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Crystal size distribution (CSD) and textural evolution of accessory apatite, titanite and allanite during metamorphism, and geochronological consequences

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Accessory phases (ACPs) and rock-forming minerals (RFMs) in metamorphic and magmatic rocks represent end products, which result from a series of chemical and mechanical processes. Thus, the interpretation of their compositions and textures is difficult and commonly ambiguous. However, for many geochronological applications the following three questions are of great interest. (1) When was an ACP formed in respect to other ACPs or RFMs? (2) How was it formed? (3) What happens to it during the later tectono-metamorphic evolution(s)? Answers to these important questions can be given by the investigation of rocks in which several stages of the evolution of ACPs and RFMs are preserved. In this paper I present results from a garnet-epidote-biotite gneiss sample from the Moine Supergroup, Scotland. This rock gives detailed information about the evolution of crystal size distributions (CSD) and shapes of accessory apatite, titanite and allanite, enclosed in three texturally distinct garnet zones (Z1 to Z3) and in the matrix (Z4). Textures and CSDs indicate that the accessory minerals were in or near to a stage of nucleation and initial growth immediately prior to garnet Z1 overgrowth, and formed within less than 20000 years. Subsequently, the CSDs were modified by different growth mechanisms, as supported by several parameters including CSDs, grain numbers, grains sizes, specific volumes and others. Agreement between CSD modeling and observations indicate that the apatite CSD evolution from Z1 to Z4 is consistent with open system LPE (Law of Proportionate effects) growth accompanied and followed by supply controlled random (kinetic) ripening. In contrast, transformation of the original titanite CSD is more consistent with Ostwald ripening,

temporarily accompanied by positive or negative McCabe growth. The allanite CSDs also point to Ostwald ripening between Z3 and Z4. The textural observations indicate that the growth evolution of the ACPs was influenced by mineral reactions with surrounding rock forming minerals, as well as by deformation and matrix coarsening. The ripening processes, and ACP-RFM interactions caused an intensive isotope redistribution between the different garnet growth events, as reflected by different age data obtained by different geochronological methods for garnet zones Z1 (c. 820 Ma) and Z4 (c. 440 Ma).