# Zircon recycling in felsic magmas

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The ubiquity of zircon and its utility for radiometric dating make it a primary tool for obtaining age information from metaluminous to weakly peraluminous felsic igneous rocks, which comprise most of Earth's felsic plutonism and nearly all compositionally equivalent continental volcanism. At anatectic conditions for felsic metaluminous magmas (e.g. biotite and amphibole dehydration), the magmas are likely undersaturated (or perhaps barely saturated) in zircon when they leave their sources. Thus the $10^3$ to several $10^5$ yr age spread often observed in geochronological studies of metaluminous volcanic and plutonic systems is commonly attributed to mixing of magmatic zircons that grew at different times within a focused zone of intrusion. The ability to now link zircon ages (single crystal TIMS or *in situ* methods), with geochemical variations (e.g. REE patterns), textures (CL imaging), temperature variations (Ti-in-zircon), and isotopic variations ($\delta^{18}O$, $^{176}Hf/^{177}Hf$) in zircons within one magmatic system, promises a much more detailed picture of zircon recycling. Using some of these different data sets, our studies so far show that within a single sample, zircons have either strongly contrasting thermal histories and distinct chemical and isotopic signatures, or in marked contrast show remarkably limited variation even when ages vary by several $10^5$ yr. Where zircons from plutonic and volcanic rocks from the same magmatic system can be compared, plutonic zircons show greater temperature and chemical variation than their volcanic counterparts; textural and chemical evidence for resorption and thermal rejuvenation is observed in both. Our ongoing studies within different magmatic systems are aimed at integrating these complementary data sets to discern if recycling involves: (a) rapid unification of isolated intrusions of varying age in large but ephemeral, melt-rich magma reservoirs; or (b) protracted growth in large but persistent, perhaps mushy, eutectic magma chambers; or (c) assimilation of intrusive precursors (plexus of dikes, pods, and sills) as magmas traverse upward.

# Chemical modification of oceanic lithosphere by hotspot magmatism: Seismic evidence from subduction of the Ninetyeast Ridge along the Sumatra-Andaman arc

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Tomogramphic images of the upper mantle, which represent perturbations in P-wave, shear wavespeed, and bulk-sound speed, illustrate the Indo-Australian plate subducting beneath the Eurasian plate along the Sumatra-Andaman arc. The detailed images of the subducting slab are well constrained by the large number of intermediate depth earthquakes and moderate seismic station coverage along the entire Indonesian-Sumatra-Andaman arc. The coherent, steeply dipping slab is defined by Benioff zone seismicity and high seismic velocity perturbations, beneath the entire arc, but at approximately 9.5-12.5°N and at a depth of 60-160 km, the slab is characterized by low P-wave perturbations, yet with only a small decrease in the S-wave speed, and a modest decrease in bulk sound speed. At this position along the arc the inactive Ninetyeast Ridge, suggested to be a plume-fed spreading ridge, is being subducted beneath the arc. The negative P-wave and bulk sound speed anomalies in the slab, along with only a small decrease in S-wave speed perturbations cannot be explained by thermal variations alone, therefore it suggests this is a result of change in composition. We find that the seismic anomalies in this region of the subducting Indo-Australian plate are best fit by orthopyroxene-rich zones within the peridotitic lithospheric mantle. We speculate that these pyroxene-rich lithologies formed by the interaction of upwelling magmas beneath the Ninetyeast Ridge with pre-existing oceanic lithospheric mantle before subduction occurred. Our observations represent one of the first seismic evidences for extensive chemical modification of lithospheric mantle.