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# Pushing the boundaries in beta-decay LA-ICP-MS/MS geochronology

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In situ beta-decay geochronology by laser – ablation inductively coupled plasma – tandem mass-spectrometry (LA-ICP-MS/MS) is emerging as a powerful tool to rapidly and robustly date a wide range of minerals at high spatial resolution. Using $NH_3$ in the reaction cell of the mass-spectrometer, $^{176}Hf$ can effectively be mass-shifted to 176+82 amu (ca. 50% reaction of total Hf), and measured free from isobaric interferences of $^{176}Lu$ (<0.003% reaction) and $^{176}Yb$ (<0.00003% reaction), enabling in situ Lu-Hf geochronology. The method has been demonstrated on both Lu-rich minerals, such as garnet and monazite, as well as Lu-poor minerals that don`t incorporate significant (initial) Hf in their crystal lattice, such as apatite, fluorite and carbonate minerals. Applied to garnet, the spatial resolution of the method enables polymetamorphic histories to be unravelled, which we will demonstrate with the first application of in situ Lu-Hf age-mapping. In exceptional cases, when Lu concentrations reach wt% levels, age uncertainties of 0.3-0.6% can be achieved. The method also enables probing in the lower crust, by analysing garnet and apatite Lu-Hf ratios in xenoliths or enclaves, albeit at much lower precision. Another promising development is in situ Re-Os geochronology, which enables rapid dating of molybdenite ($MoS_2$). Initial work using $CH_4$ as reaction gas required a significant interference correction since ca. 0.5-1 % of Re reacts to $ReCH_2$, which overlaps on the $OsCH_2$ daughter product. We demonstrate that using a mixture of $N_2O$ and He in the reaction cell, $OsO_4$ can be measured almost free from isobaric interferences, as the equivalent $ReO_4$ production rate can be reduced to <0.02 %. This analytical advancement enables in situ Re-Os dates for molybdenites as young as Cenozoic in age, with uncertainties as low as 2% in the best-case scenario. Continuing the legacy of Balz`s analytical developments, as we continue to push the boundaries of the LA-ICP-MS/MS instrument, more minerals can be accessed for in situ geochronology than ever before. This in turn accelerates our ability to time-constrain fundamental geological processes, advancing understanding of the evolution of planet Earth within the solar system.