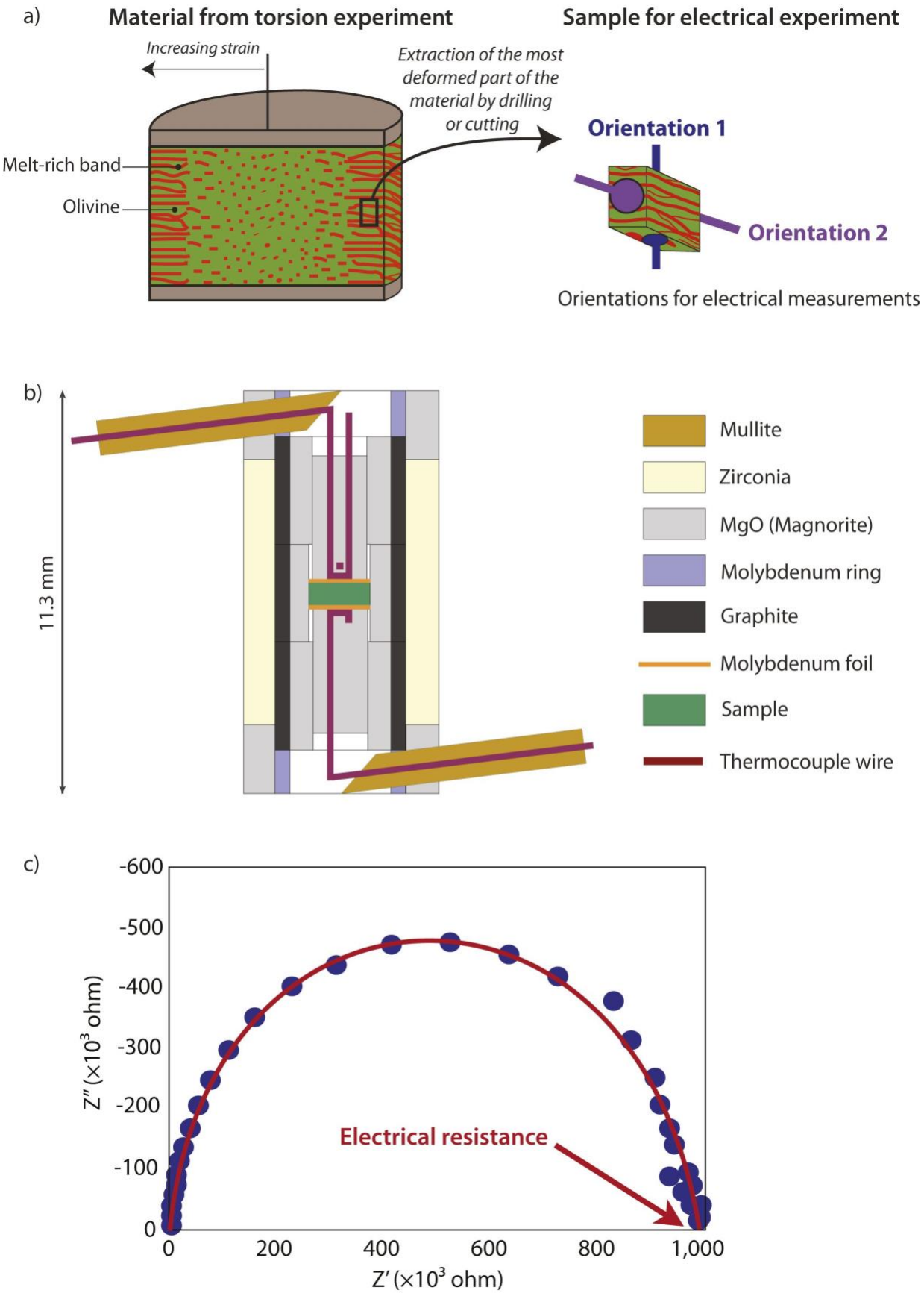
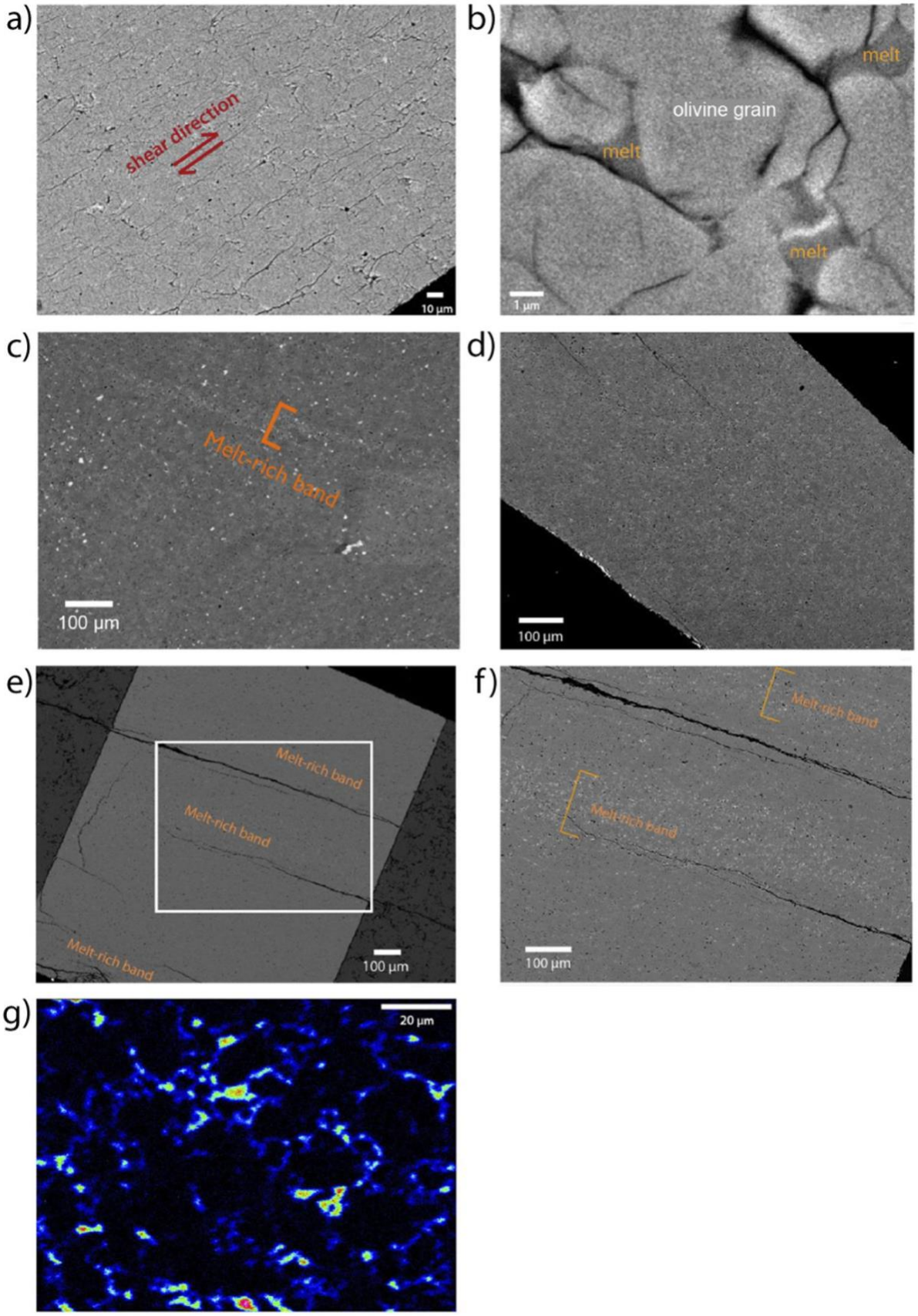
Extended Data Figure 1 Experimental protocol.

a, Starting material preparation. Deformed material is synthesized in a gas-medium apparatus at 300 MPa (left), and its outer part is extracted for electrical measurements in the multi-anvil apparatus at about 3 GPa (right). Two orientations of the sample are considered, leading to vertical (blue) and tangential (purple) electrical measurements. **b**, Cross-section of the electrical conductivity cell (14/8 multi-anvil assembly, that is, the corner-truncation edge length is 8 mm and the pressure media edge length is 14 mm). Both electrodes are made of W–Re thermocouple wire with one electrode also serving as a thermocouple. **c**, Example of a complex impedance spectrum (real part Z′ versus imaginary part Z″) for a sheared sample of olivine + 5 vol% MORB sample at 750 °C and approximately 3 GPa. The intersection between the response of the sample (blue dots, each dot corresponding to one frequency) with the real axis corresponds to the electrical resistance of the sample. The corresponding electrical conductivity value is obtained using the geometric factor (the surface of the electrode divided by thickness of the sample).


a)
Material from torsion experiment
Sample for electrical experiment
Increasing strain
Extraction of the most deformed part of the material by drilling or cutting
Melt-rich band
Olivine
Orientation 1
Orientation 2
Orientations for electrical measurements
b)
11.3 mm
Mullite
Zirconia
MgO (Magnorite)
Molybdenum ring
Graphite
Molybdenum foil
Sample
Thermocouple wire
c)
-600
-500
-400
-300
-200
-100
0
Z'' (×10³ ohm)
Electrical resistance
0
200
400
600
800
1,000
Z' (×10³ ohm)

Extended Data Figure 2 Texture and melt geometry.

a, Back-scattered electron image of sheared sample PT0683-2 after electrical measurements, showing that deformation-induced melt texture was preserved during the experiment in the multi-anvil apparatus. **b**, Back-scattered electron image of sheared sample PT0756-2 after electrical measurements, illustrating the location of melt amongst the olivine grains. **c**, Starting material PT0683 showing the presence of melt-rich bands. **d**, Back-scattered electron image of sheared sample PT0683-1HT after electrical measurements at high temperature (up to 1,573 K). The absence of pronounced melt-rich bands suggests a loss in structural anisotropy, attributed to the effect of high temperature. These observations are consistent with electrical data that showed a noticeable decrease in electrical anisotropy with increasing temperature. **e**, Back-scattered electron image of sheared sample PT0683-1LT after electrical measurements at low temperature (<1,073 K), showing several light-coloured zones identified as melt-rich bands. The rectangle corresponds to the location of image **f** below. **f**, Zoom on melt-rich bands in sample PT0683-1LT. Melt is also present between the melt-rich zones as pockets amongst the olivine grains. **g**, Map of sodium distribution in sample PT0742-2 after electrical measurements. Colours correspond to the number of counts. Warm colours (reddish) correspond to high sodium concentration and are interpreted as pockets of carbonatite melt between olivine grains.


a)
shear direction
10 µm
b)
melt
olivine grain
melt
melt
1 µm
c)
Melt-rich band
100 µm
d)
100 µm
e)
Melt-rich band
Melt-rich band
Melt-rich band
100 µm
f)
Melt-rich band
Melt-rich band
100 µm
g)
20 µm

Extended Data Table 1 Description of the starting materials.

Sample*	Composition	Av. grain size (micron)	Starting material synthesis						
			Deformation type	P (GPa)	T (K)	Stress (GPa)	Shear strain	Shear stress (GPa)	Shear strain rate (10^{-4} s^{-1})
Dry polycrystalline olivine									
PI1543-1	Fo_{90}	16	compression	0.3	1523	0.44	-	-	-
PI1543-2	Fo_{90}	16	compression	0.3	1523	0.44	-	-	-
PT0264-1	Fo_{90}	4-10	torsion	0.3	1473	-	3.5	0.24	3.5
PT0264-2	Fo_{90}	4-10	torsion	0.3	1473	-	3.5	0.24	3.5
Dry polycrystalline olivine + MORB									
PT0683-1LT	Fo_{90}+5% MORB	15	torsion	0.3	1473	-	1.2	0.12-0.15	4.6
PT0683-1HT	Fo_{90}+5% MORB	15	torsion	0.3	1473	-	1.2	0.12-0.15	4.6
PT0683-2	Fo_{90}+5% MORB	15	torsion	0.3	1473	-	1.2	0.12-0.15	4.6
PT0705-2	Fo_{90}+5% MORB	15	torsion	0.3	1473	-	9	0.12-0.15	1.5
PT0756-1	Fo_{90}+5% MORB	15	torsion	0.3	1473	-	2.16	0.12-0.15	5.5
PT0756-2	Fo_{90}+5% MORB	15	torsion	0.3	1473	-	2.16	0.12-0.15	5.5
Dry polycrystalline olivine + carbonate melt									
PT0742-1	Fo_{90}+2%$NaKCO_3$ melt	5-10	torsion	0.3	1473	-	3	0.12-0.15	1.1
PT0742-2	Fo_{90}+2%$NaKCO_3$ melt	5-10	torsion	0.3	1473	-	3	0.12-0.15	1.1
PT0742-3	Fo_{90}+2%$NaKCO_3$ melt	5-10	torsion	0.3	1473	-	3	0.12-0.15	1.1

*Extension: Electrical conductivity σ measurements perpendicular to deformation (-1), parallel to deformation (-2) and undeformed (centre of column) (-3), respectively. LT, low temperature; HT, high temperature.

Extended Data Table 2 Electron microprobe analyses of most of the run products

Sample	Phase	SiO_2		TiO_2		Al_2O_3		Cr_2O_3		FeOtot		MnO		MgO		CaO		Na_2O		K_2O		NiO		Mg#	Sum
PT0683-1LT	ol(9)*	40.7	*(16)*[b]	-		-		-		10.4	*(11)*	0.11	*(2)*	48.8	*(32)*	-		-		-		0.35	*(3)*	*0.89*	100.5
	gl(1)	46.7		0.29		13.2		0.04		5.78		0.05		22.9		5.21		2.64		0.06		-		*0.88*	96.9
PT0683-2	gl(1)	47.0		0.22		16.0		0.01		5.23		0.05		22.9		6.26		2.24		0.12		-		*0.89*	99.9
PT0683-2bis	ol(17)	40.9	*(48)*							9.67	*(11)*	0.12	*(2)*	48.8	*(31)*	-		-		-		0.37	*(3)*	*0.90*	99.9
	gl(1)	47.4		1.62		12.6		0.02		6.82		0.11		21.4		7.1		2.15		0.15		-		*0.85*	99.3
PT0705-2	ol(17)	40.9	*(19)*	-		-		-		9.25	*(14)*	0.12	*(3)*	48.4	*(23)*	-		-		-		0.37	*(4)*	*0.90*	99.1
	gl(1)	45.7		0.34		13.4		0.02		5.03		0.17		26.7		5.42		1.85		0.07		-		*0.90*	98.7
PT0756-1	ol(12)	40.9	*(16)*	-		-		-		9.64	*(13)*	0.12	*(2)*	49.4	*(29)*	-		-		-		0.35	*(4)*	*0.90*	100.3
PT0756-2	ol(10)	41.0	*(29)*	-		-		-		10.0	*(19)*	0.14	*(2)*	48.0	*(34)*	-		-		-		0.37	*(2)*	*0.90*	99.5
	gl(3)	47.3	*(9)*	0.14	*(10)*	17.0	*(24)*	0.04	*(1)*	5.08	*(17)*	0.05	*(1)*	21.1	*(68)*	6.82	*(24)*	2.37	*(19)*	0.05	*(1)*	-		*0.88*	100.0
PT0742-1	ol(29)	41.0	*(15)*	-		-		-		8.44	*(47)*	0.12	*(3)*	50.5	*(36)*	-		-		-		0.36	*(4)*	*0.91*	100.3
PT0742-3	ol(10)	41.4	*(30)*	-		-		-		8.48	*(53)*	0.11	*(2)*	50.1	*(52)*	-		-		-		0.31	*(8)*	*0.91*	100.4

Contents are in weight per cent. Ol, olivine; gl, glass. A dash indicates 'not measured'. [a]The number of microprobe analyses is shown in parentheses. [b]One standard deviation in terms of least unit cited is shown in italics and parentheses; for example, 46.11(123) indicates a standard deviation of 1.23wt% on the value of 46.11wt%.

Extended Data Table 3 Electrical results for polycrystalline olivine materials

Sample	Composition	Electrical conductivity experiments				Arrhenius equation parameters♦			
		P (GPa)	T (K)	Duration (hr)*	Rel. error on σ (%)	Ea (eV)	Error (eV)	Ln(σ_0), (σ_0 in S/m)	Error (S/m)
PI1543-1	Fo_{90}	2.8	1121-1575	2.0	7.5-10.5	0.959	0.005	0.56	0.003
PI1543-2	Fo_{90}	2.8	1274-1623	1.9	2.1-7.1	0.879	0.010	0.64	0.007
PT0264-1	Fo_{90}	2.8	873	0.5	2.2	-	-	-	-
PT0264-2	Fo_{90}	2.8	1173-1570	1.0	2.0-11.5	1.042	0.001	4.1	0.003

*Time spent in heating and cooling cycles.

♦$\ln\sigma = \ln\sigma_0 - E_a/kT$.

Extended Data Table 4 Electrical results for melt-bearing materials

Sample	Composition	Electrical conductivity experiments				Arrhenius equation parameters at T<~870°C ♦				Arrhenius equation parameters at T>~870°C ♦				Extrapolation of low-T data to T>Tg■		
		P (GPa)	T (K)	Duration (hr)*	Rel. error on σ (%)	Ea (eV)	Error (eV)	Ln(σ_0), (σ_0 in S/m)	Error (S/m)	Ea (eV)	Error (eV)	Ln(σ_0), (σ_0 in S/m)	Error (S/m)	Slope a	Intercept b	R^2
Dry polycrystalline olivine + MORB																
PT0683-1LT	Fo_{90}+5% MORB	2.8	847-1,073	1.0	0.8-1.6	1.047	0.030	3.5	0.100	-	-	-	-	-0.571	1.942	0.967
PT0683-1HT	Fo_{90}+5% MORB	2.8	1,395-1,466	1	4.1-5.1	-	-	-	-	1.223	0.047	6.0	0.667	-	-	-
PT0683-2	Fo_{90}+5% MORB	2.8	825-1,479	1.3	2.5-10.7	0.335	0.003	-3.6	0.028	0.691	0.010	0.14	0.002	-	-	-
PT0705-2	Fo_{90}+5% MORB	2.8	822-1,076	1.0	1.6-3.1	1.109	0.010	5.1	0.480	-	-	-	-	-0.542	2.023	0.984
PT0756-1	Fo_{90}+10% MORB	2.8	725-1,120	2.5	5.0-5.7	0.942	0.004	1.3	0.005	-	-	-	-	-0.499	0.775	0.995
PT0756-2	Fo_{90}+10% MORB	2.8	671-1,078	1.2	6.4-6.8	0.728	0.022	0.55	0.117	-	-	-	-	-0.178	-1.523	0.904
Dry polycrystalline olivine + carbonate melt																
PT0742-1	Fo_{90}+2% $NaKCO_3$ melt	2.8	1,023-1,473	2.0	1.6-4.2	0.381	0.018	-3.3	0.160	1.254	0.010	5.3	0.043	-	-	-
PT0742-3	Fo_{90}+2% $NaKCO_3$ melt	2.8	968-1,576	1.6	1.6-4.2	0.509	0.032	-3.1	0.196	1.358	0.013	5.6	0.053	-	-	-

*Time spent in heating and cooling cycles.

♦$\ln\sigma = \ln\sigma_0 - E_a/kT$.

•$\log\sigma_0 = a \times 10{,}000/T + b$.

Extended Data Table 5 Uncertainties on electrical conductivity values for the experiment on sample PT0683-2

Temperature (K)	Resistance (ohm)	Electrical conductivity (S/m)	Error on conductivity (%)	Upper value (S/m)	Lower value (S/m)
825	1800000	0.00027	2.5	0.00028	0.00026
848	1680000	0.00029	2.5	0.00030	0.00028
878	1500000	0.00032	2.6	0.00034	0.00031
899	1320000	0.00037	2.8	0.00039	0.00035
922	1200000	0.00041	2.9	0.00043	0.00038
945	1100000	0.00044	3.0	0.00047	0.00042
975	1000000	0.00049	3.1	0.00052	0.00046
1001	860000	0.00057	3.4	0.00060	0.00053
1024	780000	0.00062	3.6	0.00067	0.00058
1050	700000	0.00070	3.8	0.00075	0.00064
1078	640000	0.00076	4.0	0.00082	0.00070
1098	590000	0.00083	3.3	0.00088	0.00077
1126	520000	0.00094	3.6	0.00100	0.00087
1144	480000	0.00101	3.7	0.00109	0.00094
1176	420000	0.00116	4.0	0.00125	0.00107
1196	360000	0.00135	4.4	0.00147	0.00123
1221	294000	0.00166	5.0	0.00182	0.00149
1245	260000	0.00187	5.5	0.00208	0.00167
1277	220000	0.00221	6.2	0.00249	0.00194
1321	172000	0.00283	7.5	0.00325	0.00241
1378	136000	0.00358	9.0	0.00423	0.00294
1422	116000	0.00420	10.3	0.00506	0.00334
1479	110000	0.00443	10.7	0.00538	0.00348