Geophysical Research Abstracts
Vol. 14, EGU2012-12105, 2012
EGU General Assembly 2012

Application of laser-induced breakdown spectroscopy (LIBS) as a tool to determine the origin of 'conflict minerals'

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Laser-induced breakdown spectroscopy (LIBS) offers a means of rapidly distinguishing different places of origin for a mineral because the LIBS plasma emission spectrum provides the complete chemical composition (i.e. geochemical fingerprint) of a mineral in real-time. An application of this approach with potentially significant commercial and political importance is the spectral fingerprinting of the 'conflict minerals' columbite-tantalite ("coltan"). Following a successful pilot study of three columbite-tantalite suites from the United States and Canada, a more geographically diverse set of samples from 37 locations worldwide were analyzed using a commercial laboratory LIBS system and a subset of samples also analyzed using a prototype broadband field-portable system. The spectral range from 250-490 nm was chosen for the laboratory analysis to encompass many of the intense emission lines for the major elements (Ta, Nb, Fe, Mn) and the significant trace elements (e.g., W, Ti, Zr, Sn, U, Sb, Ca, Zn, Pb, Y, Mg, and Sc) known to commonly substitute in the columbite-tantalite solid solution series crystal structure and in the columbite group minerals. The field-portable instrument offered an increased spectral range (198-1005 nm), over which all elements have spectral emission lines, and higher resolution than the laboratory instrument. In both cases, the LIBS spectra were analyzed using advanced multivariate statistical signal processing techniques. Partial Least Squares Discriminant Analysis (PLSDA) resulted in a correct place-level geographic classification at success rates between 90 and 100%. The possible role of rare-earth elements (REE's) as a factor contributing to the high levels of sample discrimination was explored. Given the fact that it can be deployed as a man-portable analytical technology, these results lend additional evidence that LIBS has the potential to be utilized in the field as a real-time tool to discriminate between columbite-tantalite ores of different provenance.