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Determination of Zr isotopic ratio in zircons using laser-ablation multiple-collector inductively-coupled-plasma mass-spectrometry

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Supplementary Information

A. The image data of natural zircons

Six natural zircon megacrysts were collected from difference countries (Brazil, Burma, Malawi, Norway, Pakistan, Tanzania). The image data of these zircons are shown in Fig. S1.

Fig. S1 Photographs of six natural zircon megacraysts from difference countries.

B. The analytical results of trace elements in eleven zircons using LA-ICP-MS

Major and trace element analyses were conducted by LA-ICP-MS at the State Key Laboratory of Geological Processes and Mineral Resources, China University of

Geosciences, Wuhan. Detailed operating conditions for the laser ablation system and the ICP-MS instrument and data reduction are the same as description by Liu *et al.*[1]. Laser sampling was performed using a GeoLas HD. An Agilent 7500a ICP-MS instrument was used to acquire ion-signal intensities. A “wire” signal smoothing device is included in this laser ablation system, by which smooth signals are produced even at very low laser repetition rates down to 1 Hz.[2] Helium was applied as a carrier gas. Argon was used as the make-up gas and mixed with the carrier gas via a T-connector before entering the ICP. Nitrogen was added into the central gas flow (Ar+He) of the Ar plasma to decrease the detection limit and improve precision.[3] Each analysis incorporated a background acquisition of approximately 20–30 s (gas blank) followed by 50 s data acquisition from the sample. The Agilent Chemstation was utilized for the acquisition of each individual analysis. Element contents were calibrated against multiple-reference materials (BCR-2G, BIR-1G and BHVO-2G) without applying internal standardization[1]. The preferred values of element concentrations for the USGS reference glasses are from the GeoReM database (http://georem.mpch-mainz.gwdg.de/). Off-line selection and integration of background and analyte signals, and time-drift correction and quantitative calibration were performed by ICPMSDataCal.[1] Analytical results are listed in Table S1.

Table S1. The analytical results of trace elements in eleven zircon samples using LA-ICP-MS

Elements		GJ-1		91500		Plešovice		Penglai		Mud Tank		Zr-Bra		Zr-Bur		Zr-Mala		Zr-Nor		Zr-Paki		Zr-Tan	
		Mean (µg g^{-1})	SD (n=15)	Mean (µg g^{-1})	SD (n=15)	Mean (µg g^{-1})	SD (n=15)	Mean (µg g^{-1})	SD (n=15)	Mean (µg g^{-1})	SD (n=15)	Mean (µg g^{-1})	SD (n=20)	Mean (µg g^{-1})	SD (n=20)	Mean (µg g^{-1})	SD (n=20)	Mean (µg g^{-1})	SD (n=20)	Mean (µg g^{-1})	SD (n=20)	Mean (µg g^{-1})	SD (n=20)
Sc	**45**	43.6	69.2	34.7	5.06	115	41.9	36.0	7.68	167	20.0	76.1	68.1	55.9	6.01	69.3	8.29	84.7	10.1	105	33.6	42.9	6.06
Ti	**47**	3.68	0.86	4.10	1.11	5.43	1.32	4.58	1.10	3.54	0.61	9.67	11.79	7.24	1.24	6.95	0.85	4.58	0.84	4.25	0.89	4.98	1.20
V	**51**	< D.L.		< D.L.		< D.L.		< D.L.		< D.L.		21.1	55.5	< D.L.		< D.L.		< D.L.		< D.L.		< D.L.	
Cr	**53**	< D.L.		< D.L.		< D.L.		< D.L.		< D.L.		23.8	80.9	< D.L.		< D.L.		< D.L.		< D.L.		< D.L.	
Mn	**55**	< D.L.		< D.L.		< D.L.		< D.L.		< D.L.		239	466	< D.L.		< D.L.		< D.L.		< D.L.		< D.L.	
Fe	**57**	< D.L.		< D.L.		< D.L.		< D.L.		< D.L.		7047	12222	< D.L.		< D.L.		< D.L.		< D.L.		< D.L.	
Ni	**60**	< D.L.		< D.L.		< D.L.		< D.L.		< D.L.		9.59	19.6	< D.L.		< D.L.		< D.L.		< D.L.		< D.L.	
Ge	**72**	< D.L.		< D.L.		< D.L.		< D.L.		< D.L.		12.9	33.3	< D.L.		< D.L.		< D.L.		< D.L.		< D.L.	
As	**75**	< D.L.		< D.L.		< D.L.		< D.L.		< D.L.		13.8	66.9	< D.L.		< D.L.		< D.L.		< D.L.		< D.L.	
Se	**82**	< D.L.		< D.L.		< D.L.		< D.L.		< D.L.		33.9	52.3	< D.L.		< D.L.		< D.L.		< D.L.		< D.L.	
Y	**89**	240	72.5	130	23.7	555	415	146	48.8	104	14.8	4213	3118	1464	207	1041	548	121	30.6	423	124	257	123
Nb	**93**	2.22	0.75	1.19	0.41	4.88	2.30	1.55	0.57	3.19	0.85	1243	2317	16.3	3.27	28.9	14.4	0.61	0.28	13.6	5.14	1.75	1.00
Mo	**97**	< D.L.		< D.L.		< D.L.		< D.L.		< D.L.		< D.L.		< D.L.		< D.L.		< D.L.		< D.L.		< D.L.	
La	**139**	0.02	0.04	0.00	0.02	0.22	0.90	0.01	0.04	0.01	0.04	117	295	0.13	0.22	0.27	1.02	0.01	0.03	0.02	0.05	0.02	0.08
Ce	**140**	15.3	7.66	2.61	0.38	3.42	5.88	2.10	0.53	1.09	0.27	649	2009	248	31.0	6.04	4.14	3.11	0.52	12.10	4.34	3.39	1.22
Pr	**141**	0.03	0.05	0.02	0.03	0.35	0.89	0.01	0.02	0.07	0.04	46.95	106	0.56	0.10	0.22	0.22	0.03	0.04	0.27	0.31	0.02	0.06
Nd	**143**	0.57	0.35	0.26	0.26	2.91	4.75	0.24	0.39	0.81	0.32	218	535	5.99	1.18	3.05	2.81	0.68	0.50	3.97	3.56	0.34	0.56
Sm	**147**	1.43	0.20	0.48	0.30	3.91	4.01	0.60	0.39	1.34	0.33	83.4	244	6.92	1.18	5.09	4.44	1.46	0.72	5.45	3.59	0.61	0.47
Eu	**151**	0.97	0.20	0.25	0.10	0.99	0.95	0.51	0.23	0.88	0.17	36.3	97.3	1.23	0.29	3.75	3.07	1.20	0.56	2.75	1.68	0.69	0.68
Gd	**155**	4.16	0.75	1.26	0.43	9.42	7.67	2.05	0.71	3.15	0.58	165	307	27.0	3.69	24.7	20.2	4.33	1.59	13.49	6.33	2.60	1.53
Tb	**159**	1.83	0.22	0.78	0.19	5.40	4.35	1.21	0.44	1.46	0.19	49.9	77.2	8.93	1.27	9.04	6.94	1.75	0.57	5.77	2.32	1.69	0.81
Dy	**163**	19.6	3.38	10.5	2.17	58.7	45.1	14.5	4.84	14.4	2.57	491	580	104	13.5	110	74.2	15.2	4.62	53.02	19.2	22.41	10.7
Ho	**165**	6.51	1.21	4.43	0.89	16.5	12.8	5.05	1.69	4.16	0.59	141	123	40.4	5.16	41.4	22.5	4.10	1.07	14.97	4.59	9.00	4.27
Er	**166**	29.4	7.25	24.5	4.08	61.5	46.6	23.3	8.38	15.6	2.28	544	385	197	24.3	193	79.6	14.6	3.38	56.36	16.1	46.79	21.7
Tm	**169**	6.55	2.04	6.32	1.05	11.0	8.12	4.94	1.64	2.81	0.41	107	65.5	44.6	5.29	42.5	13.0	2.52	0.63	10.02	2.72	10.98	4.98
Yb	**173**	61.3	20.4	68.1	10.6	78.9	57.6	44.2	15.6	22.1	3.25	891	499	422	54.6	399	88.5	19.7	4.52	77.65	20.3	105.17	46.2
Lu	**175**	11.36	4.33	11.7	1.73	9.50	6.90	6.66	2.27	3.37	0.54	133	66.7	83.2	9.51	79.6	14.0	3.57	0.75	14.24	3.60	21.49	9.04
Hf	**178**	7054	1151	5857	218	10984	805	5721	313	9291	193	6908	1102	10676	300	8333	286	5421	185	11874	597	5415	501
Ta	**181**	0.70	1.95	0.55	0.08	2.59	1.64	0.74	0.19	4.27	0.64	88.9	63.2	2.89	0.36	18.7	2.21	0.19	0.06	14.08	3.72	0.82	0.22
W	**182**	< D.L.		< D.L.		< D.L.		< D.L.		< D.L.		< D.L.		< D.L.		< D.L.		< D.L.		< D.L.		< D.L.	

SD = standard deviation. D.L. = detection limit.

C. The signal intensity of the potential interference elements

To further reveal the potential interferences, the signal intensities of interference elements (Kr, Mo, Ru, Os, Pt) were collected using the mass scan mode in the MC-ICP-MS, when a zircon reference material Mud Tank was measured with common instrumental conditions for Zr isotope ratio analysis using LA-MC-ICP-MS. Results are shown in Fig. S2. The signal intensity of ^{90}Zr is ~27.7 V. However, no identifiable signal intensities of Mo, Kr, Ru, Os and Pt were observed, indicating that these elements are very low in zircons and the related interferences can be negligible.

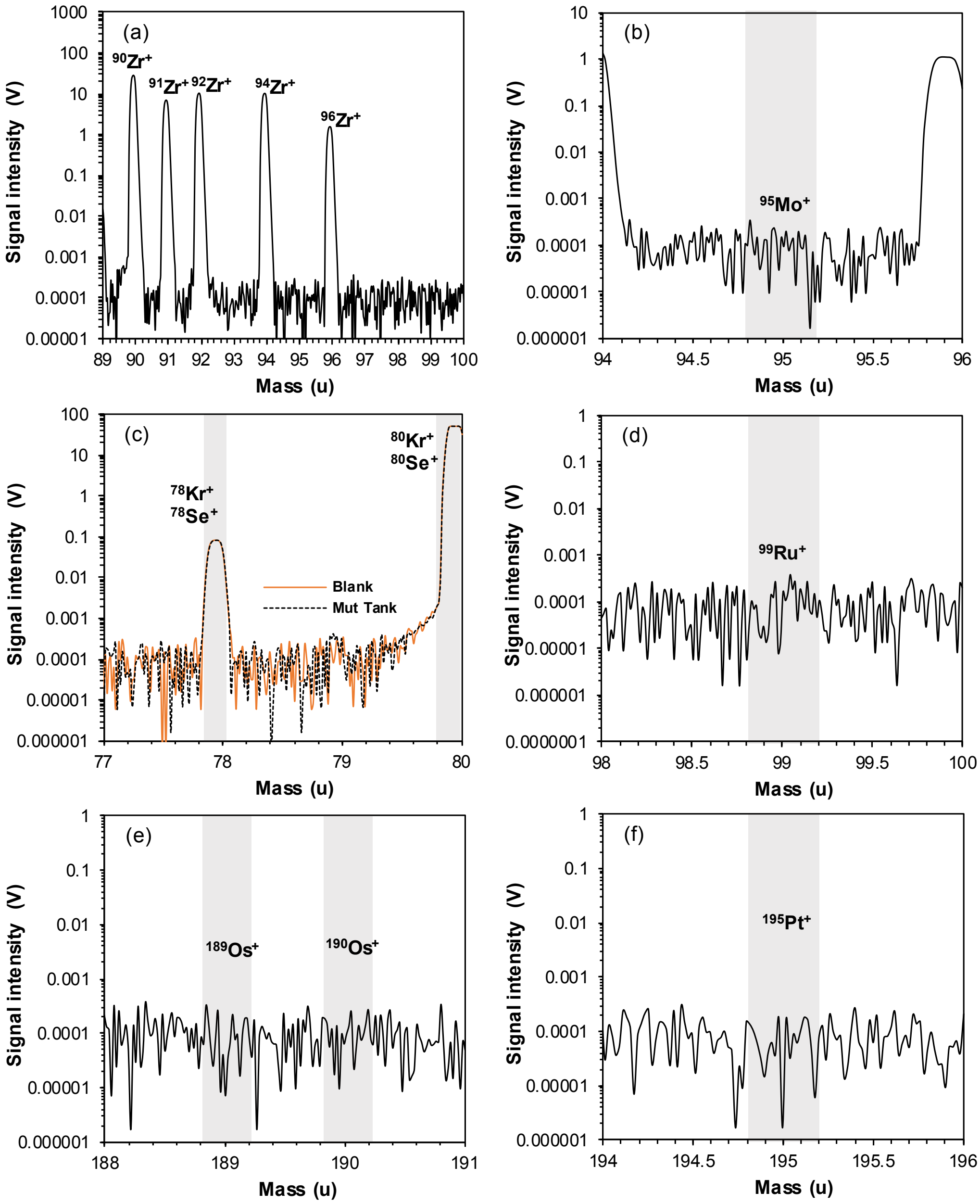

Fig. S2 the signal intensities of Zr and other interference elements (Kr, Mo, Ru, Os, Pt) when a zircon reference material Mud Tank was measured using LA-MC-ICP-MS.

References

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