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UWZ1, A Zircon Standard for Oxygen Isotope Analysis by SIMS: IMF Revisited

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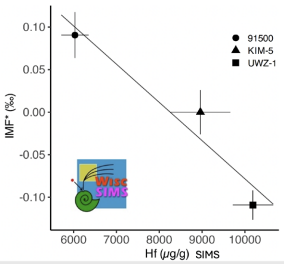
Accurate SIMS analysis requires reference materials (RM) that match samples in chemistry and structure. Constraints are especially tight for oxygen isotope analysis where precision and accuracy are desired at 0.1‰-levels. Some minerals (e.g., quartz, zircon) have been thought sufficiently stoichiometric that samples require only one RM for calibration. Other minerals like Ca-Mg-Fe carbonates, garnets, and pyroxenes have extensive solid solution and require a suite of RMs. Many different zircons are used to correct SIMS $d^{18}O$-analyses to VSMOW and most are calibrated by laser-fluorination/ gas-source mass spectrometry (LF-GSMS) to UWG2 garnet, which is tied to NIST28 (Valley et al. 1995 GCA).

Spot-to-spot precision of 0.2‰ (2SD) at WiscSIMS recently revealed small discrepancies among 2 common zircon RMs, 91500 and KIM5, and a new zircon RM, UWZ1. UWZ1 was created from a single 335g crystal (MudTank carbonatite complex, Australia) and selected for low levels of radiation damage (ave.=23mg/g U, n=46; age ~730Ma; low radiogenic Pb), which might otherwise facilitate alteration or affect instrumental mass fractionation (IMF). UWZ1 is recommended as a RM for oxygen isotopes, but not U-Pb geochronology. Eleven analyses of $d^{18}O$(UWZ1) by LF-GSMS (3-4mg/ea.) on 3 days yield 4.96 ±0.23‰ (2SD, VSMOW) bracketed by UWG2 (5.80‰ VSMOW). 508 SIMS UWZ1 analyses (80 grains, two mounts, one session) yield $d^{18}O$(raw)=3.33‰ (single-mount 2SD=0.26‰, 2SE=0.04‰) and IMF=-1.62‰.

Surprisingly, IMF varies systematically by 0.20‰ for the 3 RMs and correlates with [Hf] (see figure). All $d^{18}O$ and [Hf] data are from WiscSIMS; [Hf] is calibrated against 91500. Peck et al. (2001 GCA) plotted IMF vs. [Hf] and concluded that SIMS single-collector precision (~1‰) was not sufficient to evaluate correlation. It is important to stress that not all MudTank zircons are the same, IMF can vary with each retuning, and appropriate RMs should be analyzed in every session. The relatively small range of Hf (ca.6000-10,000 micro-g/g) spanned by these RMs represent many common igneous zircons, but a far larger range is reported, especially in radiation-damaged zircons and evolved granitic rocks. The effect of variable Hf on IMF for these compositions is unknown and under investigation.



RM	n	δ18O (‰ VSMOW)	δ18O (‰, measured)	2SD	2SE	Hf (µg/g) SIMS	Hf 1SE(%)	Hf n	IMF	IMF*
KIM-5	172	5.09 a	3.57	0.34	0.03	8960	7.8	37	-1.51	0.00
91500	39	10.07 b	8.64	0.17	0.03	6030 c	5.3	1	-1.42	0.09
UWZ-1	508	4.96	3.33	0.39	0.02	10187	4.6	20	-1.62	-0.11

[a]Valley 2003 RIMG53; [b]Wiedenbeck et al. 2004 GGR, UW-value, $\delta^{18}O$(UWG2)=5.80‰; [c]Coble et al. 2018 GGR; data for 2 SIMS mounts in 1 session; precision for UWZ1 is 0.26 in a single mount; IMF* is relative to KIM-5