Secular and cyclic variation of the heat budget of metamorphism: geodynamic implications

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Earth's radiogenic heat production has declined by >75% since the Hadean and mantle potential temperature has declined by ~200–300ºC since *c*. 3.0 Ga. The thermal history of the crust is preserved in the record of metamorphism. At present, different plate tectonic settings exhibit contrasts in heat flow that are registered as differing metamorphic facies series in distinct crustal terranes. How far back in time these relationships are reliable is unclear and the thermal effects of the formation and breakup of supercontinents are poorly characterized. To evaluate variation of the heat budget of the crust through time we use the record of metamorphism as a proxy. Plots of T and T/P against age (n = 564) show that since *c*. 3.0 Ga cyclic variations in the heat budget of the crust have been superimposed on secular cooling. A first cycle is marked by the widespread occurrence of two contrasting types of metamorphism—high dT/dP and intermediate dT/dP—synchronous with the amalgamation of dispersed lithosphere into protocontinents during the Mesoarchean–Neoarchean. Paired metamorphic belts are characteristic of convergent plate margins and subduction of ocean lithosphere, suggesting the existence of a mobile lid tectonic regime. The transition to a second cycle is marked by the fragmentation of the protocontinents into cratons and their subsequent accretion into the supercontinent Columbia during the Paleoproterozoic. Moving means of both T and T/P of high dT/dP metamorphism exceed the arithmetic means of T and T/P for most of the Proterozoic, reflecting insulation of the mantle beneath the quasi-integral continental lithosphere of Columbia and the limited geographical reorganization into Rodinia. The start of the third cycle was synchronous with the breakup of Rodinia and the appearance of low dT/dP metamorphism in the rock record at the end of the Tonian, registering a change to the deeper, colder subduction characteristic of the modern plate tectonics regime. Both T and T/P of high dT/dP metamorphism remain relatively high from the Ediacaran to the Silurian during the Pan-African thermal event. The decline in T and T/P of high dT/dP metamorphism from the Devonian to the Jurassic and the breakup of Pangea may indicate a transition to a fourth cycle.