

Laser Ablation Microsampling Enables Chemical Characterization of Meteorites by Single-Particle LIBS

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The chemical characterization of micrometeorites and heterogeneous meteoritic domains remains a significant analytical challenge due to their small size and limited availability. Here, a minimally invasive approach combining laser ablation, optical trapping, and single-particle laser-induced breakdown spectroscopy (μ LA-OT-SP-LIBS) is presented for in situ analysis of discrete particles with minimal sample consumption. Bulk meteorite samples, including iron-rich (Campo del Cielo) and silicate-rich (Jbilet Winselwan, NWA 869, NWA 13739, Vaca Muerta) meteorites, were ablated to generate dry aerosols of spherical, multielemental particles, representative of the original sample composition. Individual particles were optically trapped in air and analyzed by LIBS. Complementary SEM, XRD, and XRF analyses confirmed particle morphology, elemental composition, and bulk mineralogy.

The differences between the LIBS spectra were appreciable and a classification of the analyzed meteorites based on elemental composition was performed. For quantitative analysis, the major oxides were calculated using CF-LIBS.

In the carbonaceous chondrite Jbilet Winselwan, SP-LIBS enabled the discrimination of particles originating from Fe-rich matrix and chondrules based on characteristic intensity ratios (e.g. Mg/Fe, Na/Fe), consistent with complementary analyses. Notably, CN molecular bands were detected in some matrix-derived particles, indicating the presence of native organic carbon. These findings demonstrate that μ LA-OT-SP-LIBS can successfully characterize exiguous, discrete domains with negligible sample damage and absolute mass requirements in the low microgram range. The method provides a powerful platform for multielemental and molecular analysis of rare or valuable samples, with potential applications in meteoritics, geochemistry, and astrobiology.

Keywords: laser ablation; meteorites; SP-LIBS; optical trapping

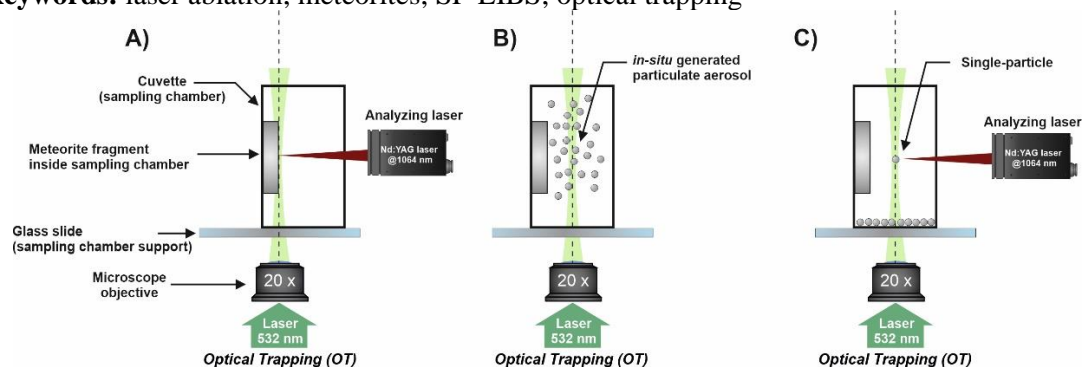


Fig. 1 Experimental procedure for particle generation, optical trapping, and in situ LIBS analysis.

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