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Quantitative multi-element imaging of geological materials by femto-second LA-ICP-MS

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Elemental mapping analysis of geological materials using X-ray related methods (EPMA, XRF) or SIMS suffers from insufficient sensitivity and poor quantification. LA-ICP-MS has advantages of high sensitivity and less matrix effect, therefore has been developed for elemental and isotopic imaging analyses over the last decade. However, quantification problem by this method remains unsolved because of the lack of a suitable sampling volume correction method and necessity of matrix-matched standard. This work presents multi-element imaging/mapping analysis of orthopyroxene and plagioclase minerals by femto-second LA-ICP-MS using a novel normalization process. Laser sampling volume is corrected for by analyzing ten major elements (SiO2, TiO2, Al2O3, FeO, MnO, MgO, CaO, Na2O, K2O, and P2O5) followed by normalization of the analyzed total sum to 100 wt% to obtain correction factor. This correction method is free from any external analysis (e.g., EPMA) for at least one internal standard element (e.g. Ca), and can be applied for both spot and line scanning LA mode. This allows LA-ICP-MS method standalone and liberates from errors inherited from any local heterogeneity of the samples picked up differently by the different analytical techniques used. Use of USGS basalt glass as a standard eliminates matrix effect in the levels less than 10% RD for these silicate minerals. Two-dimensional elemental distribution images of 43 elements were acquired from 4-6 μm depth of the sample surface with a ˜40 μm lateral resolution. An area of 500$\times$500 μm can be scanned simultaneously for 43 elements in less than 2.3 hours. Trace elements in silicate minerals can be imaged at sub-ppm concentration level, while major elements were mapped at sub-percent concentration.

Key words: femto-second LA-ICP-MS, elemental mapping, minerals