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Micron-resolution trace element imaging analysis utilising multiple-spot femtosecond laser ablation-ICP-mass spectrometry

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Elemental imaging analysis can provide key information to understanding of mineral formation processes. The imaging data is also important to define analysis spots for *in situ* age determinations. For elemental imaging analysis, laser ablation-ICP-mass spectrometry (LA-ICP-MS) is widely used as a rapid and sensitive technique[e.g., 1]. However, since the typical size of mineral samples is several tens of micrometres, the spatial resolution is sometime not enough small to derive detailed chronological information. To overcome this, two major challenges must be considered. First is the development of high-magnification laser optics for laser ablation with smaller pit sizes. Second is the higher sensitivity of the LA-ICP-MS system to measure trace elements.

Faced with these challenges, a micron-resolution multiple-spot femtosecond LA system with a Galvanometric optics is utilised in this study. Femtosecond LA enables to improve data quality of elemental analysis with enhanced sensitivity and reduced elemental fractionation[2]. The laser spot size is narrowed using a short-focal-length objective lens, and scanning of a laser spot during imaging analysis is conducted by the Galvanometric optics. The Galvanometric optics has two rotating mirrors, and, by changing the angle of two mirrors, ablation spots are moving on sample surfaces[3]. This mechanism of raster scanning eliminates a potential danger of laser defocusing due to stage movements. For the detection of trace elements, the sensitivity is enhanced by a dry sampling cone[4] attached to the vacuum interface of the quadrupole-based ICP-MS system. The resulting ion transmission through the ICP-MS system is about 0.1%, which is three-times higher than before.

Owing to these improvements, trace elements of more than 10 $\mu g\ g^{-1}$ in zircon can be measured from line scan analysis with the spot size of 2 μm and the raster speed of 1 $\mu m\ s^{-1}$. Then, the present technique is applied to elemental imaging analysis of zircon, and the improved spatial resolution to distinguish the micron-scale internal chemical zonation is demonstrated.

References

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