TABLE DR1. LOWER CRUSTAL GRANULITE XENOLITH DERIVATION AND MINERALOGY

Sample	Kimberlite	Type	Mineralogy
KX1-1	Lace	s	gt + qz + sa + rt (sil, ky, gr, su, cor, zr, mz)
KX1-2	Lace	s	gt + sa + qz + rt (sil, ky, gr, su, cor, zr, mz)
KX1-8	Lace	s	gt + qz + sa + sil + fs + rt (ky, gr, su, cd, zr, mz)
KX2-1	Voorspoed	s	gt + fs + ky + qz + sa + rt (sil, gr, su, cor, zr, mz)
KX2-2	Voorspoed	s	gt + qz + fs + sil + ky + rt (phl, sp, gr, su, cor, zr, mz)
KX4-21	Markt	m	gt + plag + cpx + qz (rt, ap)
KX4-23	Markt	m	plag + gt + hbl + cpx + qz (mt, ap, zr)
KX4-36	Markt	m	gt + hbl + cpx + plag + qz (mt, ap, zr)
KX5-7	Lovedale	m	gt + cpx + plag + qz (mt, ap)
KX20-1	Letseng-la-Terae	s	gt + ky + plag + qz + mt + rt (ap, zr, mz)
KX20-3	Letseng-la-Terae	f	qz + gt + ky + ksp + plag + rt (mt, ap, zr, mz)
KX20-4	Letseng-la-Terae	m	gt + cpx + plag + qz (mt, ap, zr)
KX20-5	Letseng-la-Terae	f	plag + ksp + qz + gt + cpx (rt, ap, zr)
KX20-8	Letseng-la-Terae	m	plag + gt + cpx + qz + rt (ap, zr)
KX31-4	Liqhobong	m	plag + gt + cpx + phl + qz + rt (ap)

*Lithologic types: s—sedimentary granulite; m—mafic granulite; f—felsic granulite.

†Mineral abbreviations: cor—corundum; fs—feldspar (plagioclase or antiperthite); gr—graphite; gt—garnet; ksp—potassium feldspar; ky—kyanite; mt—magnetite (iron-titanium oxide); mz—monazite; phl—titanian phlogopite; plag—plagioclase; qz—quartz; rt—rutile; sa—sapphirine; sil—sillimanite; sp—spinel; su—sulfide; zr—zircon. Minerals listed in approximate order of abundance; those in parentheses present in quantities <0.5%.

TABLE DR2. Lu-Hf ISOTOPIC DATA FOR WHOLE ROCK SAMPLES AND ZIRCONS

Sample	t_m† (Ga)	[Lu] (ppm)	[Hf] (ppm)	$^{176}Lu/^{177}Hf$§	$^{176}Hf/^{177}Hf$§	±	εHf_0§	εHf_m§
KX1-1 wr	2.7	0.52	3.92	0.01866	0.282024	(5)	-26.46	1.06
KX1-2 wr	2.7	0.45	3.94	0.01620	0.281842	(4)	-32.91	-0.76
KX1-2 zhf1	2.7	18	10636	0.00023	0.280971	(4)	-63.71	-1.36
KX1-2 zhf2	2.7	16	10851	0.00021	0.280977	(3)	-63.47	-1.07
KX1-8 wr	2.7	0.46	2.83	0.02313	0.282218	(3)	-19.59	-0.55
KX2-1 wr	2.7	0.42	5.55	0.01080	0.281545	(3)	-43.38	-1.01
KX2-1 zhf1	2.7	55	10161	0.00077	0.280921	(4)	-65.46	-4.14
KX2-1 zhf2	2.7	9	10590	0.00013	0.280922	(4)	-65.44	-2.89
KX2-2 wr	2.7	0.37	6.07	0.00862	0.281361	(3)	-49.90	-3.42
KX4-21 wr	1.1	0.05	0.23	0.03044	0.282875	(7)	3.63	5.74
KX4-23 wr	1.1	0.54	1.06	0.07254	0.283872	(5)	38.91	9.08
KX4-23 zhf1	1.1	608	8497	0.01016	0.282169	(5)	-21.32	-3.85
KX4-23 zhf2	1.1	541	8855	0.00868	0.282164	(4)	-21.49	-2.89
KX4-36 wr	1.1	0.18	0.73	0.03568	0.282908	(6)	4.80	2.92
KX5-7 wr	1.1	0.07	0.24	0.04107	0.283656	(8)	31.28	25.37
KX20-1 wr	1.0	1.44	5.90	0.03470	0.282786	(4)	0.50	-0.53
KX20-1 zhf1	1.0	32	10826	0.00042	0.282009	(3)	-26.98	-4.39
KX20-1 zhf2	1.0	29	9491	0.00043	0.282000	(3)	-27.32	-4.75
KX20-1 zhf3	1.0	18	5624	0.00046	0.282007	(5)	-27.06	-4.50
KX20-3 wr	1.0	0.79	9.30	0.01203	0.282177	(4)	-21.03	-6.45
KX20-4 wr	1.0	0.68	1.70	0.05664	0.283338	(5)	20.01	3.87
KX20-5 wr	1.0	0.19	4.40	0.00601	0.282062	(9)	-25.11	-6.38
KX20-5 zhf1	1.0	55	11375	0.00068	0.281972	(3)	-28.29	-5.89
KX20-5 zhf2	1.0	51	6640	0.00108	0.282004	(3)	-27.15	-5.03
KX20-8 wr	1.1	0.35	2.89	0.01709	0.282398	(4)	-13.22	-1.00
KX20-8 zhf1	1.1	582	14055	0.00588	0.282283	(3)	-17.28	3.45
KX20-8 zhf2	1.1	447	12601	0.00504	0.282281	(3)	-17.36	4.02
KX31-4 wr	1.0	0.40	3.27	0.01732	0.282454	(5)	-11.25	-0.31

Notes: 250-300 mg of whole rock powder (wr), or zircon fractions (zhf) comprising 1-5 hand picked grains were spiked with mixed ^{176}Lu-^{180}Hf tracer, Lu and Hf purified by standard cation, anion, and HDEHP ion chromatography, and isotope ratios and element concentrations (ppm) measured by isotope dilution multi-collector ICP mass spectrometry (U. Arizona).

†time of high grade metamorphism determined from U-Pb zircon and monazite analysis; zircon U-Pb dates were determined on 5% aliquots of the same solutions dissolved for Lu-Hf analysis and are reported in Schmitz and Bowring (2003a, S. Afr. J. Geol., in press; 2003b, Geol. Soc. Am. Bull. 115, 533-548).

§2σ internal error in measured $^{176}Lu/^{177}Hf \leq 0.1\%$; measured $^{176}Hf/^{177}Hf$ with absolute 2σ internal error (x10^{-6}) in parentheses; $^{176}Hf/^{177}Hf$ ratios corrected for mass fractionation with and exponential law and $^{179}Hf/^{177}Hf = 0.7325$; average $^{176}Hf/^{177}Hf$ value (n=19) for standard JMC475 was 0.282167±14 (2σ s.d.) during the measurement period; present-day εHf_0 calculated with $(^{176}Lu/^{177}Hf)_{CHUR} = 0.0332$ and $(^{176}Hf/^{177}Hf)_{CHUR} = 0.282772$; εHf_m calculated at age of high-grade metamorphism using $\lambda^{176}Lu = 1.93 \times 10^{-11}\ a^{-1}$.

TABLE DR3. Sm-Nd ISOTOPIC DATA FOR WHOLE ROCK SAMPLES

Sample	t_m† (Ga)	[Sm] (ppm)	[Nd] (ppm)	$^{147}Sm/^{144}Nd$§	$^{143}Nd/^{144}Nd$§	±	εNd_0§	εNd_m§
KX1-1	2.7	3.68	6.12	0.3632	0.516122	(14)	67.96	10.16
KX1-2	2.7	3.74	3.98	0.5672	0.519517	(9)	134.18	5.46
KX1-8	2.7	2.76	5.99	0.2787	0.514178	(8)	30.05	1.58
KX2-1	2.7	5.23	16.32	0.1937	0.512576	(7)	-1.21	-0.18
KX2-2	2.7	3.83	16.86	0.1373	0.511383	(7)	-24.48	-3.87
KX4-21	1.1	0.47	2.08	0.1364	0.512145	(8)	-9.62	-1.12
KX4-23	1.1	6.02	25.32	0.1437	0.512177	(7)	-9.00	-1.53
KX4-36	1.1	2.89	14.44	0.1211	0.512114	(10)	-10.23	0.42
KX5-7	1.1	0.64	2.30	0.1668	0.512164	(7)	-9.25	-5.06
KX20-1	1.0	6.85	31.97	0.1295	0.511930	(10)	-13.82	-5.24
KX20-3	1.0	33.4	130.6	0.1544	0.512212	(9)	-8.32	-2.91
KX20-4	1.0	5.21	18.99	0.1659	0.512279	(6)	-7.01	-3.08
KX20-5	1.0	7.32	48.34	0.0915	0.511643	(6)	-19.41	-5.96
KX20-8	1.1	5.06	24.44	0.1252	0.512042	(8)	-11.62	-1.55
KX31-4	1.0	5.84	26.16	0.1349	0.512210	(8)	-8.34	-0.43

Notes: Data collated from Schmitz and Bowring (2003a, 2003b); 100-200 mg of whole rock powder were spiked with a mixed ^{149}Sm-^{150}Nd tracer, Sm and Nd were purified by standard cation and HDEHPion chromatography techniques and isotope ratios and element concentrations (ppm) measured by isotope dilution thermal ionization mass spectrometry (M.I.T.).

† time of high grade metamorphism determined from U-Pb zircon and monazite analysis, reported in Schmitz and Bowring, (2003a, S. Afr. J. Geol., in press; 2003b, Geol. Soc. Am. Bull. 115, 533-548).

§ 2σ internal error in measured $^{147}Sm/^{144}Nd \leq 0.1\%$; measured $^{143}Nd/^{144}Nd$ with absolute 2σ internal error ($\times 10^{-6}$) in parentheses; $^{143}Nd/^{144}Nd$ ratios corrected for mass fractionation with and exponential law and $^{146}Nd/^{144}Nd$ = 0.7219; long-term reproducibility of Nd isotopic standards is ≤20 ppm (2σ s.d.) while analyses (n=12) of USGS standard BCR-1 during the course of the study yielded $^{143}Nd/^{144}Nd$ = 0.512643±9 and $^{147}Sm/^{144}Nd$ = 0.1383±3 (2σ s.d.); reproducibility of εNd_m estimated at ±0.5 epsilon units; present-day εNd_0 calculated with $(^{147}Sm/^{144}Nd)_{CHUR}$ = 0.1967 and $(^{143}Nd/^{144}Nd)_{CHUR}$ = 0.512638; εNd_m calculated at age of high-grade metamorphism using $\lambda^{147}Sm = 6.54 \times 10^{-12}\ a^{-1}$.

TABLE DR4. MAJOR AND TRACE ELEMENT COMPOSITIONS OF SELECTED SOUTHERN AFRICAN GRANULITE XENOLITHS†

Sample	KX4-21	KX4-23	KX4-36	KX5-7	KX20-1	KX20-3	KX20-4	KX20-5	KX20-8	KX31-4
Lith.§	m	m	m	m	s	f	m	f	m	m
Major elements										
SiO_2	51.51	47.97	47.46	53.34	37.15	57.61	42.17	64.27	49.05	52.37
TiO_2	0.33	1.64	0.42	0.29	2.16	1.25	1.60	0.27	1.79	1.06
Al_2O_3	18.79	15.96	17.13	17.72	33.69	15.65	12.94	13.48	17.67	15.14
$Fe_2O_3{}^T$	7.20	15.89	11.22	7.06	18.81	8.28	20.17	2.21	10.13	10.58
MnO	0.11	0.20	0.18	0.11	0.29	0.10	0.34	0.05	0.15	0.17
MgO	8.54	4.07	8.77	7.49	4.40	2.27	9.17	1.23	6.50	8.76
CaO	8.90	7.03	11.70	9.54	1.89	9.90	12.16	9.88	9.61	7.85
Na_2O	4.17	5.91	2.31	3.50	1.34	1.78	1.27	3.38	4.23	1.92
K_2O	0.50	0.82	0.80	1.12	0.42	2.80	0.28	5.39	0.60	1.85
P_2O_5	0.02	0.38	0.06	0.02	0.03	0.02	0.12	0.09	0.40	0.39
Total	100.1	99.8	100.1	100.2	100.2	99.7	100.2	100.3	100.1	100.1
Trace elements										
V	114	345	253	82	560	124	505	22	149	195
Ni	155	34	78	92	123	342	65	7	42	217
Cr	325	81	193	438	431	106	353	14	109	359
Rb	9.72	114	11.2	14.2	6.13	46.2	5.76	122	17.7	41.7
Sr	786	333	578	311	143	1480	219	244	576	447
Y	3.26	33.7	12.7	4.44	52.2	52.8	46.4	14.8	30.1	33.7
Zr	6.28	64	25	13	494	417	56	121	160	124
Nb	0.763	8.73	4.17	1.06	33.6	16.6	4.71	3.94	17.6	6.27
Cs	8.45	58.1	2.31	0.204	0.403	0.210	0.323	0.390	1.31	0.126
Ba	996	2752	1736	2310	83	589	157	1005	1268	748
La	1.88	14.1	10.1	1.31	27.2	17.9	10.0	52.7	23.8	23.0
Ce	4.08	39.1	26.7	2.79	54.1	35.7	28.5	103.5	52.2	56.0
Pr	0.548	5.25	4.04	0.406	5.64	4.27	4.17	13.05	6.85	7.56
Nd	2.44	23.9	17.0	2.06	19.9	16.3	18.2	44.7	27.9	33.3
Sm	0.587	5.92	3.61	0.613	3.75	4.58	5.03	6.79	6.00	7.53
Eu	0.460	1.84	1.20	0.836	0.498	1.15	1.56	1.37	1.92	2.23
Gd	0.542	5.54	2.66	0.654	5.18	6.41	6.01	4.30	5.57	7.42
Tb	0.093	0.930	0.395	0.122	1.07	1.27	1.10	0.551	0.894	1.06
Dy	0.548	5.67	2.28	0.716	7.43	7.87	7.14	2.56	5.12	6.19
Ho	0.116	1.21	0.450	0.158	1.76	1.73	1.59	0.488	1.03	1.18
Er	0.335	3.49	1.27	0.441	5.35	5.07	4.63	1.26	2.79	3.20
Tm	0.052	0.552	0.200	0.069	0.870	0.809	0.712	0.188	0.421	0.479
Yb	0.328	3.55	1.25	0.442	5.86	5.37	4.71	1.26	2.51	3.00
Lu	0.053	0.553	0.196	0.067	0.865	0.791	0.709	0.195	0.371	0.431
Hf	0.226	1.55	0.757	0.223	12.3	10.2	1.79	3.05	3.86	3.40
Ta	0.033	0.264	0.125	0.011	1.73	0.901	0.195	0.286	1.08	0.292
Pb	1.66	8.76	3.82	1.18	5.32	10.0	2.10	40.37	8.76	7.67
Th	0.047	1.04	0.746	0.058	8.31	5.74	0.308	29.05	0.888	0.077
U	0.040	1.42	0.524	0.145	1.60	0.504	0.057	0.956	0.379	0.043

Notes: Major elements and transition metals analyzed by standard XRF methods (U. Mass.-Amherst), other trace elements by solution quadrupole ICP-MS (MIT).

† Major and trace element compositions of metasedimentary granulites from the Lace and Voorspoed kimberlites reported in Schmitz and Bowring (2003b, Geol. Soc. Am. Bull. 115, 533-548).

§ Lithology abbreviations: s = metasedimentary; m = mafic metaigneous; f = felsic metaigneous.

TABLE DR5. ZIRCON U-Pb ISOTOPIC DATA FOR SOUTHERN AFRICAN GRANULITE XENOLITHS

	Composition						Isotopic Ratios									Dates (Ma)			
Fract.	Wt. (µg)	[U] (ppm)	[Pb] (ppm)	Th[†]/U	Pb*/Pbc	Pbc (pg)	^{206}Pb/^{204}Pb[§]	^{208}Pb/^{206}Pb[#]	^{206}Pb/^{238}U[#]	% err	^{207}Pb/^{235}U[#]	% err	^{207}Pb/^{206}Pb[#]	% err	corr. coef.	^{206}Pb/^{238}U[††]	^{207}Pb/^{235}U[††]	^{207}Pb/^{206}Pb[††]	±
KX1-2: Lace kimberlite, Garnet-quartz-sapphirine-sillimanite-kyanite-rutile granulite																			
zhf1	32.6	130	80	0.411	19	6.4	948	0.114	0.52387	(.33)	13.493	(.34)	0.18681	(.08)	0.973	2715.6	2714.8	2714.2	±1.3
zhf2	31.4	116	83	0.482	3.6	28	185	0.141	0.49041	(1.01)	12.441	(1.19)	0.18399	(.58)	0.875	2572.4	2638.3	2689.2	±9.5
KX2-1, Voorspoed kimberlite, Garnet-quartz-sapphirine-antiperthitic feldspar-sillimanite-kyanite-rutile granulite																			
zhf1	24.4	235	140	0.169	14	11	732	0.047	0.52379	(.32)	13.499	(.33)	0.18691	(.08)	0.971	2715.2	2715.2	2715.2	±1.3
zhf2	67.6	95	75	1.362	7.6	29	321	0.377	0.51795	(.27)	13.152	(.29)	0.18416	(.09)	0.950	2690.5	2690.6	2690.7	±1.5
KX4-23: Markt kimberlite; Garnet-clinopyroxene mafic granulite																			
zhf1	94.4	114	24	0.360	8.4	24	515	0.111	0.18298	(.35)	1.9288	(.54)	0.07645	(.38)	0.712	1083.2	1091.1	1107.0	±7.6
zhf2	91.9	118	22	0.308	26.1	8	1589	0.095	0.18135	(.32)	1.9010	(.34)	0.07603	(.12)	0.933	1074.3	1081.5	1095.8	±2.5
KX20-1: Letseng-la-terae kimberlite, Garnet-kyanite-orthopyroxene granulite																			
zhf1	38.8	201	40	0.237	4.9	13	321	0.074	0.16596	(.20)	1.6649	(.30)	0.07276	(.20)	0.725	989.8	995.2	1007.1	±4.1
zhf2	42.1	253	46	0.154	7.5	11	491	0.047	0.16539	(.23)	1.6530	(.28)	0.07249	(.15)	0.845	986.7	990.7	999.6	±3.0
zhf3	30.7	192	47	0.283	2.3	21	160	0.086	0.17106	(.13)	1.7245	(.75)	0.07312	(.68)	0.573	1017.9	1017.7	1017.2	±14
KX20-5: Letseng-la-terae kimberlite, Garnet-kyanite-clinopyroxene felsic granulite																			
zhf1	74.1	468	83	0.601	36.9	8.1	2083	0.190	0.15863	(.26)	1.5728	(.27)	0.07191	(.06)	0.976	949.2	959.5	983.3	±1.2
zhf2	81.4	422	95	0.627	4.1	76	247	0.191	0.16709	(.28)	1.6677	(.41)	0.07239	(.27)	0.747	996.1	996.3	996.8	±5.5
KX20-8: Letseng-la-terae kimberlite, Garnet-clinopyroxene mafic granulite																			
zhf1	91.8	205	48	1.053	15.5	13	801	0.320	0.18491	(.19)	1.9412	(.23)	0.07614	(.13)	0.832	1093.7	1095.4	1098.8	±2.5
zhf2	113	132	32	1.103	11.7	14	603	0.338	0.18275	(.09)	1.9121	(.12)	0.07588	(.08)	0.787	1082.0	1085.3	1092.0	±1.5

Notes: Data collated from Schmitz and Bowring (2003a, S. Afr. J. Geol., in press; 2003b, Geol. Soc. Am. Bull. 115, 533-548); fractions composed of 1-5 hand-picked, abraded grains; weights estimated to within 40% using measured grain dimensions and nominal density of 4.5 g/cm^3; Pb* and Pbc represent radiogenic Pb and common Pb respectively; all errors reported at 2σ, propagated using the algorithms of Ludwig (1980, Earth Planet. Sci. Lett. 46, 212-220).

[†] Th contents calculated from radiogenic ^{208}Pb and the ^{207}Pb/^{206}Pb date of the sample, assuming concordance between U-Th-Pb systems.

[§] Measured ratio corrected for fractionation and spike contribution; Pb fractionation was 0.12 ± 0.04 %/a.m.u. for Faraday detector or 0.15 ± 0.04 %/a.m.u. for Daly detector analysis, based on daily analysis of NBS-981.

[#] Measured ratios corrected for fractionation, spike, blank, and initial common Pb; nominal U blank = 0.1 pg ± 50% (2σ); nominal Pb blank = 3.5 pg ± 50% (2σ) or where lower, the total common Pb of the analysis ± 10% (2σ); measured laboratory blank composition: ^{206}Pb/^{204}Pb = 19.10, ^{207}Pb/^{204}Pb = 15.72, ^{208}Pb/^{204}Pb = 38.65 ± 0.01 (2σ); initial Pb composition from model of Stacy and Kramers (1975, Earth Planet. Sci. Lett. 26, 207-221) at the nominal age of the fraction.

[††] Isotopic ages calculated using the decay constants of Jaffey et al. (1971, Phys. Rev. C 4, 1889-1906).