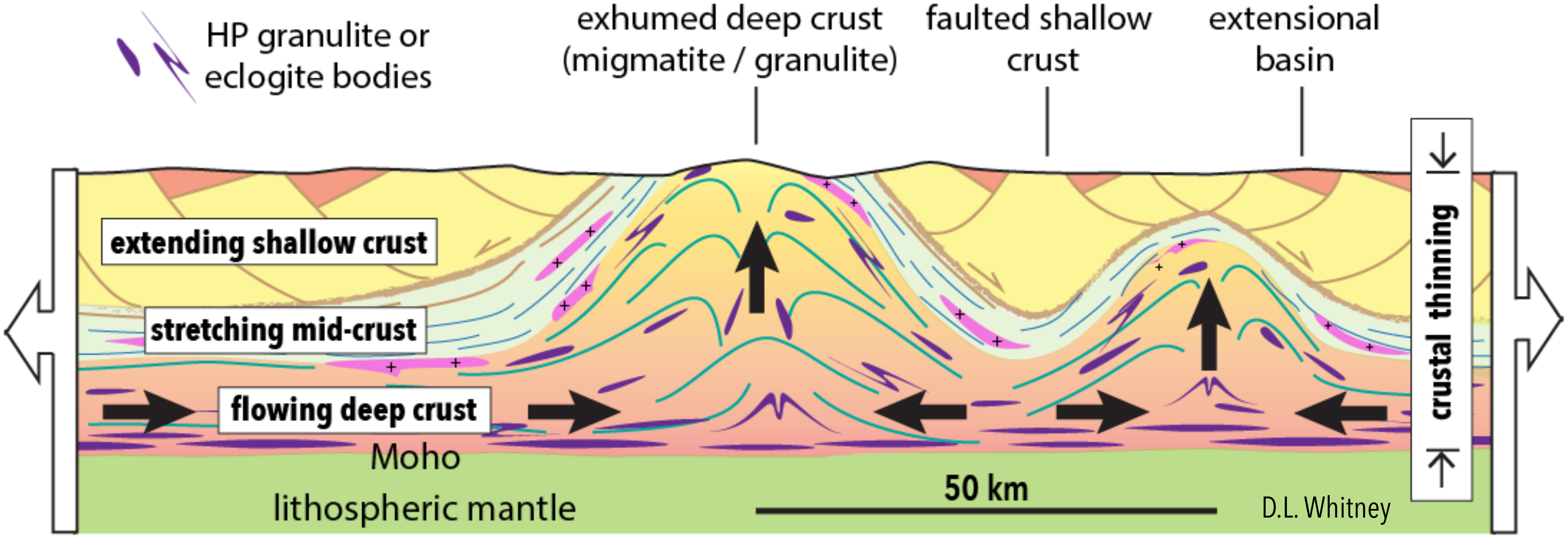
Significance of variation in extent of recrystallization of zircon in orogenic eclogite

Donna L. Whitney, Clémentine Hamelin, Christian Teyssier — *University of Minnesota USA*

Françoise Roger — *Université Montpellier FRANCE*

Patrice F. Rey — *University of Sydney AUSTRALIA*

Some **migmatite domes** are comprised of deeply-sourced crust that experienced lateral and subsequent vertical flow, with ultimate emplacement in the mid/upper crust. The record of the deep-crustal history survives in layers and lenses of refractory rock types within the dominant quartzofeldspathic gneiss.

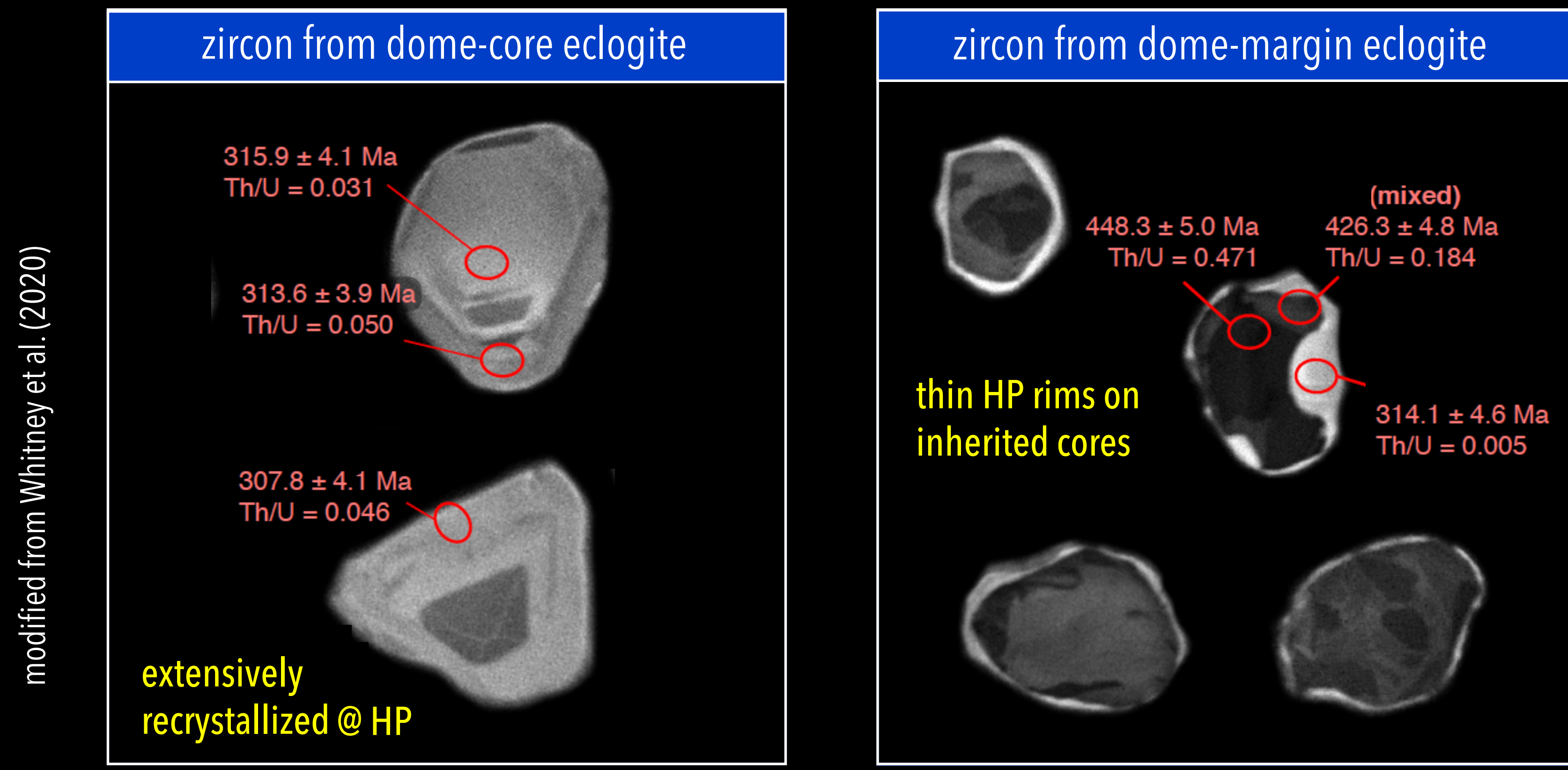


Deeply-sourced migmatite domes may be the 'tip of the iceberg' of crustal flow systems. In orogenic extensional systems, dome-formation is a mechanism for exhuming deep crustal rocks to shallow levels. Prior to exhumation, a region of deep crust may have shorter or longer residence time at high P-T conditions depending on location relative to the ascending dome. The location of a dome is controlled by the location of upper crustal structures such as normal faults.

Deep-crustal relics such as orogenic eclogites and HP granulites are archives of P-T-t-d conditions of crustal flow, although it can be difficult to extract information about the **duration** of deep-crustal residence – such as might accompany lateral flow of deep-crust prior to exhumation – because intracrystalline diffusion at protracted high temperatures may erase much of the history and/or minerals may record only the timing of final emplacement and cooling.

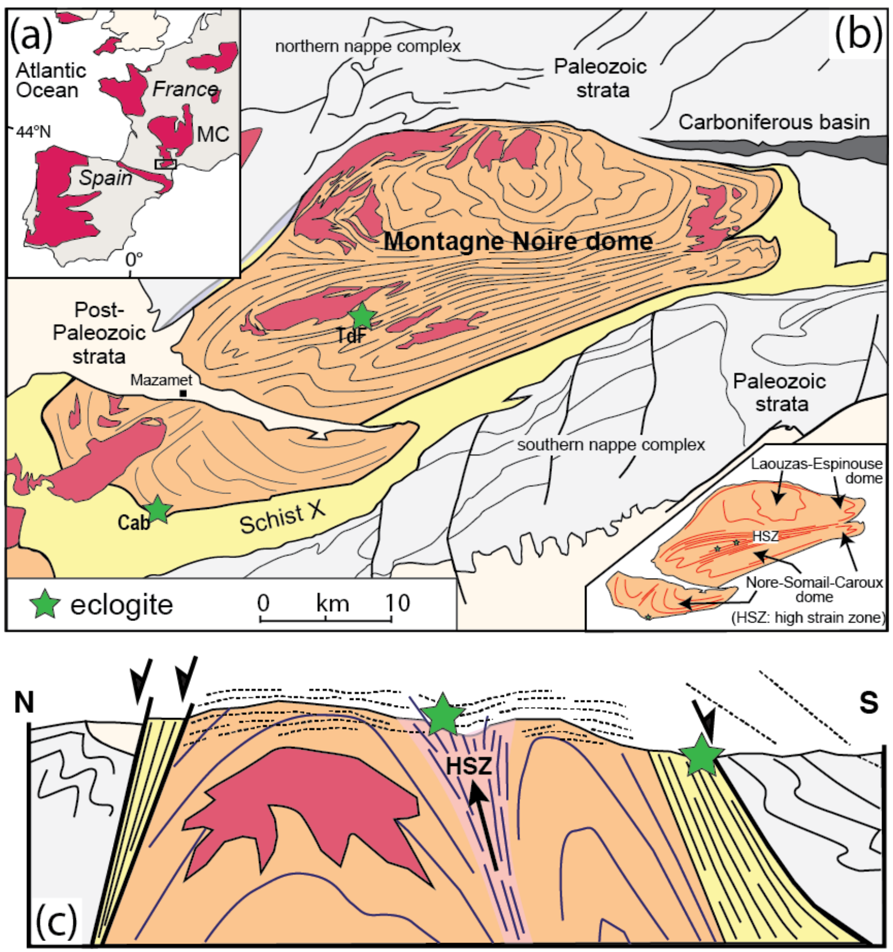
Hypothesis: the extent of recrystallization of zircon that experienced deep-crustal metamorphism may be an indicator of deep-crustal resident time.

example from the **Montagne Noire dome**, French Massif Central

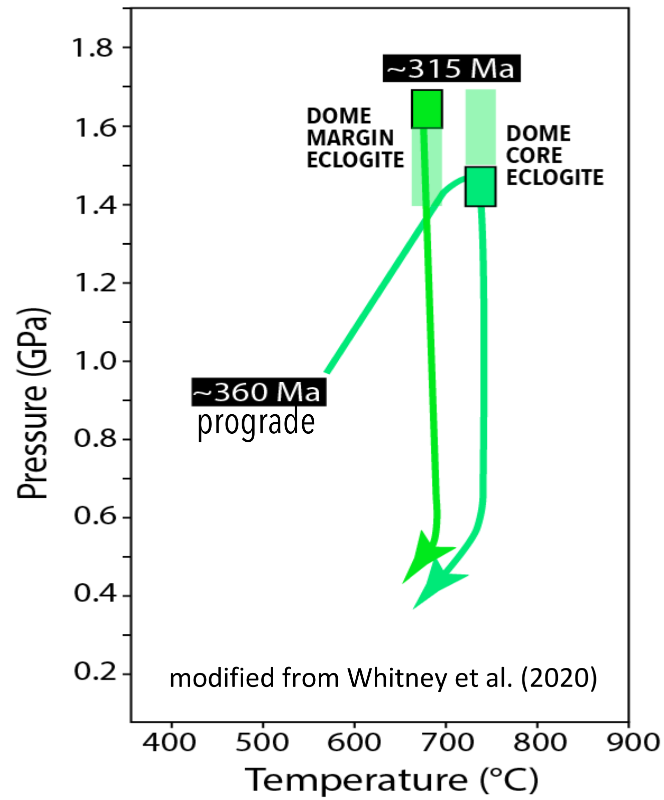


The Montagne Noire dome, French Massif Central, has two sites with fresh **eclogite** containing garnet + omphacite + rutile + quartz: one in the core of the dome and one at the margin (near the boundary between dome gneiss and schist carapace).

The two eclogites record the same age of protolith (inferred gabbro) crystallization (~450 Ma) and HP metamorphism (~315 Ma), and similar P-T conditions (700 ± 20°C, 1.4-1.6 GPa).



modified from Whitney et al. (2015, 2020)



modified from Whitney et al. (2020)

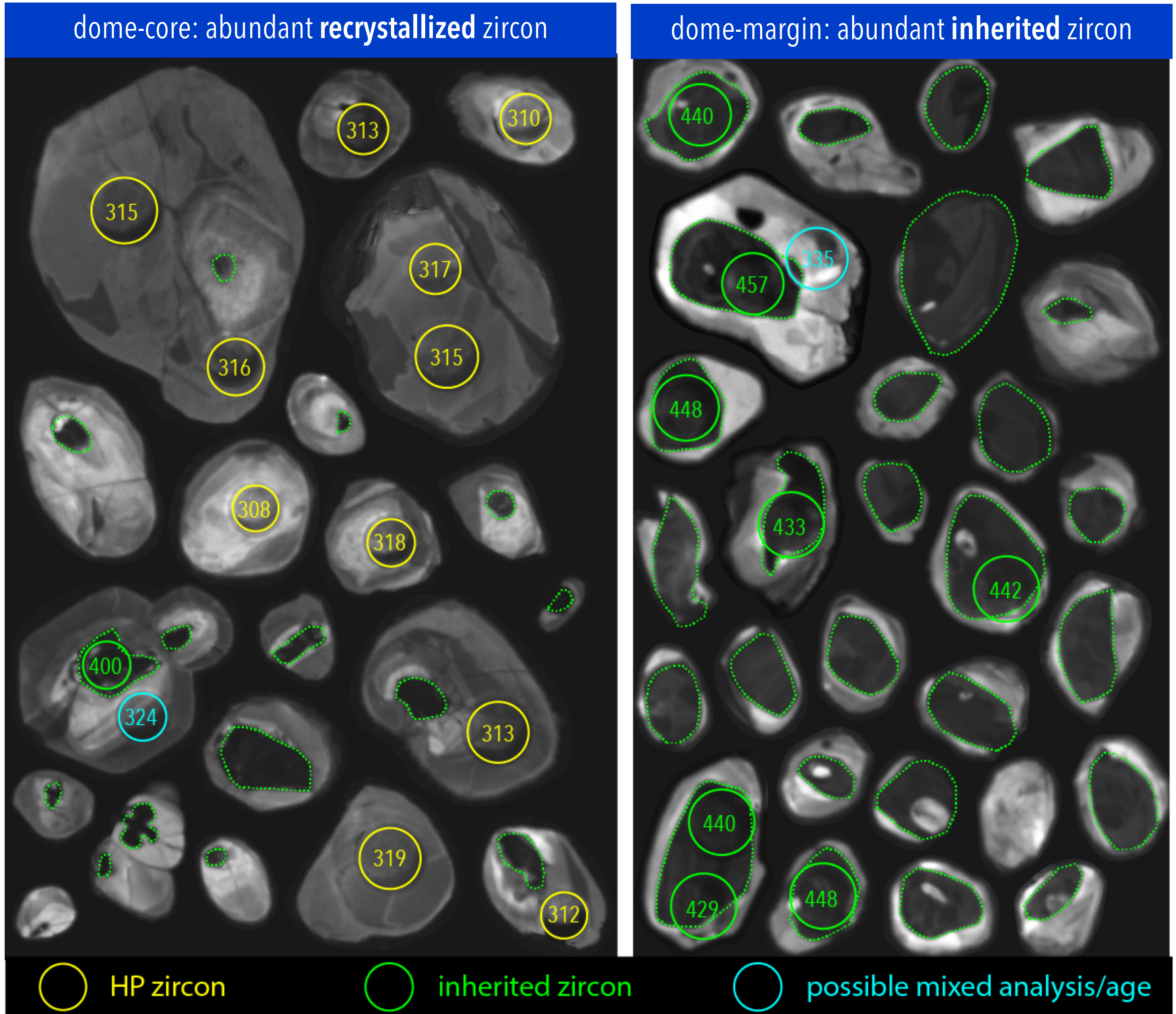
Current geochronology methods cannot discern a difference in timing of zircon crystallization in the dome-core vs. dome-margin eclogite, or eclogite vs. the oldest crystallization ages determined for host migmatite; all are the same age (~315 Ma) within analytical uncertainty.

Zircon in the dome-core eclogite has been extensively recrystallized at eclogite facies conditions. Zircon in dome-margin eclogite consists primarily of inherited cores, with thin eclogite-facies rims. Interpretation of zircon crystallization conditions is based on REE patterns (i.e., flat HREE; Whitney et al., 2015, 2020).

ages in Ma, in laser pits (UCSB LASS)

smaller circles: 15 μm, larger circles: 20 μm spot size

inherited cores indicated by dashed green line

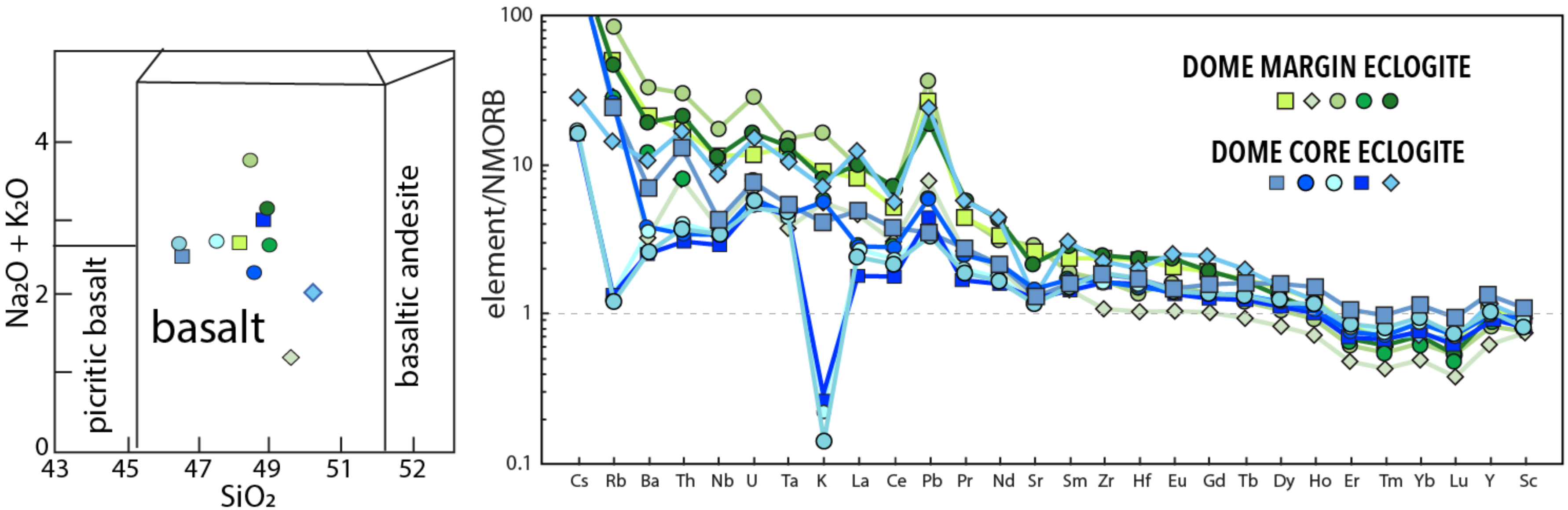


Difference in extent of zircon recrystallization in the two eclogites is unlikely to be explained by difference in P-T conditions or deformation. We cannot yet evaluate whether there were differences in interaction with an aqueous fluid.

Other possible variables that could affect extent of zircon recrystallization include:

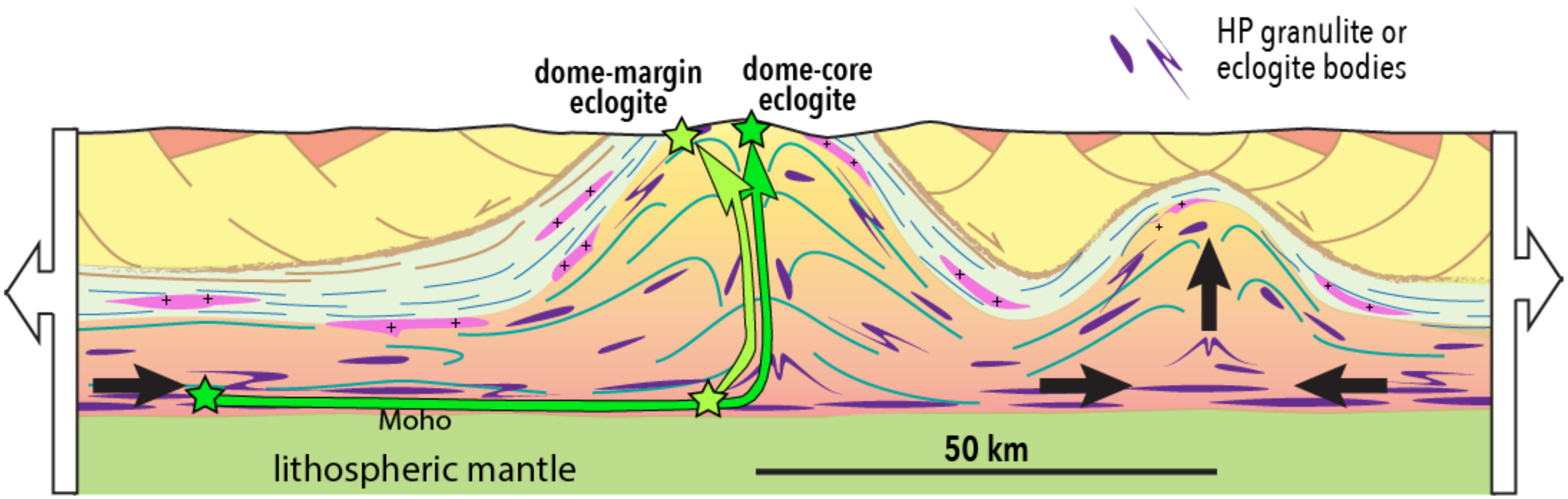
- differences in host rock chemistry (Figure),
- availability of Zr from decompression reactions involving Zr-bearing minerals,
- extent of radiation damage, and
- original crystal size.

At present, there is no evidence to suggest that these mechanisms explain the observations.



Whole-rock composition of dome-margin (green symbols) and dome-core (blue symbols) eclogite. The protoliths are inferred to have been gabbroic intrusions.

We propose that the two most likely explanations for variations in zircon recrystallization are **duration at high-T** and/or **extent of fluid-rock interaction**. In the case of the former, dome-margin eclogite may have had a shorter residence time in the deep crust and was more directly exhumed from a proximal source, whereas the dome-core eclogite may have had a more extended transit in the deep-crust before being exhumed in the steep, median high-strain zone of the migmatite dome.



Two example paths for dome-core and dome-margin eclogite, showing that the former may have had longer residence time in the deep crust (i.e., longer lateral flow path before exhumation in the dome) and the latter may have had a shorter residence time prior to being exhumed in the dome.

Future work will quantitatively evaluate extent of HP zircon re/crystallization, will assess fluid-rock interaction (via zircon and garnet stable isotope analysis), and will document eclogite rock and mineral geochemistry in other domes of the French Massif Central to test the idea of a regional crustal flow system.