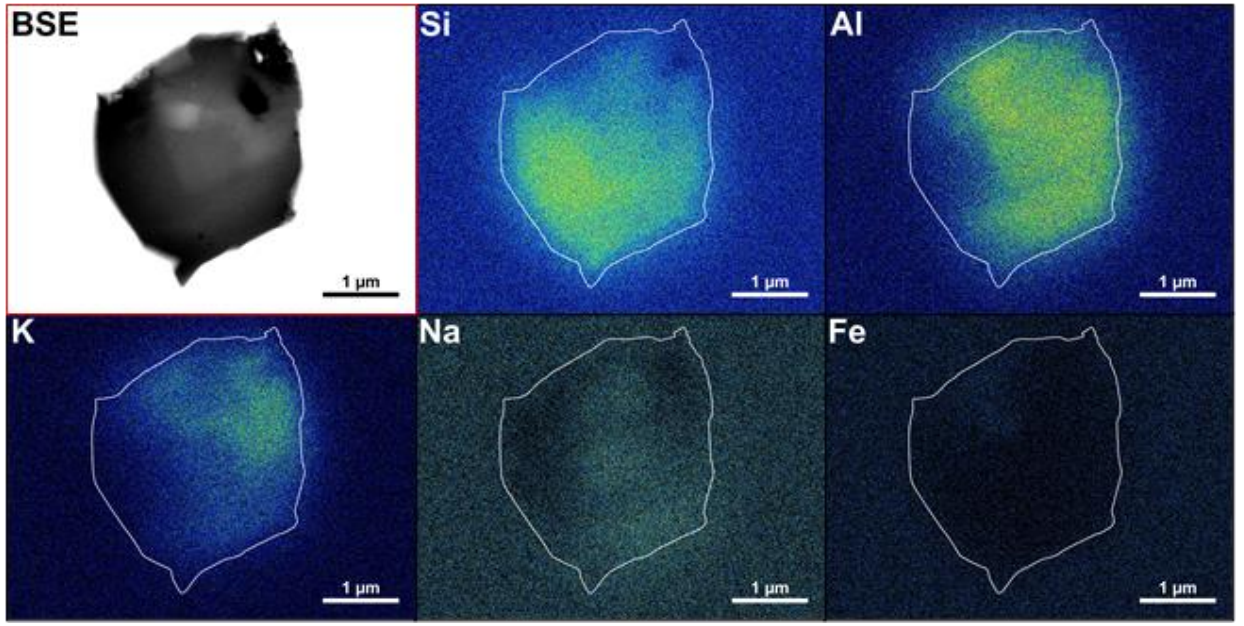
Duration of anatexis in a Neoproterozoic-Cambrian UHT terrane: constraints from prograde melt inclusions in zircon

Zrn in the rock matrix



Melt inclusion in dark-annulus of Zrn



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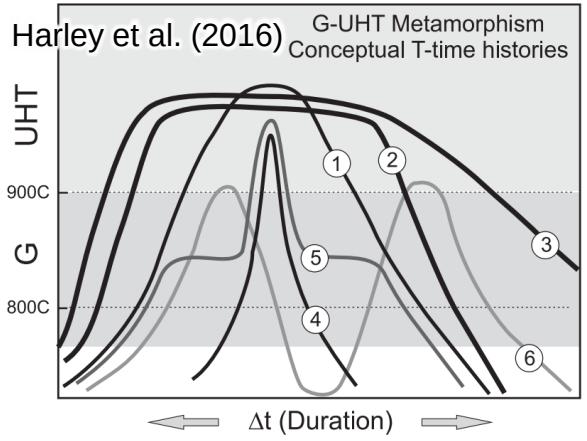
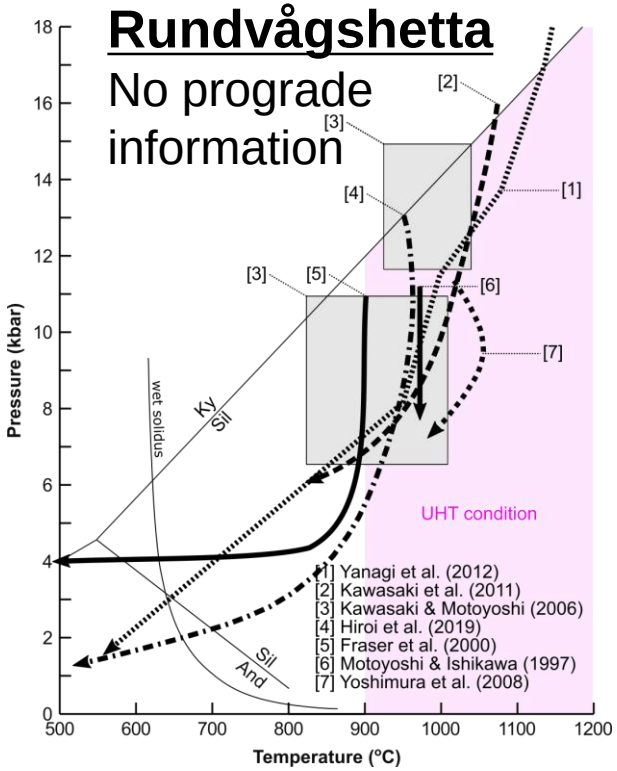
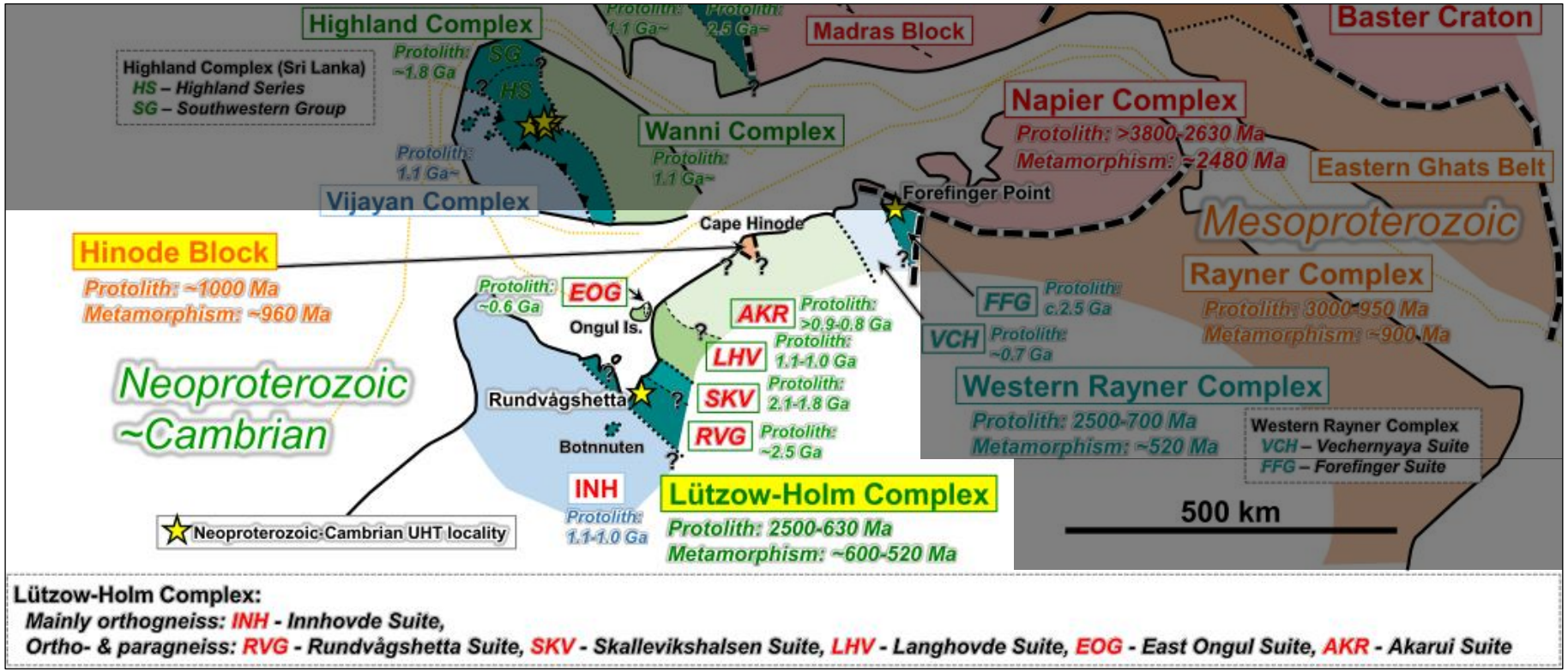
Duration of anatexis (timescale of partial melting of the continental crust)







Dunkley et al. (2020)

Problems…

(1). The prograde pressure-temperature (*P*-*T*) evolution is unclear

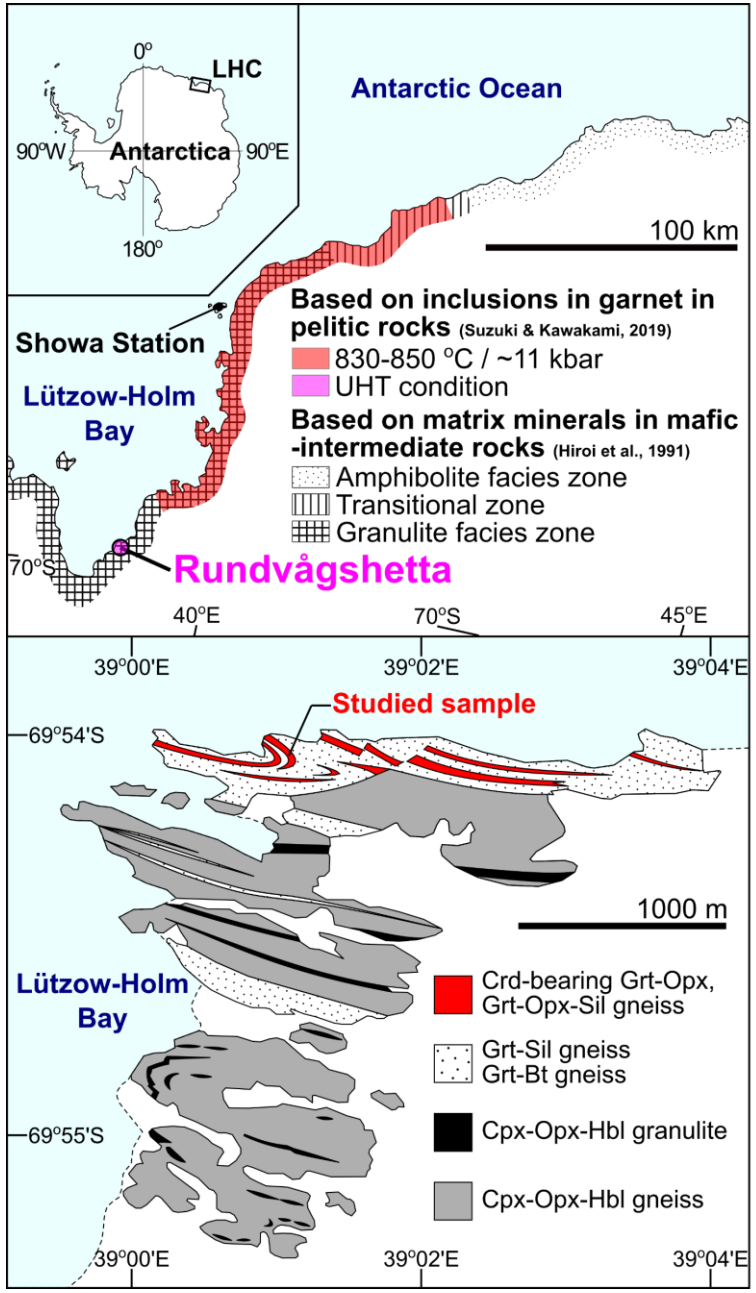
(2). Only the final melt crystallization age (~520 Ma) is constrained (Fraser et al., 2000)

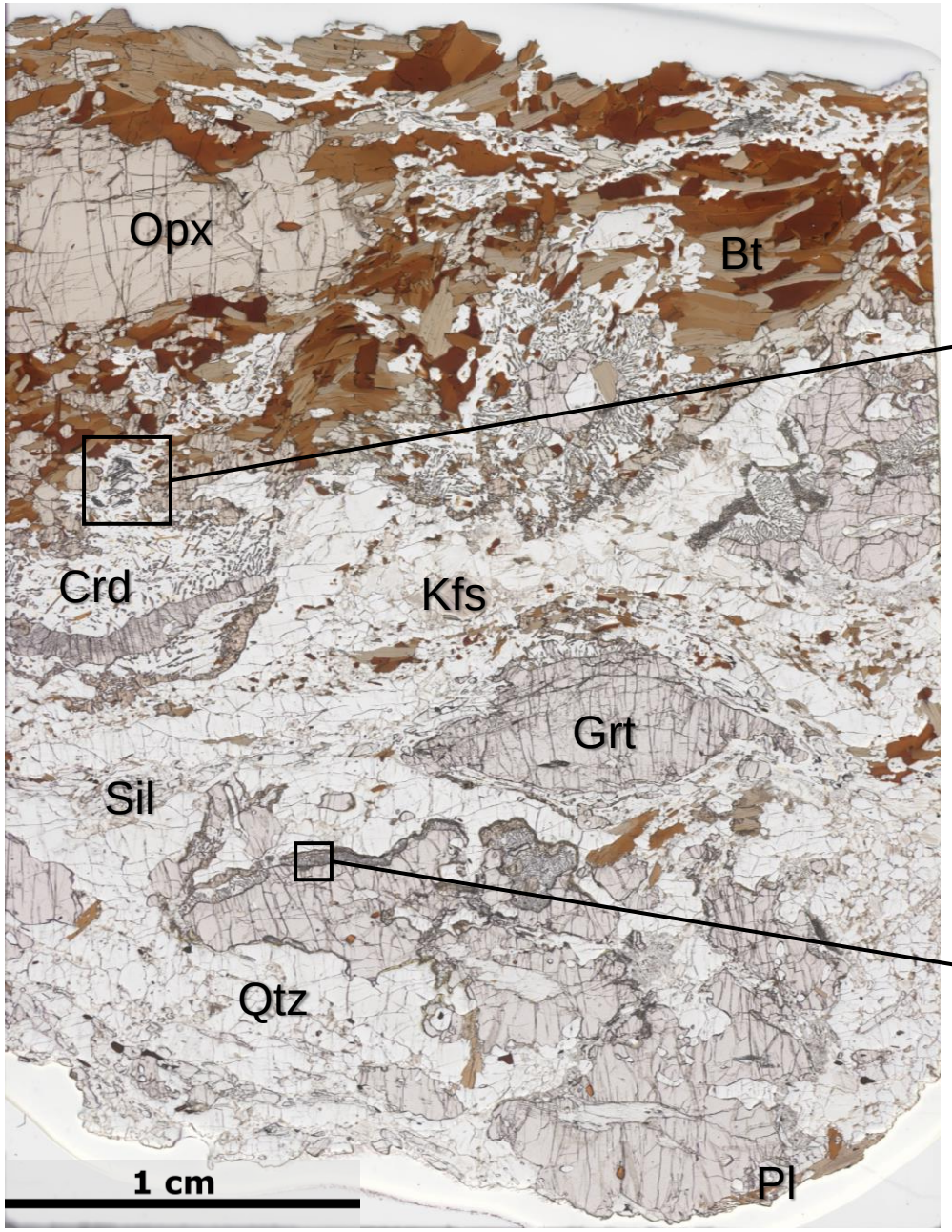
In order to constrain the duration of anatexis…

(1). Reconstructing the prograde *P*-*T* evolution

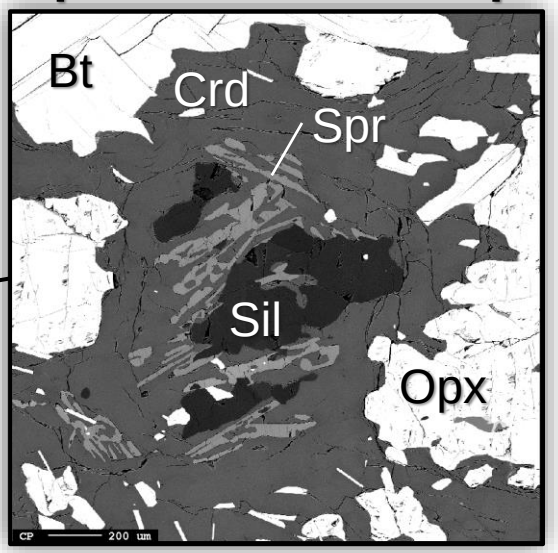
(2). Linking the *P*-*T* evolution with the U-Pb zircon ages

Geological setting and sample description

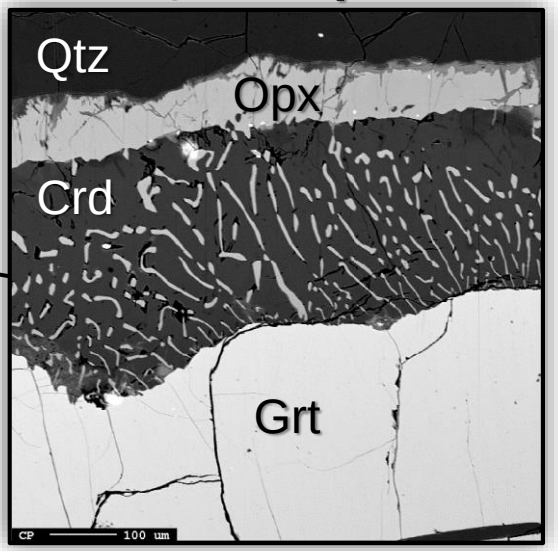




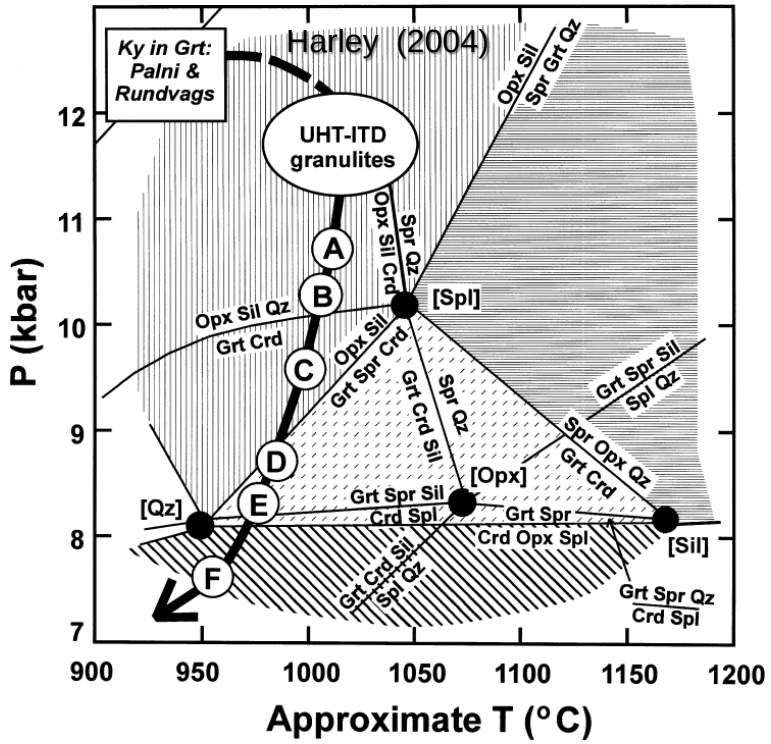
Opx + Sil = Crd + Spr

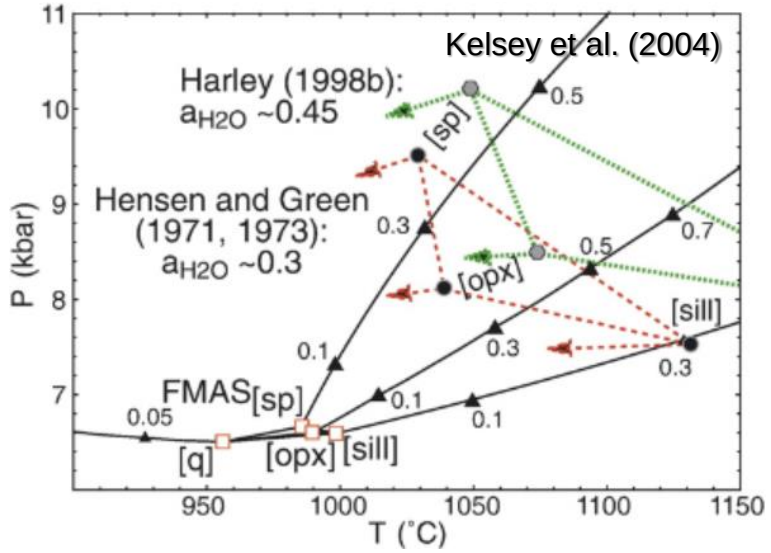


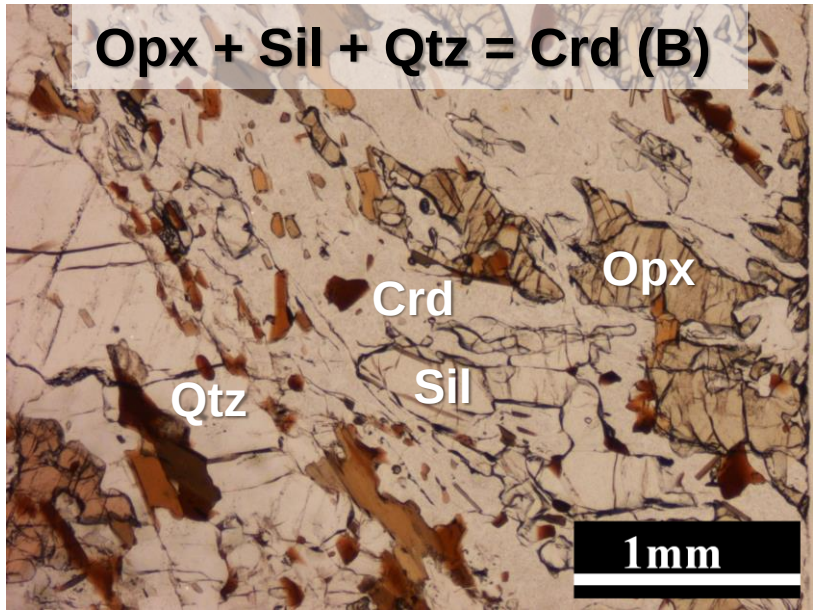
Grt + Qtz = Opx + Crd

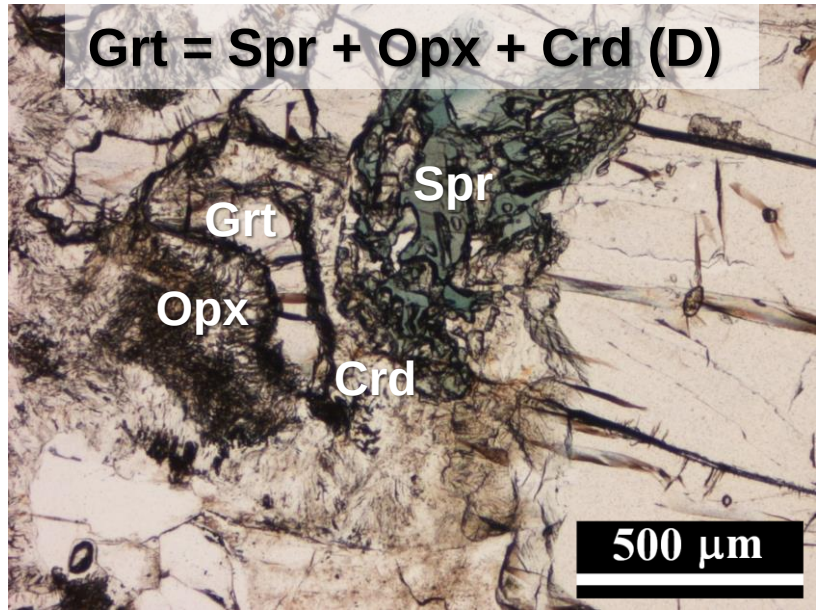


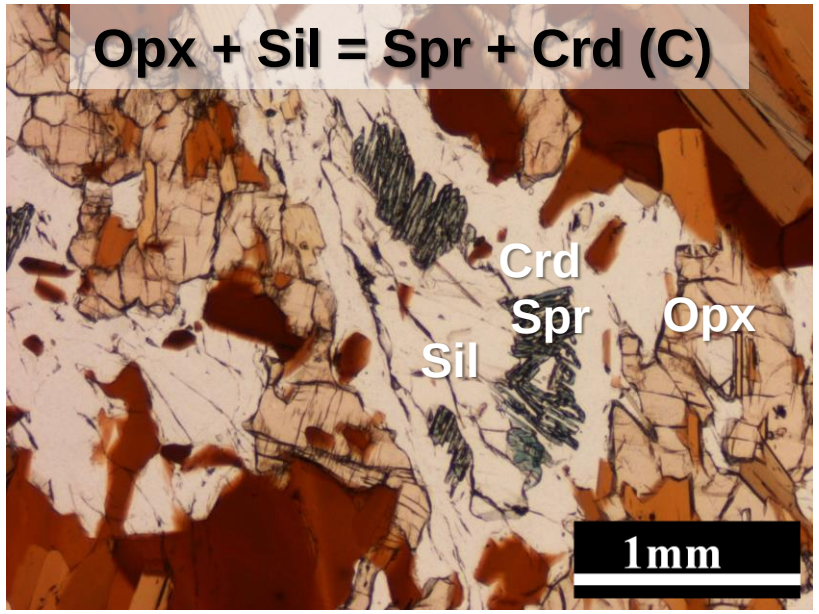
Post-peak isothermal decompression

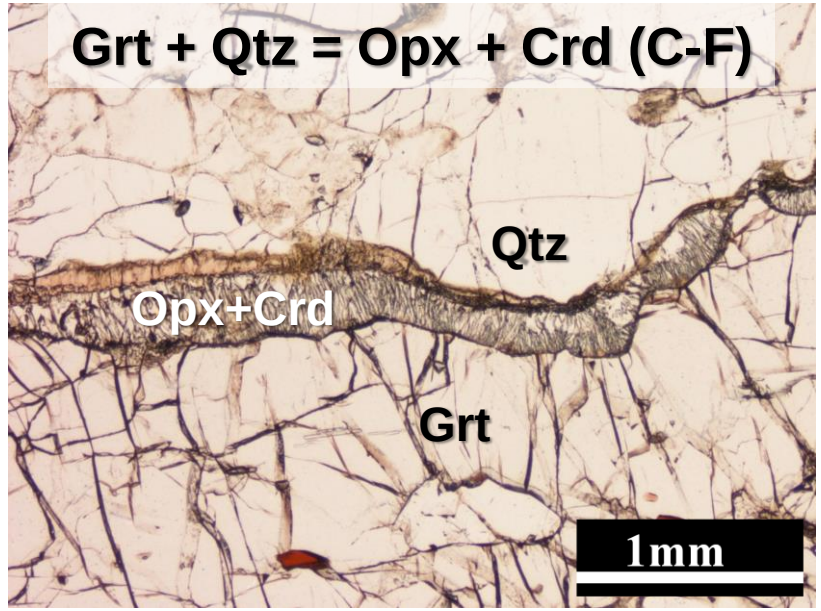




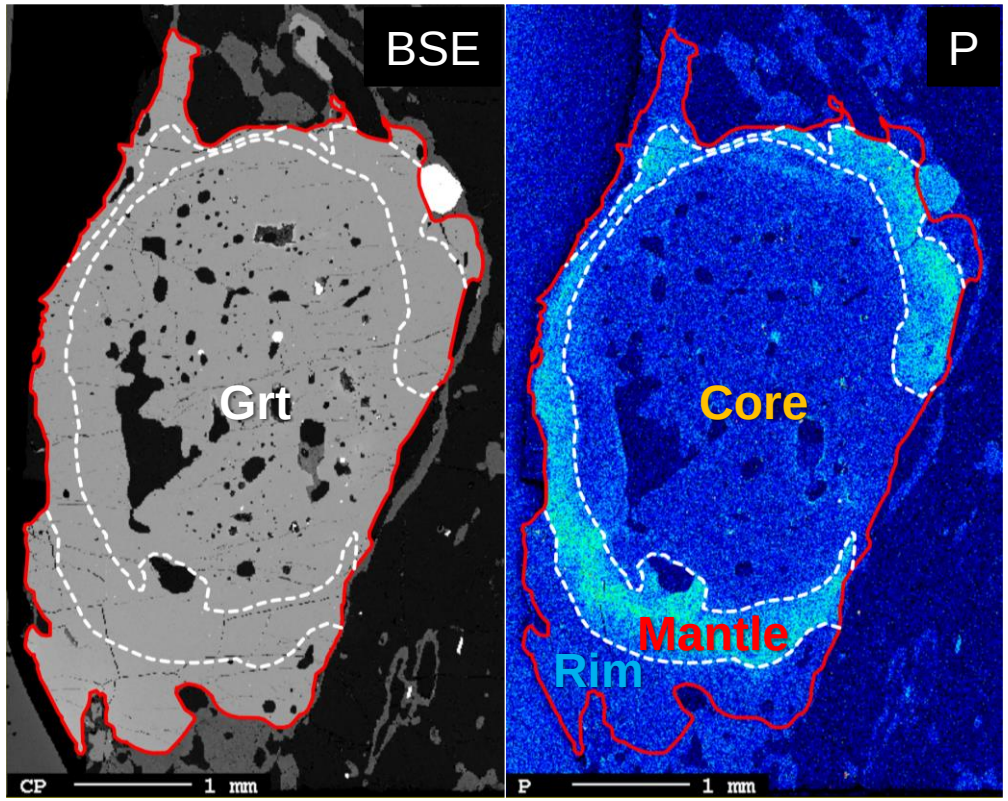




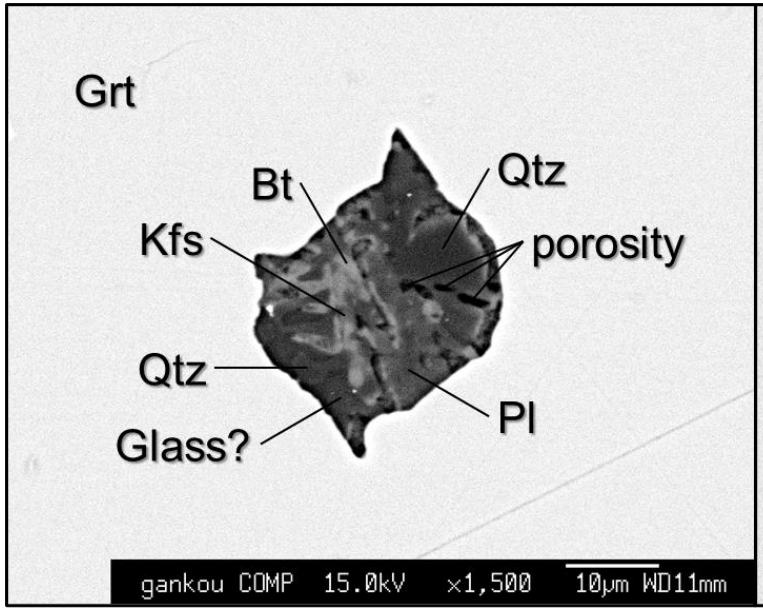




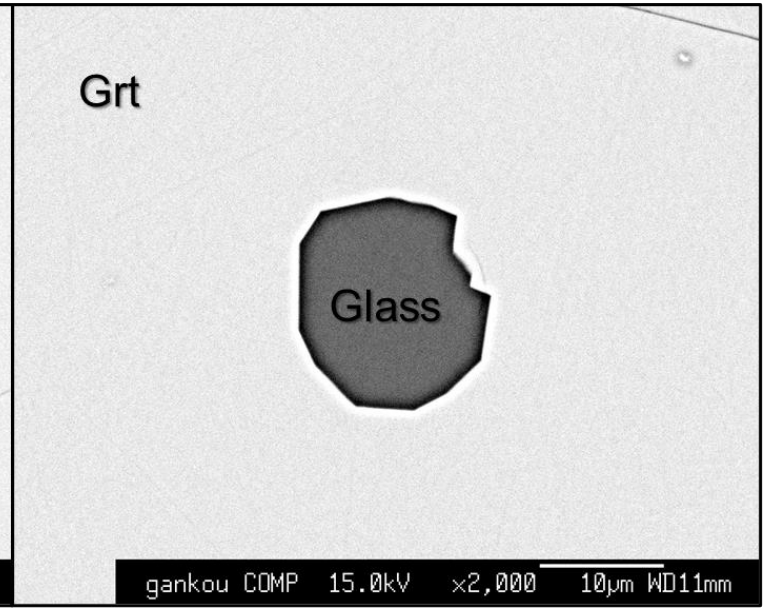
Melt inclusion in Grt core



Nanogranitoid



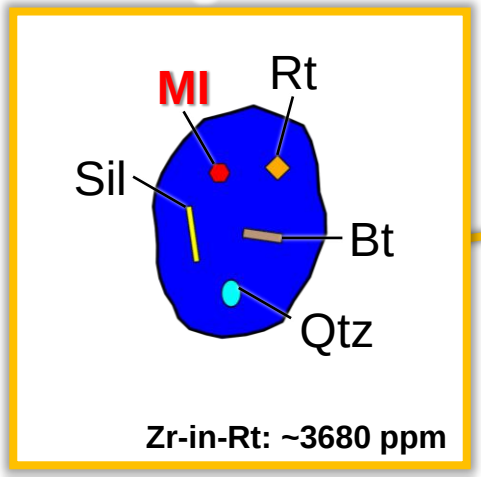
Glassy inclusion

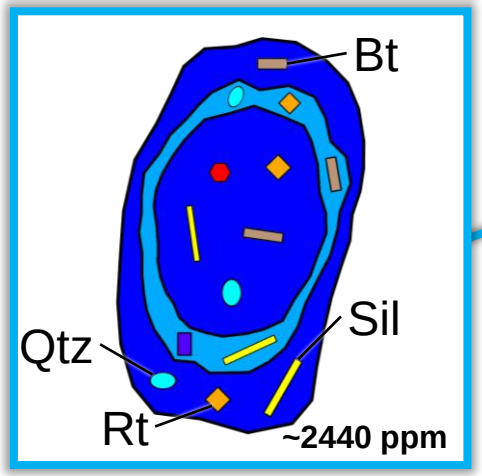


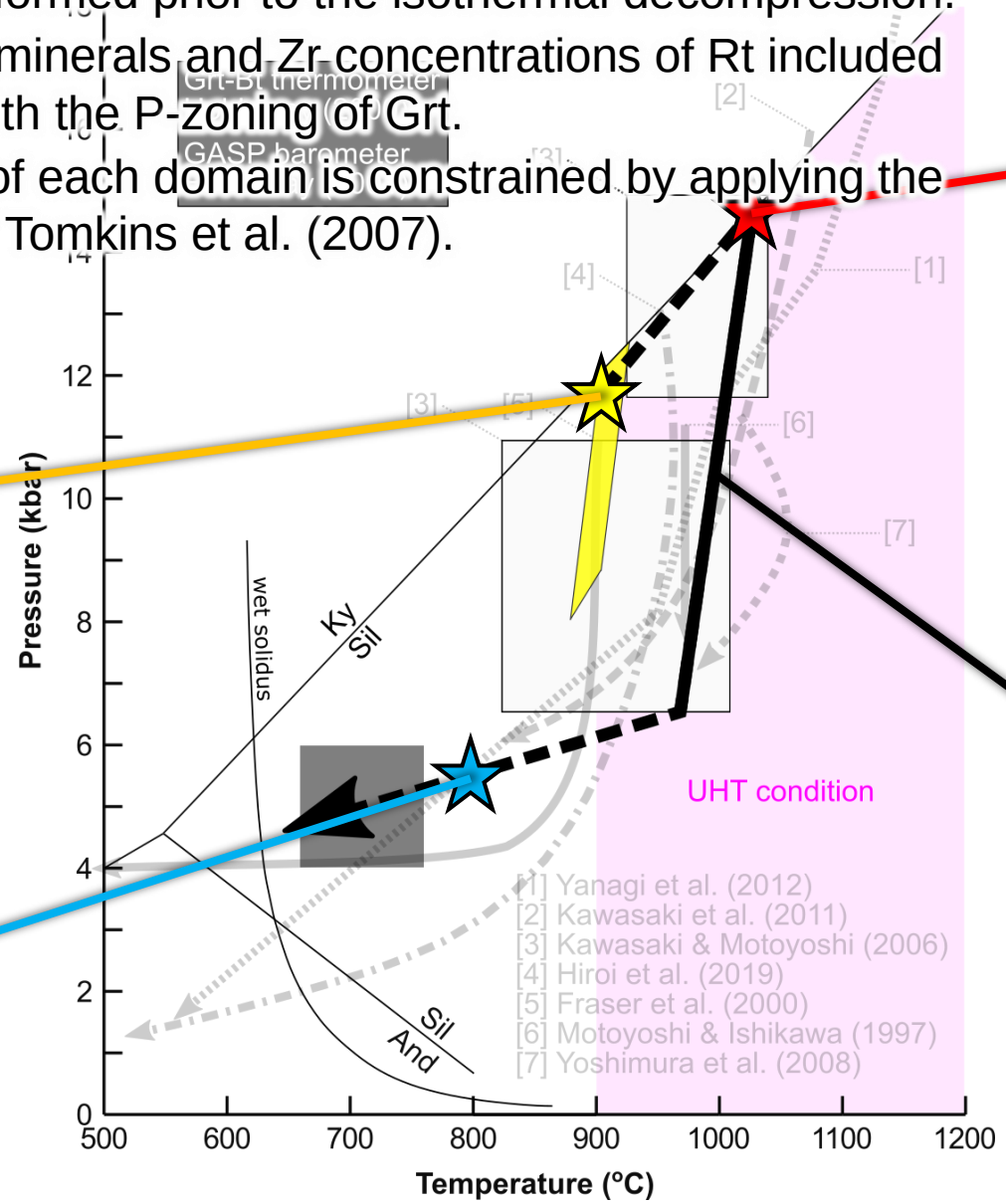
- Grt can be divided into **P-poor core**, **P-rich mantle**, and **P-poor rim**.
- The **Grt cores** enclose melt inclusions (MIs), which are commonly consist of Qtz + Kfs + Pl + Bt.
- Internal porosities in MIs were probably formed due to the increase of density during the melt crystallization in a constant cavity volume (e.g., Cesare et al., 2009).
- In addition to MIs, the **Grt cores** commonly enclose Bt, Sil, and Qtz monomineralic inclusions.
- The **Grt cores** and MIs were probably formed by the following Bt dehydration melting reaction.
  - Bt + Sil + Qtz = Grt + Kfs + melt (e.g., Spear et al., 1999)

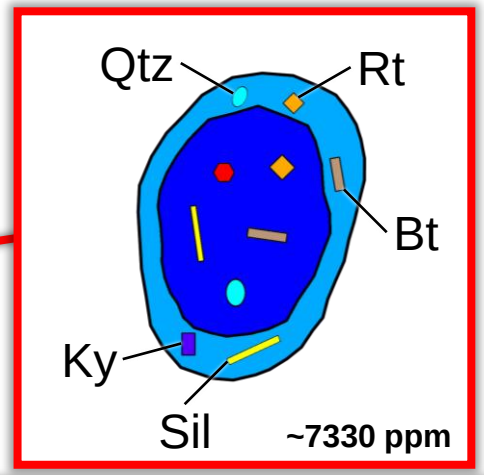
The prograde *P-T* evolution

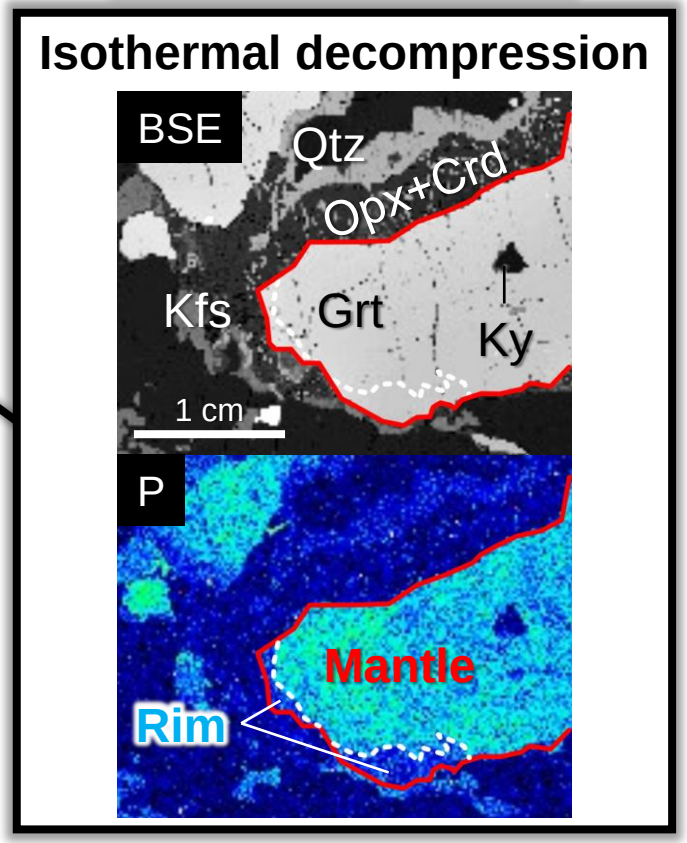
- The **Grt mantle** is truncated by the Opx+Crd symplectite, therefore, the **Grt core** and **mantle** were formed prior to the isothermal decompression.
- The polymorphs of Al_2SiO_5 minerals and Zr concentrations of Rt included in Grt vary systematically with the P-zoning of Grt.
- The temperature condition of each domain is constrained by applying the Zr-in-Rt geothermometer of Tomkins et al. (2007).



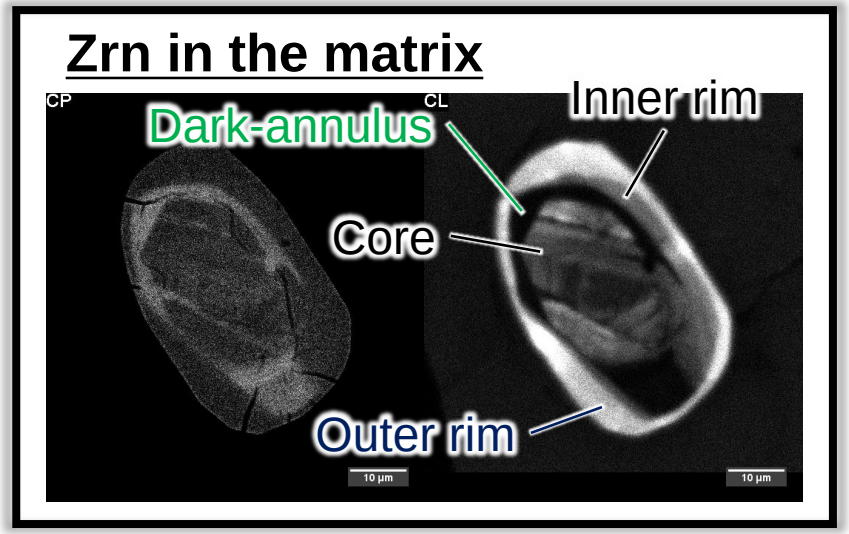




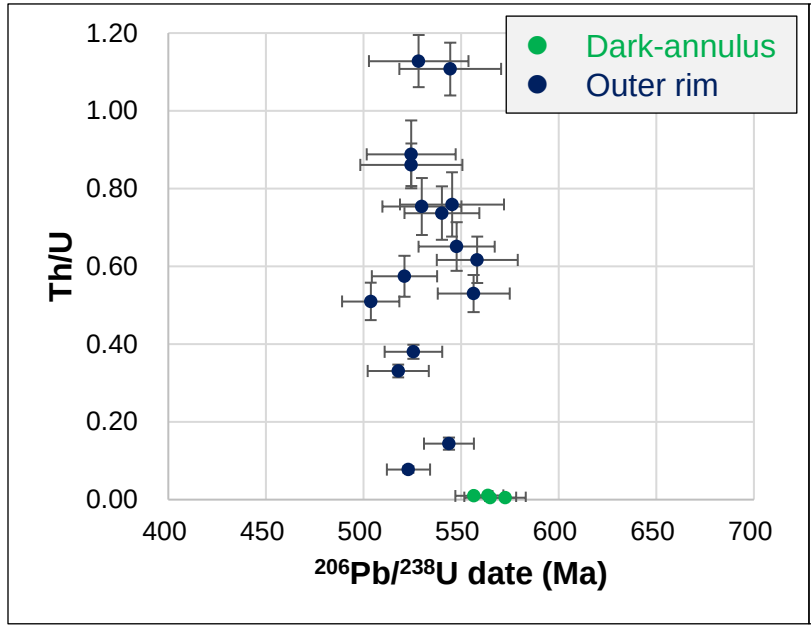


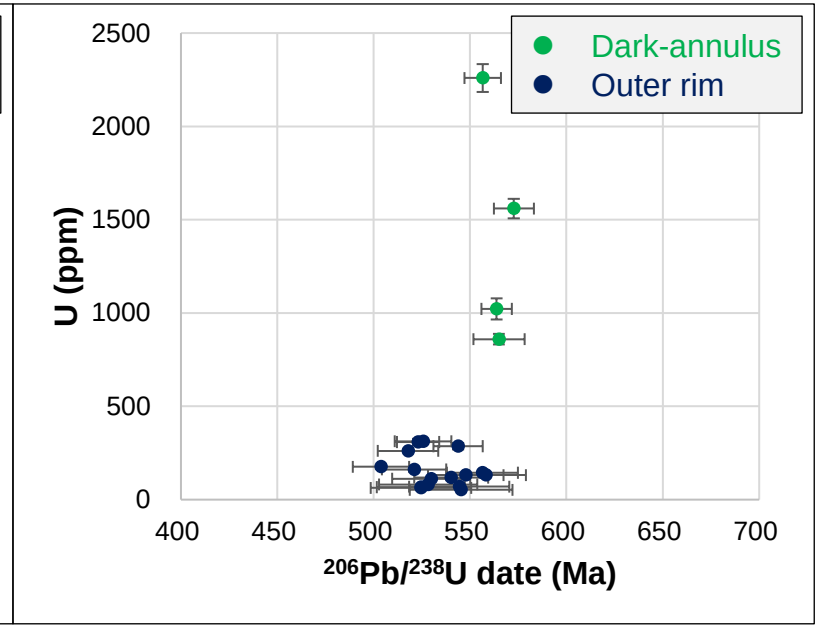


Microstructural domains of matrix Zrn

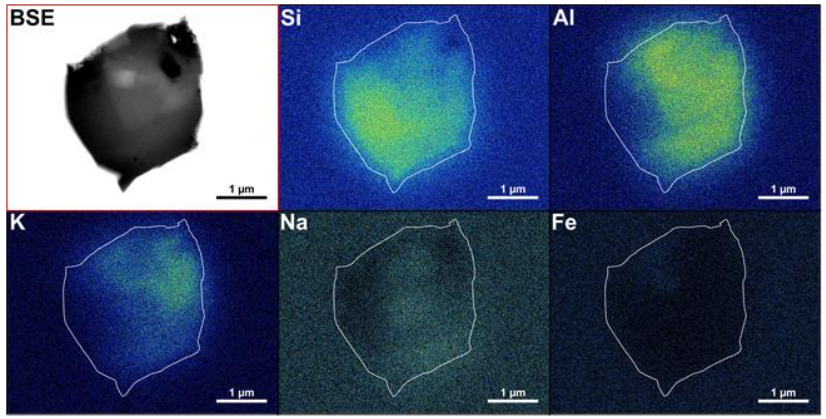


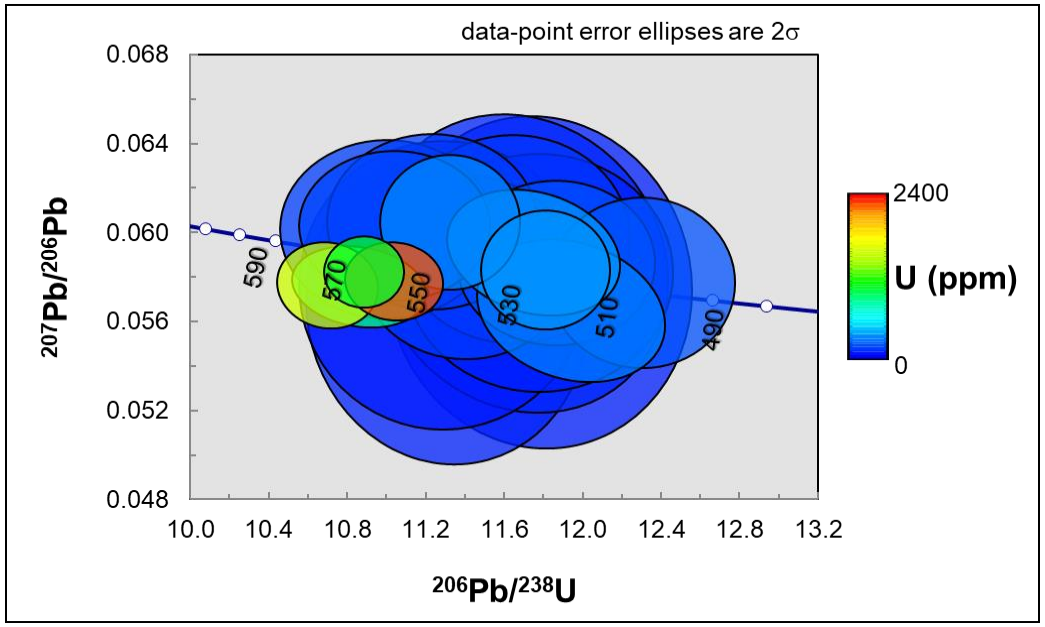
Core is inherited domain.
Inner rim is too thin for LA-ICP-MS analysis with 20 μm spot size.





MI in dark-annulus of Zrn





Dark-annulus

564.0±4.9 Ma

710-790 ºC (Ferry & Watson, 2007)

Inclusions: Ms, Qtz, Bt, Rt, MIs

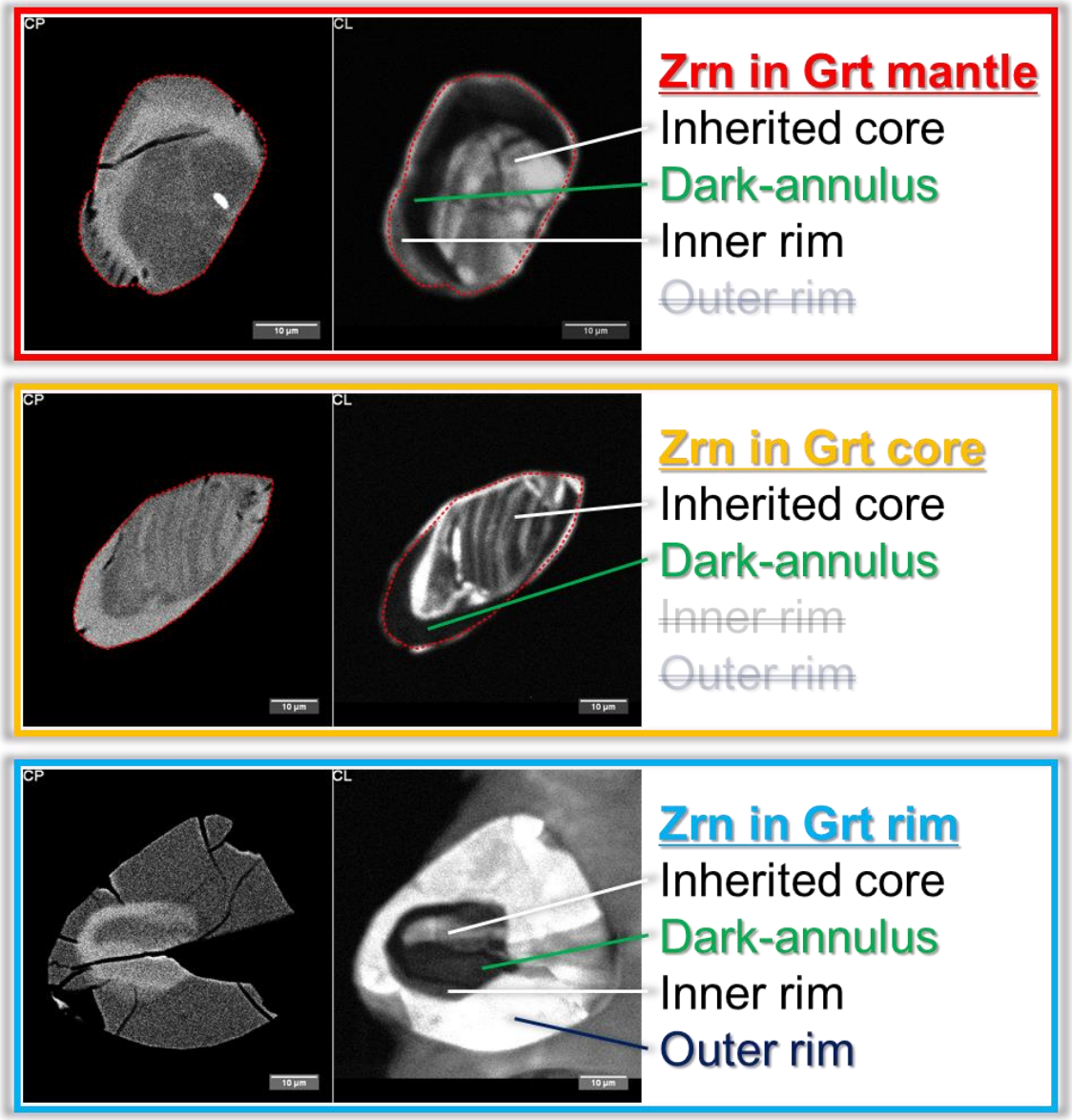
Outer rim

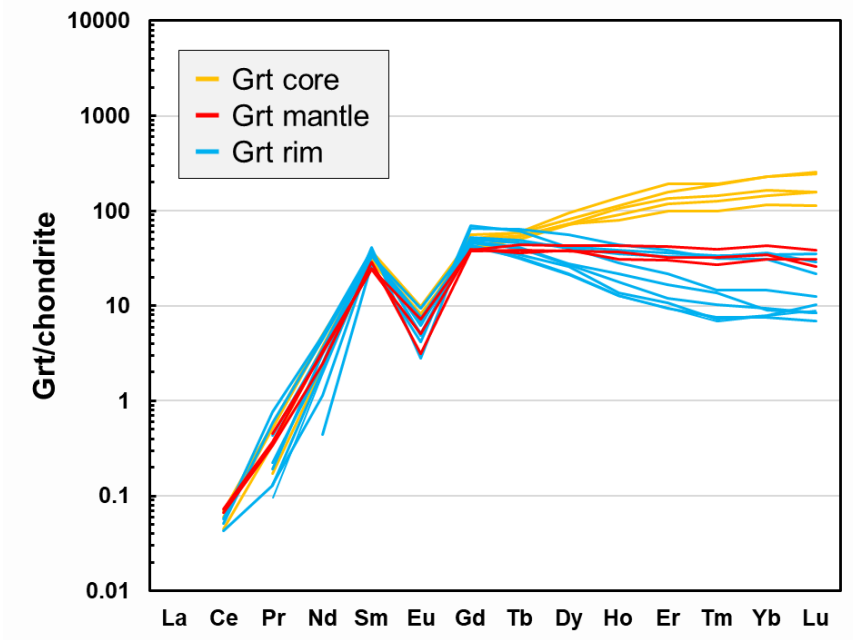
530.5±4.9 Ma

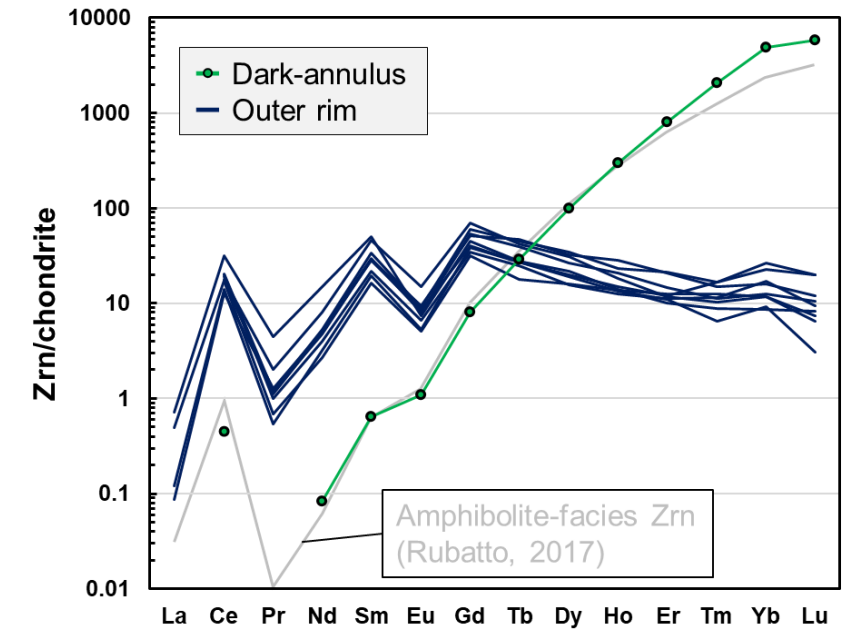
740-820 ºC (Ferry & Watson, 2007)

Inclusions: Sil, Rt, Kfs

Microstructural domains of inclusion Zrn



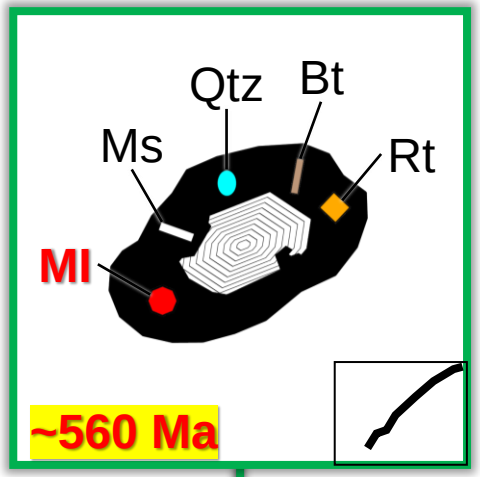




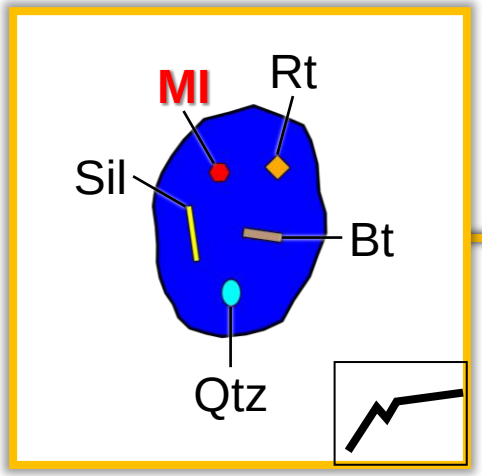
- The **dark-annulus of Zrn** grew prior to the **Grt core**.
- The **outer rim of Zrn** grew in equilibrium with the **Grt rim**.

Relative growth timings of Zrn and Grt

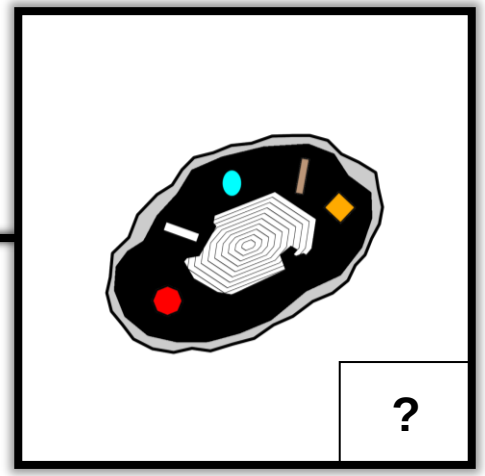
Zrn dark-annulus

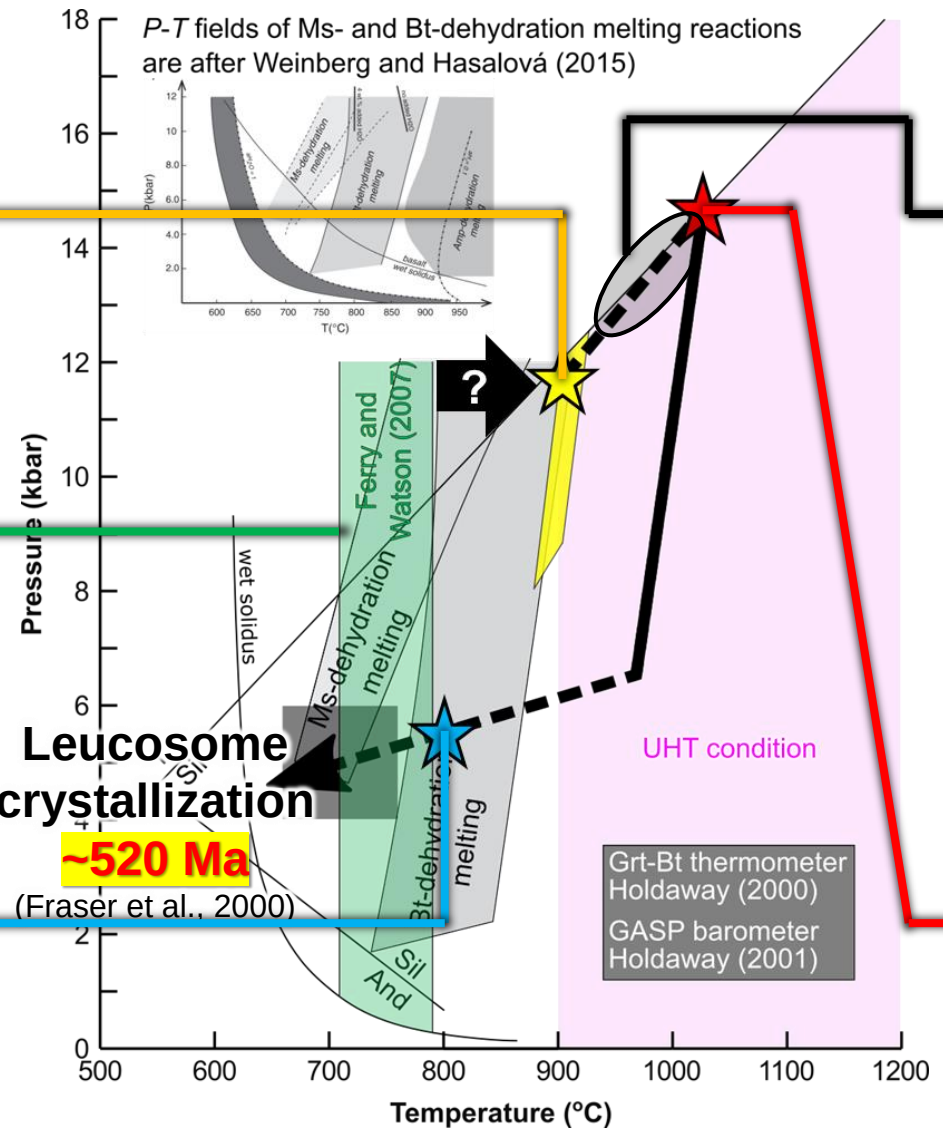


Grt core



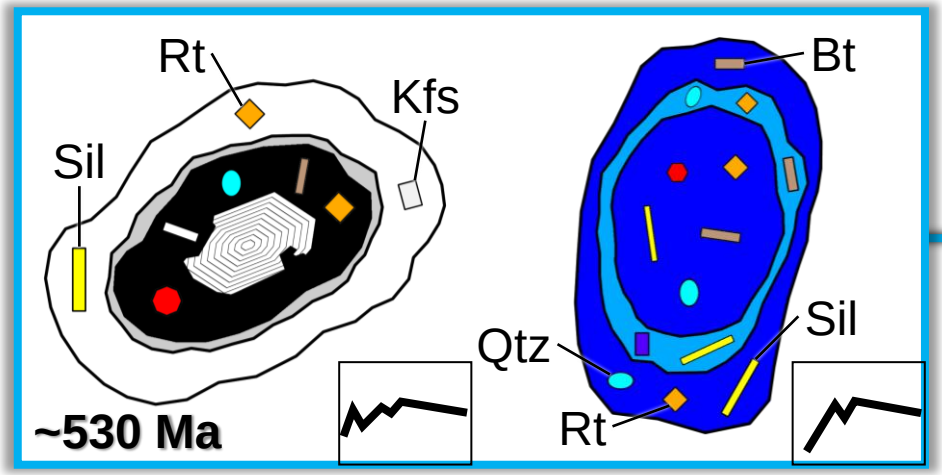
Zrn inner-rim



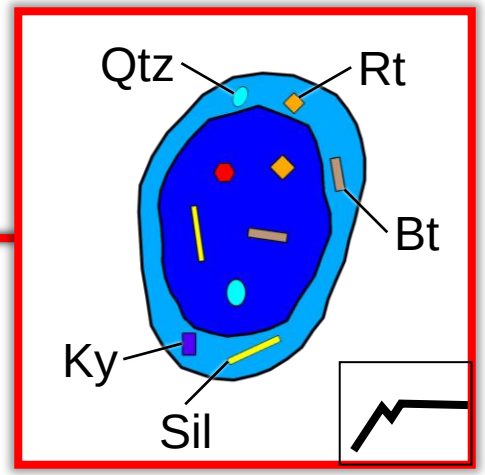


Zrn outer-rim

Grt rim

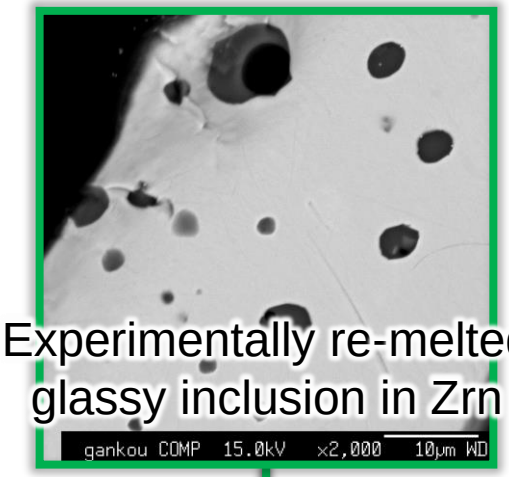


Grt mantle



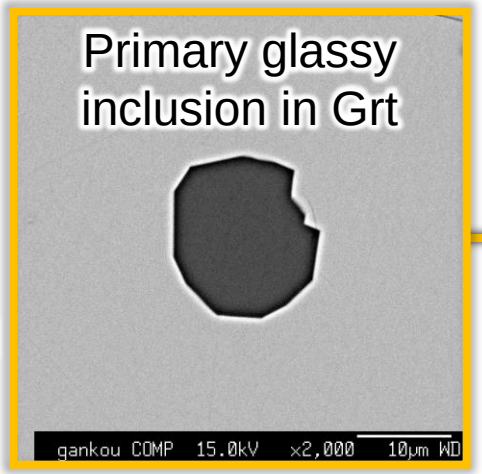
Multiple prograde melts trapped in Zrn and Grt

Zrn dark-annulus

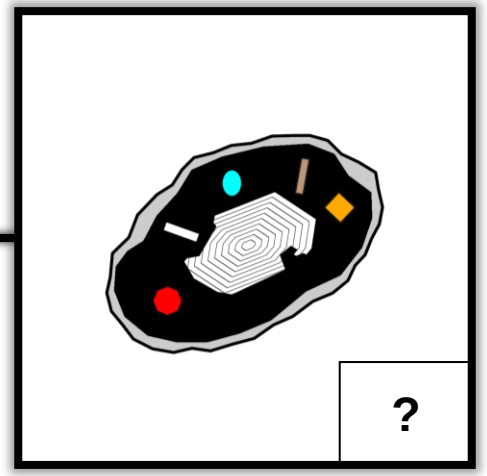


Experimentally re-melted glassy inclusion in Zrn

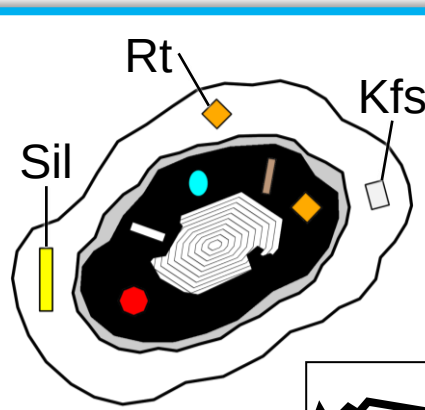
Grt core



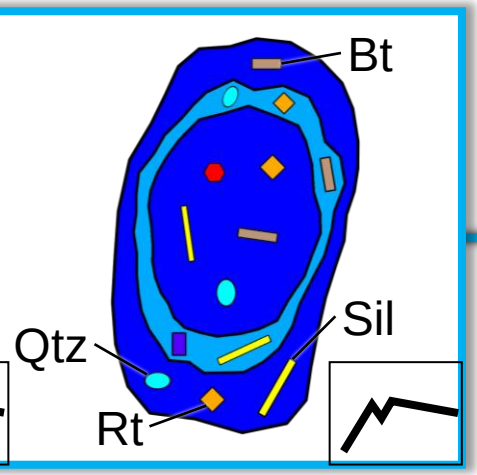
Zrn inner-rim

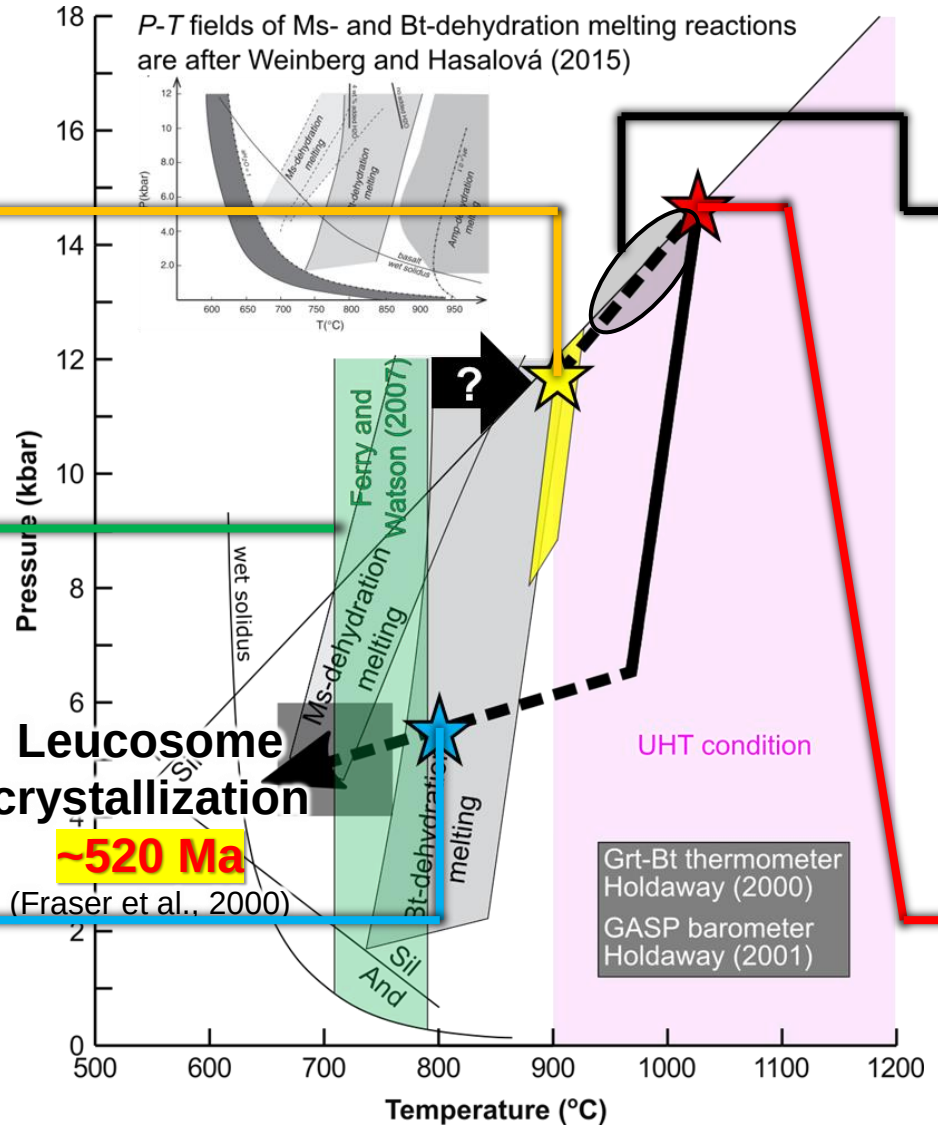


Zrn outer-rim

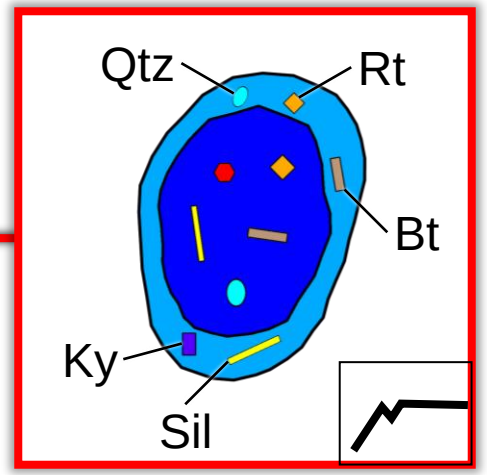


Grt rim





Grt mantle



Summary

- The **dark-annulus of Zrn** grew prior to the **Grt core**, in the presence of anatectic melt at 710-790 ^{o}C at ~560Ma.

- Taking the final melt crystallization age of ~520 Ma into account (Fraser et al., 2000), the duration of anatexis in Rundvågshetta is constrained to be at least ~40 Myr.

- We have just succeeded in acquiring multiple prograde melt inclusions trapped in different minerals (**Zrn** and **Grt**) at different *P*-*T*-*t* stages.

- The microstructural observations of **Zrn** enabled us to deduce the prograde anatexis prior to the attainment of UHT condition that is not recorded in **Grt**.