The timescale of the endogenous processes and PT conditions of garnet, biotite, and plagioclase equilibrium in the mica schists and gneisses of the Korvatundra complex (Kola region)

Nitkina E.A.[1], Belyaev O.A. [†], Kozlova N.E., Kaulina T.V.[1], Sharkov E.V.[2], Kozlov N.E.[1]

[1] GI KSC RAS, Apatity, Russia, xiao-nata@yandex.ru (N. Kozlova); kaulina@geoksc.apatity.ru (T.Kaulina); kozlov@geoksc.apatity.ru (N.Kozlov); nitkina@rambler.ru (E.Nitkina)

[2] IGEM RAS, Moscow, Russia, sharkov@igem.ru *(E. Sharkov)*

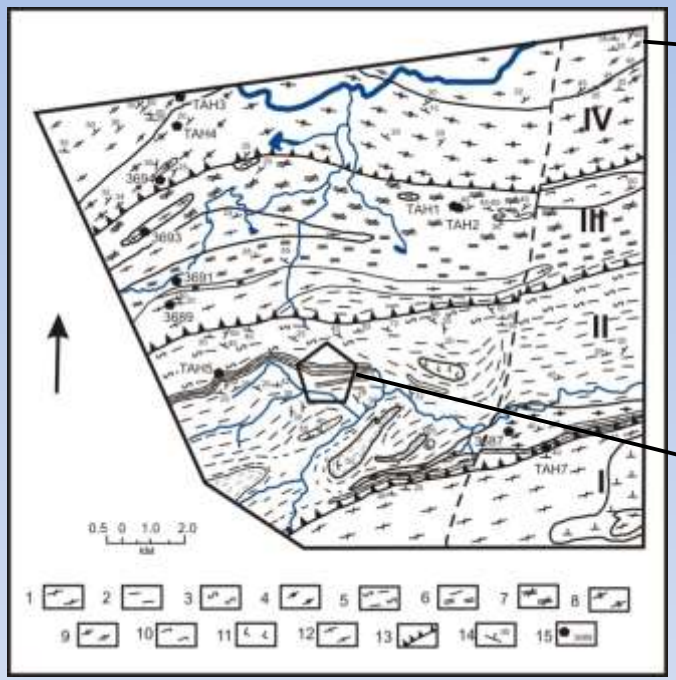
Analytical Database by Oleg A. Belyaev †

Analytical data were obtained and processed based on the field work by N.E.Kozlov, N.E.Kozlova, T.V.Kaulina and O.A.Belyaev. At the moment, Oleg A. Belyaev's conclusions and discussion are unpublished. The authors have prepared the text and graphics .

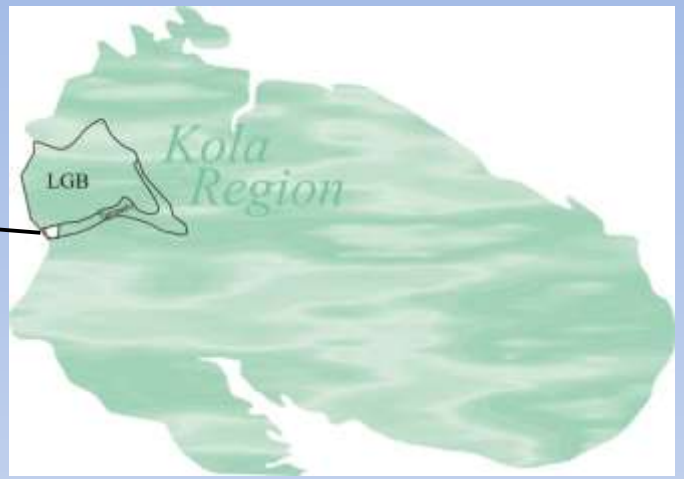
in memory of the teamwork

The Korvatundra complex is situated between the granite gneisses of the White Sea complex and the rocks of the Tanaelv belt of the Kola region (Kozlov et al., 1990; Priyatkina&Sharkov, 1979) and composed of mica gneisses, schists and quartzite schists. The metamorphism of the complex increases from south to north from the staurolite-muscovite zone to kyanite-garnet-biotite (Map of the mineral facies, 1992; Perchuk&Krotov, 1998).

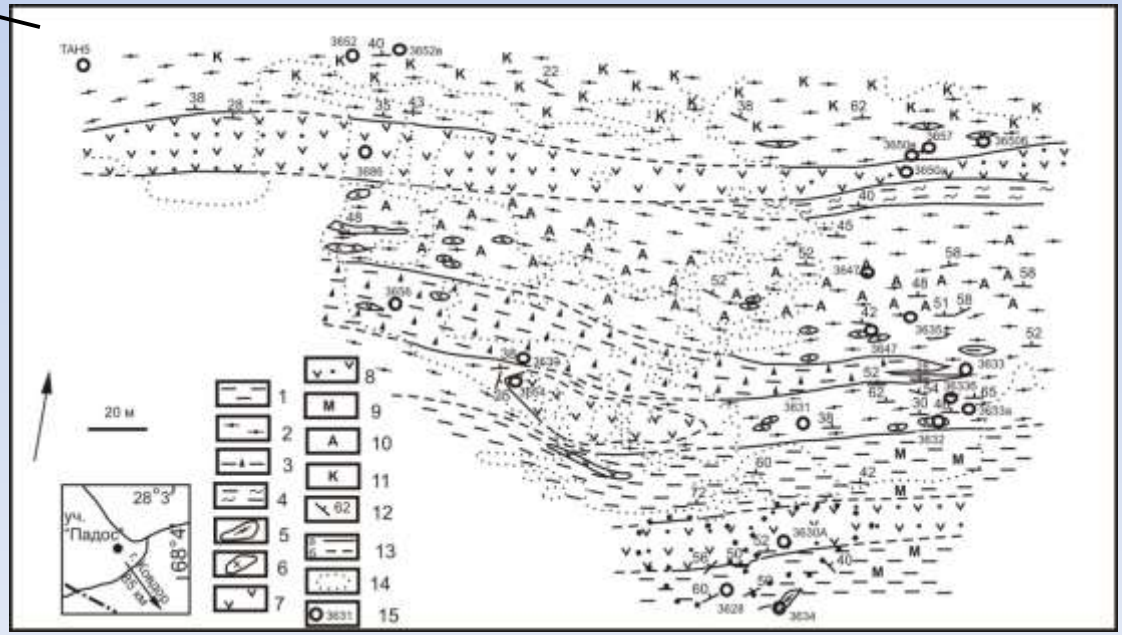
Structural and geological map of the Pados-Yavr (Osnovnie …, 1968)



I White Sea complex
II Korvatundra complex
III Tanaelv betl
IV Lapland Granulite Belt



Structural and petrographic map of the Korvatundra complex. composed by O.A. Belyaev, N.E. Kozlova



The sequence of the geological processes in the Korvatundra complex

Magmatism	Deformations	Metamorphism stages	Age
Muscovite pegmatite **П-5**	**D5**	**Diaphthoresis**	**1722±25** Ma (Rb-Sr: WR-Bt-Pl-Ap)
Quartz veins **Кв-4**	**D4**	**Retrograde metamorphism**	**1818±58** Ma (Pb-Pb titanite)
Late stage – pegmatite **П-3а** Early stage – pegmatite **П-3**	**D3**	**Tectonometamorphism**: T up to **700-750**°C, P up to **13-14** kb. Fe-Mg **Metasomatism** Grt-Hed/Cum T=**640**°, P = **7,5** kb.	**1868±82** Ma (Sm-Nd, WR-Grt)
Quartz veins (**Кв-2**) Pegmatite veins **П-2**			**1917±6** Ma (U-Pb)
Migmatite **МП-2**	**D2**	**Prograde metamorphism (peak metamorphic conditions)**: Ky+Grt, T = **576-615**°C, P = **7,5-9,1** kb.	
Gabbros emplacement			
Migmatite **МП-1**	**D1**	**Prograde metamorphism** (early stage): St-Cld, St-Chl and Grt-Bt zones, T=**385-430**°C, P=**4,6-6,6** kb	**1940±34** Ma (Sm-Nd, WR-Grt)

Chemical composition of the Korvatundra complex.

	3652в	3649	3639	3656	3628	3628а	3631	3633	3633б	3657	3652	3630	3650	3654	3630д	3642	3647	3635	3635А	3633-1	3687	3686	3687б	ТАН5	ТАН7
SiO2	81,79	66,89	64,91	63,94	62,84	64,80	65.71	64,02	65,91	66,40	56,62	49,11	48,85	48,65	48,43	46,58	61,47	58,40	60.77	66.58	46.99	48.6	44,67	55,93	59,49
TiO2	0,18	1,07	1,18	1,41	1,11	1,17	1.15	1,14	1,13	0,99	0,81	1,05	1,31	1,16	1,30	0,68	1,18	1,48	1.23	0.87	2.54	1.07	0,54	1,04	0,88
Al2O3	10,30	14,84	15,54	15,57	14,42	15,25	15.18	14,57	15,23	13,62	22,54	14,89	15,30	15,22	14,91	9,08	16,30	15,56	15.66	15.04	13.66	14.7	5,66	19,98	20,13
Fe2O3	0.00	5,65	3,40	4,16	6,39	5,62	4.71	3,42	4,07	2,76	3,41	4,46	4,17	3,81	3,78	5,06	3,12	4,42	4.34	5.07	3.92	2.45	2,01	6,54	5,24
FeO	1.67	3,36	3,93	4,77	4,50	3,40	3.69	4,54	3,16	5,13	5,77	8,08	8,26	8,51	9,84	6,28	6,01	5,50	5.04	3.02	11.34	9.78	7,06	4,48	4,29
MnO	0.03	0,03	0,07	0,04	0,04	0,03	0.03	0,09	0,04	0,08	0,10	0,17	0,15	0,18	0,16	0,21	0,05	0,05	0.13	0.04	0.22	0.24	0,14	0,12	0,09
MgO	0.15	0,99	1,02	0,85	1,64	1,24	1.06	1,46	1,29	2,35	2,02	7,62	6,91	7,31	6,84	20,38	3,14	4,02	2.33	0.47	5.23	8.76	23,33	2,37	2,07
CaO	2.32	0,88	3,23	1,61	1,95	0,87	0.91	1,80	1,19	1,67	1,61	10,78	10,26	10,61	9,80	5,79	1,03	0,66	2.39	1.55	10.13	9.96	6,90	3,17	1,80
Na2O	2.48	2,16	3,73	2,47	4,30	2,65	2.44	5,16	5,72	3,63	1,54	1,54	2,10	2,01	2,32	0,62	5,72	5,93	5.80	5.83	2.86	1.57	0,11	2,52	1,59
K2O	0.20	1,75	1,34	2,67	1,29	2,61	2.55	2,10	0,72	1,38	2,61	0,18	0,30	0,23	0,41	0,04	0,25	0,24	0.21	0.37	0.67	0.22	<0,01	1,49	1,46

Chemical composition of the coexisting garnet, biotite and plagioclase and their equilibrium P-T conditions for the Korvatundra complex.

	Garnet					Biotite		Pl	T, °C	P, kb
	Sps	Prp	Alm	Grs	X_{Mg}	X_{Mg}	TiO2*	X_{Ca}		
3643										
A1	4.2	8.6	70.1	17.1	0.104	0.628	1.43	0.277	430	6.0
A2	3.7	13.1	68.6	14.6	0.154	0.628	1.43	0.277	510	7.6
C1	1.7	17.8	68.4	12.5	0.203	0.633	1.29	0.268	574	9.0
C1*	1.7	17.8	68.4	12.5	0.203	0.628	1.43	0.268	576	8.8
3633										
A	3.8	18.6	72.9	4.6	0.195	0.580	1.84	0.146	614	9.0
C	3.9	18.4	72.9	4.8	0.194	0.609	1.81	0.161	577	7.9
3628-1										
A	11.3	17.7	64.4	6.6	0.190	0.588	1.87	0.237	607	7.5
C	14.6	15.1	64.5	5.7	0.160	0.581	1.47	0.237	570	6.1
3628-2										
A	11.5	15.3	67.6	5.5	0.162	0.598	1.71	0.189	555	6.9
C	15.9	13.0	65.4	5.6	0.138	0.578	1.57	0.189	543	6.3
3652										
A1	10.0	5.9	65.8	18.3	0.072	0.625	1.67	0.295	385	4.6
A2	1.9	19.2	68.8	10.1	0.213	0.625	1.67	0.295	587	8.1
A3**	2.5	18.2	70.0	9.3	0.201	0.651	1.83	0.295	540	6.8
A3	2.5	18.2	70.0	9.3	0.201	0.625	1.67	0.295	568	7.4
B1 -3**	2.4	21.0	66.2	10.4	0.234	0.657	1.30	0.295	586	8.4
B2 – 3	2.4	21.1	66.7	9.8	0.234	0.625	1.67	0.295	620	8.8
B3 – 3	2.3	19.5	67.7	10.5	0.218	0.625	1.67	0.295	596	8.4
C3	2.3	16.4	70.9	10.4	0.184	0.628	1.71	0.291	541	7.1
C1	2.1	18.5	67.4	12.0	0.210	0.625	1.67	0.291	589	8.8
C2	2.4	19.2	66.5	11.3	0.223	0.625	1.67	0.291	610	9.1
TAH5										
A	9.2	14.0	62.2	14.6	0.164	0.630	0.34	0.336	534	7.2
C	8.0	17.5	60.6	13.9	0.203	0.643	0.40	0.408	576	8.2
3633-5										
A1	2.3	22.9	72.8	2.0	0.234	0.574	1.38	0.131	648	7.1
A2**	2.4	23.2	72.2	2.2	0.237	0.595	1.43	0.131	638	7.6
A2	2.4	23.2	72.2	2.2	0.237	0.574	1.38	0.131	663	8.0
C1	3.4	20.3	74.3	2.0	0.207	0.576	1.16	0.130	611	6.3
3633-1										
A	5.4	12.8	71.2	10.6	0.143	0.554	1.44	0.073	611	14.2
B1	1.1	19.9	74.2	4.8	0.209	0.554	1.44	0.073	697	14.2
B2	0.9	24.3	71.9	2.8	0.250	0.554	1.44	0.073	752	13.8
C	2.5	17.7	79.1	0.7	0.178	0.575	1.59	0.084	542	3.4
3632a										
A**	6.4	18.3	72.9	3.0	0.189	0.579	0.50	0.073	635	11.3
A**	6.4	18.3	72.9	3.0	0.189	0.579	0.50	0.064	642	12.1
B**	3.0	21.5	74.9	1.2	0.218	0.584	0.60	0.054	643	9.4
C	4.0	17.7	71.2	7.1	0.191	0.573	0.56	0.104	652	12.9
3640-1										
A**	9.8	28.4	54.0	7.8	0.308	0.695	0.96	0.196	687	11.7
A	9.8	28.4	54.0	7.8	0.308	0.650	1.03	0.196	752	12.9
C	11.4	26.1	58.5	4.0	0.272	0.650	1.03	0.211	662	7.9
B	11.4	25.6	57.8	5.2	0.270	0.660	1.02	0.226	654	8.5

A - Grt middle point + Bt (in matrix) + Pl middle point; B – Grt intermediate zone + Bt (in matrix) + Pl middle point; C – Grt, Bt and Pl contact edges; C* - Grt edge, Bt (in matrix) and Pl edge; A**, B** - Bt inclusion in Grt, Grt and Pl (in matrix) ; TiO2* - TiO2 in Bt [%].

Chemical composition defined at the Institute of Experimental Mineralogy, Chernogolovka.

Metamorphism stages of the Korvatundra complex

Retrograde metamorphism

3633	C	577 °C, 7,88 kb
3633 -5	C1	611 °C, 6,28 kb
3652	C3	541 °C, 7,11 kb

Metasomatism

3633-5	A2	663 °C, 7,96 kb

Tectonometamorphism (?)

3640-1

A**	687 °C, 11,74 kb
A	752 °C, 12,92 kb
B	654 °C, 8,50 kb
C	662 °C, 9,9 kb

Prograde metamorphism (peak metamorphic conditions)

3633	A	614 °C, 9,0 kb
3652	B2-3	620 °C, 8.8 kb
3643	C1	574 °C, 9.0 kb
3652	B1-3**	585 °C, 8,4 kb

Prograde metamorphism

3652	A3**	540 °C, 6,8 kb
3643	A2	510 °C, 7,6 kb
3643	A1	430 °C, 6,0 kb
3652	A1	385 °C, 4,6 kb

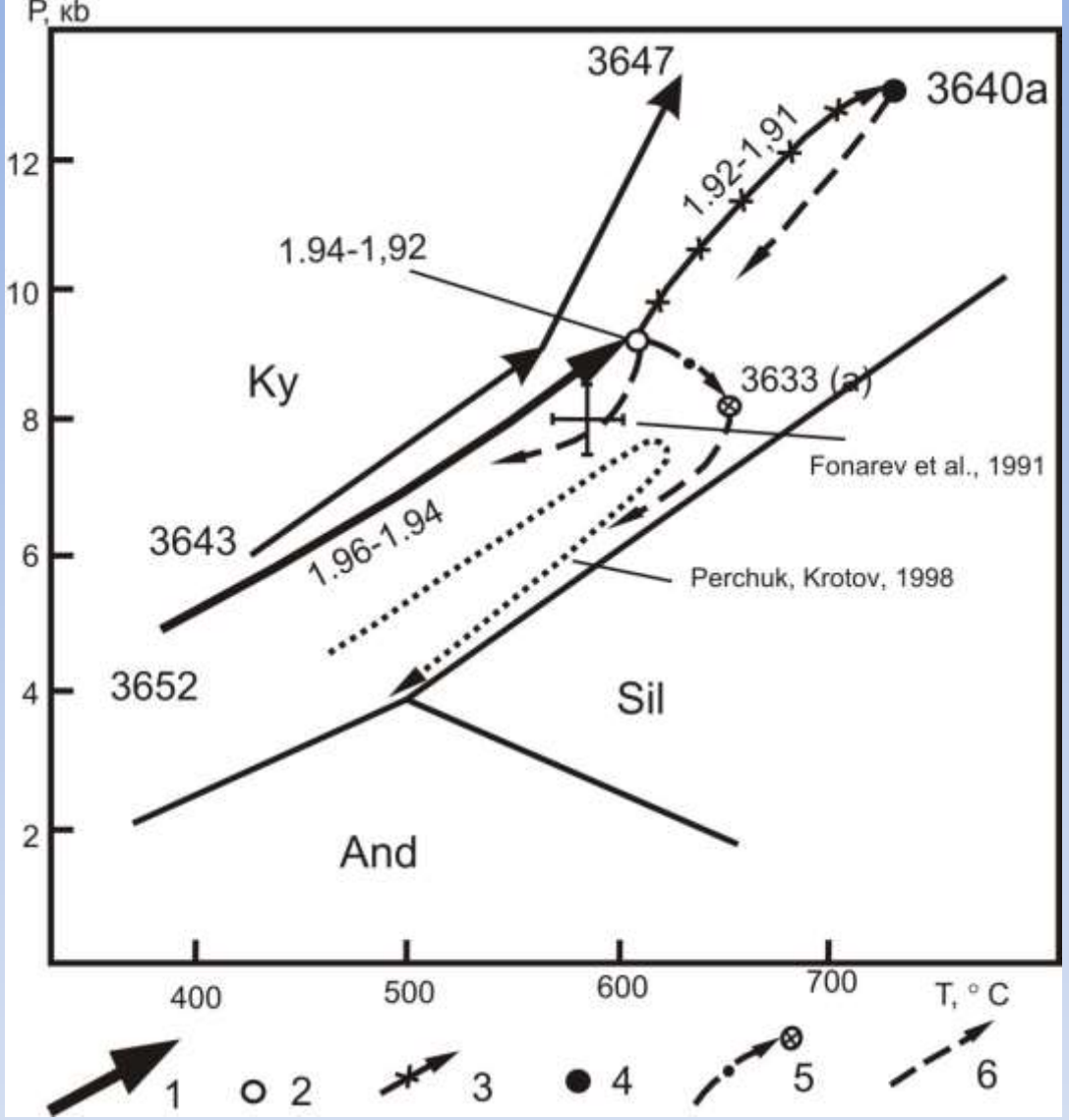


Fig. P-T conditions of the metamorphism stages of the Korvatundra complex.
1 и 2 – prograde metamorphism and peak metamorphism conditions, 3 и 4 – tectonometamorphism, 5 – ultrametamorphism and peak metamorphism conditions , 6 – retrograde metamorphism

The U-Pb age of igneous zircon from the metavolcanite is 2101±21 Ma (Kaulina et al., 2003). The early stages of the progressive metamorphism reflected in relict paragenesis in the southern part were under the conditions of the staurolite-chloritoid and staurolite-garnet-two-mica subfacies with 385-570°C and 4.6-7.6 kbar (Belyaev&Petrov, 2002). The prograde metamorphism were under the conditions of the kyanite-garnet-micas and kyanite-garnet-biotite subfacies and are reflected in the composition of newly formed, chemically non-zonal garnets, or in the similar composition newly formed garnet rim. The metamorphism stage parameters determined by the garnet indicate increasing of the temperatures and pressures to 575-615°C и 7.5-9.1 kbar (Belyaev&Petrov, 2002) or to 650°C и 7.5 kbar (Perchuk&Krotov, 1998). The time of prograde metamorphism of the Korvatundra is in the interval 1940 and 1917 Ma. Within the Korvatundra the processes of superimposed tectonometamorphism occur under conditions of the kyanite-garnet-biotite subfacies and in the north of the Korvatundra their temperatures and pressures reach of 700-750 ° C and 10-14 kbar, correspondingly.

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