On the origin of high temperature metamorphism within a magmatic arc: the case of the Cretaceous Ryoke belt (Japan)

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Magmatic arcs, located at convergent plate boundaries, are sites of crustal deformation, widespread plutonism and high temperature (HT) metamorphism. Our task is to reveal how these intricate events relate in space and time, and how heat transfers and large-scale tectonics contribute to the genesis of HT conditions within the arc crust.
The Ryoke belt (Japan) is a ca. 800 km-long association of Cretaceous magmatic and metamorphic rocks which gives direct access to the upper-middle crust of a former continental arc setting. Across the belt, a regional HT metamorphic gradient is defined by paragenetic zones that lie parallel to the main foliation of metamorphic rocks and gneissose granitoids. This gradient is opposed to localized contact metamorphic aureoles that are ascribed to later, massive plutons. By summarizing structural/petrological observations and new U–Pb zircon ages obtained in the western (Yanai) and central (Aoyama/Mikawa) parts of the Ryoke belt, we try to constrain the origin of HT metamorphism within this former magmatic arc.
(1) Deformation across the belt was polyphase, with distinct episodes of horizontal extension and shortening (Yanai), or of variable intensity (Mikawa; Adachi & Wallis, 2008).
(2) Metamorphic mineral growth, when correlated with the deformation history, appears to have been polyphase as well. Importantly, pre-tectonic porphyroblasts are observed in both areas. Syn-tectonic assemblages, assuming they were not reoriented by deformation, define the regional gradient while post-tectonic minerals are frequent.
(3) The reported U–Pb zircon ages of HT metamorphic conditions decrease from west (~100 Ma, Yanai) to east (~90 Ma, Aoyama; Kawakami *et al.*, 2013 / ~87 Ma, Mikawa; Nakajima *et al.*, 2013), indicating that the so-called regional metamorphic event was diachronous.
(4) With respect to HT metamorphism, some granitoid intrusions are older; these are usually the shallowest plutons that are not only gneissose but also massive (Skrzypek *et al.*, 2016).
(5) Although some gneissose plutons are broadly coeval with HT metamorphism (Yanai), some others can be significantly younger (Mikawa; Takatsuka *et al.*, 2017).
(6) The latest stage of voluminous plutonic activity was also diachronous and occurred without apparent deformation; its age decreases from west (~80 Ma, Yanai) to east (~70 Ma, Mikawa; Takatsuka *et al.*, 2016).
The upper-middle arc crust clearly experienced heating before, during and after the main phase of regional deformation. The importance of heat advection by granitoids is obvious; we may additionally suggest that the oldest, shallow intrusions potentially acted as a hot lid which facilitated the thermal maturation of the crust. However, we emphasize that regional HT metamorphism is not always spatially and temporally associated with plutonism. This underlines the role of heat conduction, the source of which can be found at the base of the crust where prolonged HT conditions and partial melting are needed to sustain the protracted magmatic activity (105–80 Ma, Yanai; 99–70 Ma, Mikawa). Therefore, there must have been a large-scale process (oblique ridge subduction or lateral mantle upwelling?) which was able to generate diachronous HT conditions along the base of the arc crust. Yet, was it the same process which led to the much younger, magmatic flare-ups associated with relative tectonic quiescence?

References:
Adachi & Wallis, 2008. *Island Arc*, 17, 41–56. Kawakami et al., 2013. *Contrib. Min. Pet.*, 165, 575–591.

Nakajima *et al.*, 2013. *Geol. Soc. Japan Meeting Abstract Vol.,* 51. Skrzypek *et al.*, 2016. *Lithos*, 260, 9–27. Takatsuka *et al.*, 2016. *Geol. Soc. Japan Meeting Abstract Vol., 68*. Takatsuka *et al.*, 2017. *Island Arc*, submitted.

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