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U-Pb age determination for Quaternary zircons using a laser ablation-ICP-mass spectrometry

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Age data for the Quaternary zircons are very important to understand the time sequence of many interesting and scientifically valuable events in the past, such as origin and evolution of the life, climate changes as well as geological events including volcanic eruption and earthquakes. Among the various chronometers, fission-track (FT) and K-Ar (Ar/Ar) method of dating have been widely used to define the age of young rocks or minerals. Despite the obvious success in obtaining reliable age data, because of very long half-life of the spontaneous fission, the number of tracks found in minerals is not large enough to define the precise age data for the young samples. For the age data obtained by the K-Ar (Ar/Ar) systems, better time resolution (i.e., precision and reliability) could be achieved from single grain of K-bearing minerals such as biotite or sanidine. However, system closure for the K-Ar isotope systems could be lost through weathering of the biotite grains. Moreover, the sanidine grains are not ubiquitously presented in the rocks, and the practical utility of the sanidine K-Ar (Ar/Ar) dating method is severely restricted. Zircon geochronology is one of the principal dating tools available to geologists and its use has revolutionalized our understanding of the evolution of continental crust or unveiled Archean history. Especially, the U-Pb chronology on zircons has been widely used to understand the timing of the geological events with high time resolution. This is because, (a) age data were intrinsically very accurate because the decay constants for both the 235U and 238U are well calibrated and established, (b) system closure can be evaluated by comparing the 238U-206Pb and 235U-207Pb ages (i.e., level of concordance) and (c) zircon contains high concentration U with almost very low Pb. In order to take full advantage of the zircon U-Pb chronology, we have developed a new analytical protocol to measure U-Pb age data for Quaternary zircons using a laser ablation-ICP-mass spectrometry.

In order to derive the precise and reliable U-Pb age data from young zircons, both the high elemental sensitivity of the ICPMS instrument and high transportation efficiency of the laser-induced sample aerosols from sample to the ICP ion source are essential. Moreover, evaluation and correction of the background signal especially on 207Pb is still key issue. We have applied the ABLATION BLANK protocol to obtain the true background signal of 207Pb using laser ablation of Pb-free samples. The resulting signal intensities of 206Pb and 207Pb obtained with the laser ablation (ablation blank) were systematically higher than the signal intensities obtained without laser ablation (gas blank). Moreover, signal intensities of 206Pb and 207Pb obtained by laser ablation of synthesized zircons were higher than those obtained with the ablation blank for high-purity Si wafer. This suggests that the release of the residual sample aerosols can be enhanced through the laser-induced shockwave on the zircon materials, and therefore, ablation blank must be measured on identical sample matrix or minerals. For the U-Pb age determinations for young zircons, isotope ratio measurements with high dynamic range over 5 orders of magnitude is highly desired. To overcome this, we have employed the suppressor technique on our ion counting devices, which enables us to measure isotope ratio with over 9 orders of magnitude. Using this technique, we can measure signal intensity of very small 207Pb signals together with very high intensity 238U signal from the optimum laser ablation conditions. We will demonstrate the resulting U-Pb age for young zircons of various ages ranging from 0.6 to over 2000 Ma. The U-Pb age data obtained in this study demonstrate clearly that the LA-ICPMS technique has a potential to become a significant tool for geological study using Quaternary zircons.

Keywords: ICP-MS, laser ablation, U-Pb, dating, zircon, Quaternary