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# On the relationships between the $Al_2SiO_5$ polymorphs during formation of blastomylonites (North Yenisei Ridge)

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## Abstract

***Relevance.*** When mapping the vast areas of the Precambrian polymetamorphic complexes in the North Yenisei Ridge, there is a problem of metamorphism interpretation and phasing of geological development of a particular area along with thrust tectonics. The solution of these issues is also of great importance for the purposes of areas delineation of metamorphic rocks that are favorable for the detection of high-alumina (andalusite, kyanite, sillimanite) schists.

***Purpose of the work*:** to substantiate and itemize some geological prospecting, mineralogical and petrological indicator criteria for the development of high-alumina garnet-kyanite-staurolite blastomylonites of dislocation metamorphism formed by andalusite-bearing rocks of regional metamorphism.

***Research methodology*:** detailed mapping of structural-metamorphic zoning of dislocation (collisional) metamorphism in the Mayakon key area with sampling of polymetamorphic rocks for petrographic studies of mineral parageneses. Investigation of polished thin sections of polymetamorphic rocks by microprobe analysis with elucidation of minerals zoning, their chemical composition, calculation of the *P*–*T* paths of metamorphism and determination of the absolute age of blastomylonite formation based on the $^{40}Ar/^{39}Ar$ dating of biotite. Analysis and generalization of the results obtained for the Mayakon area and their comparison with other key areas of the North Yenisei Ridge.

***Results.*** At the Mayakon potential area, a progressive metamorphic zoning of kyanite-bearing blastomylonites has been identified, and the transitional I, outer II, middle III, and inner zones are determined as the dislocation metamorphism intensifies towards the Panimba thrust fault. Based on the compositions of garnets, biotite, and plagioclase, the *P*–*T* paths of the early regional metamorphism of andalusite-sillimanite type and late local kyanite-sillimanite type were calculated. A list of geological prospecting, petrological and isotope-geochronological criteria for recognizing blastomylonites among rocks of regional metamorphism in thrust zones has been substantiated and itemized.

***Conclusions.*** Method of polymetamorphism reconstruction in the North Yenisei Ridge shows that tectonic inversion conditions took place in the Neoproterozoic, in the late Tonian era (~850 Ma ago In terms of occurrences, they are related to the final stage of the Grenville orogeny (1.1–0.85 Ga). The formation of blastomylonites of dislocation (collisional) metamorphism by metapelites of regional metamorphism in thrust zones is accompanied by an increase in the number of mineral phases and leads to a reduction in usable space of high-alumina andalusite schists.

***Keywords*:** polymetamorphic complexes, $Al_2SiO_5$ polymorphs, blastomylonites, dislocation metamorphism, Mayakon, North Yenisei Ridge.

## Introduction

The Yenisei Ridge is one of the most geodynamically interesting regions of Siberia. Its northern segment, the North Yenisei Ridge (Priangarsko-Zaangarsky), is represented by Precambrian sequences varying in age from the Paleoproterozoic to the Vendian inclusive. The most important feature of metamorphic complexes of the region is the wide development of the $Al_2SiO_5$ polymorphs in the metapelites of the Teisky metamorphic complex and the heterogeneity of metamorphism in terms of pressure. This heterogeneity is expressed in the development of the regional metamorphism of two facies series: andalusite-sillimanite (low pressures, *LP*/*HT*) and kyanite-sillimanite (moderate pressures *MP*/*HT*) [1]. The moderate pressure metamorphism follows the low-pressure metamorphism and occurs locally near thrusts, resulting in a progressive replacement of andalusite with kyanite and the formation of new mineral assemblages and deformation structures [2]. Static replacements of andalusite by kyanite (for example, the Mayakon exploration acreage at the dislocation (late) stage of metamorphism) are rare; they are of mineralogical and petrological interest since the stationary continental geotherm usually does not cross the andalusite-kyanite equilibrium line [3].

The Mayakon area was studied near ore occurrence of high-aluminous schists of the same name located in the basins of the Yeruda, Chirimba, and Panimba rivers. This is the first of the key areas where the Early Mesoproterozoic (1350–1250 Ma) [4] sedimentary rocks of the Lower Riphean Kordinskaya Formation were mapped and then studied in detail [5]; they are subject to low- and moderate-pressure metamorphism (Fig. 1). Two large black graphitic andalusite schists of irregular shape correlated with watersheds were mapped within the boundaries of the area. Andalusite (chiastolite) in these schists forms prismatic porphyroblasts ranging in size from 5 × 5 mm

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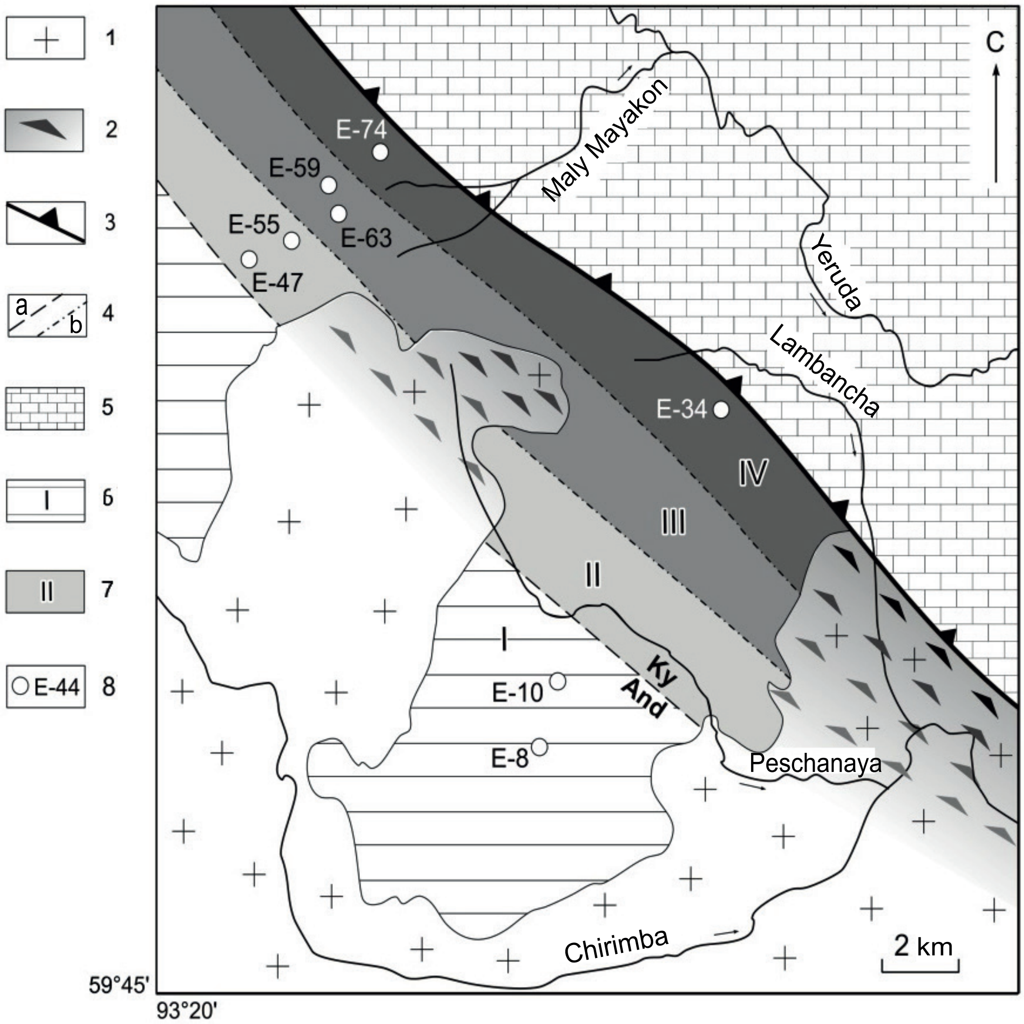


**Figure 1. Schematic map of metamorphism between the Yeruda and Chirimba rivers (Mayakon area), North Yenisei Ridge [2, 8]**. 1 – granites of the Yerudinsky massif; 2 – undivided apogranite cataclasites and blastocataclasites; 3 – the Panimba thrust fault; the thrust direction is shown with a filled triangle; 4 – And-Ky isograd (a) and boundaries between metapelite zones (b); 5 – metasiltstones and metacarbonates of the Penchenga Formation; 6 – metapelites of the And-Sil-type metamorphism of the Kordinskaya Formation; 7 – metapelites zones of Ky-Sil-type metamorphism; 8 – sampling sites.

**Рисунок 1. Схематическая карта метаморфизма между реками Еруда и Чиримба (Маяконский участок), Северо-Енисейский кряж [2, 8].** 1 – граниты Ерудинского массива; 2 – апогранитные катаклазиты и бластокатаклазиты нерасчлененные; 3 – шов Панимбинского надвига с зубцами в направлении падения; 4 – And-Ky изограда (а) и границы между зонами метапелитов (б); 5 – метаавлеролиты и метакарбонаты пенченгинской свиты; 6 – регионально-метаморфизованные метапелиты кординской свиты андалузит-силлиманитового типа метаморфизма; 7 – зоны метапелитов кианит-силлиманитового типа метаморфизма; 8 – точки отбора образцов пород.

to 15 × 15 mm in diameter and up to 3–7 cm in elongation. Metapelites here compose a NW-striking belt (zone) of polymetamorphism with a width of 2 to 7 km and a length of over 30 km, bounded from the east by the NW-striking Panimba thrust fault; behind the thrust fault (to the northeast) there is evidence of the developed Paleoproterozoic meta-carbonates (marbles, skarnoids, metaaleurolites ) of the Penchenga Formation.

**Characteristics of metamorphic zoning**

In a direction transverse to the strike of the zone, the structural-metamorphic zoning was identified: it is expressed in the degree of structural and material transformation of metapelites of the andalusite-sillimanite facies series represented by the following mineral associations: Qtz + Ms + Bt + Grt ± Pl, Qtz + Ms + Bt + St, Ms + Chl + Bt + Cld + And + Qtz + Ilm ± Crd, and **Qtz + Ms + Bt + And + Grph** (hereinafter, mineral abbreviations after [6]). The latter mineral association is of great importance for understanding the development of dynamometamorphic blastomylonites by the initial regional metamorphic rocks, similar to the andalusite ores of the Panimba deposit (Fig. 2), located southwest of the Mayakon.

Three metamorphic zones of "superimposed" kyanite-sillimanite metamorphism and structural-compositional transformation of andalusite-bearing rocks (from west to east), differing in the ratio of relict and newly formed minerals and the degree of rock deformation (Fig. 1): transitional I, outer II, middle III and inner IV.

*Transitional zone I* (visible thickness does not exceed 20 m) from andalusite schists to kyanite-sillimanite blastomylonites is characterized by destruction of metapelites with cataclasis of andalusite porphyroblasts. When they are crushed, boudinage structures are formed, the gaps between porphyroclasts are surrounded with pressure shadows of quartz. The main granolepidoblastic matrix of schists is also subject to changes

**Figure 2. Chiastolite carbonaceous schists of the Kordinskaya Formation from the outer zone of regional low-pressure metamorphism of the andalusite-sillimanite type. The porphyroblast texture (6 × 6 mm) is plan-parallel. The area of the Panimba andalusite deposit. Teisky metamorphic complex. Panimba site. The left bank of the Panimba River is in the middle course. The sample on the right is polished.**

**Рисунок 2. Хиастолитовые углеродистые сланцы кординской свиты из внешней зоны регионального метаморфизма низких давлений андалузит-силлиманитового типа. Текстура порфиробластов (6 × 6 мм) план-параллельная. Район Панимбинского месторождения андалузита. Тейский метакомплекс. Участок Панимбинский. Левый берег р. Панимбы в среднем течении. Образец справа приполированный.**

**Figure 3. Syntectonic pseudomorphs of quartz-kyanite-muscovite-staurolite composition along chiastolite porphyroblasts (6 × 6 mm to 15 × 15 mm) in graphite-muscovite-biotite schists of the Kordinskaya Formation as a result of overprint of dislocation (collisional) metamorphism on low-pressure metapelites (fig. 1) in the area of the Panimba thrust fault. Teysky metacomplex. Mayakonsky site. The middle zone. The sample on the right is polished.**

**Рисунок 3. Синтектонические псевдоморфозы кварц-кианит-мусковит-ставролитового состава по порфиробластам хиастолита (6 × 6 мм до 15 × 15 мм) в графит-мусковит-биотитовых сланцах кординской свиты как результат наложения дислокационного (коллизионного) метаморфизма на метапелиты низких давлений (рис. 1) в районе Панимбинского надвига. Тейский метакомплекс. Участок Маяконский. Средняя зона. Образец справа приполированный.**

with the development of kink bands in biotite porphyroblasts. The position of the western boundary of the transitional zone I is hypothetic since the slope of Lambancha Mountain is covered with large-platy deluvial deposits.

*Outer zone II* is represented by the products of destruction of schists showing the early stage of recrystallization of andalusite with pseudomorphic replacement of andalusite by kyanite-muscovite-quartz aggregate. The prismatic shape of crystals is preserved, the internal structure of the chiastolite "cross" and the hourglass structure are preserved due to inclusions of carbonaceous matter. Crystals are often cataclased; crystal fragments are surrounded by pressure shadows of finely granular quartz oriented along the direction of deformation. Visually, the replacement of andalusite with kyanite was not previously identified; therefore, this very important fact of the presence of the high-pressure polymorph has not been taken into account for a long time. Under the microscope, kyanite pseudomorph after andalusite is predominant over muscovite (up to 1–3%). The thickness of the deformation zones does not exceed the first tens of meters. Similar pseudomorphs of kyanite after chiastolite andalusite are reported in the Lower Proterozoic Keivy Formation [7].

**Table 1. Compositional parameters of minerals of metapelites of the Kordinskaya Formation Mayakon area (North Yenisei Ridge, [8, 12]).**
**Таблица 1. Параметры составов минералов метапелитов Кординской свиты Маяконского участка (Северо-Енисейский кряж [8, 12]).**

| Sample number | Grt | | | | Bt | | Ms | | Pl |
|---|---|---|---|---|---|---|---|---|---|
| | $X_{Grs}$ | $X_{Prp}$ | $X_{Alm}$ | $X_{Sps}$ | $X_{Ann}$ | $X_{Phl}$ | $X_{Ms}$ | $X_{Pl}$ | $X_{An}$ |
| *Ky-Sil type metapelites (inner zone)* | | | | | | | | | |
| 34 | 0.109 | 0.138 | 0.740 | 0.013 | 0.361 | 0.499 | 0.766 | 0.138 | 0.334 |
| 34 core | 0.059 | 0.153 | 0.766 | 0.022 | | | | | 0.420 |
| 32 | 0.113 | 0.126 | 0.743 | 0.019 | 0.368 | 0.449 | 0.798 | 0.090 | 0.389 |
| 33 | 0.042 | 0.074 | 0.831 | 0.052 | 0.503 | 0.300 | 0.769 | 0.850 | 0.122 |
| 74 | 0.043 | 0.077 | 0.833 | 0.047 | 0.505 | 0.269 | 0.795 | 0.207 | 0.121 |
| 74 core | 0.025 | 0.074 | 0.830 | 0.071 | | | | | |
| *Ky-Sil type metapelites (middle zone)* | | | | | | | | | |
| 59 | 0.031 | 0.077 | 0.844 | 0.048 | 0.500 | 0.295 | 0.798 | 0.084 | 0.116 |
| 63 | 0.032 | 0.077 | 0.842 | 0.049 | 0.507 | 0.297 | 0.789 | 0.089 | 0.124 |
| 44 | 0.032 | 0.079 | 0.840 | 0.049 | 0.501 | 0.306 | 0.805 | 0.068 | 0.121 |
| 44 core | 0.024 | 0.075 | 0.830 | 0.071 | | | | | |
| 61 | 0.032 | 0.078 | 0.843 | 0.047 | 0.499 | 0.298 | 0.792 | 0.081 | 0.122 |
| 61 core | 0.024 | 0.075 | 0.828 | 0.072 | | | | | |
| *Ky-Sil type metapelites (outer zone)* | | | | | | | | | |
| 55 | 0.025 | 0.077 | 0.850 | 0.047 | 0.503 | 0.292 | 0.788 | 0.086 | 0.119 |
| 47 | 0.024 | 0.077 | 0.851 | 0.048 | 0.504 | 0.300 | 0.679 | 0.232 | 0.121 |
| 51 | 0.025 | 0.075 | 0.848 | 0.051 | 0.506 | 0.295 | 0.734 | 0.165 | 0.119 |
| *And-Sil type metapelites* | | | | | | | | | |
| 8 | 0.607 | 0.392 | 0.869 | 0.130 | 0.690 | 0.309 | 0.808 | 0.083 | 0.058 |
| 10 | 0.609 | 0.390 | | | 0.695 | 0.304 | 0.843 | 0.078 | 0.096 |

Note: the following formulas were used to calculate the mole fractions of components (in formula coefficients): $X_{Alm}$ = Fe/(Fe + Mg + Ca + Mn); $X_{Prp}$ = Mg/(Fe + Mg + Ca + Mn); $X_{Grs}$ = Ca/(Fe + Mg + Ca + Mn); $X_{Sps}$ = Mn/(Fe + Mg + Ca + Mn); $X_{Ann}$ = Fe/(Fe + Mg + Mn + Ti + $Al^{VI}$); $X_{Phl}$ = Mg/(Fe + Mg + Mn + Ti + $Al^{VI}$); $X_{Ms} = (X_K)(X_{Al}{}^{VI})^2$; $X_{Pl} = (X_{Na})(X_{Al}{}^{VI})^2$; $X_{An}$ = Ca/(Ca + Na + K). Compositions of the central parts of zonal minerals are designated as cores, the rest of compositions characterize the grain rims.

*Middle III and inner zones IV* (total thickness of about 5 km) adjacent to the Panimba thrust fault differ markedly from the previous ones by thick structural and material transformation of andalusite metapelites with the formation of new high-P mineral assemblages. Shiny light lenticular-nodular crystalline schists represent metapelites with well-defined crystallization schistosity at the expense of muscovite of the main tissue. Typomorphic mineral associations of tectonites are represented by – Qtz + Ms + Grt + St + Ky + Chl, Qtz + Ms + Grt + St + Ky, Qtz + Ms + Grt + St + Ky + Pl + Ilm, Qtz + Ms + Bt + Grt + St + Ky ± Grph, near to the thrust fault – Qtz + Ms + Grt + St + Ky + Sil. As a result of increasing deformations, pseudomorphs (Ky + Ms + Qtz ± And) are transformed into lenses oriented with a long axis along the foliation. They are composed of an aggregate of the predominant sheaf-like kyanite in paragenesis with quartz, muscovite, and staurolite (Fig. 3); in rare cases, andalusite relics are noted. Submicroscopic staurolite crystals in paragenesis with garnet are observed around Ky + Ms + Qtz ± And pseudomorphoses embedded in the lepidogranoblastic matrix. Garnet from these tectonites, in contrast to well-formed rhombododecahedrons from metapelites of regional metamorphism outside of dislocation zones, has the form of flattened disc-shaped single and “chains” of porphyroblasts with a zonal structure (Table 1) surrounded by micaceous (muscovite + biotite) “rim”. The deformation of garnet crystals indicates the influence of stress during their growth. The appearance of fibrolite near the Panimba thrust fault indicates the increase in temperature during ductile deformation. In addition, this is also indicated by lenticular-nodular texture of tectonites and veins of granular quartz (a few meters thick) noted above, which lie in a deformation band in accordance with the strike of the thrust fault.

Thus, the conducted studies allow us to conclude that regionally metamorphosed andalusite metapelites in the Mayakon area were subjected to dislocation metamorphism and ductile-brittle deformation according to the scheme: cataclasites → blastocataclasites → blastomylonites upon approaching the Panimba thrust fault. However, according to mineralogical analysis, valuable concentrations of andalusite in *zone I* that reach a value of about 15% (Mayakon ore occurrence) are partially or completely depleted by dislocation metamorphism processes in the middle and inner zones, where its content is small or absent. At the same time, the content of kyanite in these zones does not exceed 3.5% (almost twofold) which is explained by the formation of new aluminosilicates (staurolite, garnet, mica, plagioclase) (Tables 1, 2).

**Metamorphic *P*–*T*-paths**

The results of geothermobarometry (Table 2) indicate a gradual increase in pressure upon approaching the Panimba thrust fault (Fig. 1): From 3.5–4 kbar in metapelites of regional

**Table 2. *P–T*-paths estimates of metapelites of the Kordinskaya Formation, Mayakon area [8, 12].**
**Таблица 2. Оценки РТ-условий метапелитов Кординской свиты. Участок Маяконский [8, 12].**

| Sample number | *T*,°C | | | | | | | | *P*, kbar | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (7) | (10) | (8) | (9) | (2) | (3) | (4) | (13, 14) | (11) | (12) | (5) | (6) | (13, 14) |
| *And-Sil type metapelites* | | | | | | | | | | | | | |
| 8 | – | | | | 542 | 549 | 551 | | | | 3.9±0.1 | 3.7±0.2 | |
| 10 | | | | | | | 562 | 553±22 | | | 3.7 | 3.6 | 3.3±0.7 |
| *Ky-Sil-type metapelites (outer zone)* | | | | | | | | | | | | | |
| 47 | 538 | 560 | 561 | 568 | | | | | 4.63 | 4.54 | | | |
| 51 | 537 | 561 | 559 | 573 | | | | | 4.83 | 4.66 | | | |
| 55 | 547 | 562 | 566 | 570 | | | | 572±13 | 5.05 | 4.85 | | | 4.6±0.2 |
| *Ky-Sil-type metapelites (middle zone)* | | | | | | | | | | | | | |
| 63 | 552 | 567 | 566 | 582 | | | | 568±18 | 5.65 | 5.73 | | | 4.8±1.0 |
| 61 | 580 | 578 | 577 | 604 | | | | 571±14 | 5.80 | 5.73 | | | 5.2±0.3 |
| 44 | 578 | 577 | 596 | 601 | | | | | 5.90 | 5.77 | | | |
| 59 | 549 | 565 | 568 | 580 | | | | 567±16 | 5.75 | 5.92 | | | 4.6±0.9 |
| *Ky-Sil-type metapelites (inner zone)* | | | | | | | | | | | | | |
| 33 | 544 | 564 | 569 | 572 | | | | | 6.22 | 6.20 | | | |
| 32 | 550 | 567 | 570 | | | | | | 6.30 | 6.29 | | | |
| 34 | 540 | 573 | 570 | | | | | 632±40 | 6.38 | 6.42 | | | 7.6±1.2 |
| 74 | 563 | 572 | 570 | 589 | | | | 572±16 | 6.68 | 6.70 | | | 5.4±0.9 |

Note: the numbers of geothermobarometers in brackets correspond to the numbers of geothermobarometers in the literature cited [2, 5]). The sample numbers correspond to those in Fig. 1.

metamorphism, 4.5–5 kbar – in the outer zone, up to 5.5–6 kbar – in the middle zone, and up to 6.2–6.7 kbar – in the inner zone near the thrust fault without significant increase in temperature (550°C to 580°C). The calculated *P–T* evolutionary trends confirm a gradual increase in pressure in the metapelites of the Kordinskaya Formation upon approaching the thrust fault by a value from 1 to 2.2 kbar without a significant increase in temperature (no more than 20 ± 15 °C), which may indicate an almost isothermal subsidence of the rock mass at very low geothermal gradient – no more than 5–7 °C/km. The increase in pressure towards the Panimba thrust fault is associated with tectonic movements of the western vergence from the Siberian Craton about 850 Ma ago, based on biotite $^{40}Ar/^{39}Ar$ dating [8].

Thus, in the study area, low-pressure metapelites, represented by the Ms + Chl + Bt + Cld + And + Qtz + Ilm ± Crd general mineral association, were formed under the conditions of the epidote-amphibolite facies. The rocks of moderate pressure characterized by the Ms + Chl + Bt + Qtz + Ky + St + Grt + Ilm + Pl association with andalusite relics and the rare presence of sillimanite (fibrolite) metamorphosed under conditions of kyanite schists [9, 10].

To explain the observed metamorphic evolution, a tectonic model was proposed [5, 11] and the necessary thermophysical calculations were made taking into account the real physical parameters of metapelites and metacarbonates, namely, radioactive heat release and thermal conductivity coefficients. The gradual increase in pressure was justified by tectonic thickening of the Earth's crust in the Panimba thrust fault zone, as a result of which the metapelites of the Kordinskaya Formation were overlapped by metacarbonates of the Pechenga Formation with 5–7 km thickness. The absence of a noticeable increase in temperature with thrust fault is explained by peculiarities of the behaviour of stationary geotherms for various types of rocks with contrasting heat-generating and thermophysical properties [5].

**Geological and mineralogical-petrological indicators and criteria of dislocation metamorphism**

In the North Yenisei Ridge, the typification of the Teisky tectonometamorphic complex is based on *geothermal gradient (dT/dH* °C/km*)*, which shows the change in the temperature values of regional metamorphism of the andalusite-sillimanite type with depth (*dT/dH from 20–30 °C/km*) and collisional kyanite-sillimanite (*dT/dH from 2.5 to 12°C/km)* – laterally [12].

The comprehensive studies carried out at the Mayakon key area were later confirmed at the Teya, Chapa and Garyovsky Polkan sites within the Ishimba-Tatar regional shear zone in the Central uplift [13, 14]. The results obtained make it possible to distinguish for the North Yenisei Ridge the following geological criteria and indicator petrological signs of dislocation (collisional) metamorphism of the kyanite-sillimanite type when it is superimposed on regionally metamorphosed low-pressure rocks [16] of the andalusite-sillimanite type: a) changing in textural-structural features of rocks, the mineral composition of blastomylonites with identification of the outer, middle (central, intermediate), and inner zones based on the increase in the degree of intensity of dislocation metamorphism towards to the thrust zones; b) zonal asymmetry of thrust-bounded blastomylonite zones, in contrast to zonal complexes of regional metamorphism of symmetric structure; c) local manifestation of zones of ductile-brittle deformation and the formation of blastomylonites (up to 5–7 km in thickness) spatially and genetically related to regional faults; d) microstructural features of blastomylonites, typical of the "shear-zone" (boudinage and discontinuity of minerals, their deformation, pressure shadows of recrystallized quartz, replacement of andalusite by an aggregate of kyanite, muscovite, quartz and staurolite (pseudomorphs) and lenticular outlines of pseudomorphs, "S"-shaped and "snowball" garnets structures, "kink-band" structure of biotite, etc.); e) an increase in the basicity of plagioclase and an increase in the grossular component at the rims of garnets towards the thrust faults; f) low geothermal gradient (*dT/dH from 2.5 to 12 °C/km*), indicating an almost isothermal metamorphism of rocks with an increase in pressure towards thrusts; g) the *P–T* paths of formation of blastomylonites of the middle and inner zones of dislocations correspond to kyanite-staurolite subfacies of the high-pressure kyanite schist facies [10] with local increase in temperature (development of fibrolite (sillimanite)); h) dislocation (collisional) metamorphism is caused by dislocations (thrusts) of crystalline blocks of western and eastern vergence; i) discreteness and discrepancy in the time of formation of late blastomylonites of moderate pressure superimposed on low-pressure metamorphic rocks of regional metamorphism [2, 5, 8, 12].

## Conclusions

Geological, mineralogical, petrological and isotope-geochronological results of the polymetamorphism study in the Mayakon site and other parts of the North Yenisei Ridge indicate that the region was subjected to an inversion of the tectonic conditions from low- to moderate pressures in the Neoproterozoic, in the late Tonian (~850 Ma ago). In terms of occurrences, they are related to the final stage of the Grenville orogeny [15]. Kyanite blastomylonite zones in the thrust zones are accompanied by an increase in the number of mineral phases, which leads to a reduction in usable space of the high-alumina andalusite schists.

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# О взаимоотношении полиморфов $Al_2SiO_5$ при образовании бластомилонитов (Северо-Енисейский кряж)

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Аннотация

***Актуальность.*** При картировании обширных площадей докембрийских полиметаморфических комплексов в Северо-Енисейском кряже существует проблема расшифровки метаморфизма и этапности геологического развития того или иного участка с надвиговой тектоникой. Решение этих вопросов имеет также важное поисковое значение для разбраковки и оконтуривания площадей метаморфических пород, благоприятных на обнаружение высокоглиноземистых (андалузит-, кианит-, силлиманитовых) сланцев.

***Цель работы*:** обосновать и составить перечень геолого-поисковых, минералогических и петрологических индикаторных критериев развития высокоглиноземистых гранат-кианит-ставролитовых бластомилонитов дислокационного метаморфизма, образующихся по андалузитсодержащим породам регионального метаморфизма.

***Методология исследования*:** детальное картирование структурно-метаморфической зональности дислокационного (коллизионного) метаморфизма на Маяконском опорном участке с отбором образцов и сколков полиметаморфических пород для петрографических исследований минеральных парагенезисов; исследование полированных шлифов полиметаморфических пород с помощью микрозондового анализома с выяснением зональности минералов, их химического состава, расчет РТ-условий метаморфизма и установление абсолютного возраста образования бластомилонитов по биотиту $^{40}Ar/^{39}Ar$ методом; анализ и обобщение полученных результатов по Маяконскому участку и их сопоставление с результатами на других опорных участках Северо-Енисейского кряжа.

***Результаты.*** На Маяконском поисковом участке установлена прогрессивная метаморфическая зональность кианитсодержащих бластомилонитов и выделены переходная, внешняя, средняя и внутренняя зоны по мере усиления дислокационного метаморфизма в направлении к Панимбинскому надвигу. На основании составов гранатов, биотита и плагиоклаза рассчитаны РТ-параметры раннего регионального метаморфизма андалузит-силлиманитового и позднего локального кианит-силлиманитового типов. Обоснован и составлен перечень геолого-поисковых, петрологических и изотопно-геохронологических критериев распознавания бластомилонитов среди пород регионального метаморфизма в зонах надвигов.

***Выводы.*** Реконструкция полиметаморфизма в Северо-Енисейском кряже свидетельствует о том, что в неопротерозое, в позднем тонии (~850 млн лет назад) в регионе происходила инверсия тектонического режима с низких давлений на умеренно барические, по времени проявления связанные с завершающей стадией гренвильской орогении (1,1– 0,85 млрд лет). Образование бластомилонитов дислокационного (коллизионного) метаморфизма по метапелитам регионального метаморфизма в зонах надвигов сопровождается увеличением количества минеральных фаз и приводит к сокращению полезных площадей развития андалузитовых высокоглиноземистых сланцев.

***Ключевые слова*:** полиметаморфические комплексы, полиморфы $Al_2SiO_5$, бластомилониты, дислокационный метаморфизм, Маяконский участок, Северо-Енисейский кряж.

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