

1. GSA Data Repository item xxxxxxx, Appendix TABLE. CHEMICAL COMPOSITIONS OF THE UDACHNAYA-EAST PIPE KIMBERLITE GROUNDMASS, LEACHATE AND RESIDUE SAMPLES

	YBK-0	YBK-1	YBK-3		YBK-0			YBK-3	
	bulk-gm	bulk-gm	bulk-gm	res	L1	L2	res	L1	L2
SiO <sub>2</sub>	27.06	26.08	25.24						
TiO <sub>2</sub>	1.23	1.12	1.40	1.43*	0.02*	0.11*	1.34*	0.10*	0.02*
Al <sub>2</sub> O <sub>3</sub>	2.13	1.74	2.11						
FeO	7.63	7.16	6.92						
MnO	0.15	0.13	0.13	0.16*	0.0*	0.03*	0.17*	0.01*	0.02*
MgO	29.41	29.59	27.79	>10*	0.6*	2.79*	>10*	1.07*	1.93*
CaO	12.70	12.04	12.41						
Na <sub>2</sub> O	3.47	4.33	5.06		2.15*			3.07*	
K <sub>2</sub> O	1.85	2.17	2.23		0.79*			1.16*	
P <sub>2</sub> O <sub>5</sub>	0.49	0.42	0.41						
NiO	0.14	0.14	0.13						
Cr <sub>2</sub> O <sub>3</sub>	0.16	0.13	0.23						
CO <sub>2</sub>	9.83	10.27	10.71		1.48 <sup>#</sup>			2.34 <sup>#</sup>	
H <sub>2</sub> O	0.45	0.45	0.63						
Cl	2.24	2.97	3.11		2.31			3.28	
SO <sub>3</sub>	0.55	0.67	0.82		0.53**			0.90**	
LOI	14.17	16.01	16.64						
Soluble part	7.30	9.67	10.77						
Li	13.9	12.2	13.3	19.1	27.7	7.6	20.2	3.6	5.0
Be	1.3	1.0	1.4	1.0	0.1	3.4	0.8	0.1	1.4
Cr	1167	1002	1755	2571	44	97	1667	57	25
Ni	1053	1102	995	1141	56	80	1559	26	63
Co	79	77	72	90	1.9	10.0	111	2.8	7.0
Cu	64	55	55	85	30.8	100	73	31.4	35.3
Zn	61	59	58	90	11.0	10.6	96	10.4	5.1
V	102	93	114	143	20.5	149	132	33.3	83
Sc	12.9	11.4	13.1	9.1	1.9	5.9	17.0	2.0	3.9
Mo	1.2	1.1	1.6	0.4	16.7	0.7	0.4	10.3	1.1
Sn	1.5	4.5	2.7	1.1	0.4	0.4	1.0	0.6	0.3
Sb	0.1	0.1	0.2	0.2	0.3	0.2	0.2	0.2	0.1
Cs	0.9	1.0	1.1	0.8	3.0	1.2	0.7	2.6	1.0
Ba	1130	1173	1211	2071	140	1179	1717	293	413
Ga	5.6	4.7	5.2	8.8	0.4	3.5	7.8	0.9	1.2
Rb	73	85	86	109	245	43	95	185	34
Sr	892	838	897	65	156	4257	57	225	3222
Y	10.2	7.7	7.7	8.6	0.7	20.1	7.8	1.3	7.8
Zr	115	98	101	172	5.3	45	164	19.7	9.8
Nb	153	131	139	273	3.7	27.3	241	24.8	3.4
La	97	81	75	151	3.1	59	130	11.8	19.0
Ce	167	140	129	270	4.0	65	240	19.8	18.0
Pr	17.5	14.7	13.5	28.2	0.4	5.8	25.3	1.9	1.5
Nd	58	49	45	97.5	1.3	20.1	88.2	6.8	5.3
Sm	7.8	6.5	6.0	12.6	0.2	3.5	11.1	1.1	1.0

<b>Eu</b>	2.0	1.7	1.6	3.2	0.1	1.2	2.8	0.3	0.4
<b>Gd</b>	4.9	4.0	3.8	7.5	0.2	3.5	6.5	0.7	1.3
<b>Tb</b>	0.6	0.5	0.4	0.8	n.d.	0.5	0.7	0.1	0.2
<b>Dy</b>	2.5	2.0	1.9	3.4	0.1	3.1	2.9	0.4	1.0
<b>Ho</b>	0.4	0.3	0.3	0.5	n.d.	0.6	0.4	n.d.	0.2
<b>Er</b>	0.9	0.7	0.7	1.1	0.1	1.5	1.0	0.1	0.6
<b>Tm</b>	0.1	0.1	0.1	0.1	n.d.	0.2	0.1	n.d.	0.1
<b>Yb</b>	0.6	0.4	0.5	0.5	n.d.	1.1	0.5	0.1	0.3
<b>Lu</b>	0.1	0.1	0.1	0.1	n.d.	0.1	0.1	n.d.	0.1
<b>Hf</b>	2.5	2.2	2.3	3.9	0.1	0.6	3.6	0.3	0.1
<b>Ta</b>	8.2	7.1	8.2	16.3	0.1	0.1	13.4	1.1	n.d.
<b>Pb</b>	3.5	5.3	7.0	2.5	0.5	3.6	11.8	1.9	7.5
<b>Th</b>	11.7	10.7	9.1	15.7	0.2	1.1	17.5	0.3	0.1
<b>U</b>	2.8	4.2	2.2	4.3	0.1	1.2	3.7	0.4	0.2

*Note:* Major element data for bulk groundmass (bulk gm) samples by XRF on fused discs; trace element data by solution-mode ICPMS. Data for Na, K, etc. for water leachates (L1) determined by Analytical Services of Tasmania (see Analytical Methods); Data for Mg, Ti and Mn for L1 by ICPMS solution. L1 = water leachates; L2 = 1M HCl leachates; res = residues from 1M HCl leach. \* - weight percent of element, #-CO<sub>3</sub>, \*\*-SO<sub>4</sub>, n.d. - not determined.

## 2. GSA Data Repository item xxxxxx, Details of Analytical Methods

***Sample preparation:*** Internal groundmass fragments (<1 mm) from fresh kimberlite were handpicked with carefully cleaned new steel and plastic tools to avoid contamination of fragment surfaces. This was necessary because the principal aim of this work was to chemically and isotopically characterize water-soluble alkali-chloride and alkali-carbonate components in the groundmass. These components were to be extracted using a leach with cold distilled water. In contrast to most other isotopic studies, this meant that the sample fragments could not be cleaned to remove laboratory contamination at any stage prior to isotopic analyses. In order to gauge the likely extent of contamination, a Pb-Sr blank was determined for the stainless steel spatula used to remove parts of the salt segregation (Fig.2). This was done by collecting repeated dilute HCl rinses from the tip of the (previously acid cleaned) spatula. This “smear” blank, representing  $\approx 2 \text{ cm}^2$  of the spatula’s surface, contained  $\approx 0.3 \text{ ng}$  of Pb, with a  $^{206}\text{Pb}/^{204}\text{Pb}$  near 17, and  $\approx 30 \text{ pg}$  of Sr. As only the very tip of the spatula, with an area of  $\approx 0.5 \text{ cm}^2$ , came in contact with the sample, the contribution from “smear” blank is unlikely to exceed 100 pg of Pb and 10 pg of Sr. These blank levels are small compared to the total amount of Pb and Sr within the analysed salt sample ( $\approx 240 \text{ ng Pb}$ ,  $20.5 \text{ ng Sr}$ ).

***Leaching, sample dissolution and aliquotting:*** Separates of groundmass fragments weighing  $\approx 100 \text{ mg}$  were leached with (1) cold distilled water, for 20 minutes, followed by (2) cold 1M HCl. After each leach step, leachates were pipetted off, combined with a water rinse, and the respective residues were dried and re-weighed to determine mass loss. The HCl-residues (“res”), as well as separate samples of unleached “bulk” groundmass, were dissolved with HF-HNO<sub>3</sub> (48 hrs) and 6M HCl (12 hrs) in Krogh-type high-pressure bombs in an oven set at 160°C. The sample solutions were then split for separate analysis of (i) trace elements, (ii) U-Pb isotope

dilution, (iii) Pb isotope composition, and (iv) Sm-Nd and Rb-Sr isotopes. The water leachates (L1) were analysed for trace elements and Rb-Sr isotopes; U-Pb and Sm-Nd isotope data were obtained on a separate water leach for sample YBK-0 (“L1\*”) after trace element data for L1 indicated Pb-Nd levels sufficient for isotopic work. The ca. 12 x 5 mm salt segregation found in YBK-3 (Fig.2) was dissolved in cold water and, following determination of approximate trace element contents on a small test aliquot, was split for separate determination of (i) U-Pb isotope dilution, (ii) Pb isotopic composition, (iii) Rb-Sr isotope dilution, and (iv) Sr isotopic composition.

*Chemical and isotopic analyses:* Major and trace element compositions of three groundmass samples, including YBK-0 and YBK-3, and trace elements in L1, L2 and res fractions, were determined at the University of Tasmania, by fused disc XRF and solution-mode ICP-MS, respectively (Yu et al., 2001). Major cation and anion contents in water leachates were measured by Analytical Services Tasmania, using ICP-AES for cations, and ion chromatography with electronic suppression and conductivity detection (Dionex DX100) for anions. Carbon was determined using a Carlo Erba CHNS-O elemental analyzer at the University of Tasmania. Selected trace and major element data were plotted on a standard multi-element diagram after normalization to primitive mantle values of Sun and McDonough, 1989.

Samples for isotopic analysis were spiked with mixed  $^{235}\text{U}$ - $^{208}\text{Pb}$ ,  $^{87}\text{Rb}$ - $^{84}\text{Sr}$  and  $^{149}\text{Sm}$ - $^{150}\text{Nd}$  spikes as required, and prepared for mass spectrometry using a combination of conventional cation exchange and EICHRON<sup>TM</sup> resin methods (Pin et al., 1994; Pin and Zalduegui, 1997; Theriault and Davis, 1999). Dissolution and chemistry blanks were measured on numerous occasions and always remained below 50 pg (Sm-Nd, Rb-Sr, U) and 100 pg (Pb, highest blanks associated with bomb dissolutions).

All isotopic analyses were done on a NU Instruments multi-collector ICP-MS at the University of Melbourne using methods adapted from several sources (Vance and Thirlwall, 2002; Waight et al., 2002a; Waight et al., 2002b; Woodhead, 2002). Simultaneous corrections for mass bias and spike in Sr and Nd isotope analyses were done on-line using an iterative algorithm. Kr interference (ca. 3 mV at 83Kr) from impurities in the Ar gas was largely removed by the on-peak-zero correction routine. Small residual Kr interferences related to drift in the Kr signal during the run were removed by a conventional isobar correction based on the 83Kr monitor isotope; the 86Kr/83Kr and 84Kr/83Kr ratios used were those measured on pure Kr background prior to introduction of Sr (i.e. with 88Sr at baseline) at the start of a Sr session. Strontium isotope data were normalized to  $^{86}\text{Sr}/^{88}\text{Sr}=0.1194$  and are reported relative to SRM987=0.71023. Results for the E&A Sr carbonate standard and spiked USGS standards BCR-1 and BHVO-1 adjusted the same way yielded  $^{87}\text{Sr}/^{86}\text{Sr}$  ratios of  $0.708005\pm47$ ,  $0.705016\pm46$  and  $0.703478\pm36$ , respectively (all errors are external precision, 2sd).  $^{84}\text{Sr}/^{86}\text{Sr}$  ratios in unspiked Sr averages  $0.05648\pm3$ . Nd isotope data were normalized to  $^{146}\text{Nd}/^{145}\text{Nd}=2.0719425$  (equivalent to  $^{146}\text{Nd}/^{144}\text{Nd} = 0.7219$ ) and are reported relative to La Jolla Nd = 0.511860. Adjusted results for Nd standard JNd<sub>i</sub>-1 average  $0.512113\pm22$ , BCR-1 yields  $^{147}\text{Sm}/^{144}\text{Nd} = 0.1380\pm2$  and  $^{143}\text{Nd}/^{144}\text{Nd} = 0.512641\pm18$ , while BHVO-1 yields  $0.1493\pm3$  and  $0.512998\pm18$ . Our data for standards compare well with TIMS Sr-Nd isotope data for these standards (e.g., Raczek et al., 2003; Tanaka et al., 2000). CHUR parameters are 0.1967 and 0.512638. Mass bias in Pb isotope analyses is corrected using a variant of the Tl-doping method (Woodhead, 2002). Under routine conditions, this method provides an external precision (2sd) of 0.02-0.03% for  $^{206,207,208}\text{Pb}/^{204}\text{Pb}$ . Errors for U/Pb are  $<\pm1\%$ . Age corrections were done for an age of 367 Ma. Absolute 2 $\sigma$  errors for initial Pb isotope

ratios, based on estimated uncertainties in U/Pb, Th/Pb and Pb isotopic ratios (1%, 2%, 0.03%), are  $\leq 0.07$ ,  $\leq 0.01$ ,  $\leq 0.24$  for  $^{206}\text{Pb}/^{204}\text{Pb}$ ,  $^{207}\text{Pb}/^{204}\text{Pb}$  and  $^{208}\text{Pb}/^{204}\text{Pb}$ , respectively. High initial  $^{208}\text{Pb}/^{204}\text{Pb}$  for YBK-0 res is probably an artifact. Decay constants are:  $^{87}\text{Rb}$   $1.42 \times 10^{-11}/\text{yr}$ ;  $^{147}\text{Sm}$   $6.54 \times 10^{-12}/\text{yr}$ ;  $^{238}\text{U}$   $0.155125 \times 10^{-9}/\text{yr}$ ;  $^{235}\text{U}$   $0.98485 \times 10^{-9}/\text{yr}$ ;  $^{232}\text{Th}$   $0.049485 \times 10^{-9}/\text{yr}$ .

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