C, N, H, O, S and trace element determinations in organic-rich sediments and some igneous rocks types by Tandem LA-LIBS ICP-MS

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Sedimentary rocks rich in organic matter (OM), such as black shale and coal, provide the source material for fossil fuel deposits and record the co-evolution of life and Earth surface conditions. To constrain the formation, post-depositional alteration, and economic potential of these deposits, many researchers have successfully used the combined chemical analysis of both their organic and mineral components. The traditional "bulk" analytical techniques for this work require large samples and thus obscure fine spatial variations. While laser ablation ICP-MS (LA-ICP-MS) has been successfully used to analyze trace concentrations at the micro-scale, few micro-analytical techniques exist that can simultaneously measure the light elements (e.g., C, H, O, and N) that form the bulk of natural OM. With the goal of contributing to an analytical routine that captures a wider range of elements at sub-millimeter resolution, we explore the potential of a new technique, "Tandem LA-LIBS" (Laser Induced Breakdown Spectroscopy) coupled with ICP-MS for the analysis of a much broader range of elements in marine and terrestrial OM-rich deposits than has been possible with traditional analytical techniques. LIBS is essentially an optical spectrometer integrated into the laser ablation system that analyzes the laser induced plasma at the sample surface across the entire optical spectrum (190nm-1040nm) for both atomic and ionic emission lines of virtually every element in the periodic table. Elements that are difficult or impossible to detect with LA-ICP-MS, such as high ionization potential elements (F, halogens) and those subject to Ar-interferences, are now possible to detect with LIBS down to low ppm levels. The fully integrated "Tandem LA-LIBS" system will allow for the simultaneous measurement of volatile and organic elements along with trace transition metals and major elements in a single laser ablation experiment. We present H, O, N, C, Li, Ca and S spectra and quantitative data on these elements and other trace and major elements obtained by Tandem LA-LIBS on coal, organic-rich marine sediments, shale reference materials and some igneous rock samples and standards.