

# Changing exhumation potential of (U)HP eclogite through geological time

*Invited contribution to EGU 2020 session:*

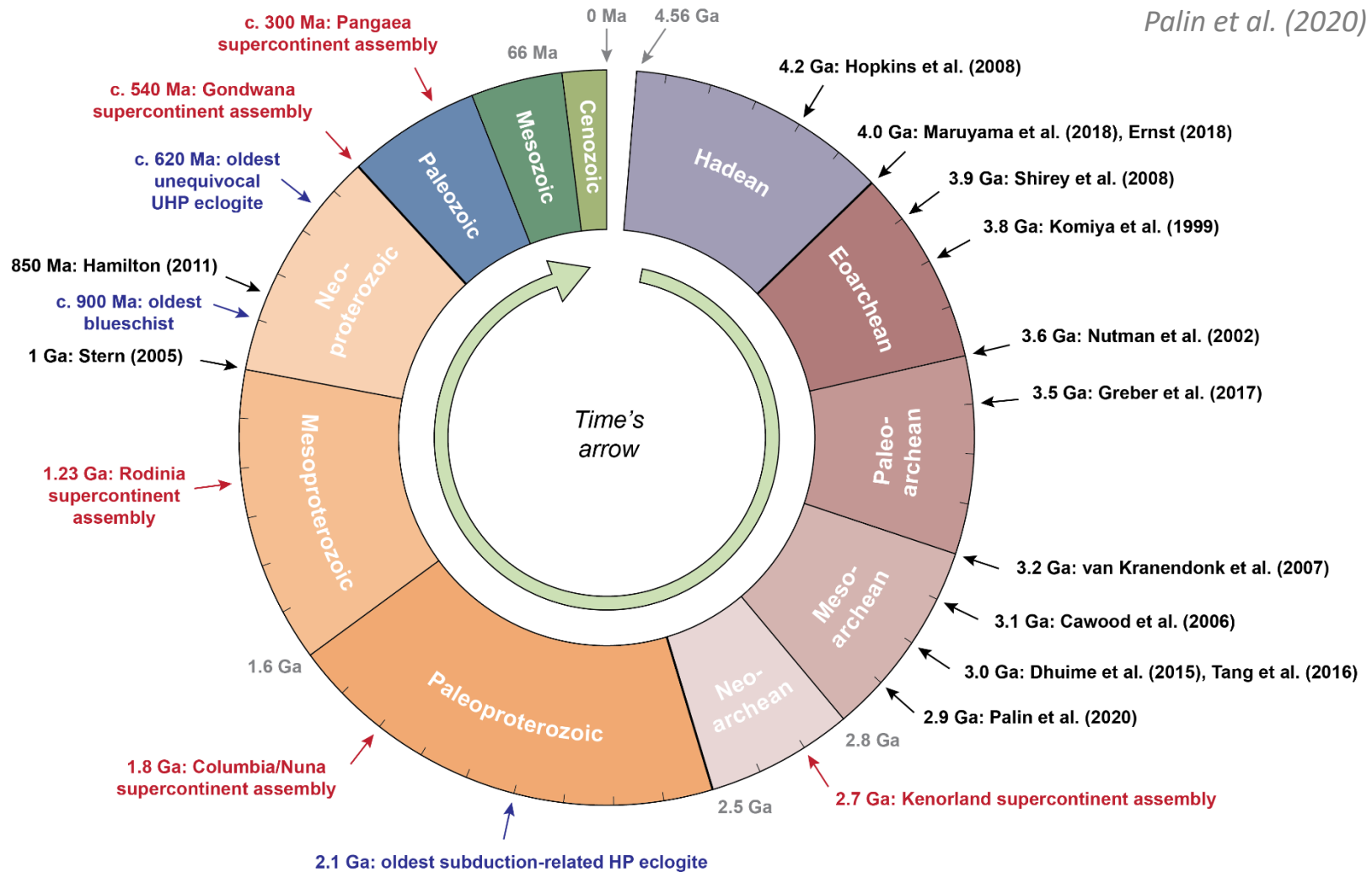
*GMPV7.1 – The metamorphic rock record: pieces of the lithospheric puzzle*

**Richard Palin, James Moore, Zeming Zhang, Guangyu Huang**

*All original materials presented herein are the intellectual property of the authors, unless otherwise stated, in which case copyright rests with the original creators*

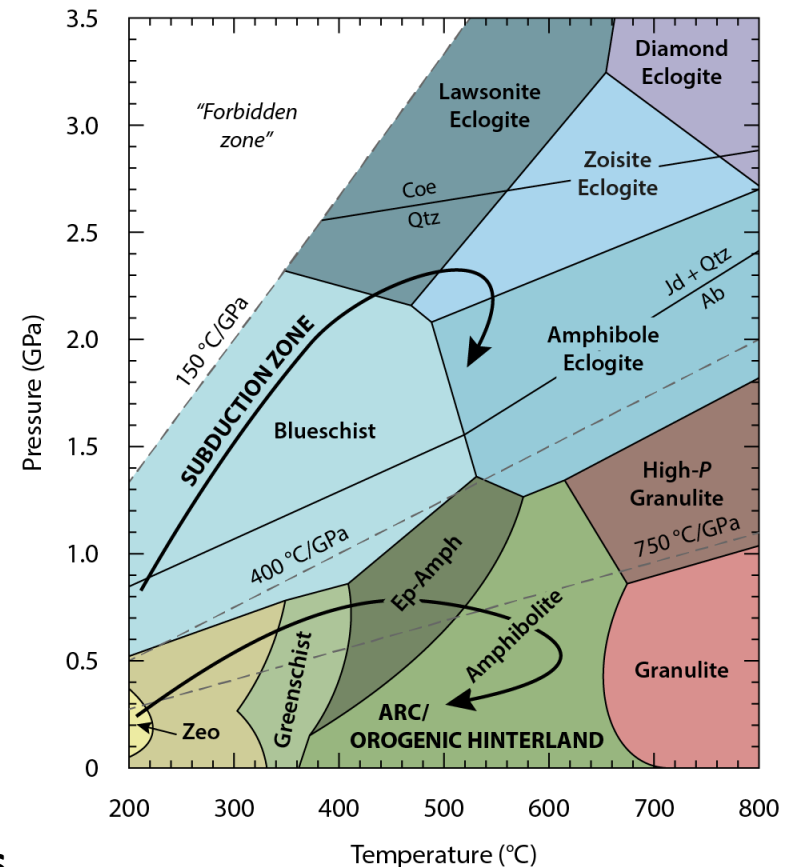
# When did plate tectonics start on Earth?

*Palin et al. (2020)*



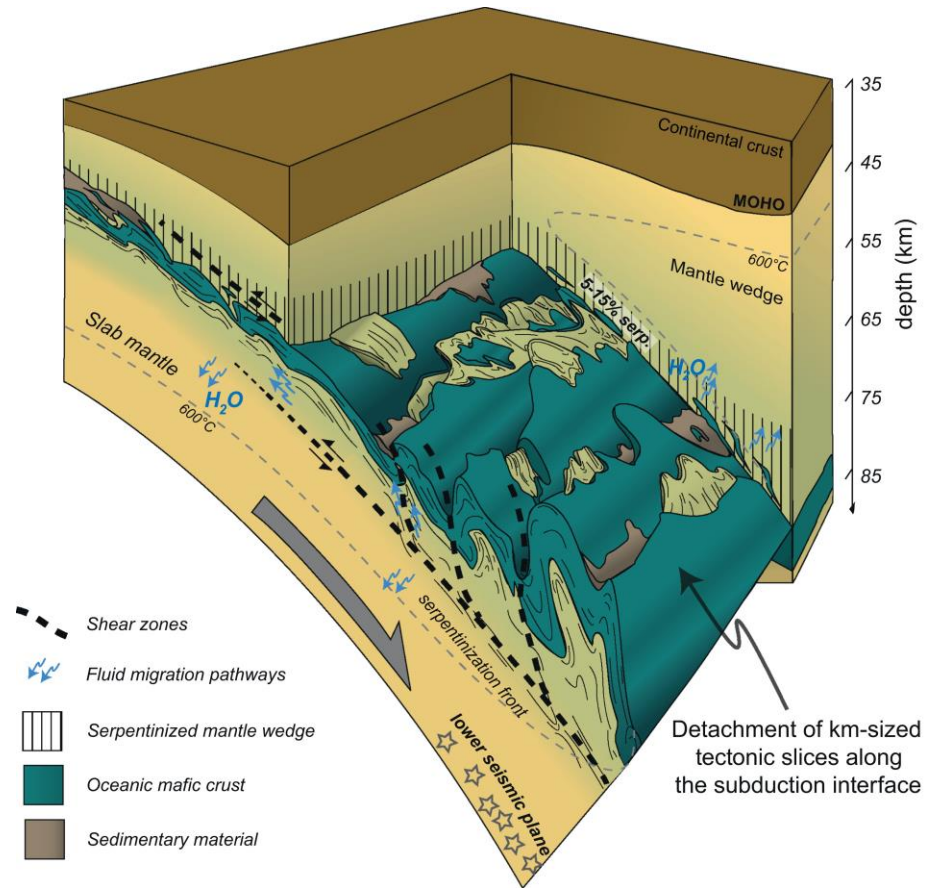
# Why is constraining this age a problem?

- Identifying plate tectonics requires **proving subduction or independent plate motion and rotation**
- Theoretical and empirical data **disagree**
  - **Geodynamic numerical modeling**
    - Subduction or sagduction?
  - **Isotope/trace element signatures**
    - Transport of pelagic sediments into the mantle at 3.5 Ga (e.g. Blichert-Toft *et al.*, 2015)
  - **Styles of deformation and magmatism**
    - Dome and keel vs. linear arcs
  - **Secular distribution of key rock types**
    - Sheeted dykes in Yellowknife (c. 2.7 Ga) (e.g. Helmstaedt *et al.*, 1986)



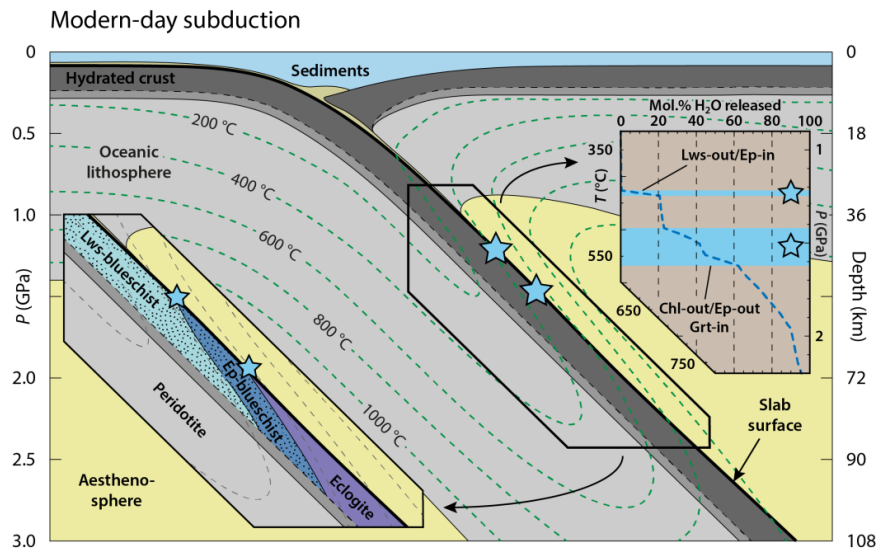
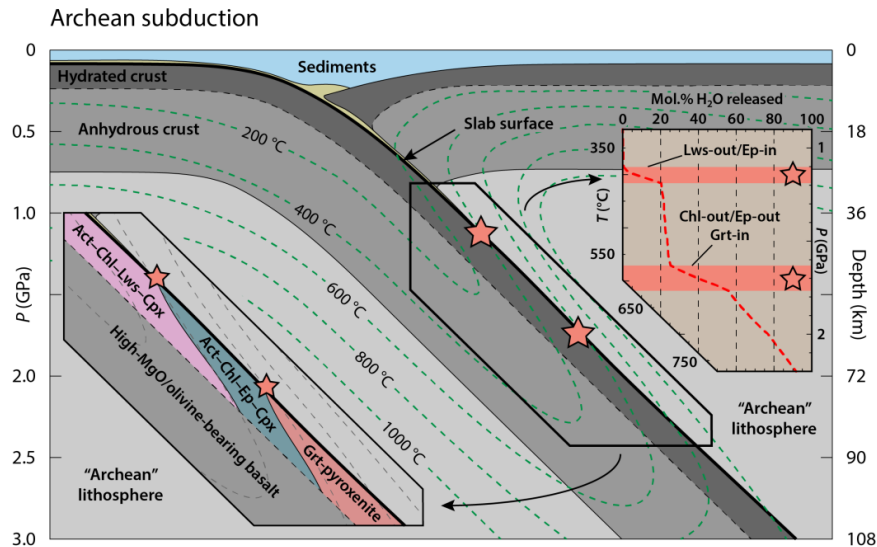
# Geological evidence for operation of plate tectonics

- **Tectonic evidence**
  - Paired metamorphic belts
  - Collisional/accretionary orogens and the supercontinent cycle
- **Geochemical and/or isotopic evidence**
  - Trace-element discrimination
  - Diamonds and their inclusions
- **Modeling**
  - Petrological and thermo-mechanical
- **Petrological evidence**
  - Blueschists, (U)HP eclogites
  - Ophiolites, andesites and arc/back-arc assemblages

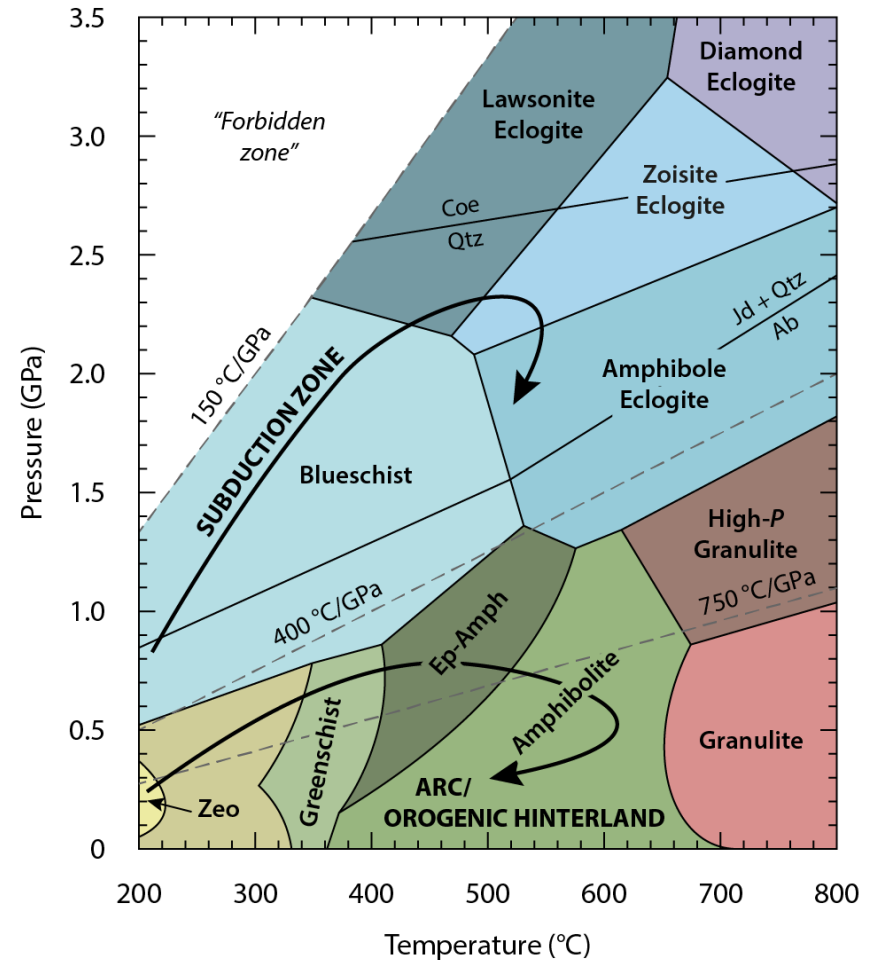


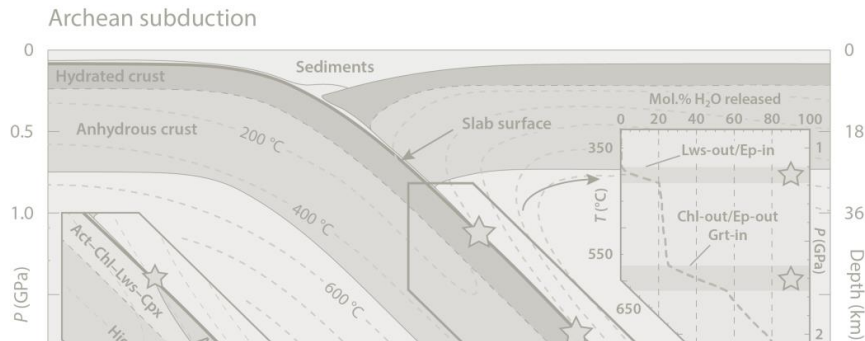
*Angiboust et al. (2012)*

# Archean vs. modern-day subduction-zone facies

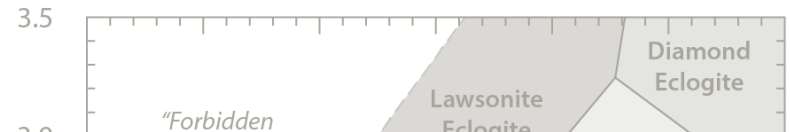


Palin and White (2016) *Nature Geoscience*





## Archean vs. modern-day subduction-zone facies



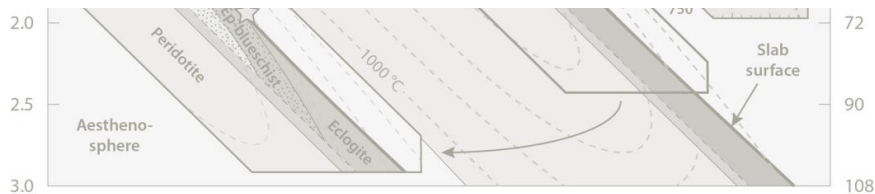
### LETTERS

PUBLISHED ONLINE: 14 DECEMBER 2015 | DOI: 10.1038/NGEO2605

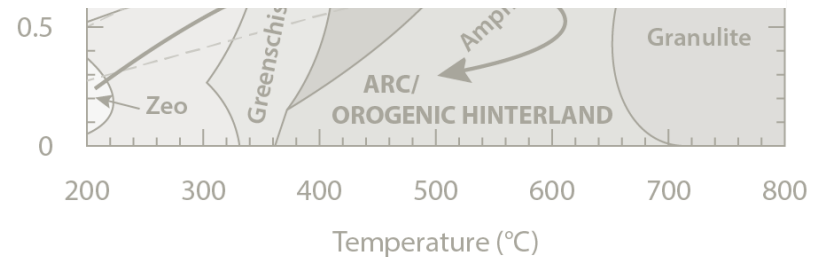
nature  
geoscience

# Emergence of blueschists on Earth linked to secular changes in oceanic crust composition

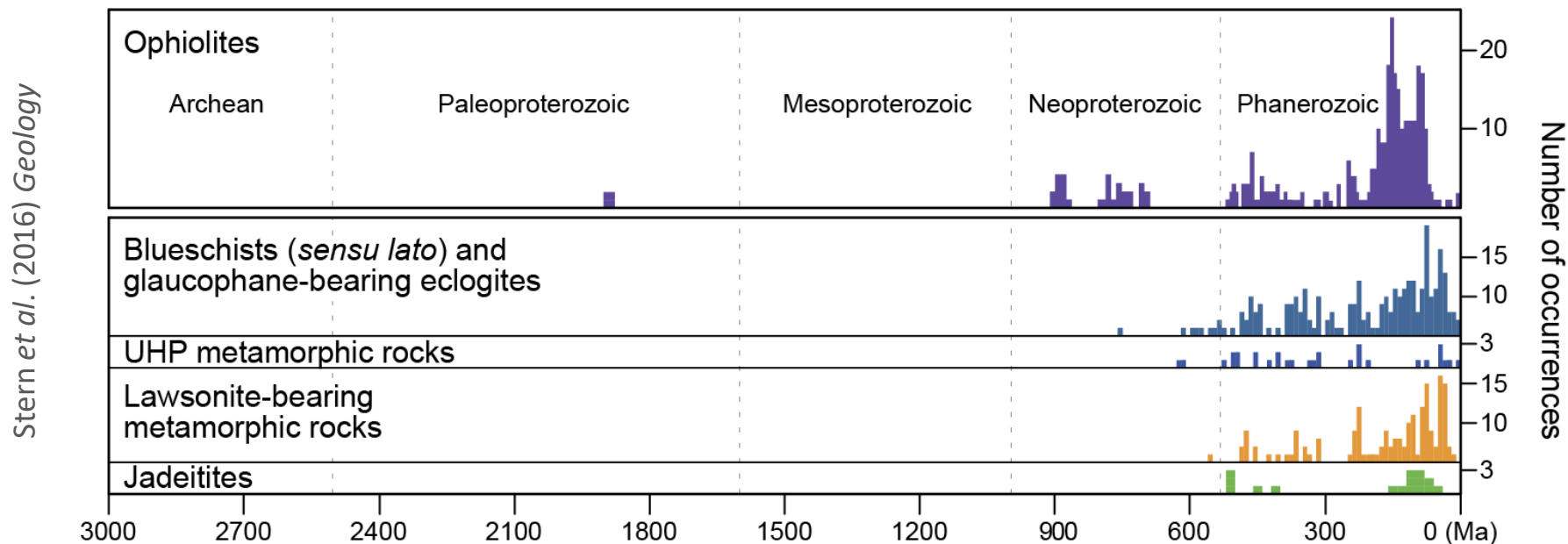
Richard M. Palin<sup>★</sup> and Richard W. White



Palin and White (2016) *Nature Geoscience*

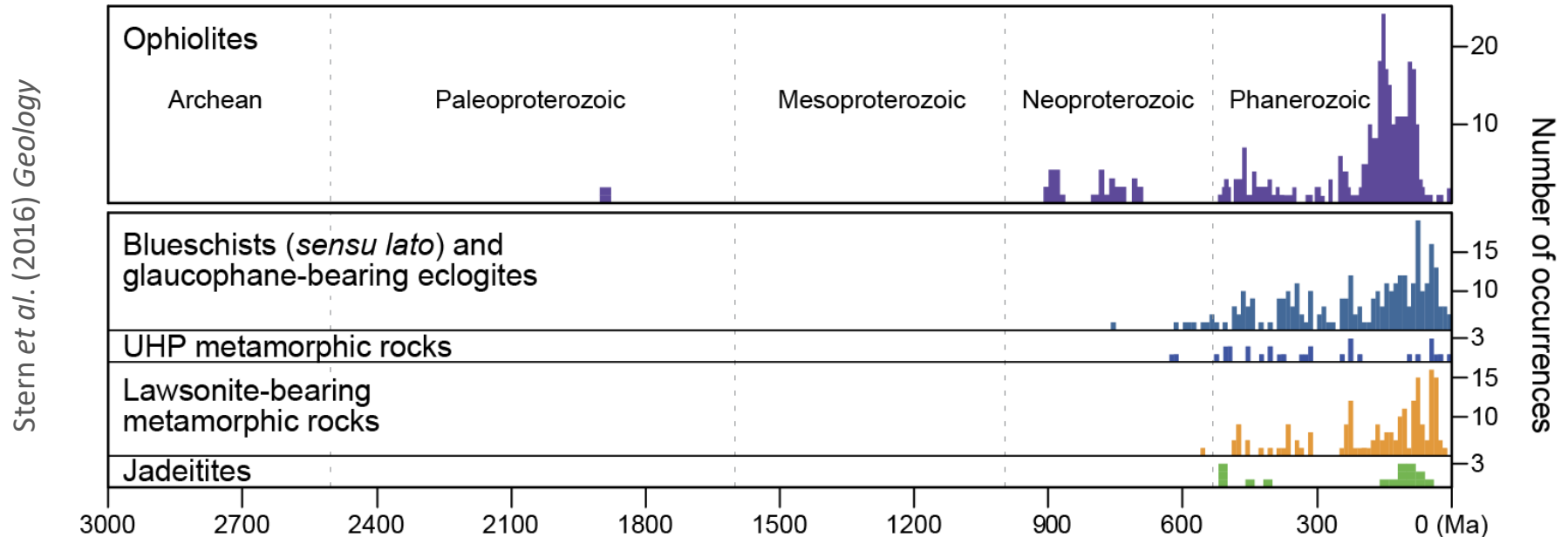


## But what about (U)HP eclogites?



- Many petrological indicators of subduction are absent from the rock record before c. 1 Ga, despite several lines of independent evidence for plate tectonics having begun much sooner
  - Blueschists, as noted previously, did not form due to the **highly mafic composition of oceanic crust** (Palin and White, 2016: Nature Geoscience)
    - A result of secular cooling of the mantle since the middle Archean

# But what about (U)HP eclogites?

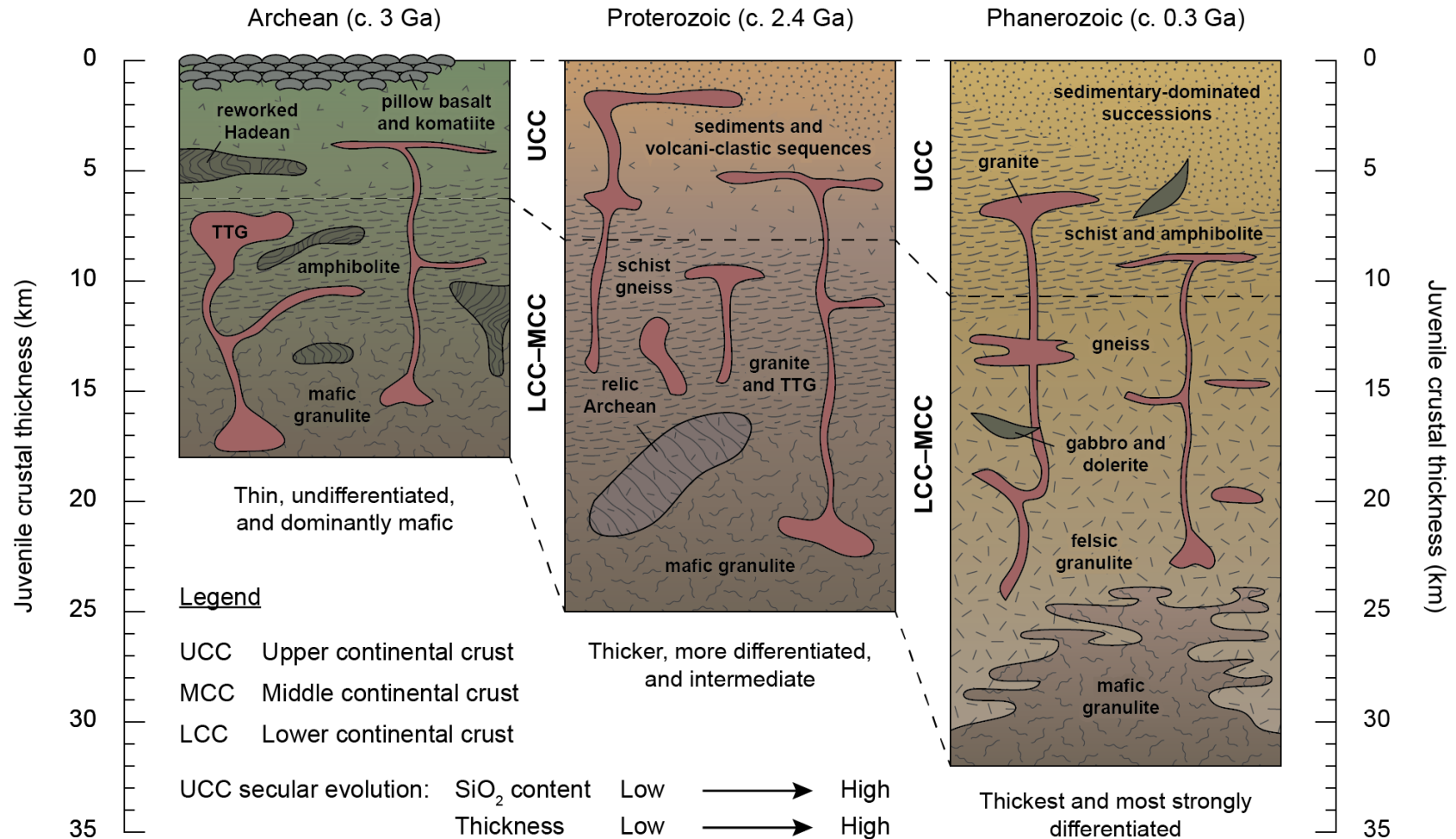


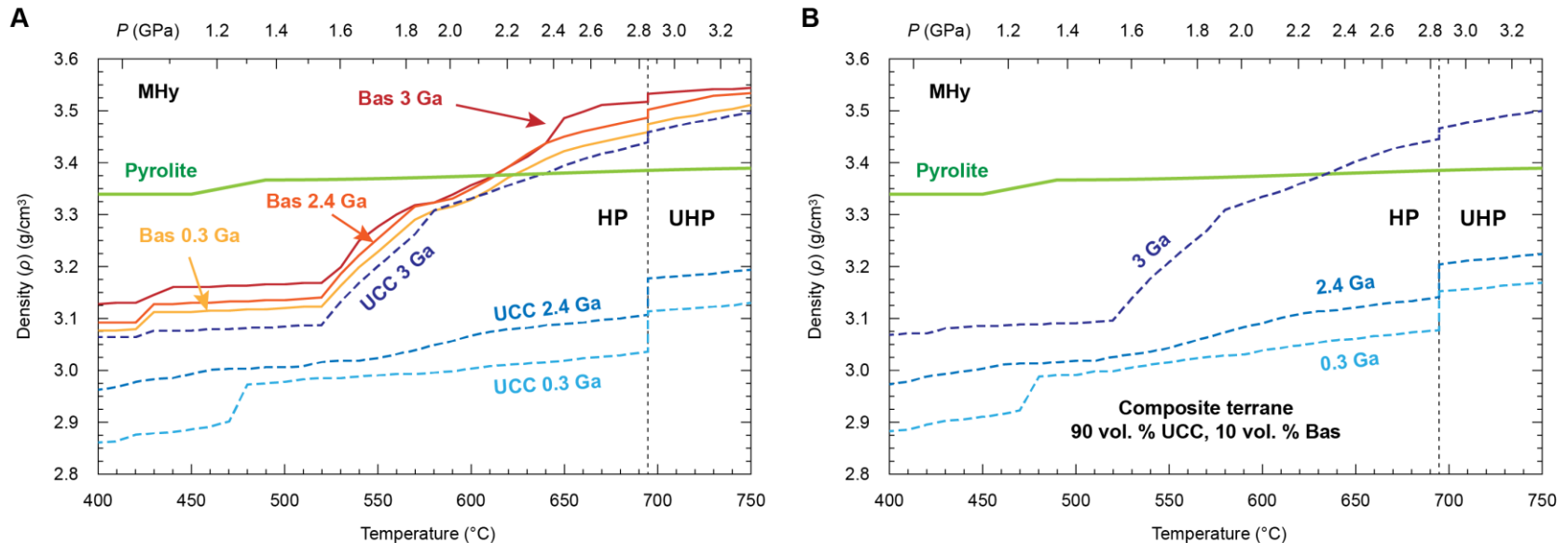
- What about the **changing nature of continental crust**?
  - Recent studies have suggested that the Archean continents were not as felsic as typical modern-day continental crust (Tang et al., 2016; Rollinson, 2017)
  - Almost all Phanerozoic (U)HP eclogites owe their exhumation to inclusion as small mafic bodies in low-density, felsic continental crust (e.g. the Himalaya)
    - Is this possible if the Archean crust was highly mafic too?



# Schematic cross sections through continental crusts

Modified after Hawkesworth et al. (2016)





- Petrological modeling of metamorphic phase changes in basalts and upper continental crust (UCC) of Archean (3 Ga), Proterozoic (2.4 Ga), and Phanerozoic (0.3 Ga) age show that all mafic lithologies reach the point of no return before the HP-UHP transition is reached
  - Intermediate/felsic materials remain buoyant past this transition
- **Subducted Archean UCC can never return to the surface via its buoyancy alone**
  - Composite terranes where a continental margin hosts mafic intrusions in a generic ratio (90:10) show different profiles density-depth profiles with age