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The fall and rise of metamorphic zircon

Matthew J. Kohn[1,*], Stacey L. Corrie[1] and Christopher Markley[1]

[1]Department of Geosciences, Boise State University, Boise, Idaho 83725, U.S.A.

Abstract

Zircon geochronology and geochemistry are increasingly important for understanding metamorphic processes, particularly at extreme conditions, but drivers of zircon dissolution and regrowth are poorly understood. Here, we model Zr mass balance to identify *P*-*T* regions where zircon should dissolve or grow. Zirconium contents of major metamorphic minerals were assessed from published data and new measurements, and models were constructed of mineralogical development and zircon abundance for hydrous MORB and metapelitic compositions along representative *P*-*T* paths. Excluding zircon, the minerals rutile, garnet, and hornblende strongly influence Zr mass balance in metabasites, accounting for as much as 40% of the whole-rock Zr budget. Clinopyroxene and garnet contain more Zr than plagioclase, so breakdown of plagioclase at the amphibolite to eclogite facies transition, should cause zircon to dissolve slightly, rather than grow. Growth of UHP zircon is predicted over a restricted region, and most zircon grows subsequently at much lower pressure. In metapelites, zircon is predicted to undergo only minor changes to modal abundance in solid state assemblages. Partial melting, however, drives massive zircon dissolution, whereas melt crystallization regrows zircon. From a mass-balance perspective, zircon growth cannot be attributed a priori to the prograde amphibolite-eclogite transition, to UHP metamorphism, or to partial melting. Instead, zircon should grow mainly during late-stage exhumation and cooling, particularly during oxide transitions from rutile to ilmenite and melt crystallization. As predicted, most zircons from HP/UHP eclogites of the Western Gneiss Region and Papua New Guinea substantially postdate eclogite formation and maximum pressures.

Keywords: Trace elements and REE, Zr, zircon, metamorphic petrology, UHP, metabasite, geochronology