The Metamorphic Signature of Suture Zones in the Geological Record

MICHAEL BROWN

Laboratory for Crustal Petrology, Department of Geology, University of Maryland, College Park, MD 20742, USA (mbrown@umd.edu)

Ophiolitic rocks occur in Phanerozoic suture zones, but the tectonic setting in which they form and recognition of ophiolitic rocks in the pre-Neoproterozoic continental geologic record remain controversial. In this contribution I argue that the continental record of metamorphism is a more robust way to identify ancient suture zones. At convergent plate boundaries subduction of the lithosphere is asymmetric (one-sided) generating lower thermal gradients in the subduction channel and higher thermal gradients in the arc–backarc or orogenic hinterland of the overriding plate. This duality of thermal regimes is the hallmark of one-sided subduction and paired metamorphic belts are the characteristic imprint of this in the geological record. If subduction is terminated by collision, the resulting suture zone between the subduction channel and the overriding plate will be characterized by thermal gradients that evolve from lower (subduction-related) to intermediate (collision-related) values. *P–T* retrieved from metamorphic rocks in combination with precise age information may be inverted to yield apparent thermal gradients for close-to-peak metamorphic conditions at a particular time in Earth history; this information may be used to infer the location of ancient suture zones. 140 metamorphic belts have been classified based on 'peak' *P–T* into 3 types: 1) high *P* to ultrahigh *P* metamorphism (HPM–UHPM); 2) medium *T* eclogite and high *P* granulite metamorphism (E-HPGM); and, 3) granulite to ultrahigh *T* metamorphism (G-UHTM). Phanerozoic sutures are marked by early subduction-related HPM and/or UHPM with apparent thermal gradients <350°C/GPa and maximum P >2.7GPa, and later collision-related E-HPGM with apparent thermal gradients of 350–750°C/GPa. G-UHTM with apparent thermal gradients of 800–1300°C/GPa is rare at the surface, but may be inferred at depth in the hinterland of some active orogens. For the Precambrian, two regimes may be distinguished. Mesoarchean–Neoproterozoic sutures are marked by E-HPGM, where the maximum P jumps from <1 GPa to around 2 GPa from the Mesoarchean to the mid-Paleoproterozoic; apparent thermal gradients are in the range 350–700°C/GPa. G-UHTM with apparent thermal gradients in the range 800–1,300°C/GPa is first registered in the Neoarchean. The appearance of E-HPGM and G-UHTM in the geological record registers a change in geodynamics that generated sites of lower heat flow, inferred to be associated with subduction and collision, and sites of higher heat flow, corresponding to be arcs–backarcs and orogenic hinterlands. Neither extreme conditions of crustal metamorphism nor paired metamorphic belts are documented before the Mesoarchean–Neoarchean, and there is no imprint of subduction of continental crust to and return from mantle conditions. Therefore, prior to the Mesoarchean it is intrinsically more difficult to recognize suture zones in continental crust.