Insights Into the Subduction of the Ligure-Piemontese Oceanic Basin: New Constraints From the Metamorphism in the Internal Ligurian Units (Northern Apennines, Italy)

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Supplementary material

Analytical conditions

Map and spot analyses were acquired with the microprobe JXA-8800 of Dipartimento di Scienze della Terra "A. Desio" of the Università di Milano Statale (Italy) and with the microprobe 8200 of Department of Earth Science of the University of Genève (Switzerland). Standard used were diopside (Si, Mg, Ca), orthose (Al, K), MnTiO3 (Mn, Ti), garnet (Fe) and albite (Na).

Spot analyses were performed at 15 KeV and 5 nA. Beam size diameter was set to 2 μm. Mapping conditions were 15 KeV and 5 nA, with a counting time of 20 ms per grid point.

For each mineral included in the maps, a series of spot analysis were acquired in order to catch the chemical variability presented. These spot analyses were then used as internal standards to calibrate all the element intensity maps obtained with the microprobe, obtaining maps of element concentrations. This calibration was performed using XMapTools 3.2.6 (Lanari et al.. 2014a) that was also used to plot ternary and binary diagrams and to export composition of chlorite and phengite. Pressure and temperature conditions were instead calculated using ChlMicaEqui (Lanari. 2012).

Table S1. Examples of mineral chemistry of white mica selected along the S1 foliation of metapelites of IL units.

	ULI3b				**ULI7**				**ULI8**			
	Wm26	*Wm27*	*Wm81*	*Wm8*	*Wm16*	*Wm5*	*Wm11*	*Wm12*	*Wm8*	*Wm99*	*Wm7*	*Wm61*
						Wt%						
SiO_2	47.4	48.76	52.30	47.40	49.31	54.14	55.38	50.28	49.72	50.19	47.68	51.33
TiO2	0.00	0.24	0.00	0.00	0.09	1.51	0.44	0.20	0.80	0.40	0.32	0.40
Al_2O_3	29.02	32.43	31.92	24.66	31.86	27.96	28.94	30.01	32.10	32.75	31.71	28.66
FeO	6.73	3.11	2.24	13.47	1.70	1.71	2.19	2.30	1.90	1.69	4.74	1.69
MnO	0.00	0.00	0.00	0.00	0.04	0.00	0.06	0.02	0.01	0.00	0.08	0.00
MgO	3.56	1.92	0.89	0.89	1.84	1.37	1.69	1.51	1.77	0.93	2.42	2.79
CaO	0.08	0.22	0.79	0.48	0.07	0.18	0.16	0.1	0.05	0.12	0.08	0.06
Na_2O	0.00	0.71	0.00	0.00	0.33	0.42	0.34	0.39	0.44	0.00	0.48	0.00
K_2O	8.25	8.03	9.28	8.25	8.99	8.81	8.27	8.26	9.17	9.50	8.24	10.50
Total	95.04	95.42	97.42	95.15	94.23	96.10	97.47	93.07	95.96	95.58	95.76	95.43
						Cations						
Si	3.21	3.22	3.36	3.33	3.28	3.51	3.53	3.38	3.26	3.29	3.17	3.40
Fe_{TOT}	0.38	0.17	0.12	0.79	0.09	0.09	0.12	0.13	0.10	0.09	0.26	0.09
Al_{TOT}	2.32	2.52	2.42	2.04	2.50	2.14	2.17	2.37	2.48	2.53	2.49	2.23
Mg	0.36	0.19	0.09	0.09	0.18	0.13	0.16	0.15	0.17	0.09	0.24	0.28
Ca	0.01	0.02	0.05	0.04	0.00	0.01	0.01	0.01	0.00	0.01	0.01	0.00
Na	0.00	0.09	0.00	0.00	0.04	0.05	0.04	0.05	0.06	0.00	0.06	0.00
K	0.71	0.68	0.76	0.74	0.76	0.73	0.67	0.71	0.77	0.79	0.70	0.89
XMg	0.49	0.52	0.41	0.11	0.66	0.59	0.58	0.54	0.62	0.50	0.48	0.75
vacancy	0.28	0.22	0.18	0.23	0.19	0.21	0.28	0.23	0.17	0.20	0.23	0.11

O basis	11	11	11	11	11	11	11	11	11	11	11	11
	ULI9				**ULI19**				**ULI22**			
	Wm36	*Wm33*	*Wm34*	*Wm40*	*Wm1*	*Wm2*	*Wm3*	*Wm5*	*Wm42*	*Wm47*	*Wm46*	*Wn39*
	Wt%											
SiO_2	50.24	48.91	52.12	49.85	47.78	48.91	50.24	49.85	47.61	45.24	46.77	48.82
TiO2	0.67	0.14	0.52	0.13	1.29	0.14	0.67	0.13	0.40	0.67	0.67	1.62
Al_2O_3	31.15	31.54	30.73	31.43	30.46	31.54	31.15	31.43	30.03	32.74	31.48	33.32
FeO	1.96	2.30	2.53	3.47	2.59	2.30	1.96	3.47	3.21	4.35	6.99	3.97
MnO	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.02
MgO	1.75	1.90	1.81	2.64	1.91	1.90	1.75	2.64	4.54	1.51	1.01	1.27
CaO	0.09	0.05	0.07	0.07	0.08	0.05	0.09	0.07	0.26	0.62	0.31	0.33
Na_2O	0.38	0.40	1.04	0.28	0.35	0.40	0.38	0.28	0.87	0.44	0.00	0.87
K_2O	8.76	8.21	8.28	8.85	8.48	8.21	8.76	8.85	9.67	9.99	10.48	7.14
Total	95.00	93.45	97.10	96.72	92.96	93.45	95.00	96.72	96.59	95.56	97.71	97.36
	Cations											
Si	3.31	3.28	3.36	3.26	3.24	3.28	3.31	3.26	3.16	3.06	3.13	3.16
Fe_{TOT}	0.11	0.13	0.14	0.19	0.15	0.13	0.11	0.19	0.18	0.25	0.39	0.21
Al_{TOT}	2.42	2.49	2.34	2.42	2.43	2.49	2.42	2.42	2.35	2.61	2.48	2.54
Mg	0.17	0.19	0.17	0.26	0.19	0.19	0.17	0.26	0.45	0.15	0.10	0.12
Ca	0.01	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.02	0.04	0.02	0.02
Na	0.05	0.05	0.13	0.04	0.05	0.05	0.05	0.04	0.11	0.06	0.00	0.11
K	0.74	0.70	0.68	0.74	0.73	0.70	0.74	0.74	0.82	0.86	0.89	0.59
XMg	0.61	0.60	0.56	0.58	0.57	0.60	0.61	0.58	0.72	0.38	0.20	0.36
vacancy	0.21	0.24	0.18	0.22	0.21	0.24	0.21	0.22	0.05	0.04	0.08	0.28
O basis	11	11	11	11	11	11	11	11	11	11	11	11

Table S2. Examples of mineral chemistry of chlorite selected along the S1 foliation of metapelites of IL units.

	ULI3B				ULI7				ULI8			
	Chl32	Chl3	Chl31	Chl29	Chl27	Chl1	Chl9	Chl6	Chl29	Chl297	Chl3	Chl29
	Wt%											
SiO2	26.49	25.29	28.90	27.69	25.05	25.05	26.82	26.82	23.86	26.03	28.20	25.10
TiO2	0.03	0.00	0.20	0.00	0.00	0.00	0.05	0.05	0.00	0.00	0.00	0.02
Al2O3	23.50	20.58	24.99	17.64	22.04	22.04	22.56	22.56	21.33	20.26	20.26	22.77
FeO	26.77	28.94	22.74	33.07	26.88	28.95	28.66	28.66	32.11	29.97	29.97	30.89
MnO	0.00	0.00	0.00	0.00	0.14	0.14	0.14	0.14	0.00	0.22	0.22	0.16
MgO	11.44	8.90	11.44	10.17	12.13	12.13	10.19	10.19	9.12	10.14	10.14	10.45
CaO	0.14	0.00	0.00	0.14	0.00	0.22	0.09	0.09	0.00	0.00	0.00	0.01
Na2O	0.12	0.00	0.00	0.00	0.00	0.00	0.03	0.03	0.00	0.00	0.00	0.00
K2O	0.71	0.84	0.17	0.17	0.42	0.00	0.09	0.09	0.00	0.19	0.19	0.03
Total	89.21	84.55	88.44	88.88	86.66	88.53	88.63	88.63	86.42	86.81	88.98	89.44
	Cations											
Si	2.75	2.83	2.92	2.99	2.70	2.66	2.82	2.82	2.65	2.84	2.98	2.66
FeTOT	2.33	2.71	1.92	2.99	2.42	2.57	2.52	2.52	2.99	2.73	2.64	2.74
AlTOT	2.88	2.72	2.98	2.25	2.80	2.76	2.80	2.80	2.80	2.60	2.52	2.84
Mg	1.77	1.49	1.72	1.64	1.95	1.92	1.60	1.60	1.51	1.65	1.59	1.65
Ca	0.02	0.00	0.00	0.02	0.00	0.03	0.01	0.01	0.00	0.00	0.00	0.00
Na	0.02	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00

K	0.09	0.12	0.02	0.02	0.06	0.00	0.01	0.01	0.00	0.03	0.03	0.00
XMg	0.43	0.35	0.47	0.35	0.45	0.43	0.39	0.39	0.34	0.38	0.38	0.38
vacancies	0.19	0.19	0.41	0.11	0.10	0.04	0.22	0.22	0.05	0.14	0.23	0.08
O basis	14	14	14	14	14	14	14	14	14	14	14	14
			ULI9				ULI19				ULI22	
	Chl26	CHl28	Chl30	Chl31	Chl1	Chl3	Chl4	Chl7	Chl12	Chl121	Chl177	Chl176
						Wt%						
SiO2	25.27	25.90	25.29	25.46	25.06	25.27	24.90	26.01	22.82	24.18	22.69	25.2
TiO2	0.01	0.02	0.04	0.05	0.03	0.01	0.05	0.08	0.01	0.00	0.00	0.00
Al2O3	22.20	22.81	22.42	22.50	23.59	22.20	21.40	22.42	19.96	21.40	20.65	20.65
FeO	29.27	29.98	27.79	26.92	33.05	29.27	28.69	27.57	32.21	28.44	29.42	29.98
MnO	0.08	0.10	0.12	0.13	0.01	0.08	0.13	0.14	0.00	0.00	0.00	0.00
MgO	9.74	9.85	12.06	12.61	6.60	9.74	11.80	10.95	9.34	8.86	9.65	12.34
CaO	0.04	0.03	0.02	0.04	0.05	0.04	0.05	0.03	0.23	0.40	0.58	0.17
Na2O	0.03	0.00	0.03	0.05	0.00	0.03	0.09	0.02	0.00	0.61	0.61	0.00
K2O	0.45	0.15	0.12	0.13	0.17	0.45	0.20	0.25	0.48	0.53	0.39	0.32
Total	89.21	88.84	87.89	87.89	88.56	87.08	87.31	87.46	85.05	84.42	83.99	88.66
						Cations						
Si	2.74	2.74	2.69	2.69	2.71	2.74	2.69	2.77	2.61	2.72	2.60	2.70
FeTOT	2.65	2.66	2.47	2.38	2.99	2.65	2.59	2.46	3.08	2.67	2.82	2.68
AlTOT	2.83	2.85	2.81	2.80	3.01	2.83	2.72	2.81	2.69	2.84	2.79	2.61
Mg	1.57	1.56	1.91	1.99	1.06	1.57	1.90	1.74	1.59	1.48	1.65	1.97
Ca	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.03	0.05	0.07	0.02
Na	0.01	0.00	0.01	0.01	0.00	0.01	0.02	0.00	0.00	0.13	0.14	0.00
K	0.06	0.02	0.02	0.02	0.02	0.06	0.03	0.03	0.07	0.08	0.06	0.04
XMg	0.37	0.37	0.44	0.46	0.26	0.37	0.42	0.41	0.34	0.36	0.37	0.42
vacancies	0.15	0.17	0.09	0.10	0.21	0.16	0.05	0.18	0.00	0.14	0.01	0.00
O basis	14	14	14	14	14	14	14	14	14	14	14	14

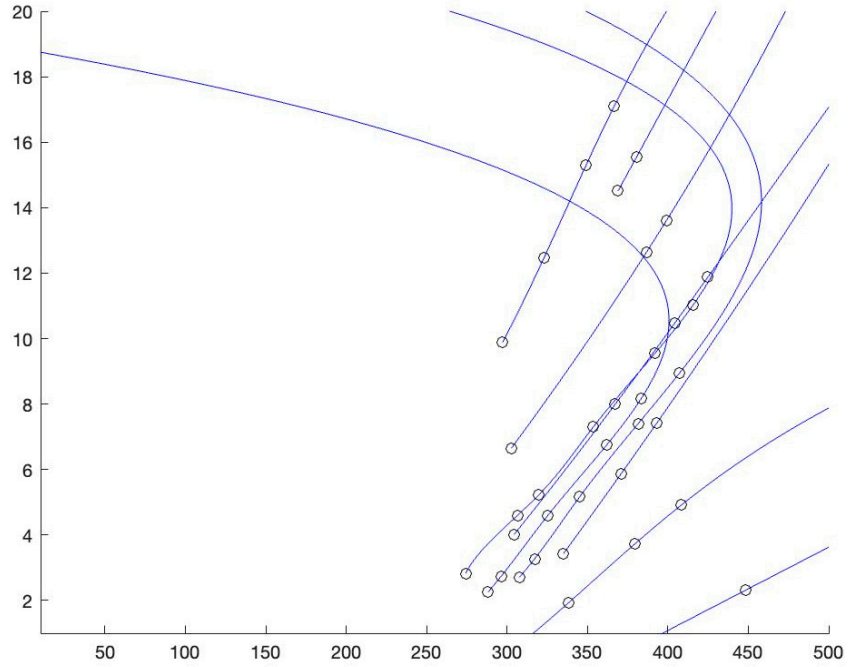
Chlorite-quartz-water method

Table S3. Starting pressure values adopted for Chlorite-quartz-water method. In bold is reported the P value chosen and the related Fe^{3+} percentage.

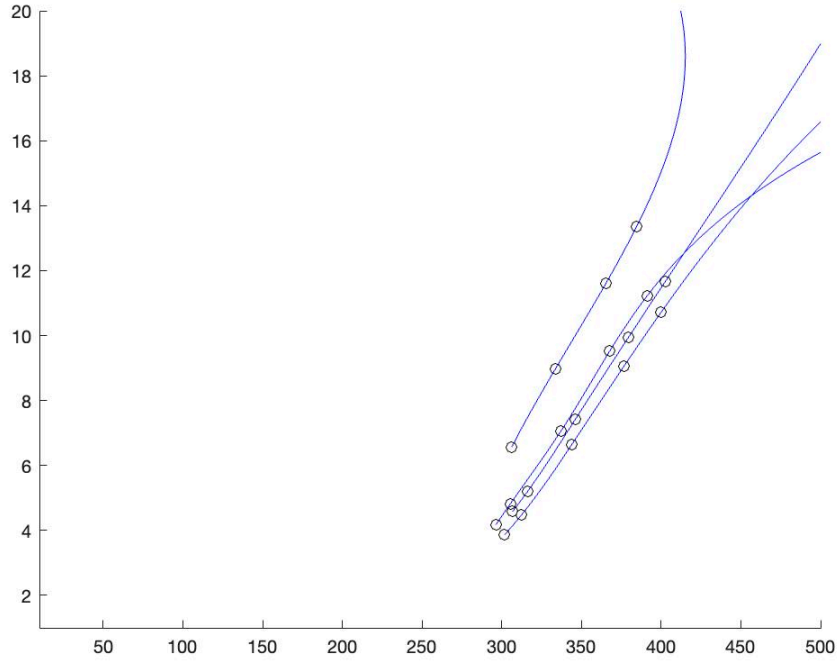
Value (GPa)	ULI3b	ULI7	ULI8	ULI9	ULI19	ULI22
0.1						X
0.2						X
0.3						**X (Fe^{3+} in FeO=30%)**
0.4	X	X			X	X
0.5	X	X	X	X	**X (Fe^{3+} in FeO=30%)**	X
0.6	X	X			X	X
0.7	X	X	X	X	X	X
0.8	X	X	**X (Fe^{3+} in FeO=20%)**	**X (Fe^{3+} in FeO=30%)**	X	
0.9	**X (Fe^{3+} in FeO=30%)**	**X (Fe^{3+} in FeO=30%)**	X	X	X	
1.0	X	X	X	X	X	

Phengite-quartz-water method

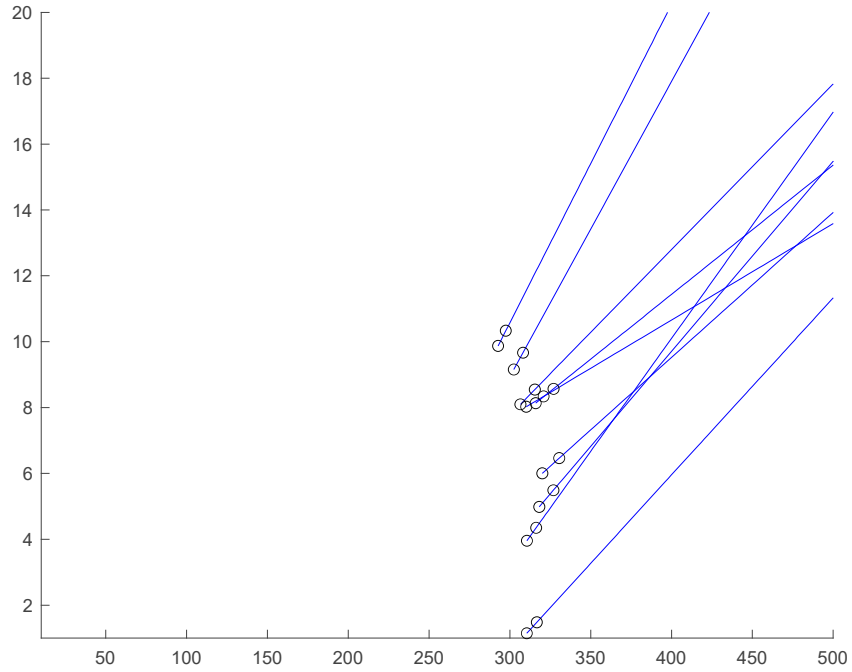
ULI3B (XH_2O= 97%)



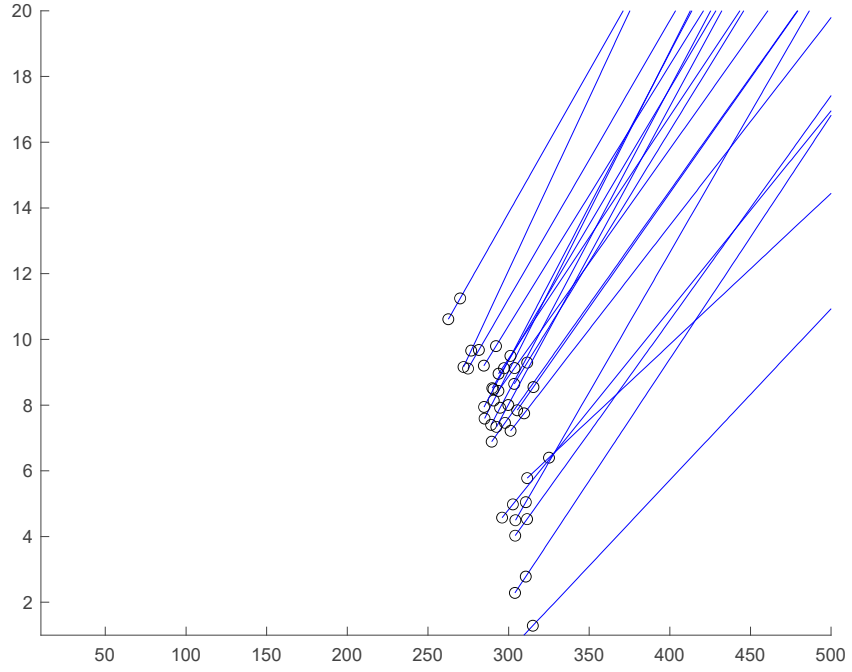
ULI7 (XH_2O= 97%)



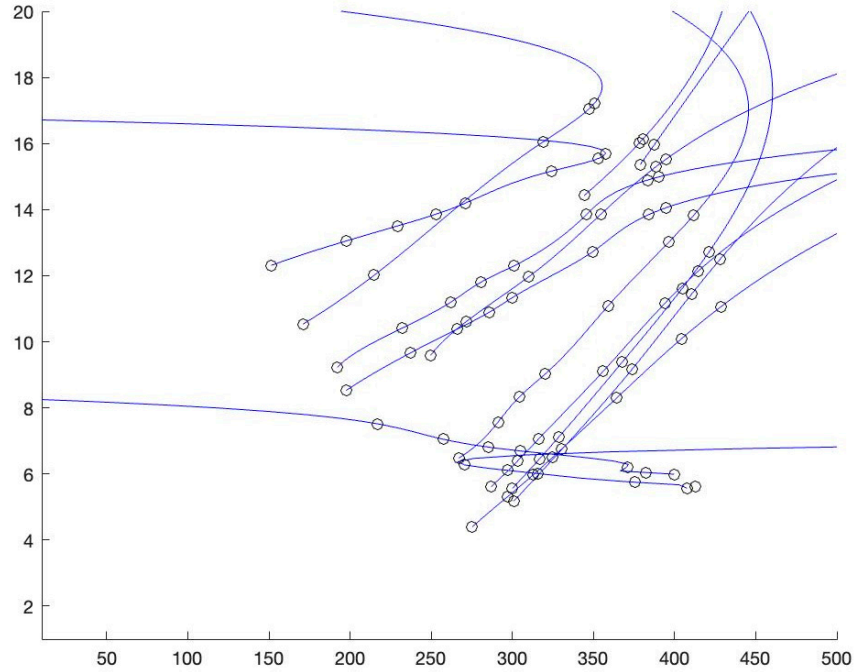
ULI8 (XH_2O= 94%)



ULI9 (XH_2O= 95%)



ULI19 (XH_2O= 96%)



ULI22 (XH_2O= 96%)

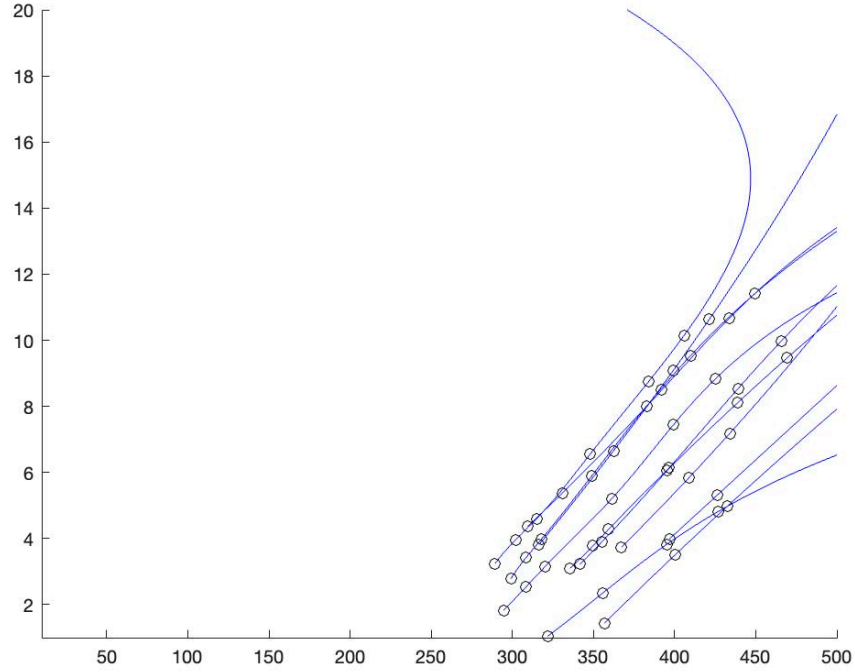
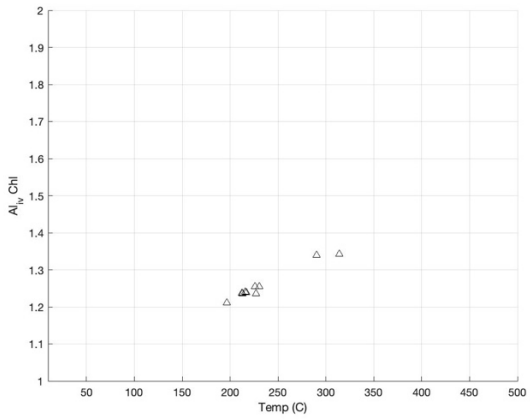
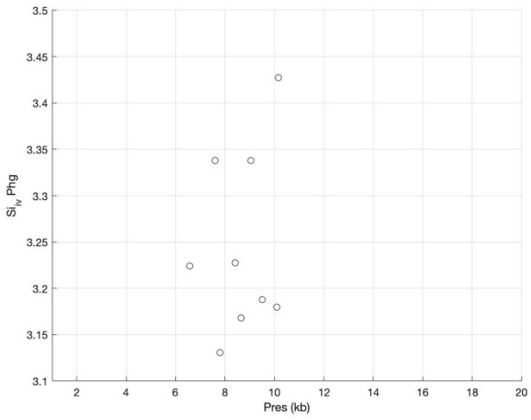


Figure S1. P/T diagrams showing for each sample. the results of the Phengite-quartz-water method of Dubacq et al. (2010). Blue lines represent analyzed phengite. Black circles along these lines indicate the structural water (XH_2O) needed to achieved such P-T conditions. XH_2O chosen for modeling (reported in Fig. 6) is also given.

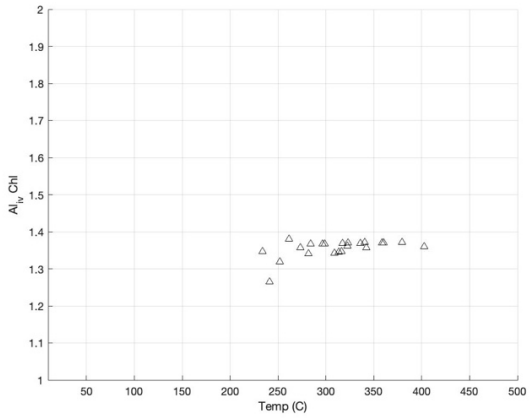
Chlorite-phengite-quartz-water method

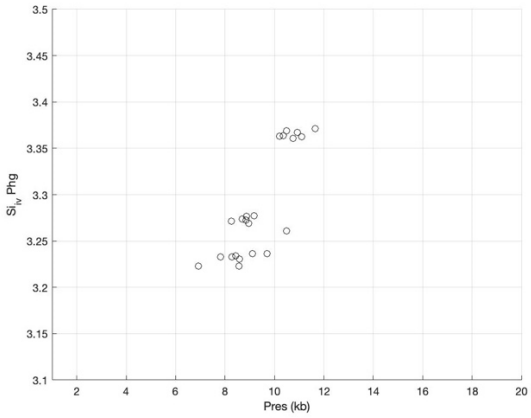
ULI3b



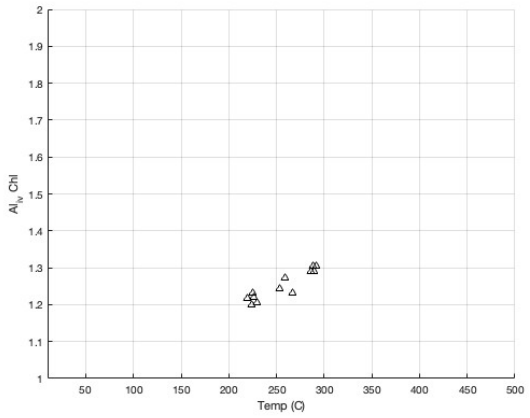


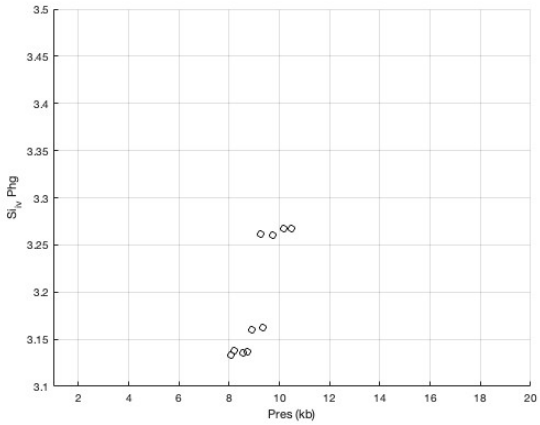
ULI7



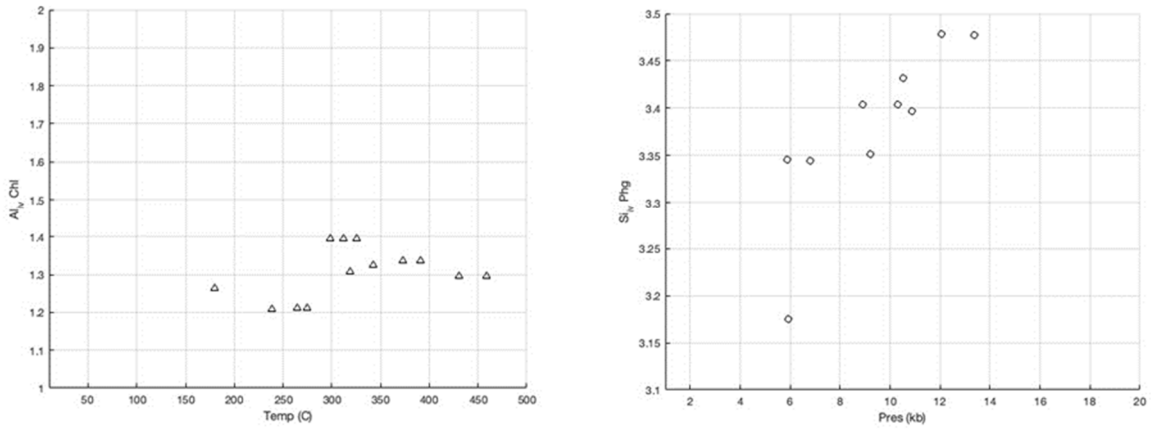


ULI8

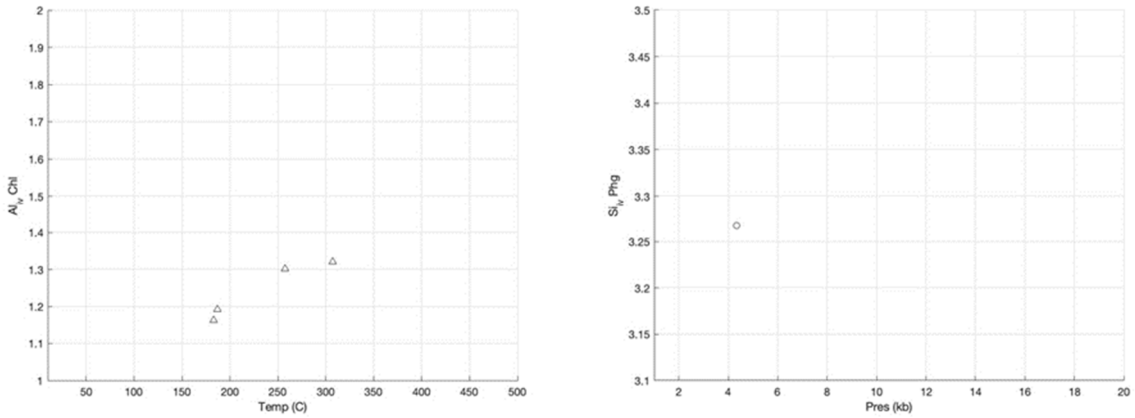




ULI9



ULI19



ULI22

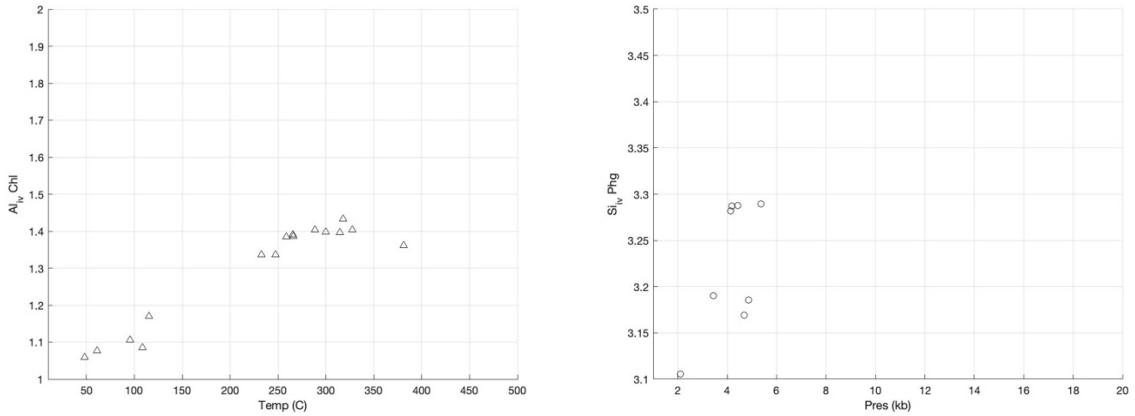


Figure S2. Diagrams showing T (°C) vs Al^{IV} in chlorite and P (kbar) vs. Si^{IV} in phengite.

Reference list

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