Deciphering the evolution of continental crust: Insights through Laser Ablation Split-Stream (LASS) petrochronology

ANDREW R.C. KYLANDER-CLARK*
AND BRADLEY R HACKER

University of California, Santa Barbara, 93106-9630
(*correspondence: kylander@geol.ucsb.edu)

One of the biggest challenges in the determination of the timing and rates of continental subduction is tying the age of a particular mineral to the conditions (i.e. pressure, temperature, fluid composition) at which that phase grew. Recent advances in microbeam techniques have greatly increased our understanding of crustal evolution by enabling this linkage. The most common target for U-Th-Pb petrochonology is zircon: its REE pattern reveals the coexistence of garnet (depleted HREE) and plagioclase (positive Eu/Eu*) and cathodoluminescence imaging can be used to link the ages and trace-element concentrations of spot analyses. The age of monazite can also be linked to certain conditions: most commonly, yttrium zoning is used a proxy for growth in the presence or absence of garnet.

Here we present a more accurate, comprehensive, and simplified procedure to obtain petrochronologic data and thus assess the P–T–t conditions of any individual spot analysis. The LASS—laser ablation split-stream—technique consists of concurrent analyses of single laser ablation spots on both a multi-collector (U-Th-Pb age) and single-collector (trace-element data) ICP-MS. LASS allows both rapid (<1 minute/spot analysis) and high-precision (<1%/age population) measurements and an unambiguous link between mineral age and (re)crystallization conditions.

The Western Gneiss Region of western Norway provides the perfect natural laboratory to exemplify the advantages of LASS petrochronology. Zircons from a garnet-bearing gneisses show >20 Myr of (re)crystallization, however, REE data show that these zircons grew under three distinct conditions: 1) garnet-poor prograde growth at 425.8 ± 4.6 Ma, 2) garnet-rich peak growth at 406.9 ± 5.7 Ma, and 3) garnet-breakdown retrograde growth at ~400 Ma. Without LASS, making this distinction would be nearly impossible. Monazite can also reveal complex age/element zoning; monazite analyzed from a meta-pelite yield high-Nd cores of 413.6 ± 3.9 Ma, Low-Nd mantles of 401.1 ± 4.4 Ma, and high-Y, low-Sr rims of 393.5 ± 3.4 Ma.

REE mineralization of high grade REE-Ba-Sr and REE-Mo deposits in Mongolia and China

J. KYNICKY[1]*, XU. CHENG[2], A.R. CHAKHMOURADIAN[3], E. REGUIR[3], H. CIHLÁŘOVÁ[1] AND M. BRTNICKÝ[1]

[1]Mendel University in Brno, 613 00 Brno, Czech Republic
(*correspondence: jindrich.kynicky@mendelu.cz)
[2]Peking University, Beijing 100871, China
(*correspondence: xucheng1999@hotmail.com)
[3]University of Manitoba, Winnipeg, Manitoba, Canada
(*correspondence: chakhmou@cc.umanitoba.ca)

The exact causes and mechanisms responsible for the uniquely high levels of REE in carbonatites relative to any other igneous rock remain debated. To investigate these mechanisms, a large suite of REE-bearing carbonatites from Mongolia (Mushgai Khudag, Lugiin Gol, Omnot Olgii, Khurimt Khad Tolgod) and China (Daluxiang, Maoniuping, Huanglongpu, Huayangchuan, Bayan Obo) was examined.

All carbonatites are predominantly composed of medium- to coarse-grained calcite (60-90%). Accessory non-carbonate phases include mainly apatite, alkali feldspars, fluorite, phlogopite, sulphates and sulphides. The principal REE hosts are fluorocarbonates (<20 vol. %) and monazite (<5 vol. %).

Fluorocarbonates occur as complex intergrowths of bastnäsite with parasite or synchysite. Bastnäsite-(Ce), synchysite- (Ce) and monazite-(Ce) also rarely occur as discrete crystals. There is a structurally controlled compositional variation among the major REE minerals, but carbonatites from different deposits feature almost identical REE-HFSE mineralization patterns.

Chondrite-normalized whole-rock REE profiles exhibit a steep negative slope and lack detectable anomalies. The REE minerals show consistent enrichment in light REE [$(La/Nd)_n$=1.0–3.4]. In this respect, the carbonatite-hosted REE mineralization differs from that in the world's largest REE deposit at Bayan Obo, where the $(La/Nd)_n$ ratios are more variable and generally lower. The REE distribution patterns of individual REE minerals are similar, with the exception of Huanglongpu and Huayangchuan, where REE mineralization is associated with Mo and Mo-Th mineralization. At these two localities, whole-rock and mineral-specific REE patterns are broadly similar, but the latter show some enrichment in heavy REE.

We propose a similar mineralogical model for all investigated deposits with the exception of Bayan Obo. The high-grade carbonate-hosted REE deposits at Daluxiang and Maoniuping are nearly exhausted, but the little-explored Huanglongpu-Huayangchuan cluster has a definite potential as a viable REE resource of the future. Small- to medium-sized deposits in southern Mongolia may also have some economic value owing to their overall high grade (7-15 wt. % REE_2O_3) and a healthy global REE market.