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Amphibole zonation as a tool for tracing metamorphic histories: examples from Lavrion and Penteli metamorphic core complexes

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The amphiboles represent the predominant minerals in high pressure/low temperature metamafic rocks. Amphibole composition (e.g. cations Si, Al, Na) depends on the bulk composition, the solid solution‘s gaps and the P-T conditions during metamorphism. The Al^{IV}, Na_A and Ti increase with temperature, whereas Al^{VI} and Na_B with pressure (Triboulet, 1992). Increase of Si^{+4} and decrease of Al^{VI} and (Na_A+Na_B) in clinoamphibole is concurrent with pressure decrease. We focus on Na- and Ca-amphiboles from greenschists and blueschists from Lavrion (upper tectonic unit-UTU) and Penteli (lower tectonic unit-LTU) metamorphic complexes (Baziotis *et al.* 2009; Baziotis & Mposkos, 2011) in order to unravel the relation of zonation with: (1) the physicochemical conditions and (2) the P-T stages during metamorphic evolution.

Amphiboles in Lavrion metabasites are the dominant rock constituents: (ferro)-glaucophane in the blueschists and actinolite in the greenschists. Blue-amphiboles occur in various textural modes: parallel to the foliation, replacing omphacite, rimmed by Ca-amphibole, as inclusions in albite and epidote or in calcitic veinlets. The blue-amphibole composition varies from glaucophane to ferro-glaucophane with the Na_B ranging from 1.617 to 1.979 a.p.f.u., whereas the green-amphiboles are actinolites. In the blueschists, actinolite has higher R^{3+} at a given Na_B compared to the greenschists, attributed to Fe^{+3}-rich bulk composition of the blueschists. Three types of zoning were observed in these amphiboles: glaucophane rimming actinolite, glaucophane with increasing Al^{IV}, Al^{VI} and Na_B values towards the rim, and actinolite mantling glaucophane. The zoning patterns in the blue-amphiboles are characterized by increasing Tschermak and glaucophane components towards the rim, consistent with increasing temperature and pressure during prograde metamorphism. Two different modes of actinolite represent different stages of the metamorphic history. The actinolite inclusions formed during prograde evolution, whereas the actinolite overgrowths on glaucophane took place at post-peak conditions, during greenschist-facies overprinting. The actinolite overgrowths indicate retrogression at slightly higher temperature for a given pressure compared to the prograde path; such overgrowths started with the assemblage actinolite–glaucophane–epidote–albite, immediately at the post-peak pressure conditions with minor fluid ingress. In the greenschists, however, the extensive actinolite overgrowths on glaucophane took place in the typical greenschist-facies actinolite–chlorite–epidote–albite stability field, triggered by internal dehydration.

The metamorphic history of Penteli amphiboles is depicted by a prograde path with Al^{VI}/ Na_B increase and Al^{IV} decrease; this suggests the formation of glaucophane around actinolite during ongoing subduction. Glaucophane replacement by actinolitic hornblende and core-to-rim decrease of Al^{VI} both suggest temperature increase during decompression. A complex amphibole, with Fe-rich hornblende or actinolitic hornblende at the core, an intermediate Na–amphibole and outer rim of actinolitic or actinolitic hornblende, suggest with pressure-temperature decrease. A patchy glaucophane grown at the outer rim, suggests another cycle of pressure increase, perhaps during renewed subduction. This might be interpreted as a temporary recapturing of that rock fragment by the downgoing slab.

References

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