Goldschmidt 2000
September 3rd–8th, 2000
Oxford, UK.

Journal of Conference Abstracts
Volume 5(2), 1096

Precise and Accurate Pb-Pb Dating of Apatite, Sphene and Monazite in situ by high Mass Resolution LAM-MC-ICPMS

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We have used a quadrupled Nd-YAG laser and a VG-Axiom high resolution multi-collector inductively coupled mass spectrometer (MC-ICPMS) to measure *in situ* Pb isotope ratios in NIST glasses and Pb-rich accessory minerals. Pb isotope ratios measured in the NIST glass standard 610 (Pb = 426 ppm; Tl = 86.8 ppm) are corrected for mass fractionation using a $^{203}Tl/^{205}Tl$ ratio of 2.38765, and a correction for any ^{204}Hg present in the argon plasma is made by monitoring ^{202}Hg. Data were acquired for 100 s and laser spot sizes were varied from 50 to 300 µm. Pb isotope ratios over several days of analysis during a two month period were: $^{206}Pb/^{204}Pb$ = 17.041 ±0.011, $^{207}Pb/^{204}Pb$ = 15.498 ±0.011, $^{208}Pb/^{204}Pb$ = 36.924 ±0.032 (n = 42; 2 sd). The reproducibility of this standard data is comparable or better than that typically quoted for the SRM981 standard analysed by conventional thermal ionisation mass spectrometry (TIMS). Moreover, these data are within analytical uncertainty of the Pb isotope ratios measured by TIMS and MC-ICPMS for this glass by others. In order to test the *in situ* Pb dating technique, we attempted to date apatite, sphene and monazite from metamorphic rocks of the Paleoproterozoic Nagssugtoqidian orogen, West Greenland. We have previously dated these minerals by conventional TIMS techniques. NIST glass was analysed interspersed with our sample analyses to monitor Pb isotope mass fractionation in the low Tl/Pb accessory minerals. The axial multiplier was used to measure the low abundance ^{204}Pb isotope, while the other Pb isotopes were measured in a set of Faraday collectors. $^{207}Pb/^{206}Pb$ ages were calculated using a common Pb isotope ratio measured on coexisting plagioclase. Individual ages were: apatite 1706 to 1700 ±6-23 Ma, sphene 1780 to 1800 ±4-15 Ma and monazite 1840 to 1836 ±4-53 Ma. Variability of mass fractionation during an analytical session accounts for an age bias of the unknowns of less than 1 m.y.. The apatite and monazite ages determined by *in situ* Pb isotope analysis are almost identical to those determined by conventional TIMS work on Pb separated from bulk mineral separates. Moreover, the analytical uncertainties of these two minute laser analyses with no prior mechanical or chemical separation are comparable to those obtained by TIMS. Detailed examination of the sphene *in situ* age data did, however, show a small discrepancy between the LA-MC-ICPMS and TIMS ages, with the TIMS ages being typically 40 m.y. younger. High resolution (RP ca. 12000) mass scans clearly showed several small isobaric interferences between 206.7 and 206.9 AMU, which overlaps with the ^{207}Pb peak at low resolution conditions (RP ca. 400) for measurement of isotope ratios. The interference is ca. 3% of the total 207 ion beam intensity and clearly accounts for the age discrepancy between the LA-MC-ICPMS and TIMS sphene ages. We have yet to identify the interferences, but the ability to see it and analyse its effect, highlights the advantage of a high resolution instrument in laser ablation isotope studies. In conclusion, LA-MC-ICPMS offers a rapid, accurate and precise method for *in situ* determination of Pb isotope ratios that can be used for geochronological studies of crustal rocks in a similar manner to a sensitive high resolution ion microprobe. Further modifications and improvements to the LA-MC-ICPMS system (e.g., an extended high mass Faraday for simultaneous ^{238}U measurement) and the laser system (e.g., enhanced sensitivity through use of different carrier gases and use of a higher energy laser) coupled with the existing multi-collector and high resolution capabilities of the Axiom may lead to this type of instrument becoming the method of choice for *in situ* Pb isotope dating.