Orogenic plateau margin and the coexistence of HP and HT metamorphic rocks

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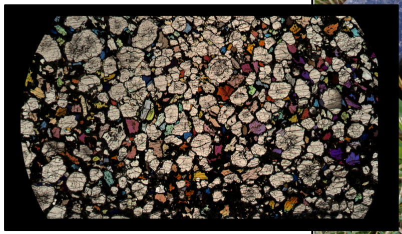
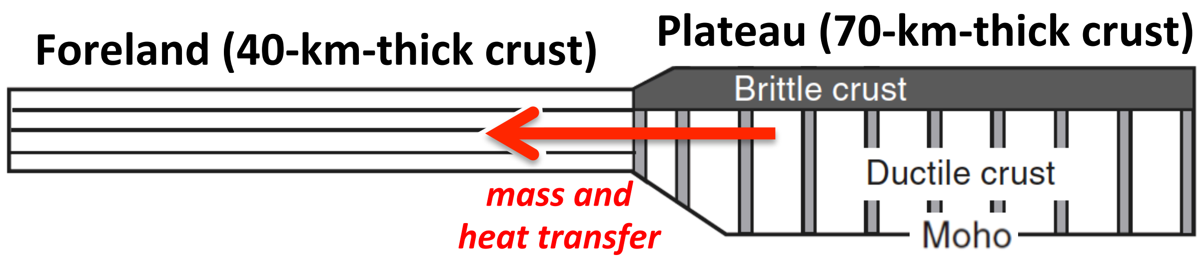
It seems counterintuitive that high-pressure rocks, such as eclogite, would form at the same time as the high-temperature migmatite rocks they are in. Using a field case study, we show that both *HP* and *HT* metamorphic rocks may form coevally at the edge of an orogenic plateau. Plateau margins in general are likely to show similar *HP-HT* associations.

Migmatite (HT) ⟵ ***HT and HP coexistence*** ⟶ **Eclogite (HP)**



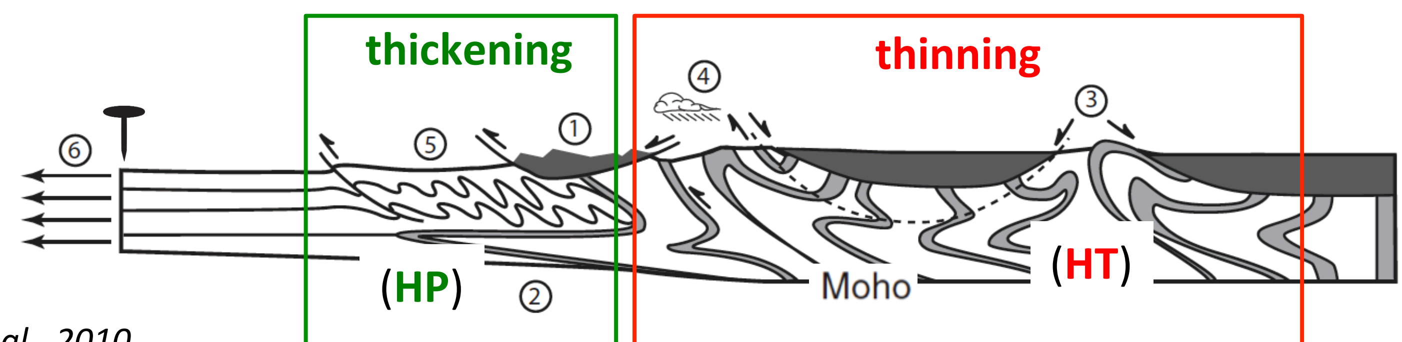
Key is transfer of orogenic material from plateau to foreland



Near the end of orogeny, material is redistributed from plateau to foreland. Processes that accommodate thinning of the plateau and thickening of the foreland include:

1. Gravitational sliding
2. Channel flow extrusion
3. Upper crust extension and flow of deep crust to form gneiss (migmatite) domes
4. Upward flow of plateau lower crust in region of aggressive erosion
5. Shortening of foreland adjacent to plateau
6. Retreating (or fixed) foreland

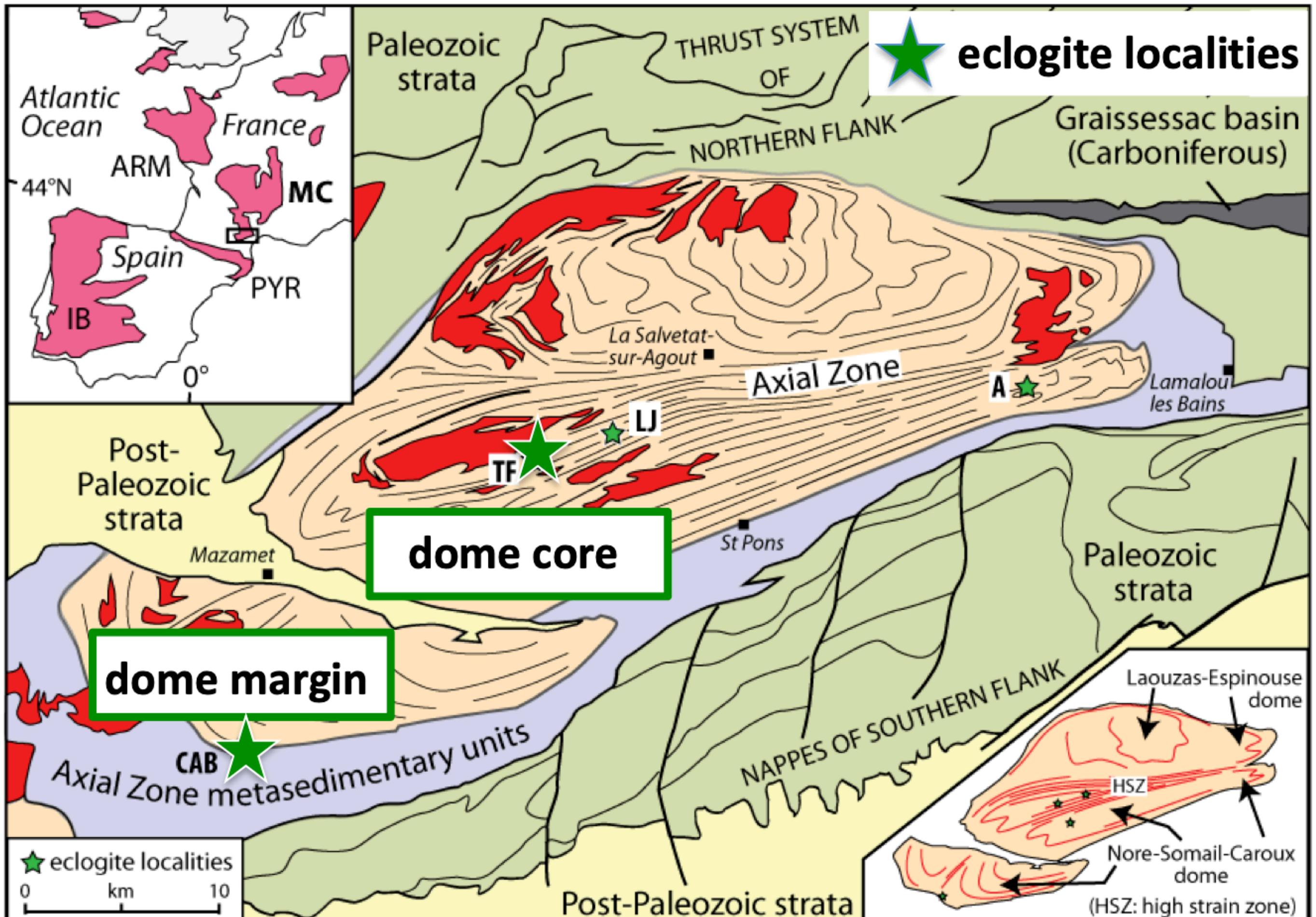
- Extrusion of deep crust (2.) transfers heat to the foreland (**HT conditions**);
- Shortening of foreland (5.) results in pressure increase in the deep crust (**HP conditions**).



after Rey et al., 2010

Example: Variscan Montagne Noire Dome (French Massif Central)

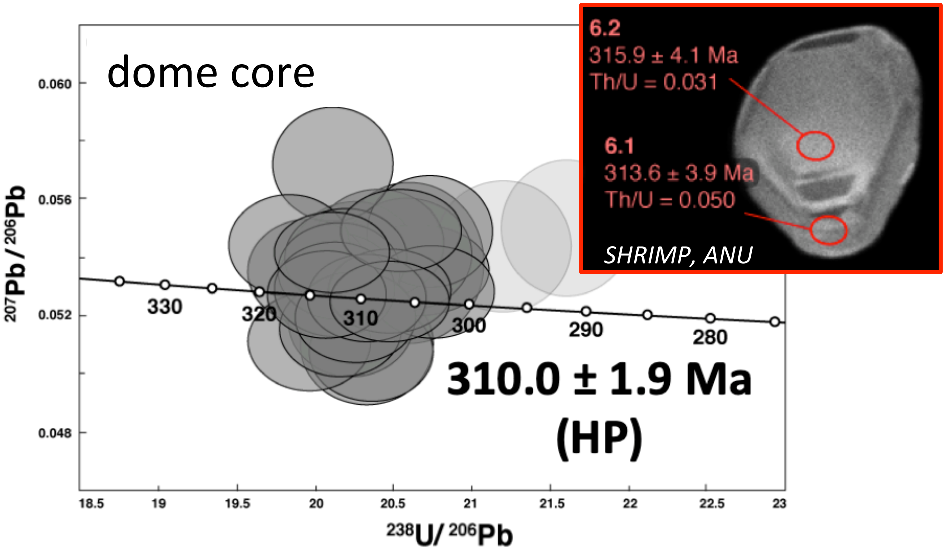
- The Montagne Noire Dome was emplaced in the foreland region of the Variscan orogen.
- The dome consists of migmatite (***HT* metamorphism: 0.5 GPa, 700°C – 315-295 Ma)** and contains rare inclusions of eclogite ★ (***HP* metamorphism: 1.5 GPa, 700°C – 315-310 Ma)**



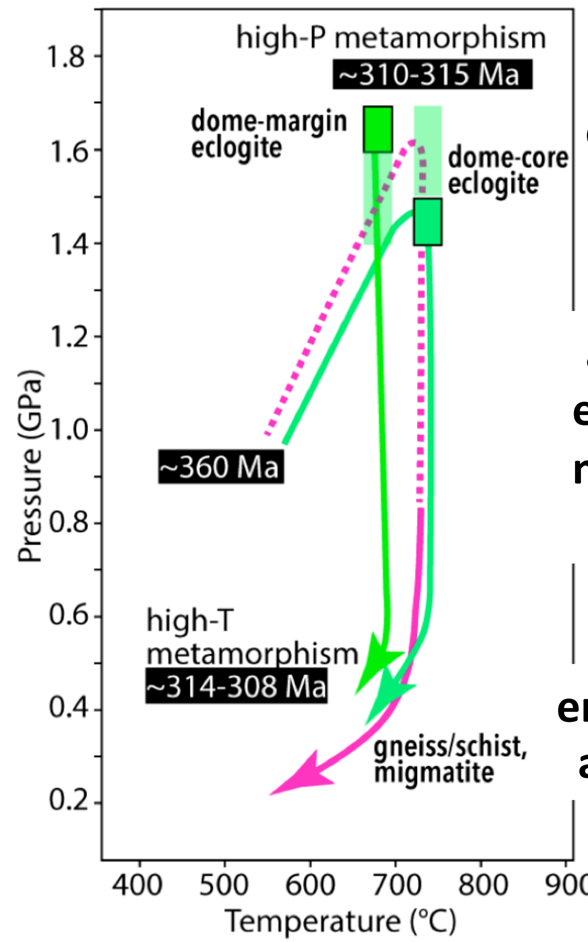
map modified from Whitney et al., 2015; after Rabin et al., 2015

The late Paleozoic Montagne Noire dome is an example where eclogite and migmatite not only coexist but evolved at the same time at the edge of the Variscan orogen.

P-T paths and dates obtained from Montagne Noire eclogite



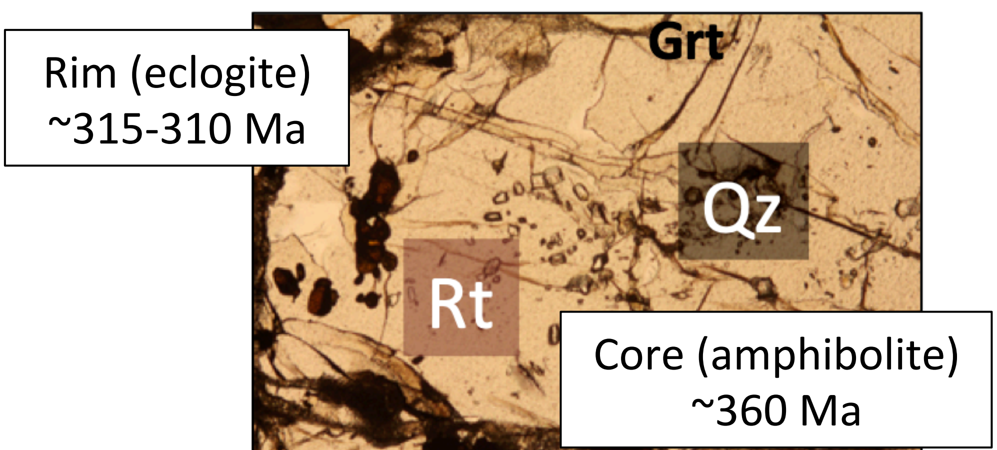
- Eclogite crystallized at 1.4-1.6 GPa and ~700°C. Zircon grains and zircon rims in eclogite grew at 315-310 Ma.
- *HT* metamorphism and deformation of felsic host have been dated at 315-300 Ma.



eclogitization
(1.5 Gpa, 700°C)

ascent of eclogite in migmatite dome

emplacement and cooling

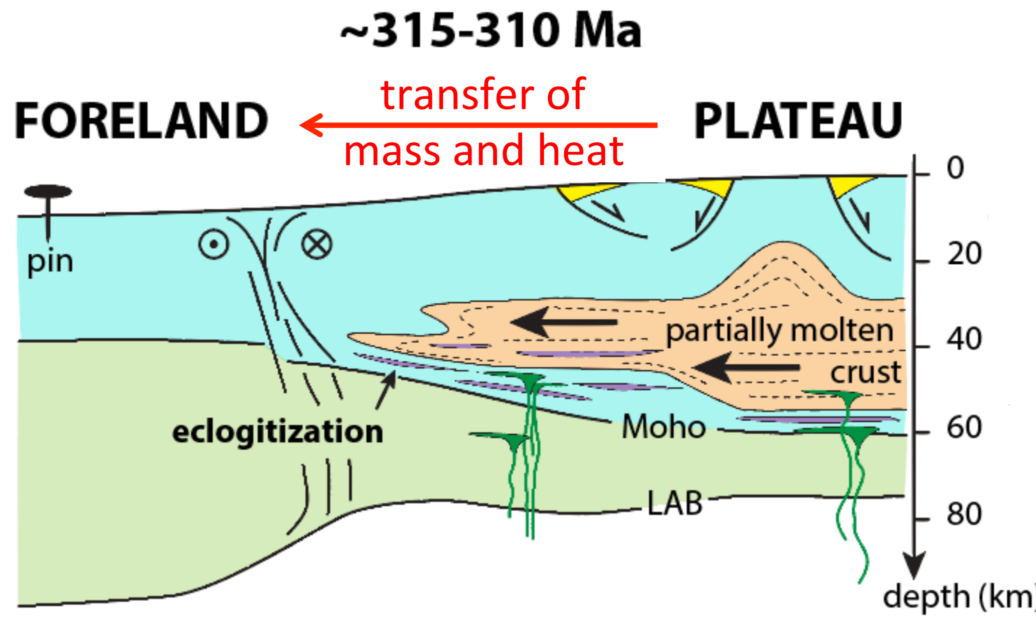


Whitney et al., 2020

Interpretation

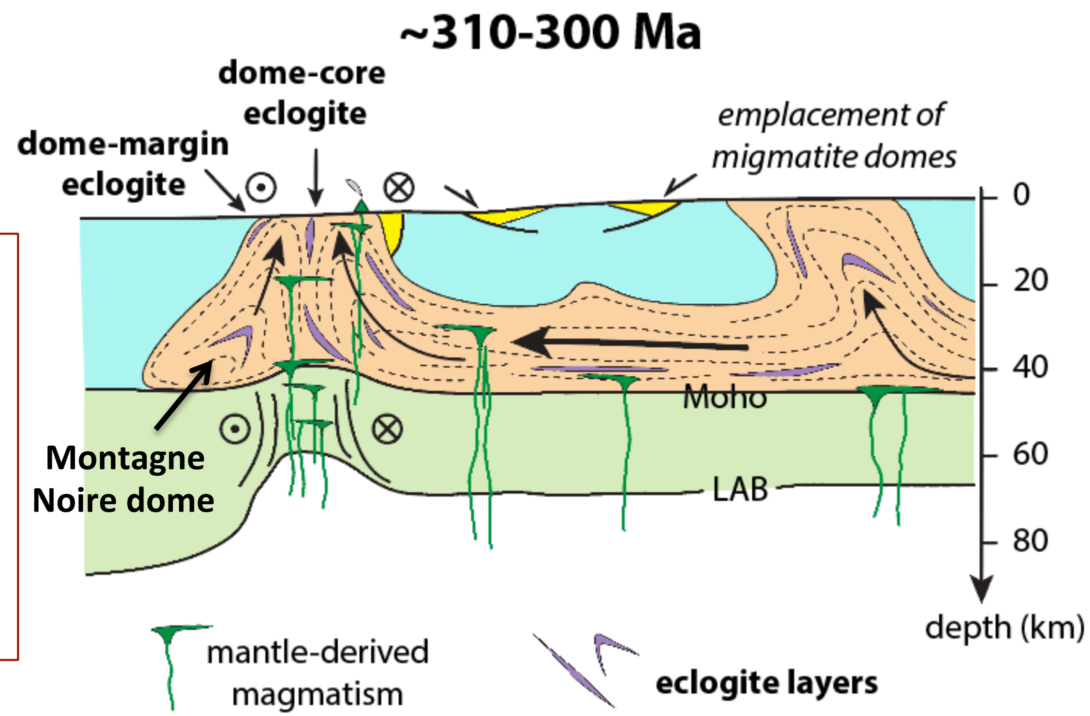
Thickening mechanism

During the collapse stage of the Variscan orogen (315-310 Ma), the deep hot crust flowed toward the foreland. The foreland was heated and the crust was thickened, resulting in HP metamorphism.



Exhumation mechanism

A strike-slip system localized at the plateau-foreland margin allowed the deep, partially-molten crust (HT metamorphic rocks) to be exhumed in an extensional pull-apart structure (310-300 Ma), forming the Montagne Noire dome.



Summary

Thank you for visiting this presentation!

We look forward to your questions and comments.

Flow of deep orogenic crust across a plateau margin transfers significant heat while the foreland is being thickened. This process **drives *HP* metamorphism**, including the possible formation of eclogite at near-Moho conditions. In general, the deep crust at the edge of plateaus likely contains *HP* rocks, which may or may not be exhumed.

Exhumation of these *HP* rocks is facilitated by **extension of the shallow crust**, for example in pull-apart domains along strike-slip systems, which are common at plateau-foreland transitions (aggressive erosion can also help exhumation). Efficient exhumation of low-viscosity crust, in which *HP* rocks are entrained, results in **migmatite domes containing fragments of eclogite**, as is the case in the Montagne Noire dome.

Coeval eclogite in migmatite informs the **deep sourcing of partially molten crust**. Felsic migmatites record only the pressure conditions of their crystallization; the actual depth of their source (near-Moho) is preserved in eclogite inclusions (layers, blocks, pods).