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Carboniferous inherited grain and age zoning of monazite and xenotime from leucogranites in far-eastern Nepal: Constraints from electron probe microanalysis

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ANALYTICAL METHODS

A JEOL JXCXA-733 EPMA used for the CHIME dating at Nagoya University equips with 4 wavelength-dispersive spectrometers (WDS) with radius of Rowland circle = 140 mm. The individual WDS equips a PET (002 pentaerythritol) diffraction crystal and sealed Xe X-ray detector. To minimize Bragg angle defocusing, 0.3mm X-ray collimator slits are placed between the diffraction crystal and the detector.

Operating conditions for compositional mappings were 15 kV accelerating voltage, and 30-100 nA for garnet and 200-300 nA probe currents for monazite and xenotime. For X-ray mapping of garnet, Mn, Ca, Mg, and Fe intensities were measured simultaneously with a 4 μ m probe diameter. The pixel step was 3 μ m and the dwell time was 3 s per pixel. For X-ray mappings of monazite and xenotime, ThM α, UM β, YL α, and CaK α intensities were measured simultaneously with a 3 μ m probe diameter. The pixel step was 3 μ m and the dwell time was 10 s per pixel.

Analytical conditions for the CHIME monazite and xenotime dating were 15 kV accelerating voltage, 150 nA probe current, and 5 μ m probe diameter. ThMα, UMβ, PbMα, and YLα lines were simultaneously measured with PET crystals and sealed Xe X-ray detectors. CaKα, SKα, KKα, SiKα, NbLβ1, and PKα lines were also measured to make interference corrections and evaluate whether the monazite composition reflects a closed system; no other elements were analyzed. The following standards were used to analyze; euxenite for Th, U, and Nb (Smellie et al., 1978), synthesized glass for Pb, Si, and C (Suzuki and Adachi, 1998), synthesized Y-glass (Y_2O_3= 10 wt. % and K_2O= 2 wt. %) for Y and K, barite for S, xenotime for P, and synthetic REE glasses for rare earth elements (Drake and Weill, 1972). The X-ray intensities for each peak and each background were integrated over 800-3200 s and over 400-1600 s respectively for Th, U, Pb, and Y. The analyses were accomplished by cyclic stepping of spectrometers five times on individual positions to ensure that changes to the sample surface caused by beam-irradiation had a minimal impact on the results. The background value for each individual peak was estimated by exponential fitting of the background readings above and below the peak to account for the curvature of the X-ray spectrum (Jercinovic et al. 2008). The spectral interferences of YLγ, ThMζ, NbLb2,15 and NdLβ3 lines on PbMα,

UMζ and NbLγ lines on PbMβ, and ThMγ line on UMβwere corrected. Normally, monazite and xenotime contain hardly detectable Nb. We have checked it for confirmation because Nb interferes in PbMα and PbMβ. After correction of background, the X-ray intensity data are calibrated with the intensity data of standards. The relative intensities are converted into concentrations through the Bence and Albee (1968) method using an α-factor table calculated by Kato (2005) from the full PAP correction and compositions of natural monazite and xenotime as references. The small difference in the matrix between the reference and analyzed spot has little effect on the ThO_2, UO_2, and PbO determinations. The maximum error in this calculation is less than the uncertainty in the X-ray counting, and is estimated to be 0.5% (Suzuki 2005).

Isotopic disturbance of the Th-U-Pb system of monazite potentially results in Pb loss and/or contamination of damaged or metamict domains. Although EPMA dating does not provide information on isotopic discordance, compositional criteria such as (Ca+Si)/(Th+U+Pb+S) and K_2O content on the basis of crystal chemistry are used to identify possibly disconcordant analyses from damaged or metamict domains (Suzuki and Kato 2008). The apparent age for single spot is determined by assuming that the initial PbO in monazite is zero, whereas the isochron age obtained via regression confirms that (i) the initial PbO is exactly zero by the intercepting of the origin, and (ii) the initial PbO in different monazite grains is almost similar (Suzuki and Kato 2008). Error on the isochron age was determined by the best-fitting regression line of York (1966), taking account of uncertainties in the individual spot analyses.

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