U-Pb Dating of Zircon Shock Microstructures with NanoSIMS

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Shock deformation in zircons from terrestrial impact structures and Apollo returned samples has been associated with distrubances to the U-Pb system, opening the prospect of a more accurate lunar impact chronology. While the highest degrees of impact metamorphism, such as recrystallization, are known to cause total Pb-loss and date impact, the local effects of intermediate shock deformation on ^{207}Pb-^{206}Pb ages are not well constrained. Moreover, many shock features are too small to investigate in this regard with conventional dating techniques (e.g. SIMS, SHRIMP), and discriminating shock disturbance of zircon Pb composition from disturbance due to regional thermal events is an ever-present challenge.

We have developed a new NanoSIMS protocol for U-Pb age dating in zircon, with a spatial resolution of ~2 μm, which is a factor ten better resolution than by conventional (~20 μm) SIMS analyses. This improvement is achieved due to the higher beam intensity of the Hyperion II primary source on the LLNL NanoSIMS 50 compared with the duoplasmatron. Using our new protocol, we measured the U-Pb sytematics in two impact shocked zircons; lunar zircon 14305 Z34 and a terrestrial zircon from the Vredefort impact structure in South Africa. Electron backscatter diffraction (EBSD) analyses of lunar zircon 14305 Z34, revealed two crosscutting sets of shock microtwins. NanoSIMS data within the larger set of twins, which were up to ~ 6 μm in width, show no resolvable variation in ^{206}Pb/^{238}U and ^{207}Pb/^{206}Pb across the twin boundaries and U-Pb ages were within error of ims-1270 analyses suggesting that the formation process of these microstructures is too rapid to cause appreciable Pb mobility. However, in the shocked zircon from the Vredefort impact, Pb-loss due to the 2.02 Ga shock event was resolved in few crystal domains whereas a 1 Ga well-known regional thermal event was seen elsewhere. This is in contrast with the previous analyses of the same zircon using the ims-1270 at UCLA that only detected the 1 Ga Pb-loss. This ability to resolve smaller age domains by NanoSIMS may lead to new insights into the diverse Pb-loss mechanisms and histories in single shocked zircons.