CHIME dating and age mapping of monazite and zircon by using an electron probe microanalyzer

Kazuhiro Suzuki[1]

[1] Nagoya University Center for Chronological Research

CHIME dating (Suzuki et al., 1991: Suzuki and Adachi, 1991) is a method for micron-scale dating of monazite, zircon and other Th- and U-bearing minerals on the basis of the EPMA analyses. It consists in measuring many spots within constant age domains showing sufficient compositional variation, and in constructing an isochron from which an age can be obtained by regression.

The EPMA is normally operated at 15 kV accelerating voltage, 150-200 nA probe current and defocused 3-6 micron probe diameter. ThMa, UMb, PbMa (PbMb) and YLa? lines are measured simultaneously with PET crystals and sealed Xe X-ray detectors. CaKa, SKa, PKa?? SiKa, KKa, (ZrLa) and NbLa lines are also measured. For the analyses of Th, U, Pb and Y, X-ray intensity is integrated over 400s period for the line peak position and over 200s period for two optimum background positions. To ensure that possible changes of the sample surface had only a minimal effect on the results, the measurement of peak and background positions are repeated five times for each analysis. For the analyses of other elements, X-ray intensities are integrated over 40s on each line peak position and 20s on two background positions. The background value for each line is estimated by either exponential fitting or linear interpolation of two readings. The standards are euxenite provided by Smellie et al. (1978) for Th, U and Nb, synthesized glass provided by Suzuki and Adachi (1998) for Pb, Si and Ca, synthesized Y-glass (Y_2O_3= 10 wt% and K_2O = 2 wt%) for Y and K, barite for S, zircon for Zr, and xenotime for P. The correction factors for the Th, U, Y and Nb interferences are estimated by using a high Th monazite with little U, a high U xenotime with little Th, the synthesized Y-glass and an inhomogeneous columbite, respectively. The X-ray intensity data are converted into concentrations through the Bence and Albee method using analyses of natural monazite as the matrix composition. The small difference in the matrix between analyzed and reference monazite has little effect on the PbO, UO_2 and ThO_2 determinations. The detection limits at a 2s confidence level are 0.006, 0.011 and 0.009 wt. % for PbO, UO_2 and ThO_2, respectively. Relative errors are about 10% for 0.03 wt.% PbO, 2% for 0.6 wt.% UO_2 and 0.5% for 7.0 wt.% ThO_2. Datasets for age calculation are screened with chemical criteria such as K2O concentration (below 0.05 wt. %) and (Ca+Si)/(Th+U+Pb+S) ratio (0.95-1.05) for monazite and Ca and S concentrations (below 0.01 and 0.005 wt. %, respectively) for zircon. The construction of isochron has the potential advantage of significant precision and the ability to work with minerals having substantial initial Pb. This can identify two or more homogeneous domains that are separated by an age gap smaller than the error on individual spot analyses of age.

The age mapping technique through EPMA analyses has an ability to highlight the geometry and distribution of age domains at micrometer scale within a single mineral grain. From the intrinsic response of the WDS, 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. For young monazite and zircon, the age-mapping procedure includes acquiring PbMa (or PbMb) intensity of individual pixels with multiple spectrometers under a probe current as high as 800 nA and correcting background with background map computed from a measured background intensity through the intensity relationships determined in advance of the measurement. This technique provides age maps showing difference in age domains on the order of 20 Ma within monazite as young as 100 Ma. Consideration of sample damage by irradiation of intense probe is briefly shown.