Analytical technique

Whole rock geochemistry

Whole-rock samples were analyzed for major oxides and trace elements by X-ray fluorescence (XRF) spectroscopy using a Phillips PW 1400 at the Centre d'Analyses Minérale, University of Lausanne, Switzerland. Rare-earth element and trace element concentrations were also determined by inductively coupled plasma mass spectrometry (ICP-MS) using a Hewlett Packard 45000 at the Institute F.- A. Forel, Versoix, Switzerland. Neodymium isotope analyses were carried out at the Department of Mineralogy, University of Geneva, Switzerland. Sm and Nd concentrations for age-correcting the isotopic data used the values determined by ICP-MS. Repeated analyses of Sm/Nd ratios using the Geological Survey of Japan JB-3 (basalt) standard yields a precision (2 σ) of better than 2.75%.

Samples for isotopic and ICPMS analysis were digested in a 5 ml of *ca* 40% HF and 1 ml of *ca* 15M HNO_3. Samples were digested in closed PTFE beakers for one week at a temperature of 170 °C. When dry, the sample were treated with 2 x 2 ml additions of *ca* 15M HNO_3 followed by 1 ml of *ca* 6M HCl. 5 ml of ca 6M HCl was then added and left to stand overnight at 170 °C. Following digestion, samples for isotopic analysis were converted to nitrate by 3 x 1 ml additions of 4M HNO_3, dissolved in 2 ml of 1M HNO_3, centrifuged and then loaded onto the ion exchange columns. Teflon-distilled HCl and HF and Ultrex-II HNO3 were used throughout the dissolution and chemical separation procedures, and reagent and total procedure blanks are neglible. Nd separation employed Eichrom TRU-Spec Resin (50 - 100 μm) in disposable PP columns in series with Ln-Spec Resin (50 - 100 μm), using the methods described in Pin & Zaldegui (1997).

Neodymium isotope ratios were measured on a seven-collector Finnigan MAT 262 thermal ionization mass spectrometer with extended geometry and stigmatic focusing using double Re filaments. $^{143}Nd/^{144}Nd$ was measured in a semidynamic mode (quadruple collectors, measurement jumping mode), mass fractionation corrected to $^{146}Nd/^{144}Nd = 0.721903$, and normalized to the La Jolla standard = 0.511837. The mean of 101 replicated analyses of this standard is 0.511837 ± 2 (2 σ).

U-Pb zircon geochronology

Zircons were separated from several kilograms of sample by conventional means. The sub-300 μm fraction was processed using a Wilfey table, and then the Wilfey heavies were passed through a Frantz magnetic separator at 1 A. The non-paramagnetic portion was then placed in a filter funnel with di iodomethane. The resulting heavy fraction was then passed again through the Frantz magnetic separator at full current. A side slope of 1º was used to separate non-paramagnetic zircons for ion microprobe analysis to maximize concordance. All zircons were hand picked in ethanol using a binocular microscope.

Ion microprobe analytical technique

Zircons were mounted in a resin disk along with the zircon standard and polished to reveal the grain interiors. The mounts were gold-coated and imaged with a Hitachi S-4300 scanning electron microscope (SEM), using a cathodoluminescence probe (CL) to image internal structures, overgrowths and zonation. Secondary electron mode (SE) imaging was employed to detect fractures and inclusions within the grains. U–Th–Pb zircon analyses (Table DR4) were performed on a Cameca IMS 1270 ion-microprobe following methods described by Whitehouse and Kamber (2005) which were modified from Whitehouse et al. (1999). U/Pb ratio calibration was based on analyses of the Geostandards zircon 91500, which has an age of 1065.4±0.3 Ma and U and Pb concentrations of 80 and 15 ppm, respectively (Wiedenbeck et al., 1995). Replicate analyses of the same domain within a single zircon were used to independently assess the validity of the calibration. Data reduction employed Excel macros developed by Whitehouse at the Swedish Natural History Museum, Stockholm. Age calculations were made using Isoplot version 3.02 (Ludwig, 2003). U–Pb data are plotted as 2σ error ellipses (Fig. 3). All age errors quoted in the text are 2σ unless specifically stated otherwise. Presence of common Pb was monitored using the ^{204}Pb signal. With the exception of one analysis, none of the samples exhibited levels of ^{204}Pb that were significantly elevated relative to the detector background (averaged over the entire session). Therefore no common Pb corrections were applied. The one analysis (DC 10/1/5, spot 2) which exhibited significant levels of ^{204}Pb (f^{206} = 1.01%) is interpreted as contaminated by significant amounts of present day terrestrial Pb, as it lies on a discordia (Fig. 3) between the concordia age and the modern day average terrestrial common Pb

composition of $^{207}Pb/^{206}Pb = 0.83$ (Stacey and Kramers, 1975). A detailed rationale for choosing present day Pb as a contaminant is given by Zeck and Whitehouse (1999).

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Table 1a. XRF major and trace

Sample Number	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	LOI
DC-10/01/06	76.57	0.21	12.92	1.79	0.05	0.84	0.71	5.47	0.45	0.24	1.09
DC-08/01/26	41.29	1.04	18.79	12.62	0.18	7.94	13.07	1.40	0.04	0.44	3.28
DP-11	51.45	0.87	12.89	11.65	0.23	6.71	12.04	2.26	0.42	0.12	0.92
DC-08/01/24	64.94	1.14	16.23	7.33	0.08	2.03	0.25	1.36	3.86	0.24	2.60
DC-08/01/25	57.90	0.94	15.84	9.94	0.34	4.69	2.08	1.94	2.29	0.34	3.58

Table 1b. ICPMS data

Sample Number	Sc	Ti	V	Cr	Co	Ni	Cu	Zn	Rb	Sr	Y
DC-10/01/06	5.39	651	18.7	6.33	3.15	1.24	35.0	21.8	8.1	140	11.5
DC-08/01/26	25.1	3250	258	105	34.2	35.0	32.6	61.2	1.44	243	15.0
DP-11	21.6	2726	255	54.8	28.8	25.9	29.8	53.6	13.6	357	12.5
DC-08/01/24	7.9	3506	71	53.2	21.5	22.3	8.0	52.3	105.8	42	13.0
DC-08/01/25	13.7	2893	150	157.3	35.5	73.3	60.0	76.6	71.1	114	16.5

*Normalized to the carbonaceous chrondrite values of McDonough & Sun (1995)

Table 1c. XRF trace (long count time)

Sample Number	Nb	Zr	Y	Sr	U	Rb	Th	Pb	Ga	Zn	Ni
DC-10/01/06	2.8	99	22	146	<2<	7.9	3	<2<	13	33	3
DC-08/01/26	1.9	30	26	234	<2<	1.2	3	<2<	18	105	78
DP-11	1.6	28	22.2	338	<2<	12.1	<2<	9	19	88	51
DC-08/01/24	18.3	319	24.4	45	<2<	106	9	5	23	81	48
DC-08/01/25	14	115	29.5	115	<2<	69.4	7	14	20	122	163

Cr_2O_3	NiO	Total	Nb	Zr	Y	Sr	U	Rb	Th	Pb	Ga	Zn
0.00	0.00	100.33	4	81	29	137	2	8	5	7	14	37
0.03	0.01	100.14	3	50	27	235	<2<	3	<2<	14	18	102
0.02	0.01	99.58	4	46	22	346	<2<	12	2	27	17	86
0.01	0.01	100.08	19	314	28	42	3	101	11	8	23	83
0.05	0.02	99.95	15	117	34	114	5	68	8	21	21	121

Zr	Nb	Ba	La	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho
63.6	1.93	1004	5.95	12.6	1.77	7.35	1.94	0.47	2.67	0.50	3.36	0.78
39.8	0.41	54.7	1.82	5.04	0.99	5.83	2.41	1.27	3.67	0.67	4.39	1.01
29.9	0.45	255	1.56	4.36	0.84	4.96	2.01	0.83	3.21	0.58	3.82	0.88
199.4	18.46	643	44.37	81.51	9.90	37.32	7.05	1.49	6.01	0.84	4.46	0.94
76.0	13.64	494	35.20	66.74	7.87	30.61	6.40	1.67	6.51	0.97	5.56	1.17

Cr	V	Ce	Ba	La
6	23	13	876	4
194	313	<3<	32	<4<
98	313	<3<	257	<4<
97	92	68	567	42
309	208	63	456	22

Cu	Ni	Co	Cr	V	Ce	Nd	Ba	La	S	Hf	Sc	As
46	<2<	8	11	33	15	4	1053	8	131	8	20	<3<
50	79	63	214	367	20	13	45	<4<	17	9	44	3
45	44	46	100	327	18	11	256	13	33	7	38	14
12	42	30	98	117	149	56	660	49	3	11	17	8
69	149	48	330	254	87	30	532	57	180	6	47	129

Er	Tm	Yb	Lu	Hf	Ta	Pb	Th	U	La/Sm	La/Sm_N*	ΣREE
2.33	0.33	2.32	0.35	2.35	0.39	0.44	3.19	0.79	3.07	1.92	43
2.94	0.42	2.76	0.42	1.41	0.80	b/d	0.27	0.22	0.75	0.47	34
2.52	0.37	2.44	0.36	1.06	0.38	7.98	0.26	0.20	0.78	0.49	29
2.57	0.35	2.38	0.35	4.93	1.62	4.09	17.81	1.90	6.29	3.93	200
3.21	0.44	2.91	0.43	1.88	1.16	12.66	11.33	2.96	5.50	3.43	170

Table 2. Sm-Nd isotopic data

Sample Number	Sm (ppm)	Nd (ppm)	$^{147}Sm/^{144}Nd$	$^{143}Nd/^{144}Nd$	± 2 σ	$\varepsilon_{Nd(490)}$	± 2 σ	T_{DM}*
DC-10/01/06	1.94	7.35	0.1593	0.512539	0.000029	0.41	0.93	1393
DC-08/01/26	2.41	5.83	0.2495	0.513132	0.000007	6.33	0.42	-
DP-11	2.01	4.96	0.2450	0.513091	0.000006	5.81	0.39	-
DC-08/01/24	7.05	37.32	0.1142	0.511600	0.000004	-15.11	0.55	2199
DC-08/01/25	6.40	30.61	0.1264	0.512030	0.000006	-7.47	0.34	1752

*T_{DM} ages were calculated using the depleted mantle curve of DePaolo (1981).

Table 3. U-Pb SIMS zircon data

Sample / spot	U (ppm)	Th (ppm)	Pb (ppm)	Th/U	f^{206} (%)	$^{238}U/^{206}Pb$	± σ%	$^{207}Pb/^{206}Pb$	± σ%	$^{206}Pb/^{238}U$	(Ma ± σ)	^{207}Pb corr.	(Ma ± σ)
DC 10/1/5													
2	188	45	17	0.24	{1.01}	12.71	0.79	0.06407	1.0	488.4	3.9	484.0	3.8
3	198	52	18	0.26	{0.11}	12.87	0.92	0.05670	0.99	482.0	4.3	482.6	4.3
6	212	80	20	0.38	{0.1}	12.62	0.85	0.05646	0.97	491.0	4.0	491.8	4.1
9	242	85	21	0.35	{0.46}	13.21	0.85	0.05795	1.2	468.2	3.8	469.4	3.9
15	217	127	22	0.59	{0.09}	12.54	0.86	0.05669	0.99	494.1	4.1	494.7	4.2
16	217	74	19	0.34	{0.21}	13.31	0.84	0.05703	0.95	466.0	3.8	466.5	3.9
18	150	46	13	0.31	{0.12}	12.76	0.81	0.05804	1.1	485.9	3.8	485.8	3.9
25	194	62	18	0.32	{0.08}	12.70	0.87	0.05788	0.97	488.1	4.1	487.9	4.2
26	154	38	14	0.25	{0.21}	12.67	0.92	0.05652	1.1	488.8	4.3	490.0	4.4
28	184	68	17	0.37	{0.12}	12.53	0.95	0.05790	1.1	494.3	4.5	494.3	4.6
DC 10/1/6													
2	105	21	9	0.20	{0.2}	12.96	0.81	0.05794	1.3	478.3	3.7	478.4	3.8
3	176	53	16	0.30	{0.09}	12.55	0.85	0.05613	1.0	493.7	4.0	494.7	4.1
5	155	49	14	0.32	{0.11}	12.79	0.79	0.05717	1.1	484.8	3.7	485.1	3.8
8	221	52	20	0.24	{0.03}	12.57	0.91	0.05722	0.92	493.3	4.3	493.2	4.4
10	175	60	16	0.34	{0.2}	12.83	1.0	0.05720	1.0	482.9	4.7	483.5	4.8
11	163	53	15	0.32	{0.14}	12.82	0.85	0.05648	1.1	483.6	4.0	484.5	4.1
13	108	23	9	0.21	{0.21}	12.76	0.84	0.05771	1.3	485.4	4.0	485.9	4.0
14	210	80	19	0.38	{0.15}	12.74	1.0	0.05732	1.1	486.4	4.8	486.8	4.9
22	112	32	10	0.28	{0.10}	12.85	0.89	0.05593	1.4	483.2	4.1	483.7	4.2
23	168	48	15	0.29	{0.06}	12.53	0.94	0.05715	1.1	494.9	4.5	494.9	4.6
24	145	31	13	0.21	{0.15}	12.70	0.92	0.05641	1.1	487.9	4.3	489.0	4.4
b24	152	49	14	0.32	{0.03}	12.64	0.86	0.05740	1.1	490.8	4.0	490.5	4.1
25	173	50	16	0.29	{0.16}	12.68	1.0	0.05878	1.0	488.6	4.8	488.2	4.9

f^{206} (%) is the percentage of common ^{206}Pb, estimated from the measured ^{204}Pb. Values in parentheses indicate that no correction has been applied owing to insignificant levels of ^{204}Pb. All errors are at the 1σ level. ^{207}Pb corr. indicates the age derived from the uncorrected Tera-Wasserburg ratios assuming a common $^{207}Pb/^{206}Pb$ of 0.83 (present day terrestrial average of Stacey & Kramers (1975)). Calculations use the routines of Ludwig (2003) and follow the decay constant recommendations of Steiger and Jäger (1977).