

Oxygen fugacity and chemical potentials as determinant factors in constraining the metamorphic evolution of subducted rodingites and enclosing ultramafic rocks.

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Rodingites are Ca-, Al-enriched and Si-undersaturated rocks formed from mafic precursors enclosed in peridotites. Formation of both rodingites and serpentinites occurs simultaneously during serpentinization. Therefore, rodingites are common rocks associated with serpentinites in exhumed terrains, which experienced subduction and HP metamorphism. However, uncertainties remain about the factors that constrain the diverse mineral associations occurring in meta-rodingites as well as their response to devolatilization and redox reactions during subduction. In the Cerro del Almirez ultramafic massif (S-Spain) meta-rodingite bodies are enclosed both in Atg-serpentinite and Chl-harzburgite, which are separated by a transitional zone that represents the front of prograde serpentinite dehydration during subduction. Different types of meta-rodingites are found associated with these two ultramafic lithologies: Grandite-meta-rodingite (type 1) within Atg-serpentinite, Epidote-meta-rodingite (type 2) within both of them, especially in the vicinity of the dehydration front, and Pyralspite-meta-rodingite (type 3) within Chl-harzburgite. Type 1 consists of garnet, chlorite and clinopyroxene with minor titanite, magnetite and ilmenite. Several garnet generations are found within this meta-rodingite type: Grt1 (Ti-rich hydrogrossular, 78-90 wt% grossular), Grt2 (6-20 wt% pyralspite, 80-93 wt% grandite), and Grt3 (Ti-rich grandite, 38-40 wt% andradite). Type 2 meta-rodingite consists of epidote and clinopyroxene with minor titanite, garnet and chlorite. It appears partially transforming type 1 rocks within Atg-serpentinite and its amount increases gradually towards the dehydration front. Just across this front, in the Chl-harzburgite domain, all meta-rodingites are type 2. Type 3 meta-rodingite overgrew type 2 assemblages and consists of garnet (Grt4, 38-50 wt% almandine, 12-31% pyrope, 17-35% grossular), epidote, clinopyroxene, amphibole, chlorite, titanite and rutile. All meta-rodingite types underwent a retrograde partial amphibolitization, more pronounced in types 2 and 3. Meta-rodingite bodies are surrounded by a bimetasomatic reaction rim consisting, from the rodingite body to the enclosing ultramafic rock, of Chl-blackwall (chlorite+clinopyroxene+titanite), Chl-diopsidite (clinopyroxene+ chlorite) and Chl-Olivine-diopsidite (olivine+clinopyroxene,+chlorite± antigorite). In this study we present a phase relationships thermodynamic model for the rodingites metamorphic evolution. In type 1, Grt1 represents the relic low-grade rodingitic association ($T < 260^{\circ}\text{C}$, $P < 7$ Kbar). Grt2 and Grt3 grew sequentially during subduction-linked prograde metamorphism ($T < 630^{\circ}\text{C}$, $P = 7-16$ Kbar), just before their transformation to epidote-meta-rodingite and antigorite breakdown in the enclosing serpentinite. Metamorphic peak is marked by the maximum pyrope content (30 wt%) in Grt4 (type 3 meta-rodingite) at $\sim 670^{\circ}\text{C}$ and $P < 16$ Kbar. Oxygen fugacity variation was a crucial factor to stabilize the observed mineral assemblages and their chemistry both in meta-rodingites and ultramafic rocks. $\text{Log}f_{\text{O}_2}$ ranged from -45 to -38 in Grt1 stability conditions and increased progressively up to -13 to -10 during the formation of Grt2 and Grt3 and epidote-meta-rodingite. Chemical potentials gradients between meta-rodingites and ultramafic rocks also concur to explain the observed transformations. Diffusion was catalyzed by fluids released during the prograde dehydration breakdown of the enclosing Atg-serpentinite to Chl-harzburgite. Type 1 to type 2 transformation was the result of decreasing μ_{CaO} (< -703 kJ) and increasing μ_{SiO_2} (-857.5 to -852 kJ). Transformation of Type 2 to type 3 was also enhanced by a decrease in μ_{CaO} .