

## Titanite U-Pb geochronology and trace element analytical methods using Stanford-USGS SHRIMP-RG

Titanite grains were separated from crushed and ground samples using standard magnetic and heavy liquid techniques, hand-picked under a binocular microscope, and mounted in epoxy discs. Titanite mounts were ground to expose grain interiors, polished, and imaged using back-scattered electron (BSE) imaging on a JEOL 5600 SEM to identify internal structure (rims, core, etc.). Titanite U-Pb ages were obtained with the Stanford-U.S. Geological Survey (USGS) Sensitive High Resolution Ion Microprobe with Reverse-Geometry (SHRIMP-RG) at Stanford University. Samples were analyzed in 1 analytical session in 2014. The SHRIMP-RG was operated with an O<sub>2</sub><sup>-</sup> primary ion beam with a typical spot diameter of 20-25 micrometers. Mineral surfaces were rastered by the primary beam for 120-180 seconds before data were collected. For all samples, the following peaks were measured sequentially: 89Y<sup>+</sup>, 90Zr<sup>+</sup>, 91Zr<sup>+</sup>, 93Nb<sup>+</sup>, 139La<sup>+</sup>, 140Ce<sup>+</sup>, 141Pr<sup>+</sup>, 146Nd<sup>+</sup>, 147Sm<sup>+</sup>, 153Eu<sup>+</sup>, 157Gd<sup>16</sup>O<sup>+</sup>, 163Dy<sup>16</sup>O<sup>+</sup>, 172Yb<sup>16</sup>O<sup>+</sup>, 40Ca<sup>48</sup>Ca<sup>48</sup>Ti<sup>216</sup>O<sup>+</sup>, 204Pb<sup>+</sup>, a background measured at 0.045 mass units above the 204Pb<sup>+</sup> peak, 206Pb<sup>+</sup>, 207Pb<sup>+</sup>, 208Pb<sup>+</sup>, 232Th<sup>+</sup>, 238U<sup>+</sup>, 232Th<sup>16</sup>O<sup>+</sup>, 238U<sup>+</sup>, 238U<sup>16</sup>O<sup>2+</sup>, 232Th<sup>16</sup>O<sup>2+</sup>, and 238U<sup>16</sup>O<sup>2+</sup>. Mounts were analyzed with 5 scans (peak-hopping cycles in mass order) and measurements were made at mass resolutions of M/ $\Delta$ M = 7500-8500 (10% peak height). Raw data were reduced using Squid2 2.51 software (Ludwig, 2009), with corrections for background and collector deadtime. Measured 206Pb/238U was corrected using a standard Pb<sup>+</sup>/U<sup>+</sup> versus UO<sup>+</sup>/U<sup>+</sup> calibration for sputtering bias (Williams, 1997). Radiogenic U-Pb ratios were derived after correction for common Pb using a 207Pb correction scheme (Williams, 1997), or from measured 204Pb with model common Pb compositions from Stacey and Kramers (1975). 238U/235U was assumed to be 137.82 (Heiss et al. 2012). Concentration data for U, Th and all of the measured trace elements were standardized against the titanite standard BLR (Mazdab, 2009), which had standard deviations (2 sigma) of about  $\pm 3\%$  for Hf,  $\pm 5\text{--}10\%$  for Y and the heavy rare earth elements (HREE),  $\pm 10\text{--}15\%$  for the light rare earth elements (LREE), and up to  $\pm 40\%$  for La. U-Pb ages were also calculated relative to the BLR titanite standard (1097 Ma; Aleinikoff et al., 2007). Data were reduced using methods described by Williams (1997) and Ireland and Williams (2003), using Excel and the add-in programs Isoplot3 and Squid 2.51 (Ludwig 2003, 2009).

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