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Geochemistry, Geophysics, Geosystems

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Supporting Information for

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Strain localization in the root of detachment faults at a melt-starved

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mid-ocean ridge: a microstructural study of abyssal peridotites from the

6

eastern Southwest Indian Ridge

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Additional Supporting Information (Files uploaded separately)

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Captions for Tables S2 to S3

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(tables S2 and S3 larger than 1 page, uploaded as separate files)

24

25 **Introduction**

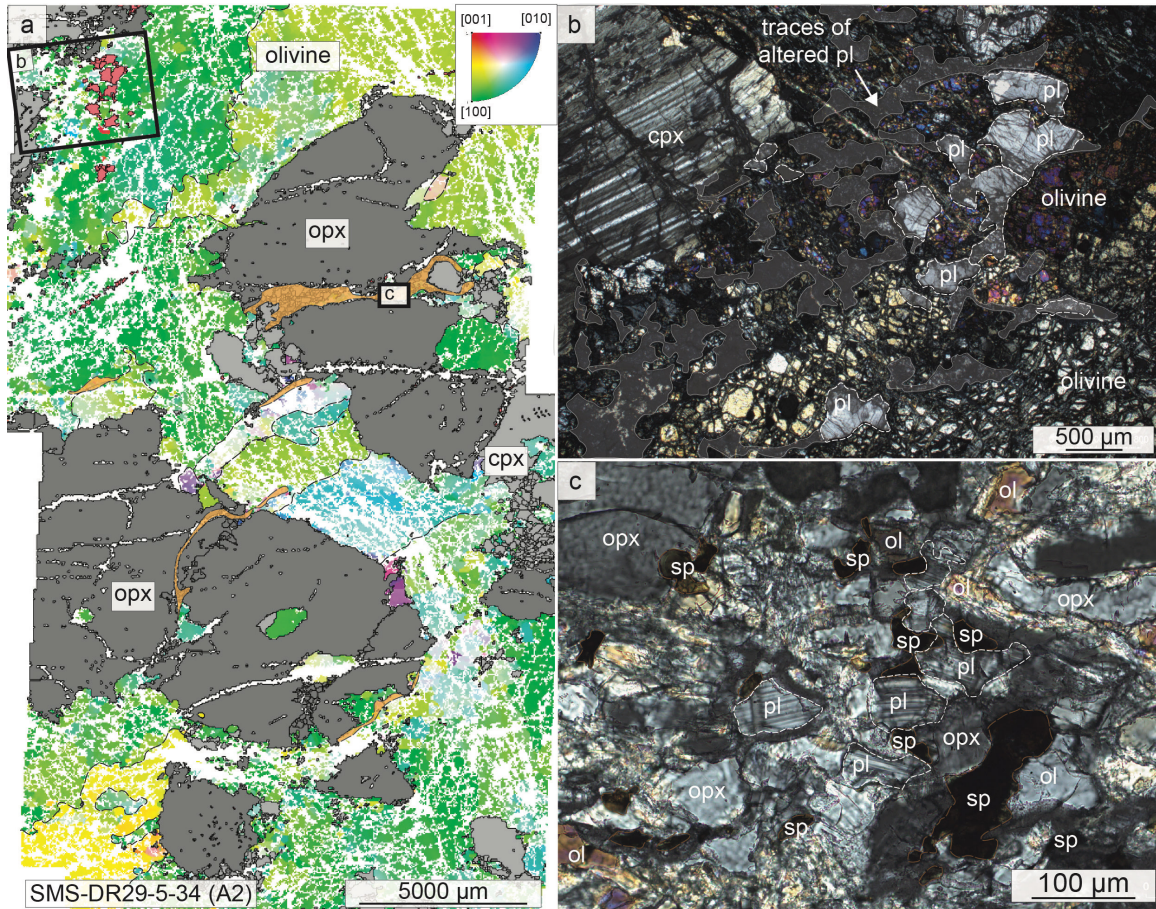
26 In this section we provide tables of data and additional figures in further support
27 for the results presented in the paper.

28 Table A1 displays the depths and positions of the dredges. Table A2 provides the
29 IGSN code of the samples analyzed in this. Table A3 provides microprobe data on a
30 selection of syn-, late and post-kinematic amphiboles. Table A4 compares olivine grain
31 sizes from olivine-rich and polymineralic GSR zones, and two methods of measurements
32 (optical microscopy and EBSD).

33 Figure A1 illustrates the texture of plagioclase impregnations. Figure A2 shows
34 microphotographs and SEM images of a polymineralic GSR zone. Figure A3 shows the
35 olivine CPO for 10 samples. Figure A4 shows the CPO of syn- to late kinematic
36 amphibole in a polymineralic GSR zone.

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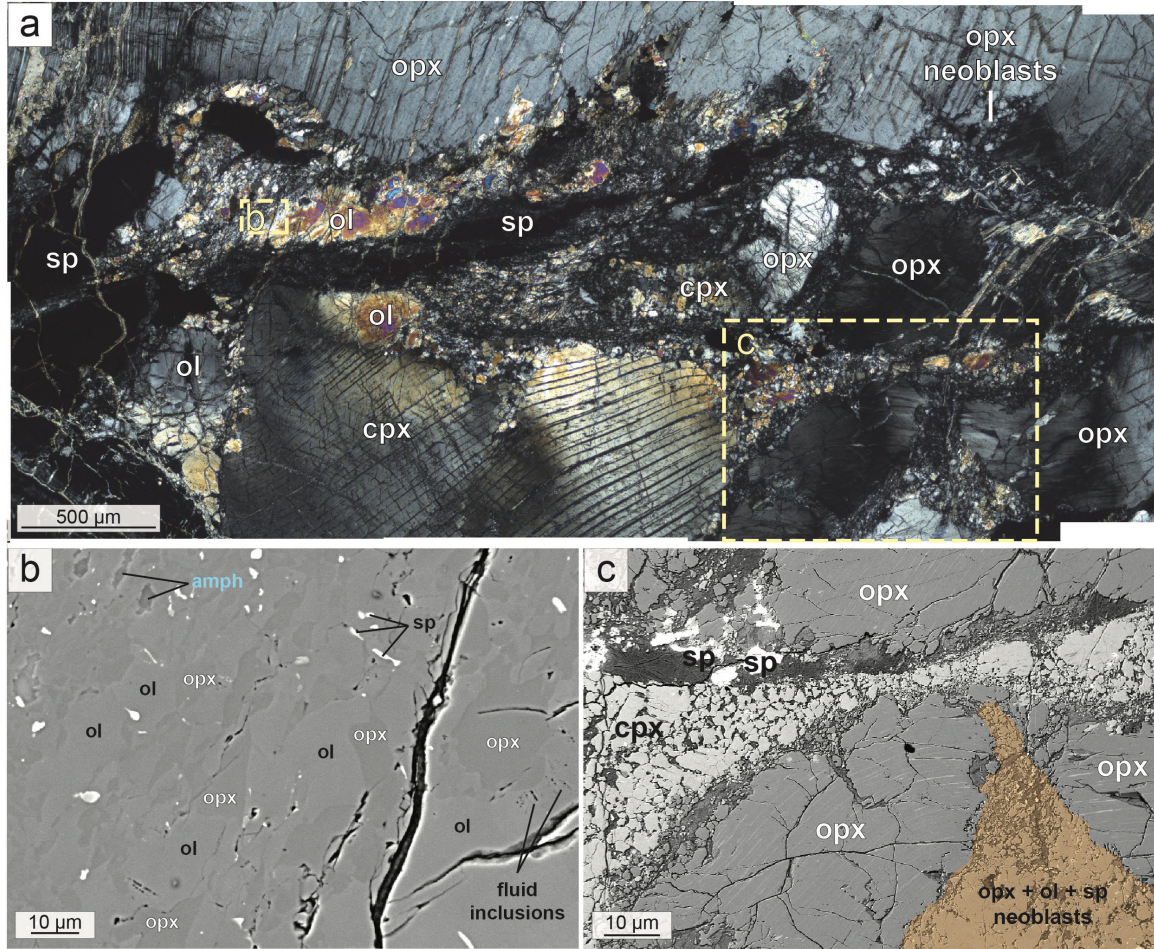
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40 **Figure S1.** Plagioclase in partially serpentinized sample SMS-DR29-5-34 (textural type
 41 A2). (a) EBSD map of olivine CPO, showing the location of crossed-nicols
 42 microphotographs (b-c). EBSD pixel size is 35 μm * 35 μm. Inverse Pole Figure (IPF, long
 43 axis of the map) color key is shown at the top right of the EBSD map. (a) Orthopyroxene
 44 is displayed in dark grey, clinopyroxene in light grey, spinel in dark blue, and GSR zones
 45 in orange. (b) Plagioclase (pl, partially altered) occurs as patches of interstitial grains into
 46 olivine (ol). (c) Plagioclase (pl, also partially altered) forms smaller interstitial patches in a
 47 GSR zone made of recrystallized olivine (ol), orthopyroxene (opx), and spinel (sp) grains.
 48 Plagioclase is not recrystallized and displays mostly magmatic twins, more irregular
 49 mechanical twins are uncommon.

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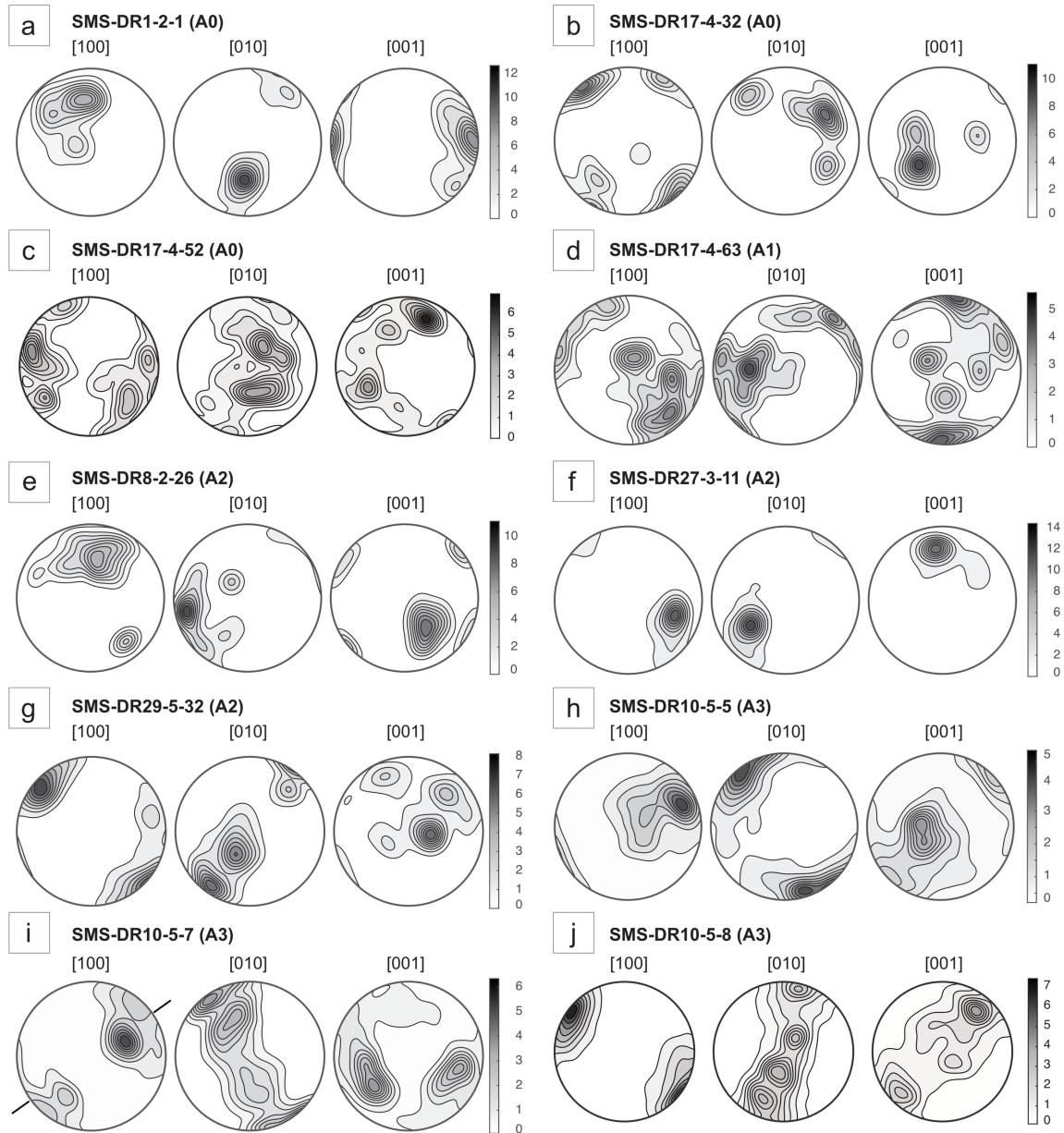


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52 **Figure S2.** Textural type A3: Microphotographs and SEM images of a GSR zone along an
 53 orthopyroxene porphyroclast from sample SMS-DR10-4-13. (a) Crossed-nichols
 54 microphotograph of a GSR zone. Clinopyroxene and spinel are deformed and show tails
 55 of recrystallization. (b) SEM image of the recrystallized assemblage, which is composed
 56 of olivine (ol) + orthopyroxene (opx) + spinel (sp) and occasional late to post-kinematic
 57 amphibole (amph). (c) Clinopyroxene (cpx) recrystallizes into an assemblage of
 58 clinopyroxene and interstitial spinel grains. Dynamic recrystallized olivine, orthopyroxene,
 59 and spinel grains (orange shading) fill an open fracture into an orthopyroxene (opx)
 60 porphyroclast.

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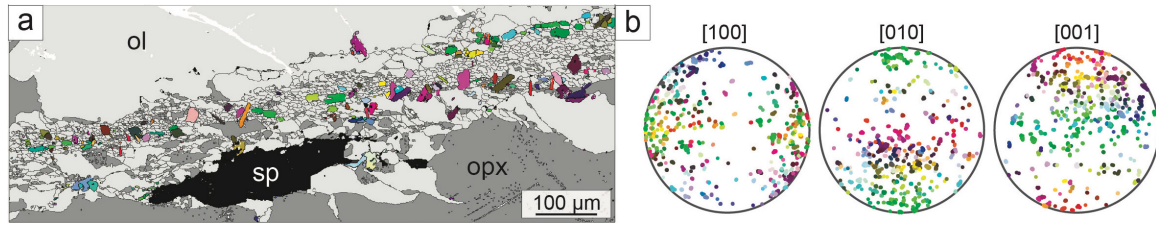


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64 Figure S3. Equal area lower hemisphere stereographic projections of the [100], [010], and [001]
 65 crystallographic axes of olivine in partially serpentinized peridotite samples with textural types A0
 66 (a-c), A1 (d), A2 (e-g), and A3 (h-j). EBSD pixel size is 35 μm * 35 μm . Pole figures are shown in
 67 density contours of the distribution at 1 multiple of a uniform distribution intervals. EBSD
 68 measurements were completed for each sample in only one thin section. Sample number and
 69 textural type (in brackets) are shown in upper left for each CPO figure. (e, f) Small black lines
 70 indicate the trace of GSR zones for samples with textural type A3. (i) Small black lines indicate
 71 the trace of GSR zones, when possible.

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75 **Figure S4.** EBSD crystal orientation maps (a) and equal area lower hemisphere
76 stereographic projections (b; all measurements plotted as one point per pixel) in the
77 EBSD map reference frame of the [100], [010], and [001] crystallographic axes of
78 amphibole in a thin GSR zone at the contact between orthopyroxene and olivine in
79 sample SMS-DR17-4-6 (textural type A2; see Figure 15). EBSD pixel size is 1 μm². In (a)
80 olivine (ol) is in light grey, orthopyroxene (opx) in dark grey and spinel (sp) in black.

81

Dredge	Number of ultramafic samples		Number of partially serpentinized samples		Deformation textures in variably serpentinized ultramafic samples				Deformation textures in partially serpentinized samples											
					Kinks in OPX	Recryst. px	GSR zones		Recryst. ol	A0	A1	A2	A3							
SMS-DR1	6	(1)	5	(1)	6	(1)	6	(1)	0	-	0	-	5	(1)	-	-	-	-	-	
SMS-DR2	6	-	1	-	5	-	1	-	3	-	0	-	1	-	-	-	-	-	-	
SMS-DR3	5	(1)	1	-	5	(1)	4	(1)	0	-	1	-	-	-	1	-	-	-	-	
SMS-DR4	4	-	0	-	4	-	0	-	4	-	0	-	-	-	-	-	-	-	-	
SMS-DR5	14	-	0	-	7	-	4	-	4	-	0	-	-	-	-	-	-	-	-	
SMS-DR6	11	(3)	8	(2)	11	(3)	5	(3)	3	(1)	2	-	3	-	3	(1)	2	(1)	-	
SMS-DR7	11	(1)	5	(1)	8	(1)	1	-	2	-	1	-	3	(1)	1	-	1	-	-	
SMS-DR8	10	(2)	3	(1)	7	(2)	3	(1)	5	(1)	1	-	1	-	-	-	2	(1)	-	
SMS-DR9	1	-	0	-	1	-	1	-	0	-	0	-	-	-	-	-	-	-	-	
SMS-DR10	16	(1)	14	(1)	16	(1)	16	(1)	16	(1)	11	-	-	-	-	-	5	-	9	
SMS-DR11	13	(2)	1	(1)	9	(2)	2	-	2	-	0	-	1	(1)	-	-	-	-	-	
SMS-DR12	17	(4)	0	-	10	(3)	7	(1)	1	-	0	-	-	-	-	-	-	-	-	
SMS-DR13	15	(4)	0	-	13	(3)	7	(3)	5	-	0	-	-	-	-	-	-	-	-	
SMS-DR14	7	-	0	-	3	-	1	-	3	-	0	-	-	-	-	-	-	-	-	
SMS-DR15	14	-	1	-	6	-	3	-	1	-	1	-	-	-	1	-	-	-	-	
SMS-DR16	4	-	0	-	2	-	0	-	0	-	0	-	-	-	-	-	-	-	-	
SMS-DR17	44	(4)	27	(2)	31	(3)	11	(1)	13	(2)	5	(1)	15	(1)	4	(1)	4	-	4	
SMS-DR20	3	(1)	0	-	1	(1)	0	-	0	-	0	-	-	-	-	-	-	-	-	
SMS-DR21	7	-	0	-	7	-	0	-	0	-	0	-	-	-	-	-	-	-	-	
SMS-DR22	17	(6)	0	-	16	(6)	0	-	3	(1)	0	-	-	-	-	-	-	-	-	
SMS-DR26	4	(1)	0	-	4	(1)	1	-	0	-	0	-	-	-	-	-	-	-	-	
SMS-DR27	34	(2)	4	-	28	(2)	3	(1)	8	(1)	0	-	2	-	-	-	2	-	-	
SMS-DR28	10	-	0	-	6	-	1	-	1	-	0	-	-	-	-	-	-	-	-	
SMS-DR29	48	(5)	28	(2)	39	(4)	13	(3)	15	(1)	11	(1)	11	-	7	(1)	9	(1)	1	
SMS-DR30	9	(4)	0	-	6	(4)	2	(2)	2	(1)	0	-	-	-	-	-	-	-	-	
SMS-DR32	3	(1)	0	-	2	-	0	-	0	-	0	-	-	-	-	-	-	-	-	
SMS-DR33	15	(6)	1	(1)	11	(6)	10	(3)	8	(3)	0	-	-	-	-	-	-	-	1	
SMS-DR34	28	(11)	0	-	19	(9)	11	(6)	4	-	0	-	-	-	-	-	-	-	-	
SMS-DR35	9	-	0	-	9	-	8	-	7	-	0	-	-	-	-	-	-	-	-	
TOTAL	385	(61)	99	(12)	292	(53)	121	(27)	110	(12)	33	(2)	42	(4)	17	(3)	25	(3)	15	(2)
Proportion (partially serpentinized)	-	-	0.00	(0.20)	0.00	(0.99)	0.49	(0.83)	0.39	(0.42)	0.33	(0.17)	0.42	(0.33)	0.17	(0.25)	0.25	(0.25)	0.15	(0.17)
Proportion (extensively serpentinized)	-	-	0.74	(0.80)	0.68	(0.84)	0.25	(0.35)	0.25	(0.14)	-	-	-	-	-	-	-	-	-	-

82
83 **Table S1.** Depths and positions of the dredges done on and off axis during
84 *Smoothseafloor* cruise (2010 ; R/V Marion Dufresne ; Pi : D. Sauter and M. Cannat).
85 Positions are based on on-bottom/off-bottom positions and recalculated from ship
86 positions. Abbreviations: longitude (long.), and latitude (lat.). Shaded dredges
87 correspond to the dredges without any partially serpentinized peridotites.

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89

90 Table S2 is uploaded as separate file.

91 **Table S2.** Name and IGSN code (<http://www.igsn.org>) of partially serpentinized samples
92 used in this study.

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95 Table S3 is uploaded as separate file.

96 **Table S3.** Mineral composition of amphiboles in GSR zones from 5 samples of
97 serpentinized peridotites. Compositions are reported in oxide-weight percent (wt%), and
98 units of the structural formula. In situ major elements concentrations in amphibole were
99 measured using a Cameca SX-100 electron microprobe (CAMPARIS service, Paris). The
100 acceleration voltage was fixed at 15 kV and beam current at 10 nA. The spot size was 1-

101 2 μ m. Counting time was 10s. Three types of amphibole are distinguished: fibrous (post
 102 deformation), prismatic and polygonal (in GSR zones).

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104

Sample	Textural type	Method	Recrystallized assemblage	Number of measured grains	d (μ m)	std (μ m)	Mean calculated stress (MPa)	Calculated stress range (MPa)
SMS_DR8_2_26B	A2	Manual ^a	ol	310	22	12	120	86 - 218
		EBSDB ^b	ol	791	12	9	186	123 - 490
		EBSDB ^b	ol + opx + sp \pm amph	739	14	9	-	-
SMS_DR17_4_6	A2	Manual ^a	ol	228	10	5	219	162 - 364
		EBSDB ^b	ol + opx + sp \pm amph	3619	6	4	-	-
SMS_DR10_4_8A	A3	Manual ^a	ol	555	11	5	200	150 - 320
		EBSDB ^b	ol	12522	9	6	233	160 - 502
SMS-DR10-4-13	A3*	Manual ^a	ol	68	37	13	79	64 - 110
SMS_DR10_5_7	A3	Manual ^a	ol	65	10	4	215	170 - 304
		EBSDB ^b	ol + opx + cpx + sp	5179	7	5	-	-

105

106 **Table S4.** Dynamically recrystallized olivine grain sizes measured in GSR zones in 5
 107 selected samples, and in aggregates of coarser olivine grains (similar to texture A1) were
 108 measured away from the GSR zones of sample SMS-DR10-4-13. In each sample, grain
 109 diameters were measured in several areas in both olivine-rich and polymineralic GSR
 110 zones (see Bickert et al., 2020). Two methods of measurements were used: (a) manually
 111 (data from Bickert et al., 2020), (b) using the EBSD with a step size of 2 μ m and a
 112 disorientation angle $>15^\circ$ between adjacent pixels of the same mineral as a criteria to
 113 draw grain boundaries. For each area, we also provide the nature of the recrystallized
 114 assemblage, the number of measured grains, the mean diameter (d) in μ m, and, for
 115 olivine-rich domains, the corresponding deviatoric stresses in MPa calculated using the
 116 Van der Wal et al. (1993) piezometer and the external range of stress in MPa. The
 117 external limits of the stress range for each sample were calculated by integrating the
 118 standard deviation into the mean corrected grain size.

119