Geophysical Research Letters

Supporting Information for

Deformation, CPO and Elastic Anisotropy in Low-grade Metamorphic Serpentinites, Atlantis Massif Oceanic Core Complex

R. Kuehn[1], J. H. Behrmann[2], M. Stipp[1], R. Kilian[1], and B. Leiss[3]

[1]Martin-Luther-University Halle, Institute of Geosciences and Geography, Von-Seckendorff-Platz 3, 06120 Halle (Saale), Germany; [2] GEOMAR Helmholtz Centre for Ocean Research Kiel, Marine Geodynamics, Wischhofstr. 1-3, 24148 Kiel, Germany; [3] Geoscience Center of the Georg-August-Universität Göttingen, Department of Structural Geology and Geodynamics, Goldschmidtstr. 3, 37077 Göttingen, Germany.

Contents of this file

Introduction

The supporting information contains data regarding four serpentinite samples from the Atlantis Massif Oceanic Core Complex. There are different types of data:

S1-S4) µXRF maps as image files for the elements Al, Cr, Fe, Mn, Mg & Si acquired with a Bruker Tornado µXRF. These maps were used for the microstructure analysis.

Table S5) contains the ACF related data determined from these maps.

S6-10) Data set of elasticity tensors calculated from the CPO results and the elasticity tensor as determined by Auzende et al., (2006) and Tsuchiya (2013) using the Matlab Toolbox MTEX.

S11-12) Figures showing the development of Vp with increasing pressure as calculated from the elasticity tensors calculated by Tsuchiya (2013).

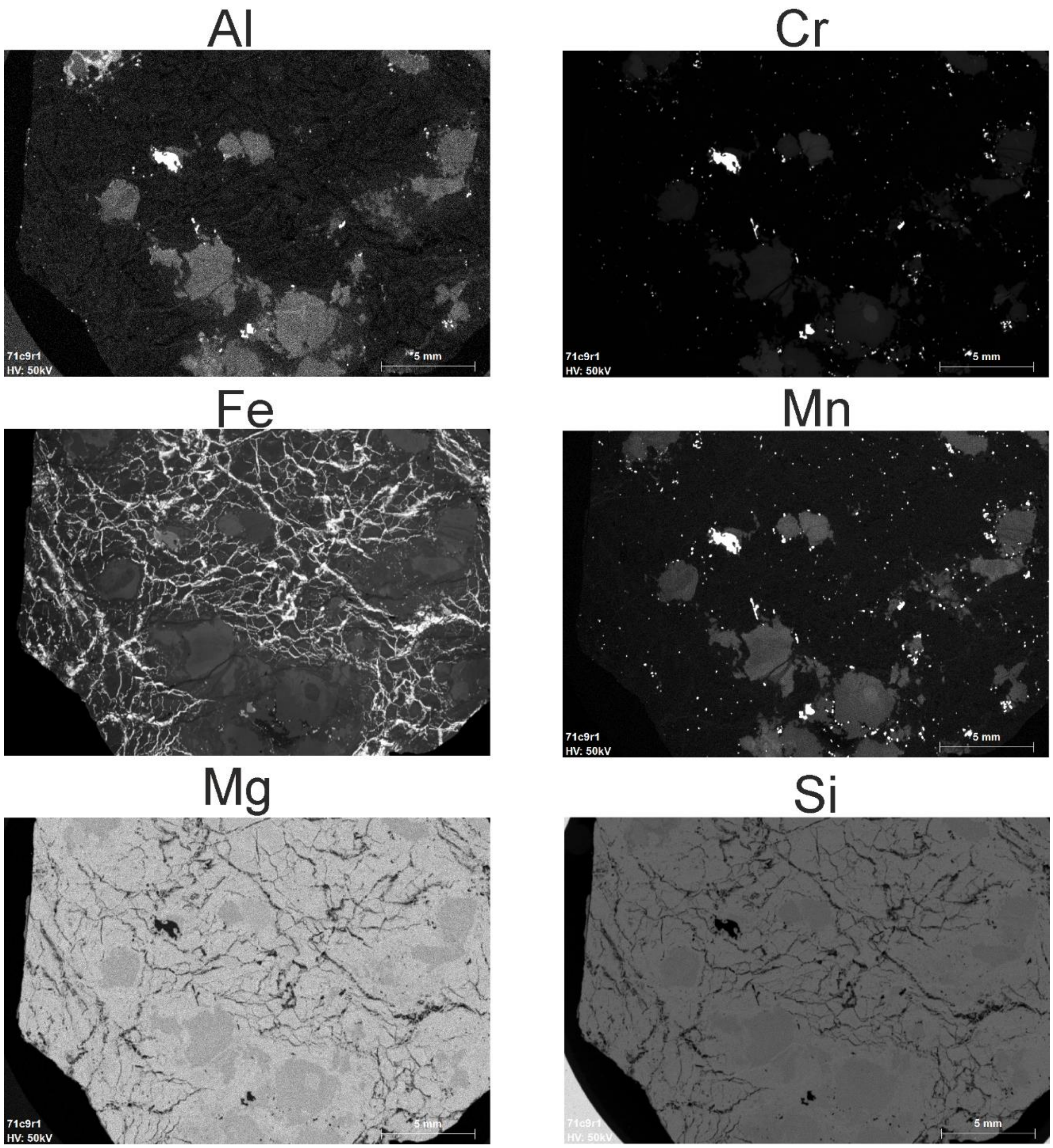

Figure S1. Images of µXRF maps for sample 71C9R1.

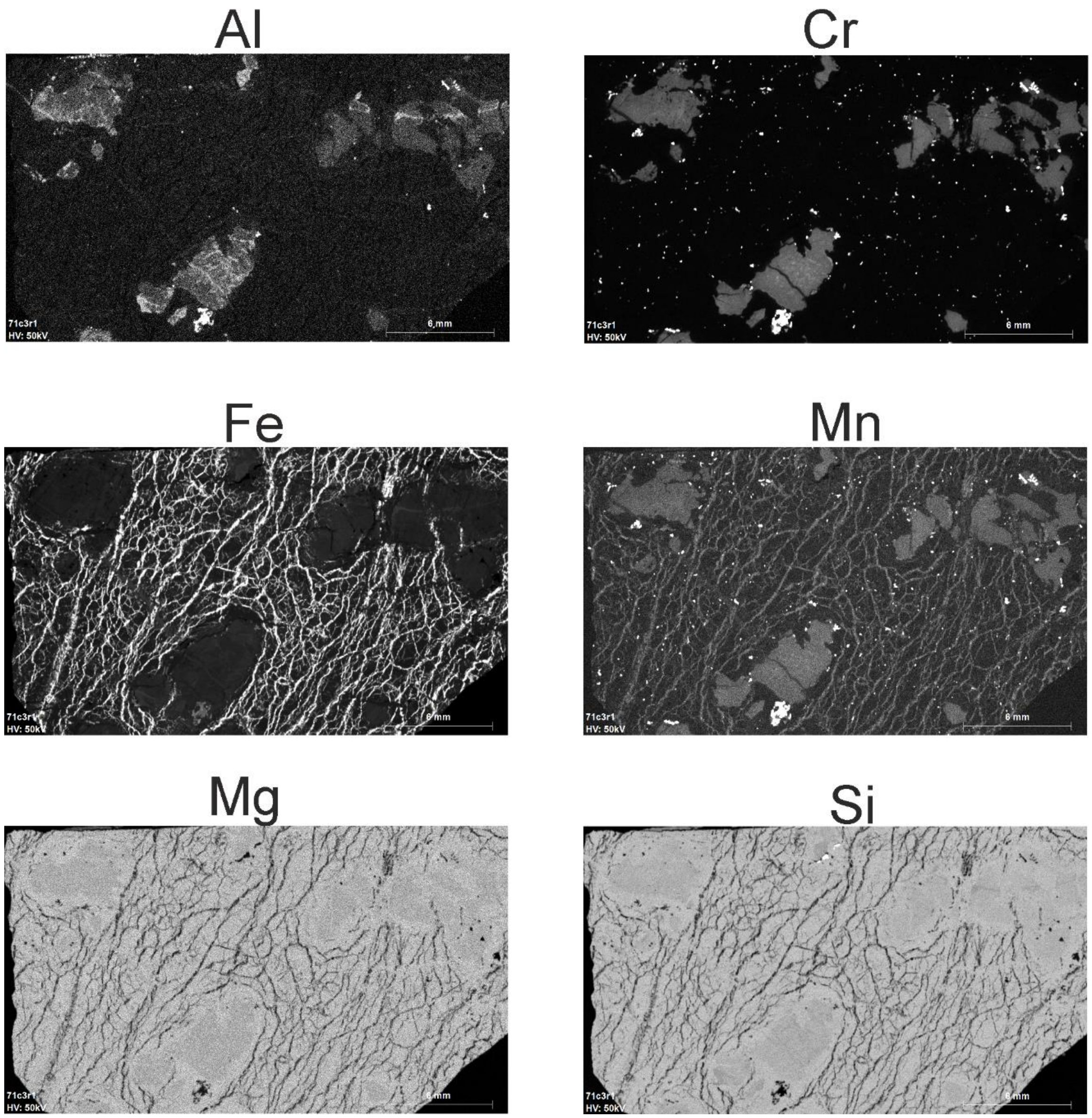

Figure S2. Images of µXRF maps for sample 71C3R1.

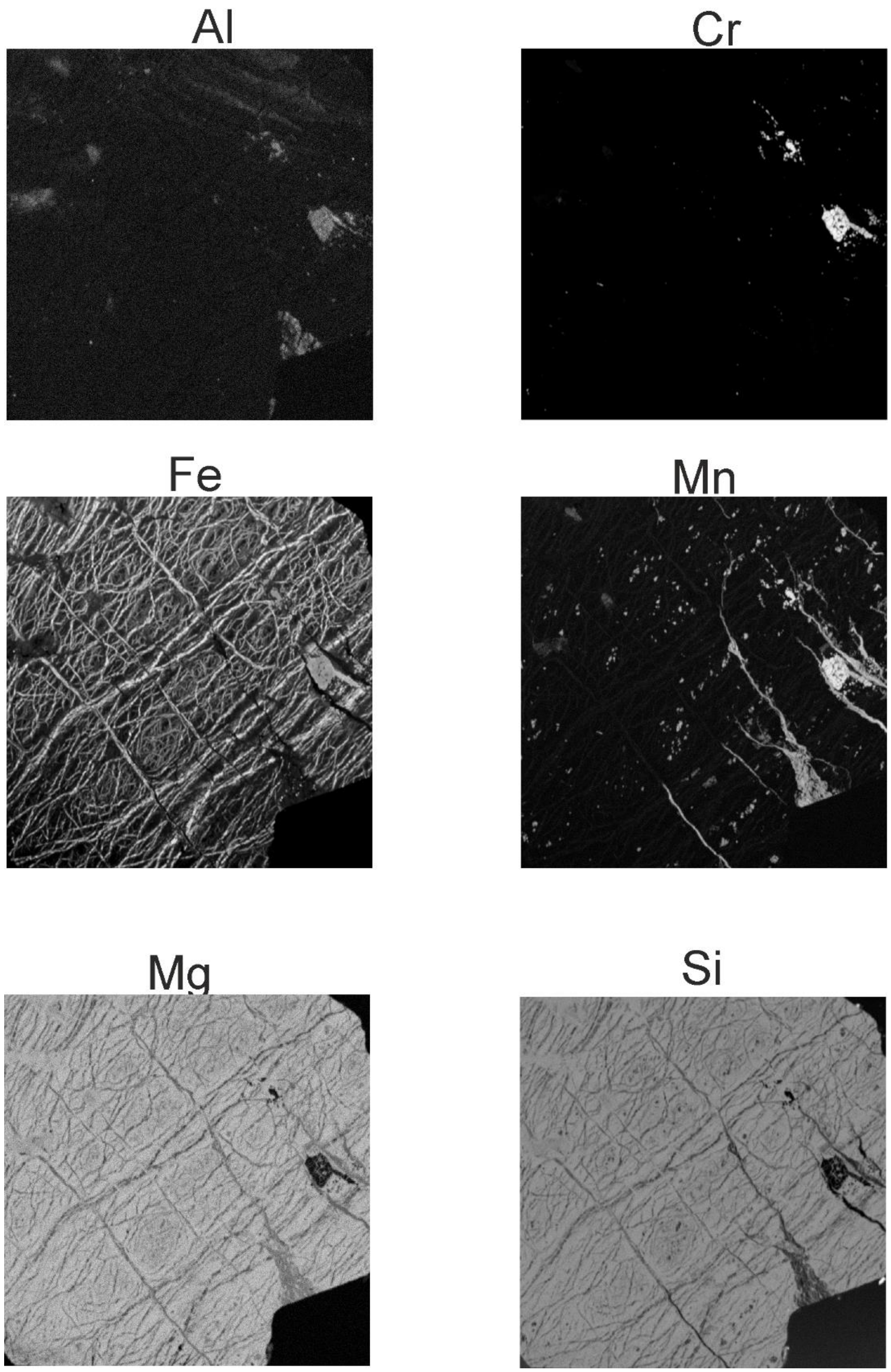

Figure S3. Images of µXRF maps for sample 76B5R1.

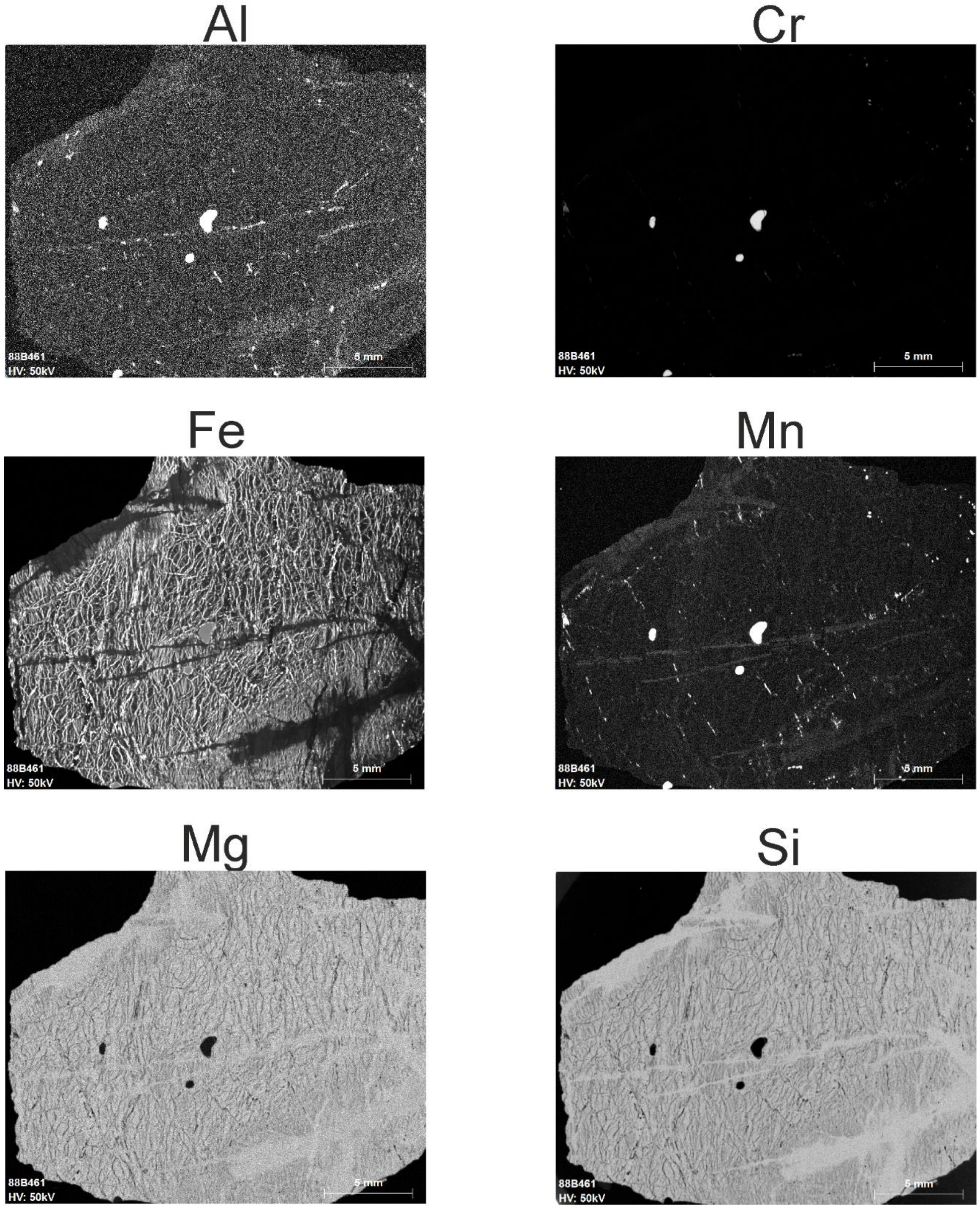

Figure S4. Images of µXRF maps for sample 768B4R1.

Table S5. Results of ACF analysis

Sample	Average px size of grain area	Major axis of ACF ellipse fit	Minor axis of ACF ellipse fit	Fs
71C9R1	800	37.34	27.38	0.26
71C3R1	500	39.74	16.18	0.58
76B5R1	700	66.68	13.16	0.8
68B4R1	500	43.92	17.18	0.67

Table S6. Tensor data for velocity calculations.

<table>
<tr><td></td><td colspan="6">Auzende et al., 2006; roomT, 0 GPa pressure,
density: 2.5155; %g/cm^3</td><td colspan="6">Tsuchiya 2013, 0 GPa pressure
density: 2.5155; %g/cm^3</td></tr>
<tr><td>Crystal symmetry</td><td colspan="6">312, a=5.323, b=5.323, c=7.272
X||a*, Y||b, Z||c</td><td colspan="6">31m, a=5.3, b=5.3, c=7.4
X||a*, Y||b, Z||c*</td></tr>
<tr><td rowspan="6">Single crystal stiffness Tensor</td><td>229.08</td><td>89.04</td><td>13.56</td><td>0</td><td>0</td><td>0</td><td>212.6</td><td>73.28</td><td>8.5</td><td>1.3</td><td>0</td><td>0</td></tr>
<tr><td>89.04</td><td>229.08</td><td>13.56</td><td>0</td><td>0</td><td>0</td><td>73.28</td><td>212.6</td><td>8.5</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>13.56</td><td>13.56</td><td>45.84</td><td>0</td><td>0</td><td>0</td><td>8.5</td><td>8.5</td><td>57.3</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>0</td><td>0</td><td>0</td><td>12.77</td><td>0</td><td>0</td><td>1.3</td><td>0</td><td>0</td><td>11.6</td><td>0</td><td>0</td></tr>
<tr><td>0</td><td>0</td><td>0</td><td>0</td><td>12.77</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>11.6</td><td>0</td></tr>
<tr><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>70.02</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>69.68</td></tr>
<tr><td>Transformed crystal symmetry</td><td colspan="6">-3m1, a=5.3, b=5.3, c=7.3
X||a, Y||b*, Z||c*</td><td colspan="6">-3m1, a= 5.3, b=5.3, c=7.3
X||a, Y||b*, Z||c*</td></tr>
<tr><td rowspan="6">Transformed single crystal stiffness tensor</td><td>229.08</td><td>89.04</td><td>13.56</td><td>0</td><td>0</td><td>0</td><td>212.61</td><td>73.27</td><td>8.5</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>89.04</td><td>229.08</td><td>13.56</td><td>0</td><td>0</td><td>0</td><td>73.27</td><td>212.61</td><td>8.5</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>13.56</td><td>13.56</td><td>45.84</td><td>0</td><td>0</td><td>0</td><td>8.5</td><td>8.5</td><td>57.3</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>0</td><td>0</td><td>0</td><td>12.77</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>11.6</td><td>0</td><td>0</td></tr>
<tr><td>0</td><td>0</td><td>0</td><td>0</td><td>12.77</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>11.6</td><td>0</td></tr>
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</table>

Table S7. Calculated bulk elasticity tensor for sample 71C9R1 using the elastic stiffness tensors from Auzende et al. (2006) and Tsuchiya (2013)

	Elasticity data from Auzende et al. (2006)						Elasticity data from Tsuchiya (2013) for 0 GPa pressure					
Voigt	160.94	58.36	57.33	-0.24	-1.19	-1.06	137.25	44.87	43.57	-0.1	-1.24	-1.21
	58.36	156.72	56.14	-0.69	-0.19	-0.53	44.87	133.21	42.36	-0.65	0.15	-0.3
	57.33	56.14	154.44	-0.97	-1.65	-0.42	43.57	42.36	130.99	-1.12	-2.02	-0.38
	-0.24	-0.69	-0.97	48.86	-0.28	0.03	-0.1	-0.65	-1.12	43.37	-0.33	0.25
	-1.19	-0.19	-1.65	-0.28	49.67	-0.1	-1.24	0.15	-2.02	-0.33	44.42	-0.04
	-1.06	-0.53	-0.42	0.03	-0.1	50.47	-1.21	-0.3	-0.38	0.25	-0.04	45.61
Reuss	64.89	22.59	22.34	0	-0.42	-0.4	75.19	29.98	29.52	0.1	-0.5	-0.59
	22.59	63.37	22.1	-0.23	0.08	-0.17	29.98	73.53	29.21	-0.23	0.34	-0.05
	22.34	22.1	62.63	-0.34	-0.6	-0.07	29.52	29.21	72.79	-0.48	-0.93	-0.08
	0	-0.23	-0.34	20.1	-0.13	-0.02	0.1	-0.23	-0.48	21.12	-0.18	0.13
	-0.42	0.08	-0.6	-0.13	20.5	-0.06	-0.5	0.34	-0.93	-0.18	21.74	-0.03
	-0.4	-0.17	-0.07	-0.02	-0.06	20.87	-0.59	-0.05	-0.08	0.13	-0.03	22.44
Hill	112.92	40.47	39.83	-0.12	-0.8	-0.73	106.22	37.42	36.55	0	-0.87	-0.9
	40.47	110.05	39.12	-0.46	-0.05	-0.35	37.42	103.37	35.79	-0.44	0.24	-0.17
	39.83	39.12	108.54	-0.65	-1.12	-0.24	36.55	35.79	101.89	-0.8	-1.47	-0.23
	-0.12	-0.46	-0.65	34.48	-0.2	0	0	-0.44	-0.8	32.25	-0.25	0.19
	-0.8	-0.05	-1.12	-0.2	35.08	-0.08	-0.87	0.24	-1.47	-0.25	33.08	-0.03
	-0.73	-0.35	-0.24	0	-0.08	35.67	-0.9	-0.17	-0.23	0.19	-0.03	34.02

Table S7. Calculated bulk elasticity tensor for sample 71C3R1 using the elastic stiffness tensors from Auzende et al. (2006) and Tsuchiya (2013)

	Elasticity data from Auzende et al. (2006)						Elasticity data from Tsuchiya (2013) for 0 GPa pressure					
Voigt	163.53	60.43	59.09	-0.82	0.23	1.21	133.07	44.61	43.03	-0.87	0.07	1.04
	60.43	165.81	59.01	-1.66	0.16	1.58	44.61	136.34	42.6	-2.02	0.11	1.74
	59.09	59.01	162.55	-1.22	0.64	0.97	43.03	42.6	133.16	-1.18	0.82	1.15
	-0.82	-1.66	-1.22	51.1	0.7	0.09	-0.87	-2.02	-1.18	43.46	1.03	0.08
	0.23	0.16	0.64	0.7	51.33	-0.56	0.07	0.11	0.82	1.03	43.97	-0.75
	1.21	1.58	0.97	0.09	-0.56	52.35	1.04	1.74	1.15	0.08	-0.75	45.41
Reuss	61.03	21.68	21.37	-0.14	0.06	0.38	73.4	30	29.43	-0.18	-0.04	0.34
	21.68	61.83	21.24	-0.55	0	0.53	30	75	28.96	-0.87	-0.06	0.76
	21.37	21.24	60.77	-0.37	0.21	0.19	29.43	28.96	73.75	-0.36	0.38	0.34
	-0.14	-0.55	-0.37	19.46	0.3	0.04	-0.18	-0.87	-0.36	21.21	0.58	0.03
	0.06	0	0.21	0.3	19.53	-0.26	-0.04	-0.06	0.38	0.58	21.48	-0.45
	0.38	0.53	0.19	0.04	-0.26	19.97	0.34	0.76	0.34	0.03	-0.45	22.32
Hill	112.28	41.06	40.23	-0.48	0.14	0.8	103.23	37.31	36.23	-0.53	0.01	0.69
	41.06	113.82	40.13	-1.11	0.08	1.05	37.31	105.67	35.78	-1.44	0.03	1.25
	40.23	40.13	111.66	-0.79	0.42	0.58	36.23	35.78	103.46	-0.77	0.6	0.74
	-0.48	-1.11	-0.79	35.28	0.5	0.06	-0.53	-1.44	-0.77	32.33	0.8	0.06
	0.14	0.08	0.42	0.5	35.43	-0.41	0.01	0.03	0.6	0.8	32.73	-0.6
	0.8	1.05	0.58	0.06	-0.41	36.16	0.69	1.25	0.74	0.06	-0.6	33.87

Table S7. Calculated bulk elasticity tensor for sample 76B5R1 using the elastic stiffness tensors from Auzende et al. (2006) and Tsuchiya (2013)

	Elasticity data from Auzende et al. (2006)						Elasticity data from Tsuchiya (2013) for 0 GPa pressure					
Voigt	162.88	62.26	60.76	-0.03	-3.35	4.59	125.61	43.35	41.71	-0.07	-3.1	3.74
	62.26	179.48	65.06	-0.7	-1.24	4.97	43.35	139.69	45.18	-1.04	-0.81	4.26
	60.76	65.06	176.44	0.78	-3.36	3.08	41.71	45.18	137.28	1.21	-3.14	2.88
	-0.03	-0.7	0.78	55.83	2.19	-0.68	-0.07	-1.04	1.21	45.73	2.55	-0.6
	-3.35	-1.24	-3.36	2.19	53.01	-0.04	-3.1	-0.81	-3.14	2.55	42.8	-0.07
	4.59	4.97	3.08	-0.68	-0.04	54.19	3.74	4.26	2.88	-0.6	-0.07	44.31
Reuss	55.41	20.46	20.1	-0.08	-0.92	1.26	70.79	29.82	29.19	-0.16	-1.19	1.36
	20.46	60.18	20.65	-0.3	-0.09	1.48	29.82	76.46	29.67	-0.69	0.07	1.75
	20.1	20.65	59.23	0.23	-0.96	0.52	29.19	29.67	75.55	0.65	-1.24	0.78
	-0.08	-0.3	0.23	19.32	0.88	-0.33	-0.16	-0.69	0.65	22.67	1.48	-0.4
	-0.92	-0.09	-0.96	0.88	18.16	-0.04	-1.19	0.07	-1.24	1.48	20.94	-0.07
	1.26	1.48	0.52	-0.33	-0.04	18.58	1.36	1.75	0.78	-0.4	-0.07	21.69
Hill	109.15	41.36	40.43	-0.06	-2.14	2.92	98.2	36.58	35.45	-0.12	-2.14	2.55
	41.36	119.83	42.85	-0.5	-0.66	3.22	36.58	108.07	37.43	-0.86	-0.37	3
	40.43	42.85	117.83	0.5	-2.16	1.8	35.45	37.43	106.42	0.93	-2.19	1.83
	-0.06	-0.5	0.5	37.58	1.53	-0.5	-0.12	-0.86	0.93	34.2	2.02	-0.5
	-2.14	-0.66	-2.16	1.53	35.58	-0.04	-2.14	-0.37	-2.19	2.02	31.87	-0.07
	2.92	3.22	1.8	-0.5	-0.04	36.38	2.55	3	1.83	-0.5	-0.07	33

Table S10. Calculated bulk elasticity tensor for sample 68B4R1 using the elastic stiffness tensors from Auzende et al. (2006) and Tsuchiya (2013)

	Elasticity data from Auzende et al. (2006)						Elasticity data from Tsuchiya (2013) for 0 GPa pressure					
Voigt	200.67	76.61	70.97	-0.85	1.37	1.23	126.32	41.59	38	-0.49	0.31	0.66
	76.61	237.31	82.82	-2.7	0.96	2.46	41.59	148.74	46.15	-2.15	0.4	1.99
	70.97	82.82	217.55	-0.95	4.2	0.15	38	46.15	136.53	-0.22	3.39	-0.21
	-0.85	-2.7	-0.95	70.72	-0.12	0.5	-0.49	-2.15	-0.22	46.55	-0.28	0.27
	1.37	0.96	4.2	-0.12	62.29	-0.54	0.31	0.4	3.39	-0.28	39.33	-0.41
	1.23	2.46	0.15	0.5	-0.54	66.15	0.66	1.99	-0.21	0.27	-0.41	42.45
Reuss	44.03	15.99	15.39	-0.07	0.18	0.21	71.66	28.38	27.51	-0.06	-0.13	0.2
	15.99	51.27	16.74	-0.63	0.01	0.53	28.38	81.4	29.92	-1.25	-0.13	1.05
	15.39	16.74	47.09	-0.16	0.78	-0.08	27.51	29.92	75.73	0.07	1.54	-0.33
	-0.07	-0.63	-0.16	15.78	0	0.15	-0.06	-1.25	0.07	23.09	-0.13	0.15
	0.18	0.01	0.78	0	13.69	-0.14	-0.13	-0.13	1.54	-0.13	19.16	-0.22
	0.21	0.53	-0.08	0.15	-0.14	14.58	0.2	1.05	-0.33	0.15	-0.22	20.68
Hill	122.35	46.3	43.18	-0.46	0.77	0.72	98.99	34.99	32.75	-0.28	0.09	0.43
	46.3	144.29	49.78	-1.66	0.48	1.49	34.99	115.07	38.03	-1.7	0.13	1.52
	43.18	49.78	132.32	-0.56	2.49	0.04	32.75	38.03	106.13	-0.07	2.46	-0.27
	-0.46	-1.66	-0.56	43.25	-0.06	0.32	-0.28	-1.7	-0.07	34.82	-0.21	0.21
	0.77	0.48	2.49	-0.06	37.99	-0.34	0.09	0.13	2.46	-0.21	29.25	-0.31
	0.72	1.49	0.04	0.32	-0.34	40.37	0.43	1.52	-0.27	0.21	-0.31	31.56

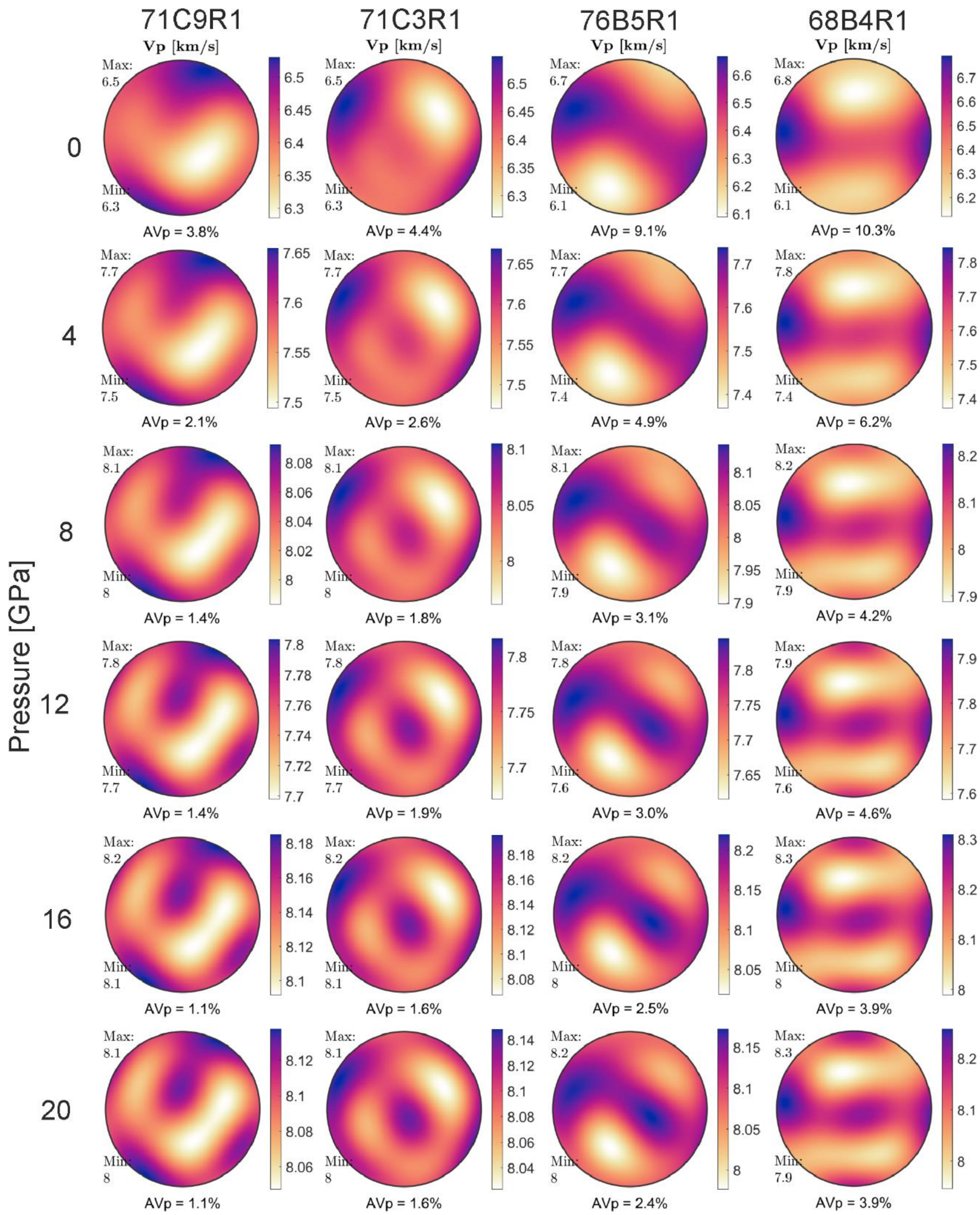

Figure S11. P-wave velocities calculated from the measured lizardite CPO and the tensors for different pressures in Tsuchiya (2013) for the four samples in the study. AVp is the anisotropy.

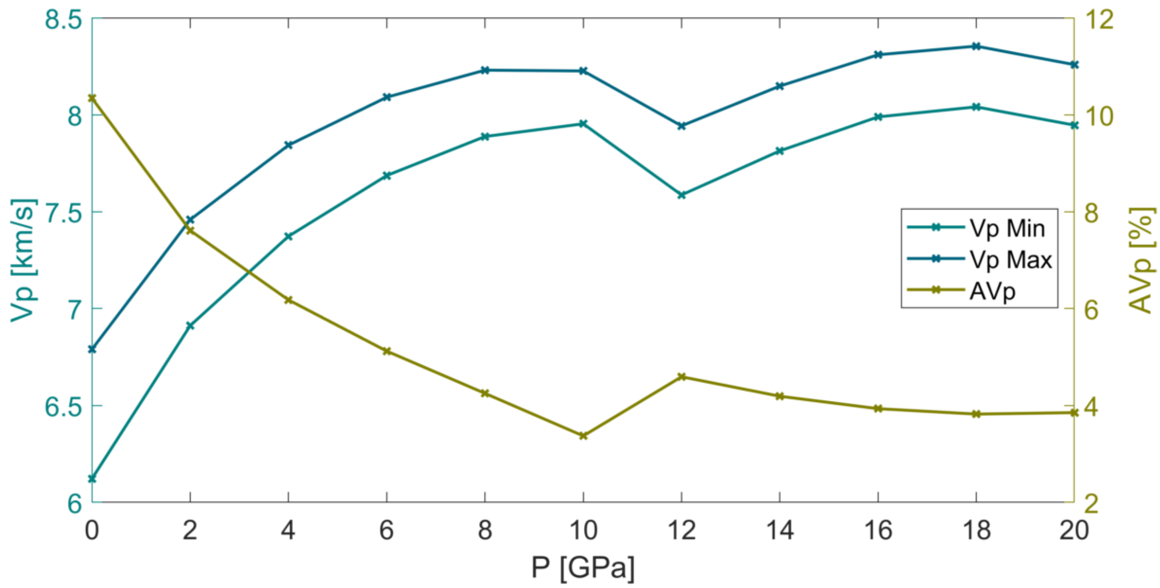

Figure S12. Development of p-wave velocity Vp and its anisotropy AVp with increasing pressure P exemplary for sample 68B4R1 with the strongest CPO calculated from the elasticity data from Tsuchiya, 2013.

References

Auzende, A.L., Pellenq, R.J.M., Devouard, B., Baronnet, A., Grauby, O. (2006), Atomistic calculations of structural and elastic properties of serpentine minerals: the case of lizardite. Phys. Chem. Miner. 33, 266–275. doi: 10.1007/s00269-006-0078-x

Tsuchiya, J (2013) A first-principles calculation of the elastic and vibrational anomalies of lizardite under pressure. American Mineralogist 98, (11-12), 2046-2052. doi: 10.2138/am.2013.4369