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Fir-Tree and Nebulously Zoned Zircons from Granulite Facies Rocks: Evidence for Zircon Growth and Interaction with Metamorphic Fluids

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The purpose of this contribution is to describe the internal structures, the U-Th chemistry and the relative ages of characteristic zircons from a number of high-grade metamorphic rocks and to address the question of whether these zircons structures can be attributed to growth during melt generation or possibly to "solid state" growth catalysed by fluid activity during the metamorphism. The rock types considered range from mafic granulites, where there is no evidence of melt segregations, to a felsic gneiss with melt patches and melt veins. These rocks contain zircons with characteristic zoning structures and ages attributable to the formation of the parent rock. In addition they contain secondary zircons with distinctive fir-tree (see cathodoluminescence image) sector and curvilinear zoned structures (Vavra et al., 1996) as rims and reaction areas around primary zircon and as individual crystals with no evidence of older zircon cores. In some examples water-clear fir-tree zoned zircons are accompanied by zircons composed of domains with relatively uniform cathodoluminescence and generally sharp, curved interfaces with surrounding domains, which we refer to as nebulous zoning. Nebulously zoned domains can compose the whole grain or form overgrowths around primary zircon cores. These secondary zircon domains have distinctive U and Th contents and younger ages, that distinguish them from the primary zircon. The occurrence of zircons with these structures and chemistry may be explained as crystallisation from melt segregations in the felsic gneisses but this is more difficult as an explanation for zircons from mafic granulites, which have no obvious melt phase. In these rocks the structures can be explained as a series of overgrowths and resorptions controlled by variations in the composition of metamorphic fluids. Keppler and Wyllie (1990) demonstrate the importance of concentrations of F, CO_2 and Cl in controlling the solubility of U and Th in magmatic fluids. Fluctuations in the concentration of these elements in fluids active during metamorphism could equally influence the U and Th contents of metamorphic zircons and zircon overgrowths. The presence of bright CL rims, depleted in U compared with Th, on rounded, nebulously zoned zircons from the granulite facies Pium enderbite (from Brazil) can be explained as a result of leaching of trace elements from the crystal margins by surrounding fluids rich in chloride and/or CO_2 (Keppler and Wyllie, 1990). Low U and Th, fir-tree zoned zircon overgrowths and single zircons from a mafic granulite from southwestern Australia can also be explained by solid state zircon growth in the presence of fluids containing a low concentration of fluorine. Secondary zones with a range of Th-U signatures are less easily interpreted, but probably reflect changing compositions and physical conditions of the metamorphic fluids.

Vavra G, Gebauer D, Schmidt R, & Compston W, *Contrib Mineral Petrol*, **122**, 337-358, (1996).
Keppler H & Wyllie PJ, *Nature*, **348**, 532-533, (1990).

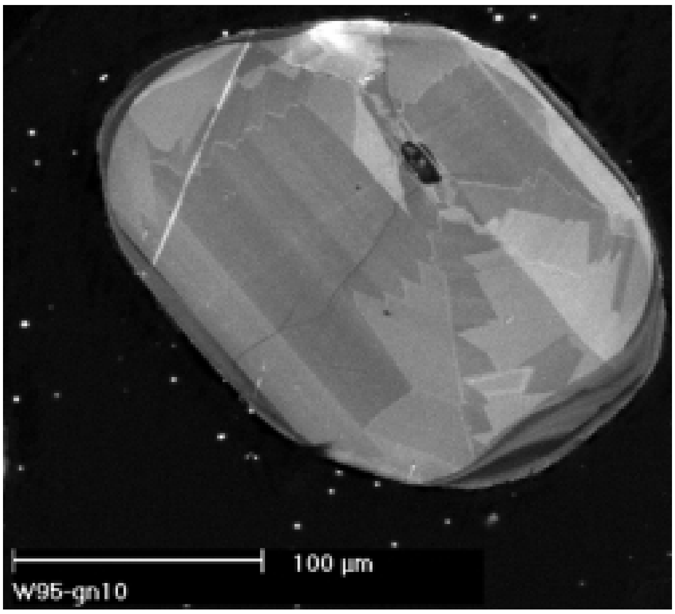

Figure 1: Zircon showing fir-tree zoning