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Atoll garnet textures in eclogitic rocks of the Diego de Almagro Island, Chilean Patagonia: Genesis and tectono-metamorphic implications

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The evaluation of chemical zoning in garnet represents a critical step for thermobarometry and interpretation of the tectono-metamorphic evolution of garnet-bearing blueschists and eclogites, once garnet textures can record information on the subduction (prograde metamorphism) and exhumation processes (retrograde metamorphism). The recognition of atoll texture in garnet is a significant indication that the original garnet zoning may have been altered during the formation of the atolls. The study of atoll garnet by means of compositional maps enables the identification of features related to their development, such as fractures, dissolution channels and peninsulas, and the processes involved in the crystallization of the secondary garnet or of the atoll rings.

The garnets in atoll and non-atoll textures of the first described eclogitic rocks in the Diego de Almagro Island, Chilean Patagonia, were characterized by X-ray compositional maps and profiles, which were compared with compositional profiles in garnet of blueschist, in an attempt of understand the generation of atoll textures in the former rocks and correlate them with subduction and exhumation processes.

The generation of the atoll garnet was indeed related to a metamorphic fluid activity, as it is highlighted by the presence of veinlets, peninsulas, micro-channels and by the replacement of garnet I by garnet II, especially where there is concentration of micro-fractures, even whether the fractures are concentrated inside the garnet I grains. The percolation of metamorphic fluids along micro-fractures in garnet crystals caused dissolution and releasing of elements responsible for the growth of secondary garnet and hydrous minerals (amphibole, phengite and epidote). Fluids and micro-fractures aided diffusion processes, which are usually uncommon in such rocks.

The compositional profiles obtained for garnet from eclogitic rocks and blueschists are very similar and indicate that both rocks shared a common subduction history up to the exhumation of the blueschists. Thermobarometry pointed out high pressure values for the garnet-bearing blueschist, around 15 kbar and 480 ºC. Temperature obtained from quartz c-axis patterns is 600 $\pm$50 ºC, which represents the maximum temperature achieved during the deformation that preceded the blueschist exhumation. For the eclogitic rocks, an interesting metamorphic evolution between garnet I core, garnet I mantle, and garnet II was depicted, respectively at: 15 kbar and 450–500 ºC (core); 16.8 kbar and 457 °C (mantle); 15 kbar and 517 °C (mantle, with lower Ca and higher Mg); and 20.4–21.2 kbar and 530–615 °C (grossularitic garnet II), pointing out the eclogite facies field.

Both high-pressure rocks evidence a possible common progressive history inside the blueschist facies stability field, until the blueschists reach the baric peak and begin the relaxation stage, with increasing temperature ($\sim$600 ºC), before reaching the inversion point and the start of the uplift history. During this stage, the eclogitic rocks could have been partially exhumed and physical conditions for the penetration of external fluids were created as a consequence of thrust faults developed during the exhumation that resulted in the development of a mylonitic foliation. Fractures of garnet grains could be also generated during this partial decompression, along where, the dissolution of garnet I and secondary garnet growth preferentially occurred. The fluids involved in the chemical transformations may have originated from the coeval South Patagonian Batholith activity (120 to 70 Ma), responsible by the generation of magmatic fluids and metassomatism of the neighboring rocks, and also being a consequence of dehydration reactions during progressive metamorphism. The fluids became available for the formation of atolls before the metamorphic peak was reached at higher pressures and temperatures than those of the blueschists. In that point grossularitic garnet II formed at crystal rims, producing the unusual atoll textures.