Paper Number: 3493

Archean metamorphism and geodynamics: from episodic and local to continuous and global subduction and mobile-lid plate tectonics

Michael Brown

Department of Geology, University of Maryland, College Park, MD 20742-4211, USA; mbrown@umd.edu

---

On Earth, present-day plate tectonics is characterized by asymmetric (one-sided) subduction, but how do we recognize the imprint of subduction in the geologic record? How do we weigh global (commonly younger) vs local (commonly older) datasets or distinguish initiation from episodic from continuous (global) subduction? What is the role of preservation, how reliable are data gaps, what about sampling bias? In the Archean, did a hotter mantle, higher heat production and weaker lithosphere modify global geodynamics to the extent that (mobile-lid) plate tectonics was not possible? If not plate tectonics, what preceded subduction and how do we recognize that regime?

Based on an expanded data set, two types of metamorphism, intermediate d*T*/d*P*, with apparent thermal gradients of 350–775 °C/GPa (for the interval 2.8–1.5 Ga, mean of 603 +/- 111 (1s)), and high d*T*/d*P*, with apparent thermal gradients of 775–2000 °C/GPa (for the interval 2.8–1.5 Ga, mean of 1110 +/- 227 (1s)), appear widely in the rock record beginning at ca 2.8 Ga (Figure 1). The emergence of paired metamorphism is interpreted to register the onset of one-sided subduction, which introduced an asymmetric thermal structure at developing convergent plate margins characterized by lower d*T*/d*P* in the subduction channel and higher d*T*/d*P* in the overriding plate [1]. By contrast, prior to 2.8 Ga the crust commonly registers sporadic high d*T*/d*P* metamorphism (in both 'high-grade' gneiss terranes and 'low-grade' greenstone belts) and rare intermediate d*T*/d*P* metamorphism (e.g. Isua, southern West Greenland, the Barberton Greenstone Belt, South Africa). This pattern may reflect a stagnant lid regime [2] in which the rare occurrences of intermediate d*T*/d*P* metamorphism record local episodes of subduction [3]. Thus, the advent of paired metamorphism is interpreted to record a transition from a dominantly (deformable) stagnant lid regime to subduction and global (mobile-lid) plate tectonics.

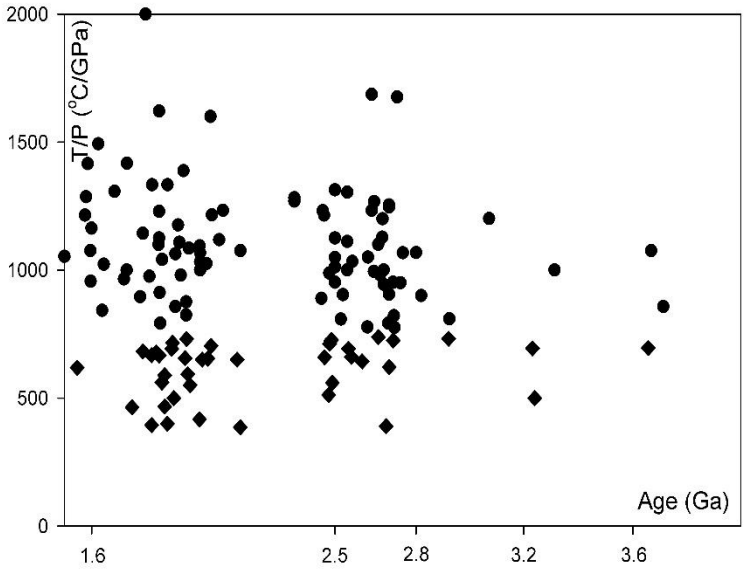

Figure 1: T/P (°C/GPa) vs Age (Ga) for high dT/dP (filled circles) and intermediate dT/dP metamorphism (filled diamonds).

In common with the distribution of zircon ages from the crust, the metamorphic record from the late Mesoarchean to the early Mesoproterozoic correlates with a period of supercraton assembly from 2.8

to 2.4 Ga, followed by supercraton breakup (data gap) and formation of the first supercontinent (Columbia/Nuna) in the interval 2.2 or 2.0 to 1.5 Ga (Figure 1). To conclude, I will discuss the wide range of evidence for the growing consensus that the late Mesoarchean to early Paleoproterozoic was a 600 Myr long period of transition to continuous (?) subduction and global (?) plate tectonics.

References:

[1] Brown M (2014) Geosci Frontiers 5: 553-569.

[2] Johnson TE et al. (2014) Nature Geosci 7: 47-52.

[3] Sizova E et al. (2015) Precambr Res 271: 198-224