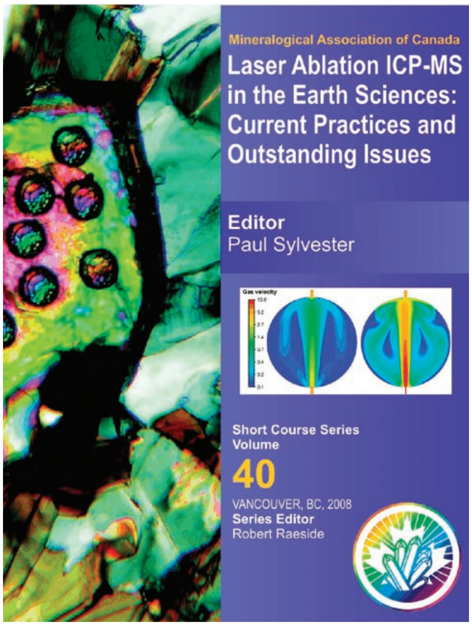
LASER ABLATION ICP–MS IN THE EARTH SCIENCES: CURRENT PRACTICES AND OUTSTANDING ISSUES*

Laser ablation ICP–MS has been an important analytical tool in the Earth sciences since the early 1990s. Eight years ago, a workshop was held in St. John's, Newfoundland, Canada, on the topic. As a result of the workshop, a collection of papers describing the technique and its application to trace element analysis, along with a brief consideration of isotope ratio measurements, was published (*LA–ICP–MS in the Earth Sciences: Principles and Applications*, Mineralogical Association of Canada short course volume 29). The present volume, dedicated to current practices and outstanding issues, shows how much this method has matured since 2001. Recent developments in laser ablation procedures, aerosol formation, isotope fractionation, matrix effects, data acquisition and reduction for trace element and isotope ratio measurements are discussed in a well-presented, pedagogical way. This volume highlights the versatility of LA–ICP–MS and its applications in the various fields of geoscience.

The Mineralogical Association of Canada Short Course Series volume 40, *Laser Ablation ICP–MS in the Earth Sciences: Current Practices and Outstanding Issues*, presents the current state of knowledge and potential future developments in this versatile analytical technique. Compared to the previous publication, the new volume has a greater focus on isotope ratio measurements, which came to the fore with the development of multiple collector ICP–MS. The editor, Paul Sylvester (Memorial University, Newfoundland), has gathered a collection of papers from leading scientists that will be useful to anybody interested in LA–ICP–MS techniques, from the student to the most expert researcher in the field.

H. Longerich (chapter 1) inaugurates the new volume, as he did in the earlier one. He pulls the instrument apart and takes the reader on a virtual laboratory tour, explaining the use of each component. A comparison of the different laser ablation systems and mass spectrometers is made, from the point of view of the user's application and budget.

D. Günther and J. Koch (chapter 2) review the effects of the formation of aerosols generated by laser ablation and their impact on elemental fractionation in LA–ICP–MS, and D. Bleiner and Z. Chen (chapter 3) present the results of a computer simulation of laser ablation elemental microanalysis. Both of these chapters show that the ability to visualize aerosol behavior in the sample cell and the tubing, which depends on the gas medium and the laser ablation system, is of critical importance. Ingo Horn (chapter 4) compares results obtained using fs and nanosecond(ns) laser interactions with different geological matrices. Data on an impressive collection of in situ stable isotope ratios (Fe, Cu, and Si isotopes), acquired using an femitosecond(fs) laser ablation system, are provided, thus giving us a glimpse into our possible analytical future.



P. Sylvester (chapter 5) highlights the versatility of the technique for measuring trace elements and reviews the operating conditions necessary to minimize matrix effects. He shows that, unless high precision is required and providing that the samples and the standard are reasonably similar, precision and accuracy are easily better than 10%.

J. Košler (chapter 6) reviews and compares two laser ablation sampling modes (single spot versus raster). The use of scanning ablation is preferred, when possible, since it improves data quality and allows a visual control of the ablated area. N.J. Pearson, W.L. Griffin, and S.Y. O'Reilly (chapter 7) point out that many factors influence accuracy and precision for precise isotope ratio measurements. After a detailed review of different methods, they suggest several techniques for mass fractionation correction, mainly based on Hf isotope ratio measurements. C. McFarlane and M. McCulloch (chapter 8) show that it is possible to measure the in situ Nd isotope composition of various common LREE-enriched accessory phases, such as apatite, allanite, and monazite. This technique is best applied when high spatial resolution analysis and high sample throughput are required, such as in provenance studies. J. Woodhead, J. Hellstrom, C. Paton, J. Hergt, A. Greig, and R. Maas (chapter 9) present a guide to depth profiling and to trace element and isotope mapping applications. Using trace element and isotope mapping of speleothems, otoliths, and feldspars as examples, they show that the laser ablation system and the sample cell are critical for high-resolution images.

K.P. Jochum and B. Stoll (chapter 10) review the available reference materials for trace element and isotope ratio measurements in various matrices. They highlight the general lack of suitable reference materials for precise and accurate measurements and promote their very useful GeoReM website. S. Jackson (chapter 11) reviews the different calibration techniques for trace element analysis by LA–ICP–MS. Trace element analyses of diamond and sulfides are presented as examples. He also shows that accurate data can be generated when elements share the same fractionation index, even with poorly matrix-matched standards. T. Pettke (chapter 12) discusses the measurement of elemental and isotope ratios in fluid inclusions. The main limiting factor in the calibration technique is the uncertainty of the internal standard value. P.R.D. Mason, I.K. Nikogosian, and M.J. van Bergen (chapter 13) review the different calibration techniques for the analysis of major and trace elements in melt inclusions. They also compare this technique with more traditional microanalytical techniques, such as SIMS/EPMA.

A. Simonetti, L. Heaman, and T. Chacko (chapter 14) show the results of in situ U–Pb dating of zircon, monazite, and perovskite in petrographic thin sections using multiple discrete-dynode secondary electron multipliers. A.K. Souders and P. Sylvester (chapter 15) show the use of multiple continuous-dynode channeltron ion counters for the analysis of common lead in silicate glass. They review all possible errors related to the stability and linearity of ion counters, mass bias corrections, and interference corrections and then show some results using international standards. M.S.A. Horstwood (chapter 16) presents a unique paper dedicated to data reduction strategies and error propagations inherent to LA–(MC)–ICP–MS. This is a very interesting attempt at a comprehensive and unifying calculation strategy for isotope measurements using this technique. Finally the volume includes nine of the most common data reduction software programs available for trace element and/or isotope ratio measurements.

This short course volume is available for a very modest price compared to the value of its contents. Short course volume 40 should stand on the shelf beside your favorite analytical system, and it should be routinely consulted by anybody remotely interested in laser ablation (MC)–ICP–MS. The earlier volume, short course volume 29, is also included on a CD accompanying the volume.

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