Evaluation of major to ultra trace element bulk rock chemical analysis of nanoparticulate pressed powder pellets by LA-ICP-MS

D. PETERS AND T. PETTKE
Institute of Geological Sciences, University of Bern, Baltzerstrasse 1+3, 3012 Bern, Switzerland
(correspondence: daniel.peters@geo.unibe.ch, pettke@geo.unibe.ch)

Introduction
We present [1] a method combining the advantages of nanoparticulate pressed powder pellets (PPP) [2] and the addition of a mechanical and laser light absorbing binder [3] to achieve precise and accurate major to trace element analysis of bulk rock samples via 193 nm LA-ICP-MS. Focus is put on major elements; unconventional fluid-tracers, e.g., B, As and Sb, and on trace elements not commonly measured. Data are calculated with GSD-1G as external standard (if not indicated otherwise) and internally standardised to the sum of major element oxides.

Materials
The LA-ICP-MS PPP analytical procedure was optimised and evaluated using six different geological reference material (GRM) powders (JP-1, UB-N, BCR-2, GSP-2, OKUM, and MUH-1). Calibration based on external standardisation using NIST SRM 610, SRM 612, BCR-2G, and GSD-1G glasses allows for evaluation of possible matrix effects during LA-ICP-MS analysis.

Evaluation of different matrices with BCR-2(G)

Fig. 2 Examination of matrix effects based on the GRM BCR-2G, quantified using SRM 610 as the external standard and measured in three different measurement sessions (dates in brackets). (A) Measured concentrations of pressed powder pellet (PPP) with MCC binder normalised to binder-free PPP. (B) Comparison of measured concentrations for PPP and glass employing BRC-2 basalt by plotting BCR-2 MCC-PPP measured concentrations normalised to reference data (Meas/Ref) = MCC-PPP divided by BCR-2G measured concentrations normalised to reference data (Mean/Ref). Error bars represent the 1 SD uncertainties on the external reproducibility of six spot analyses (n = 6).

Elemental fractionation using NIST SRM 610/612

Fig. 3 Measured element concentrations of MCC-bound PPP relative to the respective reference values quantified by using different external standards: SRM 612, BCR-2G, and GSD-1G. The use of basaltic glasses as external standard minimises the apparent depletion of Y+REEs. Similar observations were made for the GRMs BCR-2G, GSP-2 and OKUM when externally standardised with NIST SRM 610/612. Error bars represent 1 SD uncertainties on the external reproducibility (n = 6).

Accuracy & Precision

Fig. 4 Plots illustrating the analytical accuracy for International Association of Geoanalysts (IAG) ultrabasic rocks OKUM (A) and MUH-1 (B). Data symbols are filled black for elements with concentrations above 50 ng g⁻¹, filled red for elements with concentrations below 50 ng g⁻¹, and red circles filled white for elements which did not return significant mass fractions for each spot measurement. Note that the GRMs have several elements without reference concentrations; these elements are marked with an asterisk on the x-axis and our measurement data are plotted at y = 1.0. Error bars represent the 1 SD uncertainties on the external reproducibility of six spot analyses (n = 6; except for red circles filled white).

Geochemical application

Fig. 5 Comparison of MCC-PPP data from this study vs. liquid ICP-MS data [4]; bomb digestion), based on JP-1, plotted as a primitive mantle (PM)-normalised spider diagram (PM values [5]). Most analytical uncertainties are smaller than the symbol size.

Selections
- LA-ICP-MS analysis of MCC-bound nanoparticulate PPPs is an accurate and efficient alternative for the analysis of bulk major to trace element concentrations
- Unconventional geochemical tracers, such as Li, B, As, Sb, as well as highly refractory elements (e.g., Cr, HFSE) are accurately quantified
- Elemental fractionation for analysis of intermediate to ultrabasic bulk rock compositions (PPP and glass samples) is minimised/eliminated when basalt glasses are employed as external standard
- Employing MCC as a pellet binder allows (i) for the analysis of all solid materials, and (ii) has great potential for standard addition approaches