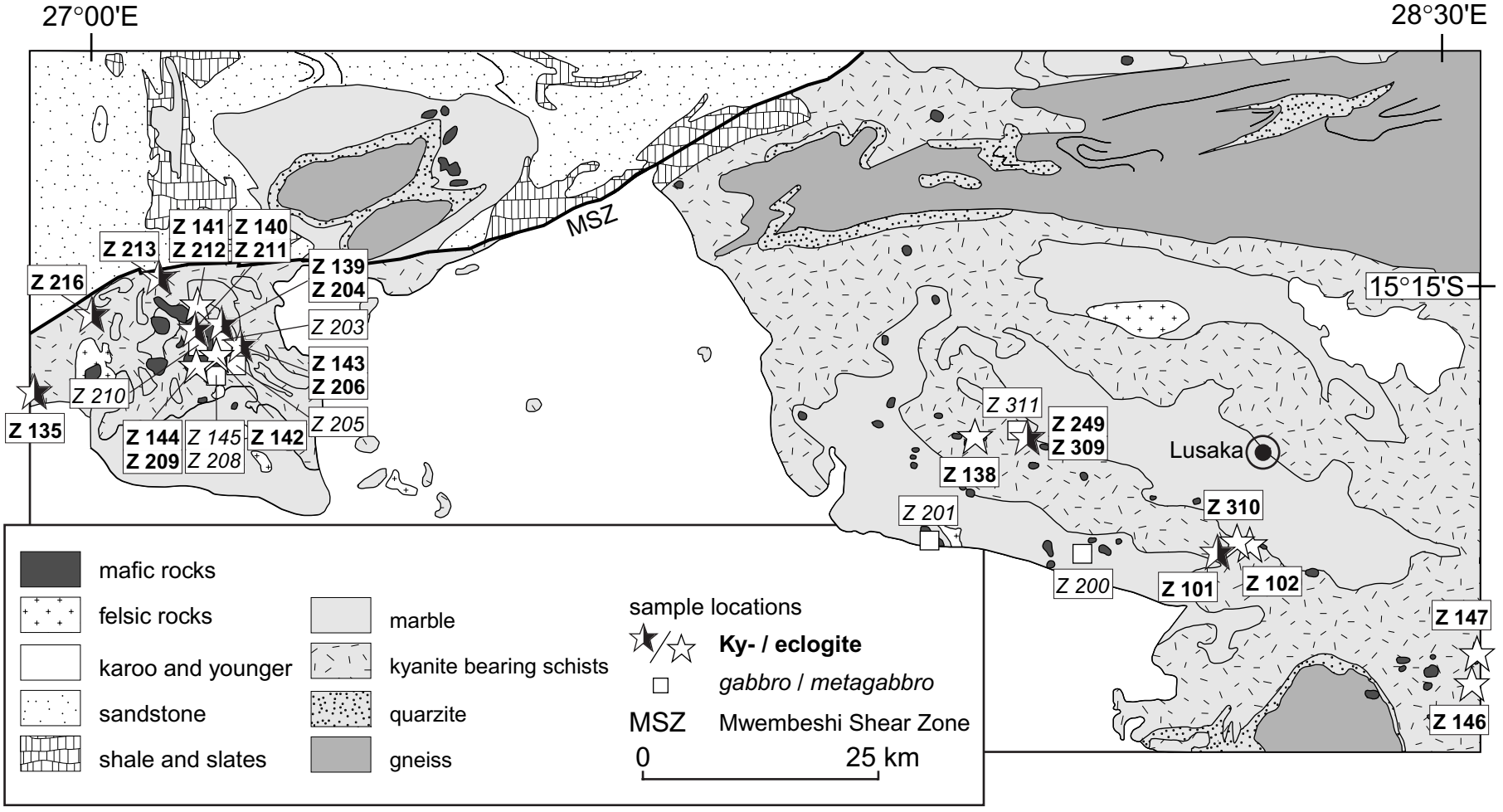
DR2003022


27°00'E
28°30'E
15°15'S
MSZ
Z 141
Z 140
Z 213
Z 212
Z 211
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Z 143
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Z 142
Z 209
Z 208
Z 311
Z 249
Z 309
Lusaka
Z 138
Z 201
Z 310
Z 200
Z 101
Z 102
Z 147
Z 146
mafic rocks
felsic rocks
karoo and younger
sandstone
shale and slates
marble
kyanite bearing schists
quarzite
gneiss
sample locations
Ky- / eclogite
gabbro / metagabbro
MSZ Mwembeshi Shear Zone
0
25 km

TABLE DR1. REPRESENTATIVE MAJOR ELEMENT CONTENTS AND STRUCTURAL FORMULAE OF GARNET (Grt), AMPHIBOLE (Amp), PYROXENE (Cpx), AND PHENGITE (Phe)

Sample	Z 101-5	Z 101-5	Z 101-5	Z 101-5	Z 101-5	Z 101-7	Z 101-7	Z 101-7	Z 101-7	Z 101-7	Z 101-11	Z 101-11	Z 101-11	Z 101-11	Z 101-11
mineral	Amp	Cpx	Grt	Grt	Phe	Amp	Cpx	Grt	Grt	Phe	Amp	Grt	Grt	Cpx	Phe
analysis	amp1p2	cpx2p5	grt1p7	grt2p78	ph1p17	am4p1	cpxx1p2	grt1ap1	grx1p24	phx1p2	am7p1	grx1p24	grt6p3	cpxx1p3	phx1p3
used for	ga*	gc†;ph§	ga	gc;gp#;ph	gp;ph	ga	gc;ph	ga	gc;gp;ph	gp;ph	ga	gc;gp;ph	ga	gc;ph	gp;ph
SiO_2	49.77	55.46	39.95	39.71	51.31	47.36	55.78	40.09	39.63	51.00	49.01	37.87	40.22	55.43	47.93
TiO_2	0.19	0.06	0.04	0.04	0.32	0.32	0.06	0.03	0.09	0.30	0.27	0.10	0.00	0.08	0.54
Al_2O_3	9.40	10.30	22.67	22.42	25.80	13.27	10.34	22.26	22.31	26.08	12.34	21.63	22.01	10.15	29.06
Cr_2O_3	0.02	0.03	0.01	0.02	0.06	N.D.	0.01	0.00	0.10	0.07	N.D.	0.01	0.00	0.14	0.02
FeO	7.37	2.47	18.37	20.90	1.54	7.74	2.52	19.78	18.36	1.24	6.99	25.33	18.38	4.48	1.87
Fe_2O_3	N.D.**	2.40	N.D.	0.08	N.D.	N.D.	1.66	0.00	0.24	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
MgO	16.48	8.51	12.56	9.06	4.28	14.92	9.04	10.22	9.11	4.19	15.08	3.42	12.77	8.78	3.19
MnO	0.03	0.00	0.46	0.41	0.01	0.00	0.02	0.42	0.40	0.00	0.06	2.61	0.52	0.02	0.01
CaO	9.91	12.84	5.70	7.81	0.00	10.64	13.51	8.01	9.73	0.04	8.20	8.90	4.83	12.68	0.01
Na_2O	2.63	6.96	0.00	0.00	0.21	2.94	6.64	0.00	0.00	0.19	4.23	0.00	0.00	7.05	0.70
K_2O	0.65	0.00	0.00	0.00	11.04	1.08	0.00	0.00	0.00	11.14	0.61	0.00	0.00	0.00	10.37
Total	96.44	99.02	99.76	100.45	94.56	98.27	99.58	100.81	99.96	94.25	96.79	99.87	98.73	98.81	93.71
Si	7.119	1.990	5.969	5.996	3.448	6.711	1.988	6.002	5.985	3.436	6.963	5.972	6.057	1.999	3.260
Al^{IV}	0.000	0.010	0.000	0.000	0.552	1.289	0.012	0.000	0.000	0.564	1.037	0.000	0.000	0.001	0.740
Al	1.585	0.426	3.992	3.990	1.491	0.927	0.423	3.928	3.971	1.507	1.029	4.020	3.906	0.431	1.590
Ti	0.021	0.001	0.005	0.005	0.016	0.034	0.002	0.003	0.010	0.015	0.029	0.012	0.000	0.002	0.028
Cr	0.002	0.001	0.001	0.002	0.003	0.000	0.000	0.000	0.011	0.004	0.000	0.001	0.000	0.004	0.001
Fe^{2+}	0.882	0.074	2.295	2.639	0.087	0.917	0.075	2.477	2.318	0.070	0.830	3.341	2.315	0.135	0.106
Fe^{3+}	0.000	0.065	0.000	0.009	0.000	0.000	0.045	0.000	0.027	0.000	0.000	0.000	0.000	0.000	0.000
Mg	3.514	0.455	2.797	2.040	0.429	3.152	0.480	2.281	2.051	0.421	3.194	0.804	2.867	0.472	0.323
Mn	0.004	0.000	0.058	0.052	0.000	0.000	0.001	0.053	0.052	0.000	0.007	0.349	0.066	0.001	0.001
Ca	1.519	0.494	0.912	1.264	0.000	1.615	0.516	1.285	1.574	0.003	1.248	1.504	0.779	0.490	0.001
Na	0.729	0.484	0.000	0.000	0.027	0.808	0.459	0.000	0.000	0.025	1.165	0.000	0.000	0.493	0.092
K	0.118	0.000	0.000	0.000	0.946	0.195	0.000	0.000	0.000	0.958	0.111	0.000	0.000	0.000	0.900
total	15.491	4.000	16.030	15.997	7.000	15.648	4.000	16.030	16.000	7.002	15.613	16.003	15.990	4.027	7.042
XFe	0.20	0.14	0.45	0.56	0.17	0.23	0.14	0.52	0.53	0.14	0.21	0.81	0.45	0.22	0.25
Alm			37.9	44.0				40.6	38.7			55.7	38.4		
Andr			0.0	0.2				0.0	0.7			0.0	0.0		
Grs			15.0	20.8				21.1	25.3			25.0	12.9		
Prp			46.1	34.0				37.4	34.2			13.4	47.6		
Sps			1.0	0.9				0.9	0.9			5.8	1.1		
Uv			0.0	0.0				0.0	0.3			0.0	0.0		

Structural formulae on the basis of: Amp = 23 oxygens; Cpx = 6 oxygens; Grt = 24 oxygens; Phe = 11 oxygens.

* ga = garnet-amphibole thermometry.

† ga = garnet-clinopyroxene thermometry.

§ ph = phengite barometry.

gp = garnet- phengite thermometry; ** N.D. = not determined.

TABLE DR1. CONTINUED

Z 139-7 Grt grt1p5b gc	Z 143-8 Cpx omp2.6 gc	Z 143-8 Grt grt1.2 gc	Z 249-6 Cpx pyx7p1 gc	Z 249-6 Grt grx1.94 gc
38.47	56.30	39.53	56.47	39.01
0.00	0.05	0.00	0.12	0.00
21.26	11.03	22.24	9.69	22.14
0.00	0.00	0.00	0.01	0.00
25.85	2.01	21.84	5.14	23.90
0.79	1.39	0.57	N.D.	0.61
3.98	8.96	8.99	8.84	6.73
0.57	0.04	0.26	0.03	0.23
9.74	13.43	7.14	14.22	8.21
0.00	6.93	0.00	6.53	0.00
0.00	0.00	0.00	0.01	0.00
100.66	100.14	100.56	101.06	100.83
6.000	1.988	5.984	1.992	5.969
0.000	0.012	0.000	0.008	0.000
3.908	0.447	3.968	0.395	3.993
0.000	0.001	0.000	0.003	0.000
0.000	0.000	0.000	0.000	0.000
3.372	0.059	2.764	0.099	3.059
0.093	0.037	0.065	0.053	0.070
0.925	0.472	2.029	0.465	1.535
0.075	0.001	0.033	0.001	0.029
1.628	0.508	1.158	0.537	1.346
0.000	0.474	0.000	0.447	0.000
0.000	0.000	0.000	0.000	0.000
16.000	4.000	16.000	4.000	16.000
0.78	0.11	0.58	0.18	0.67
56.2		46.2		51.2
2.3		1.6		1.8
24.8		17.7		20.8
15.4		33.9		25.7
1.3		0.5		0.5
0.0		0.0		0.0

TABLE DR2. RESULTS OF THERMOBAROMETRIC CALCULATIONS

Sample	Thermometry [°C] Grt - Hbl ± 50	Grt - Cpx ± 25	Grt - Phe ± 25	Barometry [kbar] Phe ± 2.5	Pg#	Remarks
Z 101-5	670	700	735	25.6	—	*; Grt-Hbl only $Fe^{2+} = Fe^{tot}$
Z 101-7	680	770	740	28.3	—	*; Grt-Hbl only $Fe^{2+} = Fe^{tot}$
Z 101-11	655	575	580	15.8	—	all calculations with $Fe^{2+} = Fe^{tot}$
Z 139-7	—	630	—	—	c. 19.7	min T, min P
Z 143-8	—	585	—	—	c. 19.4	min T, min P
Z 249-6	—	640	—	—	c. 20	min T, min P

Paragonite breakdown to Jd_{50} + Ky + H_2O

* Peak-pressures are 1.5 kbar (Z 101-5) and 0.5 kbar (Z 101-7) lower applying the barometer version 1996 (unpubl.- www.earth.ox.ac.uk/~davewa/research/ecbarcal.html)

DR3. GEOCHEMICAL DATA OF ECLOGITES (e) AND GABBROS OR METAGABBR

Sample	Z 142-2	Z 144-2	Z 146-6	Z 201-1	Z 203-9	Z 205-1	Z 249-12
rock-type	e	e	e	g	g	g	g
SiO_2	48.25	48.09	49.81	48.00	47.51	48.71	49.40
Al_2O_3	13.17	14.10	15.22	15.12	13.67	14.16	13.11
TiO_2	1.80	1.43	0.93	1.14	1.62	1.00	1.17
Fe_2O_3	15.32	13.61	10.28	11.91	13.56	10.91	13.87
MnO	0.40	0.28	0.11	0.28	0.25	0.16	0.21
MgO	6.87	7.42	8.81	7.53	7.20	8.61	7.11
CaO	11.35	11.88	12.78	11.85	11.57	12.55	11.02
Na_2O	2.40	2.76	3.05	2.75	3.29	2.31	2.64
K_2O	0.11	0.41	0.15	0.10	0.16	0.09	0.12
P_2O_5	0.13	0.11	0.06	0.07	0.11	0.08	0.08
LOI	0.74	0.57	0.53	N.D.*	N.D.	N.D.	N.D.
total	100.54	100.66	101.73	98.75	98.94	98.58	98.73
Mg#	0.34	0.39	0.50	0.42	0.38	0.48	0.37
K	913.22	3403.82	1245.30	830.20	1328.32	747.18	996.24
P	732.42	636.64	349.31	394.38	619.74	450.72	450.72
Ti	10791.00	8572.85	5575.35	6834.30	9711.90	5995.00	7014.15
Rb	1.93	5.83	1.29	3.16	3.54	1.97	1.90
Sr	88.39	150.49	29.54	209.89	130.64	97.79	80.75
Y	38.10	27.49	18.31	25.95	35.80	20.54	28.01
Zr	84.85	70.73	41.43	62.83	75.67	49.16	56.40
Nb	2.17	2.21	1.21	1.22	1.76	2.02	2.45
Cs	0.05	0.31	0.07	0.08	0.04	0.10	0.01
Ba	74.50	40.84	14.39	128.78	93.04	27.06	18.59
La	1.96	3.27	1.69	2.06	1.93	2.49	2.58
Ce	6.90	9.76	4.60	6.08	6.42	6.47	6.73
Pr	1.44	1.72	0.85	1.11	1.28	1.10	1.14
Nd	8.81	9.64	4.83	6.37	7.92	6.10	6.39
Sm	3.66	3.63	1.82	2.49	3.39	2.28	2.79
Eu	1.33	1.41	0.58	0.98	1.23	0.87	1.01
Gd	5.32	4.86	2.37	3.60	4.97	3.19	3.74
Tb	1.07	0.90	0.51	0.71	0.97	0.59	0.73
Dy	7.42	5.84	3.81	4.62	6.46	3.89	4.96
Ho	1.64	1.24	0.85	1.01	1.38	0.82	1.10
Er	4.96	3.70	2.61	2.78	3.81	2.24	3.02
Tm	0.73	0.53	0.38	0.43	0.59	0.34	0.48
Yb	4.69	3.41	2.44	2.91	3.89	2.25	3.16
Lu	0.72	0.52	0.39	0.44	0.59	0.34	0.47
Hf	2.77	2.44	1.50	1.95	2.35	1.63	1.89
Ta	0.15	0.16	0.09	0.08	0.12	0.13	0.16
Pb	1.06	2.34	0.74	3.05	0.89	1.18	0.76
Th	0.14	0.17	0.14	0.13	0.13	0.15	0.17
U	0.06	0.42	0.05	0.03	0.04	0.04	0.05

* N.D. = not determined

TABLE DR4. $(La/Sm)_N$ AND Nb/La RATIOS OF SAMPLES

Sample		$(La/Sm)_N$	Nb/La
Z 101-7	e*	0.498	0.429
Z 138-1	e	0.345	0.671
Z 138-3	e	0.430	0.947
Z 138-5	e	0.352	0.594
Z 138-10	g†	0.417	0.611
Z 139-7	e	0.460	1.497
Z 140-1	g	0.391	0.600
Z 140-5	e	0.592	0.331
Z 142-1	e	0.527	0.675
Z 142-2	e	0.337	1.110
Z 143-8	e	0.508	1.041
Z 144-1	e	0.510	0.819
Z 144-2	e	0.567	0.675
Z 146-1	e	0.502	0.968
Z 146-6	e	0.583	0.715
Z 147-3	e	0.567	0.754
Z 200-2	g	0.480	0.831
Z 201-1	g	0.521	0.591
Z 203-1	g	0.334	0.926
Z 203-9	g	0.358	0.914
Z 205-1	g	0.686	0.812
Z 206-9	e	0.970	1.039
Z 210-1	g	0.453	0.517
Z 216-1	e	0.507	0.436
Z 216-9	e	0.434	0.676
Z 249-1	e	0.422	1.041
Z 249-12	g	0.581	0.949

* e = eclogite

† g = gabbro or metagabbro

TABLE DR5. Sm-Nd DATA

Sample		Sm (ppm)	Nd (ppm)	$^{147}Sm/^{144}Nd$	$^{143}Nd/^{144}Nd$ (now)	εNd (now)	$^{143}Nd/^{144}Nd$ (720 Ma)	εNd (720 Ma)
Gabbros and Metagabbros								
Z 201-1*	wr	2.18	5.74	0.2296	0.513175 (11)	+10.5	0.512091	+7.5
Z 203-9*	wr	3.01	7.16	0.2546	0.513292 (10)	+12.8	0.512090	+7.4
Z 205-1	wr	2.01	5.54	0.2196	0.513150 (8)	+10.0	0.512114	+7.9
Z 249-12†	wr	N.D.§	5.50	N.D.	0.513216 (8)	+11.3	N.D.	N.D.
Ky-bearing Eclogites								
Z 143-8	wr	0.809	2.14	0.2283	0.513076 (8)	+ 8.5	0.511998	+5.6
	grt	0.0128	0.0180	0.4280	0.513911 (75)	+24.8	N.A.#	N.A.
Z 309-5	wr	1.29	3.04	0.2563	0.513305 (5)	+13.0	0.512095	+7.5
	grt**	0.225	0.153	0.8880	0.515766 (19)	+61.0	N.A.	N.A.
Other Eclogites								
Z 142-2	wr	3.36	8.43	0.2407	0.513241 (7)	+11.8	0.512105	+7.7
Z 144-2	wr	3.27	8.88	0.2225	0.513123 (9)	+ 9.5	0.512073	+7.1
Z 146-6	wr	1.61	4.48	0.2165	0.513115 (10)	+ 9.3	0.512093	+7.5

Note: Garnet separates were prepared at UniversitŠt Kiel and UniversitŠt MŸnster using a steel jaw crusher, magnetic separator, and hand picking. To remove surface contamination, garnets were washed for 10 minutes in cold 1M HCl, then rinsed with distilled water. All samples were spiked with a mixed ^{149}Sm-^{150}Nd tracer before being digested with HF-HNO_3-$HClO_4$ in bombs at 180¡C. Sm and Nd data were measured on a VG Sector 54 TIMS at the Zentrallabor fŸr Geochronologie in MŸnster. Nd isotope ratios were normalized to $^{146}Nd/^{144}Nd$ = 0.7219. The mean $^{143}Nd/^{144}Nd$ of the La-Jolla Nd standard was 0.511858 during this study; no correction for instrumental bias has been applied here. Procedural blanks for Nd and Sm were less than 200 pg and 50 pg, respectively. Chondritic uniform reservoir (CHUR) parameters used for calculating ε_{Nd} values are $^{143}Nd/^{144}Nd$ = 0.512638, $^{147}Sm/^{144}Nd$ = 0.1967.

*Garnet-bearing gabbros.

†Amphibole-bearing gabbro.

§N.D. = not determined.

#N.A. = not applicable.

**Impure garnet separate.