

The $\Delta 33$ Uraninite U-Pb internal standard

Small grains of euhedral uraninite from a sample of leucogranite from southern Tibet were used as a U-Pb LA-PIMMS internal standard for dating uraninite from this study. The sample was collected by BC Burchfiel, KV Hodges, and L Royden from the east side of the Rongbuk Valley, northeast of Mt Everest ($86^{\circ}50'E$, $28^{\circ}10'N$, approximately) and other geological and age information for this sample is contained in Copeland et al. (1988). In that study, monazite analyses are inherited with a maximum age of ~ 21 Ma and there is reported a single somewhat imprecise concordant U-Pb age of zircon of 19.5 ± 0.4 Ma. Subsequent to that study, uraninite and further monazite analyses were obtained from this same sample, as shown in the following table. The five uraninite analyses have a weighed mean $^{206}Pb/^{238}U$ age of 19.93 ± 0.17 Ma and a weighted mean $^{207}Pb/^{206}Pb$ age of 41 ± 1 Ma, indicating slight normal discordance. This discordance is attributed to excess ^{207}Pb arising from preferential incorporation of ^{231}Pa during crystallisation, (see Parrish and Noble 2003). In this study, a reference age of 20.0 Ma is used for the $\Delta 33$ uraninite used to calculate the ages of uraninite unknowns in the samples for this study using LA-PIMMS analysis with similar laser settings. Thus the uraninite data in this study are matrix matched to a uraninite standard.

The U-Pb data in the accompanying table used the ID-TIMS method and were made at the Geological Survey of Canada in 1995 by R Parrish using methods summarised in Parrish et al. (1987). The LA-PIMMS data for the $\Delta 33$ uraninites are also shown in an accompanying table to illustrate the quality of the analyses and reproducibility of the data.

References

- Copeland, P., Parrish, R. R., and Harrison, T. M., 1988, Identification of inherited radiogenic Pb in monazite and its implications for U-Pb systematics; *Nature*, 333, 760-763.
- Parrish, RR, and SR Noble (2003) Zircon U-Pb geochronology by isotope dilution – thermal ionisation mass spectrometry (ID-TIMS), in John M. Hanchar and Paul W.O. Hoskin, eds., *Zircon, Reviews in Mineralogy and Geochemistry*, v. 53 p. 183-213, Mineralogical Society of America and Geochemical Society.
- Parrish, R. R., Roddick, J. C., Loveridge, W. D., and Sullivan, R. W., 1987, Uranium-Lead analytical techniques at the geochronology laboratory; Geological Survey of Canada Paper 87-2, p. 3-7.

Laser Ablation U-Pb analyses

Sample	206/238norm	error %	207/235norm	error %	206/238 age age(Ma)	2s err (Ma)	207/206 age (Ma)	2s err (Ma)
Uraninite crystals from sample Δ33								
Analysis 1	0.00315	1.0	0.0199	2.4	20.3	0.4	-11	103
Analysis 2	0.00297	1.6	0.0193	2.6	19.1	0.6	60	95
Analysis 3	0.00264	0.9	0.0172	2.7	17.0	0.3	59	122
Analysis 4	0.00293	0.8	0.0208	2.3	18.9	0.3	263	97
Analysis 5	0.00331	0.9	0.0220	2.2	21.3	0.4	106	95
Analysis 6	0.00349	0.9	0.0224	2.0	22.4	0.4	31	87
Analysis 7	0.00329	1.8	0.0210	2.8	21.2	0.7	13	103
Analysis 8	0.00347	0.9	0.0227	2.2	22.3	0.4	69	95
Analysis 9	0.00310	1.0	0.0197	2.0	20.0	0.4	-3	85
Analysis 10	0.00281	1.3	0.0171	2.3	18.1	0.5	-105	93
Analysis 11	0.00296	0.7	0.0187	2.3	19.0	0.3	-13	105
Mean	0.00310	8.7	0.0201	9.6	20.0	1.7	43	92

Notes:

Uncertainties are based upon the signal intensity measurement errors; the reproducibility of these standards is quadratically included in all uncertainties of unknowns

Common Pb correction in these analyses was negligible

norm, refers to normalised values of measured ratios, using a mean age of 20.0 Ma as determined from ID-TIMS measurements

Isotope dilution U-Pb analyses

Analysis	Weight (mg, microns)	U (ppm)	Pb** (ppm)	206Pb^ 204Pb	Pbc^^ (pg)	Th*** U	206Pb*^ 238U	1 std err (%)	207Pb*^ 235U	1 std err (%)	207Pb*^ 206Pb	1 std err (%)	206Pb*^ 238U	2 std err (Ma)	207Pb*^ 235U	2 std err (Ma)	207Pb*^ 206Pb	2 std err (Ma)	Corr. coeff	
Uraninite crystals from sample Δ33																				
U-5	1.7	951450	2673	60490	5.2	0.044	0.003110	0.3	0.02008	0.3	0.04681	0.03	20.0	0.1	20.2	0.1	39.5	1.4	0.99	
U-4	6.2	700800	1971	221800	3.8	0.050	0.003111	0.42	0.02009	0.42	0.04684	0.03	20.0	0.2	20.2	0.2	40.9	1.3	0.99	
U-3	1.0	581010	1638	9061	12.4	0.063	0.003114	0.16	0.02011	0.16	0.04684	0.07	20.0	0.1	20.2	0.1	40.9	3.2	0.91	
U-6	24.3	850980	2378	39230	101	0.044	0.003094	0.08	0.01998	0.12	0.04684	0.05	19.9	0.1	20.1	0.1	40.9	2.5	0.94	
U-8	6.8	926650	2582	98610	12.2	0.050	0.003083	0.17	0.01991	0.19	0.04685	0.05	19.8	0.1	20.0	0.1	41.3	2.4	0.97	
Weighted Mean													20.0	0.2			41	1		

** radiogenic Pb

*** atomic ratio of Th to U, calculated from radiogenic 208Pb/206Pb

^ Measured ratio, corrected for spike and Pb fractionation (0.09%/amu)

^^ Total common Pb in analysis, corrected for fractionation and spike

^^ Corrected for blank Pb and U, and common Pb (Stacey-Kramers model Pb equivalent to interpreted age of mineral)