Radiation damages in calcite and diopside crystals surrounding thorianite

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In most crustal rock-types, natural actinides (U and Th) are concentrated in accessory minerals. The auto-destruction of the hosting crystal network by U and Th α-decay is well documented, and may produce an amorphous structure named metamict state. But radioactive minerals also irradiate the surrounding minerals, creating concentric structure named "pleochroic halos" or "radiohaloes". We studied by TEM, SEM, and EMPA, radiohaloes formed around urano-thorianite (Th) from the Tranomaro granulitic skarns (SE-Madagascar). These rocks formed at ~570 My under high temperature conditions (850°C) and in presence of CO_2-rich fluids. The studied structure is made of a thorianite grain surrounded by both aluminous diopside (Cpx) and calcite (Cc_1). Optical microscope and SEM images revealed (1) the presence of radiating cracks around the thorianite probably due to swelling of the metamict thorianite, (2) a diffuse optical halo at Cc_1/Th interface, and (3) a wide "reaction zone" at Cpx/Th interface. SEM and EMPA show that the latter boundary is composed of "secondary calcite" (Cc_2) with a low temperature sheet silicate, probably smectite (φ). The structural state of Th, Cc and Cpx was investigated by TEM. The samples were prepared across the Th-Cc and Th-Cpx using FIB. Calcite is mostly crystalline: only a narrow 100 nm amorphous zone exists along the boundary. In contrast a large ~25µm "reaction zone" is present along the Cpx/Th interface. Nanostructures of Cpx (SiCaMgAlFe-phase) at this interface shows preferential dissolution along cleavage. The composition of phases within the reaction zone (Ca-phase + SiAlMgFe-phase) suggests that this zone formed by dissolution of Cpx, followed by recristallization of Cc_2 + φ. The presence of Th, U, and/or Pb inclusions within Cc_2, and φ, indicates that thorianite was also dissolved at this stage. Because the transformation of Cpx in this rock is limited to the Th-Cpx interface, we think that those structures are due to a higher solubility of metamict diopside around thorianite.