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Ultra-low-pressure, anthophyllite-free contact metamorphism of serpentinite over the roof of a granite intrusion

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Contact metamorphic aureoles in serpentinite bodies intruded by granitic rocks generally develop a regular series of mineral assemblages such as antigorite (atg), atg-olivine(ol)-diopside, atg-ol-tremolite(tr), ol-tr-talc(tc), ol-tr-anthophyllite, and ol-tr-enstatite, which form zones arranged from far side to the intrusive contact in this order (e.g. Bergell aureole, Central Alps; Evans, 1977). Typical example in Japan includes Tari-Misaka aureole in the Chugoku Mountains (Arai, 1974, 1975), although anthophyllite occurring in the Tari-Misaka aureole is identified as protoanthophyllite (Konishi et al., 2002; 2003). In some aureoles, Mg-cummingtonite appears in place of anthophyllite (e.g. Oeyama; Uda, 1984), or the anthophyllite zone is followed by the cummingtonite-enstatite-spinel zone adjacent to the granite (e.g. Miyamori; Seki, 1951). All these aureoles are in contact with the well exposed granite intrusions, suggesting relatively deeper levels of erosion, and hence higher pressure of contact metamorphism.
Our studies on the Sekinomiya ultramafic body in the eastern Chugoku Mountains (Matsumoto, Master thesis of Kanazawa Univ., cited in Ishiwatari & Hayasaka, 1992) and on the Kotaki ultramafic bodies in the Hida Marginal Belt (Machi & Ishiwatari, submitted to J. Geol. Soc. Japan) revealed that the ultramafic rocks are affected by contact metamorphism, although no granite bodies are exposed in contact with or in the vicinity of the ultramafic bodies. The underlying granite bodies are expected by the presence of rhyolitic volcanic rocks (both places) and hydrothermal ore deposits in a dome-shaped tectonic window (Nakase, Sekinomiya), suggesting the shallow, ultra-low-pressure "contact" metamorphism on the roof of the plutonic bodies. In both areas, the mineral assemblage varies from diopside zone to enstatite zone, but anthophyllite zone is absent, and the distribution of mineral zones is irregular. Matsumoto et al. (1995) showed some other serpentinite aureoles that lack anthophyllite zone in Chugoku Mountains, and Nozaka (2003) suggested low pressure for the reason of its absence.
Experimental data and thermodynamic calculation of Hemley et al. (1977) indicate that anthophyllite becomes unstable in the olivine-bearing assemblages at less than 0.05 GPa pressure (<2 km depth), suggesting that the talc zone is directly followed by the enstatite zone at lower pressures without any appearance of anthophyllite or cummingtonite. In Chernosky's (1976) experiments, anthophyllite is synthesized only in the runs at more than 0.18 GPa, and only talc or enstatite appears in lower pressures. The anthophyllite-free "contact" metamorphism of the Sekinomiya and Kotaki ultramafic bodies is thus concluded to be taken place at low pressures (<= 0.05 GPa), as suggested by their geological occurrence (absence of granite exposure, irregular distribution of mineral zones) and published experimental data (anthophyllite instability under 0.05 GPa or less pressure).
If we assume that all these granite intrusions headed up to the same depth (say 2 km, 0.05 GPa), we can think that the erosion levels are not as deep as the roofs of the intrusions in Sekinomiya and Kotaki, where the rooftop aureoles are anthophyllite-free, but the roofs were already eroded away and deeper walls of the intrusions are now exposed in the other contact aureoles with well-developed anthophyllite (or Mg-cummingtonite) zones. The pressure of these "wall" aureoles may not exceed 0.3 GPa as indicated by the olivine-cordierite assemblage in metachromitite of Tari-

Misaka (Arai, 1975), but may be deeper in the Miyamori aureole with Mg-Al spinel-enstatite assemblage (Seki, 1951).
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Keywords: serpentinite, granite intrusion, contact aureole, anthophyllite, ultra low pressure, Sekinomiya Kotaki