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Late Pleistocene Zircons from Cascades Arc Volcanoes Dated by U-Th Analysis with Shrimp RG

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Granitoid rocks occur as lithic clasts in pyroclastic deposits and as xenoliths in lava flows at Mount Mazama (Crater Lake) and Medicine Lake volcanoes in the Cascades arc of western North America. Mount Mazama is a basaltic andesite to rhyodacite stratovolcano and silicic dome complex active throughout the last 400 k.y. Crater Lake caldera formed in Mount Mazama during its climactic eruption of ~50 km^3 of mostly rhyodacitic magma 7700 yr ago (6845±50 ^{14}C yr BP). The Medicine Lake volcano is a basaltic to rhyolitic shield volcano behind the axis of the Cascades arc and active during the last ~500 k.y. The ages and sources of the medium- to fine-grained intrusive rock fragments at both volcanoes have been controversial. We have resolved these issues by measuring U, Th, and Pb isotope ratios in zircons from a variety of granitoid samples with the SHRIMP RG (Sensitive High Resolution Ion Micro Probe - Reverse Geometry) jointly operated by the USGS and Stanford University. No zircons with crystallization ages older than Pleistocene were identified by U-Pb analysis and no evidence was seen in cathodoluminescence (CL) images for anomalous cores or non-igneous textures. Therefore, the granitoid samples are broadly coeval with local Quaternary volcanics. Because the U-series results are the more precise, we restrict the remainder of this report to them.

The samples from Crater Lake are two unmelted porphyritic granodiorite blocks ejected during the climactic, caldera-forming eruption. Petrologic and isotopic data for these and similar rocks containing from 0 to 50% partial melt indicate that the granodiorite body formed the walls of the climactic magma chamber at a depth of ~5 km. SHRIMP RG U-Th analyses of zircon crystals and crystal fragments (70-150 μm) from the two unmelted samples yield a $^{230}Th/^{238}U$ isochron age of 112±24 ka (95% confidence level, MSWD = 1.1). The age implies that the granodiorite is related to lavas of Mount Mazama and not to the (younger) climactic magma chamber.

The samples from Medicine Lake volcano are four incipiently melted to unmelted, diorite and granite xenoliths from two silicic lava flows, Medicine Dacite (~2000 yr old) and Crater Glass Flow (1065±90 ^{14}C yr BP). The intrusive sources of these xenoliths must underlie the (drilled) modern geothermal system at >3km depth. Multiple spots on individual crystals yield internal single grain isochrons, indicating relatively rapid crystallization and initial $(^{230}Th)/(^{232}Th)$ activity ratios of 1.12 ±0.57. Within one granitic xenolith, single grain zircon $^{230}Th/^{238}U$ isochrons range from 131±19 ka to 8±30 ka. Model ages for single-spot analyses from the xenoliths range between these two ages and clearly pre-date the eruption ages. Although CL images reveal complexity, zircons are not zoned with respect to age, indicating that they did not re-equilibrate with a melt after they crystallized. We infer that from ~130 ka to ~10 ka, a time of dominantly basaltic to andesitic volcanism at Medicine Lake volcano, intrusive bodies underwent multiple partial melting and crystallization events, presumably caused by repeated intrusion of mafic magmas.