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Multi-range imaging mass spectrometry using laser ablation-ICP-mass spectrometry

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Time-resolved elemental and isotopic data can provide key information about the time changes of the geochemical conditions of the surface environmental of the Earth, and therefore, critical restriction for the origin or evolutional sequence of the surface environment of the Earth and the life could be derived. To obtain reliable and exclusive information from the samples, tremendous efforts have been given to develop various analytical techniques, which could provide both the higher elemental sensitivity and higher analytical throughput. Among the analytical techniques, plasma ion source mass spectrometer coupled with the laser ablation sample introduction technique (LA-ICPMS) has now become the most sensitive and user-friendly analytical tool to derive elemental and isotopic distribution among the different phases or minerals. Moreover, in the LA-ICPMS technique, atomization and ionization of the analytes were independently carried out from the sampling (i.e., post ionization technique), and therefore, the sampling and ionization conditions could be separately optimized. The post ionization technique results in the smaller contribution of the matrix effect, which could be the major source of analytical error. Furthermore, for the LA-ICPMS technique, sample was located under the atmospheric pressure sample cell, and laser induced sample aerosols were carried into the ICP ion source using a He carrier gas. This suggests that no evacuation of the sample housing is required, and therefore, biological cell or tissue samples (i.e., wet samples) can be directly subsidized to elemental imaging analysis, obviating the drying or freezing procedure for the analysis. The LA-ICPMS technique has further advantages of imaging analysis for samples with various sizes, ranging from 10 microns to >10 mm. Because of high capability for quantitative imaging of ultratrace-elements, together with high analytical capability to measure large-sized samples, the LA-ICPMS technique has blossomed to become the key analytical technique for the imaging analysis of trace-elementals and isotopes. This is very important to obtain elemental and isotopic images for not only biological samples, but also various rock or minerals. In fact, imaging data for whole rock pierces or minerals can tell us the substantial process for the elemental distribution or diffusion among the samples. We should recall that we could not see the forst for the trees. Despite the obvious success in obtaining the elemental and isotopic imaging data, neither quantitative evaluation of the detection limits for the elements nor the dependence of the analytical conditions (e.g., laser pit size, raster rate, system setup or condition for data acquisition) onto the resulting spatial resolution were made. To investigate these, we have measured imaging analyses of several trace- and ultratrace-elements from meteorite samples and biochemical samples under the various analytical conditions. In this presentation, we will described the effect of the system setup and operational settings onto the resulting spatial resolution and onto the limit of detection for the elements.

Keywords: laser ablation, ICP-mass spectrometry, imaging mass spectrometry, multi-scale imaging, trace-elements, quantitative imaging