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Evaluating matrix effects for Critical Rare Earth Element bearing minerals: implications for LA-ICP-MS U-Pb and Th-Pb bastnäsite geochronology

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Determining timing of Critical Rare Earth Element (CREE) mineralization is necessary for accurate assessment of CREE potential of prospective mineral deposits and modeling CREE-bearing mineral systems. Lack of suitable matrix-matched reference materials is a major obstacle of LA-ICP-MS U-Th-Pb geochronology of CREE-bearing phases (e.g. bastnäsite, and to a lesser extent monazite and xenotime). In this study we evaluate matrix effects of U-Th-Pb LA-ICP-MS age determinations for bastnäsite [$(Ce,La,Nd,Y)CO_3F$] samples of known age (30–520 Ma) using 91500 zircon and bastnäsite K9 as external calibration materials. Analyses were made in two different laboratories to systematically assess the accuracy of both U-Pb and Th-Pb ages for 4 different bastnäsite minerals of known age (K9, LZ1384, MAD38, TPZ). Analyses at Texas Tech were made using a Nu AttoM ICP-MS coupled to a NWR 193 TV3 excimer laser system. Analyses at the USGS La-TRACE facility were done with an Agilent 8900 ICP-MS/MS and a RESOlution-SE excimer laser system. Additional matrices (NIST 612/610, titanite, calcite, and monazite) were also analyzed during each analytical session for additional comparison. Single-spot laser ablation parameters varied from session to session in each lab. Laser fluence varied from 2–4 J/cm^2, laser repetition rate from 5–10 Hz, and laser spot size from 20–50 µm. Using zircon 91500 as the external calibration material, Tera-Wasserburg U-Pb ages for the 4 bastnäsite samples analyzed were all biased 1-13% high. The weighted mean Th-Pb ages using zircon 91500 as the calibration material were all biased low from 1 – 29% analyses for all bastnäsite samples analyzed. Using a matrix-matched bastnäsite (K9) as the external calibration material, the Tera-Wasserburg U-Pb ages analyses are within 20% of the preferred ages. We interpret this variability due to large fractions of common ^{207}Pb and ^{206}Pb. The weighted mean Th-Pb ages for all bastnäsite sample analyzed, using bastnäsite K9 as the external calibration material, are accurate within 5% of the known age. The results of these experiments demonstrate the potential of LA-ICP-MS Th-Pb geochronology for determining the age of CREE-bearing minerals and the need for future Th-Pb characterization of these minerals for use as matrix-matched calibration materials.