Age mapping of young monazite and zircon

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The age mapping technique through electron microprobe analyses has an ability to highlight the geometry and distribution of age domains at micrometer scale within a single mineral grain. Most age mapping techniques are applied to Proterozoic or older monazite that contains sufficient amounts of Pb (>2000 ppm) and shows difference in age on the order of 100 Ma or more. This describes a mapping protocol for young monazite and zircon.

From the intrinsic response of the JCXA-733 detector, a dwell time of 0.5 to 1 second may be sufficient for monazites with 1.0 wt. % PbO under a 15 keV and 150 nA condition. However, the dwell time for young monazites with 300-600 ppm PbO ranges 50 to 100 seconds to get a reasonable level of counts. Further, for age mapping of young monazite, we cannot apply a single background value determined previously, because background intensity is strongly influenced by composition. The background maps for individual spectrometers are indispensable. The time to measure peak and background intensities on a map with 200x200 pixels exceeds 1000 hrs. We use 3 spectrometers for the Pb measurement with a beam current of around 1000 nA. The rest spectrometer is used for acquiring a background map. Backgrounds for individual line positions of every spectrometer are calculated from the map through the intensity relationships determined in advance of the measurement. Normally, the ThMα, UMβ and YLα intensities are measured prior to the PbMα and background acquisitions with a probe current of 200 to 500 nA. By using two spectrometers for UMβ measurement, we adopt a dwell time of 3 s for the measurement of ThMα, UMβ and YLα. We further shorten the measurement time by skipping the area outside the desired mineral. Usually, the time needed for 200x200 pixels mapping is shorter than 60 h.

The raw intensity data are first corrected for background and interference and converted into concentration in the same way as the spot by spot analysis. Apparent ages of individual spots are calculated by assuming no initial Pb:

Total Pb = Pb$_{initial}$ + Th $\{\exp(\lambda_{232}t)-1\}$ + U $[\{\exp(\lambda_{235}t) + 137.88 \exp(\lambda_{238}t)\} / 138.88 - 1]$

These calculations were performed on NEC PC-98 using the N88-BASIC(86) programming environment. Compositional and age maps were constructed using an "EPMACOLORMAP" program on the WINDOWS environment.

Digital mapping requires measurement at extraordinarily high probe current, which sometimes causes severe damage on mineral surface and carbon coating at and around metamict portions, cleavages, and cracks. This damage makes the surface of the grain unsuitable for precise determination of the Th, U, and Pb contents. Spot analyses coupled with examination of polished thin sections under the optical microscope are preferable before the digital mapping for assessing chronological heterogeneity.